Strategies for Sustainability

Angela Carpenter
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Sustainability in the Maritime Domain

Towards Ocean Governance and Beyond

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Strategies for Sustainability

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My research in the maritime domain continues to be inspired by Rachel Carson (1907-1964), Marine Biologist and author of 'The Sea Around Us'.

Angela Carpenter

Inspired by A.K.M Abdul Matin, Professor and Marine Biologist (1949-2006)

Tafsir Johansson

Before looking ahead for insight into what will surely be a collective challenge to sustain our oceans, our air and ourselves---I first look back to Thucydides (c. 460 BC – c. 400 BC).

Jon A. Skinner.

Contents

Part II Moving to a More Secure and Safe Maritime Regulatory Regime

Part IV Good Ocean Governance

Chapter 1
Introducing Sustainability in the Maritime Domain

Angela Carpenter, Tafsir M. Johansson, and Jon A. Skinner

Abstract The impact of human activities on the marine environment has been well known for decades if not centuries. Man has polluted as long as he has used the seas, whether caused by discarded nets in which marine mammals get tangled, sewage, plastics, or other waste thrown overboard during long voyages, releases of oil and other chemicals from ships and oil production platforms, or plastics and microplastics floating in the sea consumed by organisms within the food chain. These are all visible impacts of man on the sea. However, other impacts are not as visible—the noise from a ship cannot be seen but can have detrimental impacts on sea life; atmospheric pollution such as greenhouse gases are not visible but contribute significantly to ocean acidification and global warming. This introductory chapter provides context for the complete volume. It introduces the concepts of sustainability, sustainable development, and delineates the UN Sustainable Development Goals. It also defines the maritime domain as all human activities on and beneath the sea. This volume includes chapters from a wide spectrum of sources—academia, non-governmental organisations, security/port practitioners, and shipping industry experts, among others. Each chapter analyses an issue of concern within the maritime domain, presents key aspects of those areas of concern, and then sets them within the context of the UN Sustainable Development Goals. Current problems are both detailed—and potential future solutions identified. Each chapter is summarised in the following introduction from the perspectives of the authors and co-editors of the volume.

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The impact of human activities on the marine environment has been well known for many decades. International efforts to reduce impacts in an ad hoc way have been developed for more than a century—from a 1914 Convention on Safety of Life at Sea (SOLAS) developed in the wake of the sinking of the *RMS Titanic* and the later 1974 version of that Convention, a key convention of the International Maritime Organization (IMO), the 1973 International Convention on Prevention of Pollution from Ships (MARPOL), and the 1977 Torremolinos Convention for the Safety of Fishing Vessels, and more recently the 2007 Nairobi International Convention on the Removal of Wrecks (IMO 2019). A landmark step forward in the fight to protect, preserve, and conserve the marine environment was the UN Convention for the Law of the Sea (also known as the Law of the Sea Treaty), an international agreement resulting from the third UN Conference on the Law of the Sea, and passed on 10 December 1982. With the introduction of this Convention, rules were set in place across the marine environment including: rules for maritime activities, both on and under the sea, and on and under the seabed and ocean floor; rules on the legal status of territorial waters and on rights of navigation; measures for the protection and preservation of the marine environment; and measures relating to the development and transfer of marine technology (Oceans and Law of the Sea 2001). Sustainability and sustainable development were not, however, topics covered in the UNCLOS. Work in these areas has taken place more recently, leading to the UN Sustainability Goals for 2030 (UN 2020) and the Decade of Ocean Science for SD (UNESCO 2017).

Within this context, this book explores sustainable options while exploring in multidisciplinary fashion the 'Maritime Domain': defined as all human activities occurring both above and below the sea surface, as well as activities on and below the seabed. These activities include: maritime transportation—the movement of raw materials, goods, and people by ship between seaports; Maritime Spatial Planning (MSP)[1], that is, planning for the use of various maritime resources such as fisheries, wind and wave energy, tourism, and oil and gas extraction from under the seabed (see Fig. 1.1); maritime education and training; maritime traffic and advisory systems; and maritime security.

Maritime activities covered in this book include greening the blue economy, green ports and sustainable shipping, maritime security at international and national levels, pollution prevention, and the impacts of underwater noise, and unfortunately but very topically, the impact of Covid-19 is examined through a national case

[1] The UN Food and Agriculture Organization (UN FAO 2016) clearly iterates that MSP provides *"a step-by-step process that allows for the cooperative integration of the major marine uses and users within a defined marine area,* where *all stakeholders* are able *to work towards ensuring the long-term sustainability of identified marine activities".*

Fig. 1.1 Marine spatial planning. (Source: UN Food and Agriculture Organization (UN FAO 2016))

study. In addition to practical examples, good ocean governance is also examined at an international and regional level through the activities of the International Maritime Organization (IMO) as the main body responsible for implementing the UN Sustainable Development Goals for 2030 as they relate to the marine environment and maritime domain (see Fig. 1.2).

Maritime transportation is the foundation of international shipping and supports around 80% of the world's seaborne trade by volume (UNCTAD 2019) and includes: carriage of goods by sea, fishing, tourism, exploration and exploitation of the sea, and mineral resource extraction, as well as scientific research. Such activities help keep the global economy moving and contribute to the livelihood of people globally. According to the IMO (2013): "world trade and maritime transport are … fundamental to sustaining economic growth and spreading prosperity throughout the world, thereby fulfilling a critical social as well as an economic function".

While the positive attributes of maritime transport are widely acknowledged by all (developed countries, least-developed countries, Small Island Developing States (SIDS), as well as international organisations and UN bodies), the repercussions that accompany these multifarious positive attributes of maritime transport and international shipping are unfortunately offset by a clear and evident decline in the health of the oceans of the same increased shipping and maritime activities. The positive news for mankind is that there is a plan to reverse that decline as international organisations, regions, nations, and civil society from across the world are coming

Fig. 1.2 UN Sustainable Development Goals for 2030. (Source: UN Department of Economic and Social Affairs (UN DESA undated))

together to protect, preserve, and conserve the oceanic resources by addressing the negative impacts of international shipping and other maritime activities.

Today, government, industry, civil society, and academia, together with international organizations and UN bodies, are engaged in promoting a wide range of "sustainability" actions. These include: lowering anthropogenic emissions such as greenhouse gases (GHGs), polluting chemicals and microplastics, empowering women through the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) Decade of Ocean Science for SD (UNESCO 2017, 2019), implementing lessons learnt from other sectors, and increasing technical cooperation in order that the oceans' resources meet the needs of today without comprising the needs of future generations. In line with the development of sustainability actions, the book draws on the IMO's concept of a *Sustainable Maritime Transportation System*, which includes a set of goals and actions related to maritime safety and security; education, training, and gender empowerment; energy efficiency and ship-port interface; technological innovation; technical cooperation; liability regime; and innovative financial mechanism. These and other themes are addressed against the backdrop of the UN 2030 Agenda for SD (UN 2020), with a specific focus on the interconnectedness between and among the various goals, as well as pertinent trade-offs, in order to achieve ocean sustainability in the coming decades.

In developing and bringing this book to fruition, the main aim was to provide the building blocks needed for a framework for good ocean governance, identified by the UN (2020) as a framework that will serve through the next decade and, hopefully, well beyond the 2030 milepost of the UN Agenda for Sustainable Development. In short, this book brings together the problems of the current world and sustainable solutions that are in the development process and will eventually materialise in the not so distant future. To satisfy its aim, the book provides expert insights from academics at all levels—including long-standing and early-career researchers from a range of disciplines, from practitioners in the maritime industry, and from experts from the charitable and non-governmental sectors as well as operational subject matter experts. These authors and experts provide a framework to enable readers to look at cross-cutting solutions pertaining to the maritime domain from a sustainable perspective.

The objective of this book is to present a trans-disciplinary analysis of integral sustainable maritime transportation solutions and crucial issues relevant to good ocean governance that have recently been discussed at different national, regional, and international fora. It, therefore, highlights ongoing work to develop and support governance systems that facilitate industry requirements and to meet the needs of coastal states and indigenous peoples, of researchers, of spatial planners, and of other sectors dependent on the oceans. By building on a trans-disciplinary foundation and taking into account stakeholders' objectives, it crosses disciplinary boundaries to provide a holistic perspective of maritime domains.

An important aspect of the work is the trans-disciplinary nature of the contributions by experts from industry, civil society, government and regional entities, international organisations, and UN bodies. These are, moving forward, some of the key stakeholders that consider not only the steps necessary to achieve the UN 2030 Agenda, but also who will go on to transcend its expiry in order to continue to develop "sustainability" actions to maintain ocean governance beyond the ambit of the Agenda's vision. With this in mind, one of our objectives was that it will not only remain relevant until 2030, that is, when the targets of the Sustainable Development Goals (SDGs) are due to fully mature, but will continue to offer a resource for academics, industry stakeholders, and those concerned with implementation, compliance, and enforcement of sustainable maritime transportation rules in the years to come.

The book branches out into four parts: Part I chapters (Chaps. 2–4) fall under the broad heading of 'Moving to the Green-Blue Economy', Part II chapters (Chaps. 5–9) relate to 'Moving to a More Secure and Safe Maritime Regulatory Regime', Part III chapters (Chaps. 10–17) examine 'Improvements in Management/Technology of Best Practices for Sustainable Shipping', and Part IV chapters (Chaps. 18–21) fall under the theme of 'Good Ocean Governance'.

The final chapter of the book (Chap. 22) then looks at the SDGs and their associated targets and highlights areas where the targets are directly, or partially, related to the maritime domain, including examples of that relationship. It does not attempt to summarise all the conclusions presented in the various chapters—rather it shows the interconnectedness of the SDGs and their relevance to the maritime domain now and in the future.

As noted above, the chapters in Part I of this volume (Chaps. 2–4) fall under the broad heading of 'Moving to the Green-Blue Economy'.

Chapter 2 by Spalding et al. (2021) on Greening the Blue Economy focuses on the ocean economy, including both the positive and negative economic benefits to be gained from using the oceans for maritime transportation. It also focuses on the wide range of challenges facing the maritime transportation sector. Topics covered include measures to reduce GHGs emissions, designing cleaner ships, reducing pollution from shipping including waste in water or waste discharged to ports, and improving ship safety and emergency response. These and other aspects of the blue economy are explored within the lens of the UN's SDG 14—Life Below Water (and others such as climate actions (SDG 13), reducing hunger (SDG 2), or economic growth (SDG 8)) as they are applicable to various aspects of maritime transportation. They are also examined within a framework of ten Sustainability Actions (SA; some already underway and others still being developed), covering areas such as standardising inspection and enforcement (SA 1), designing and building greener ships (SA 3), and operating to avoid whale strikes (SA 9). As Spalding et al. note "Anticipating and acting rather than reacting when things go wrong is a key requirement of improving any sector's sustainability". They further note that a transdisciplinary approach needs all parties, including government and industry, to implement measures so that maritime transportation is done in a sustainable way, so that "… oceanic resources can meet the needs of today without comprising the needs of future generations". All of the SA (and applicable SDGs) are, therefore, considered within the context of transforming the maritime transportation sector so that it operates in a more sustainable and more ocean-friendly manner. Based on this assessment, Spalding et al. conclude that while harmful human activities have reached a point where they are causing significant harm to biodiversity and ecosystems and that increased ocean-based trade is continuing to cause significant problems (ocean acidification, transportation of invasive species and diseases, and increasing pollution), it is still possible to find solutions to those problems. The maritime transportation sector, as a whole, can contribute to those solutions through increased efficiency and innovation and by embedding sustainability into maritime transportation practices.

Chapter 3 by Alam (2021) assesses Regional Marine Spatial Planning (MSP) as a tool for greening the blue economy in the Bay of Bengal (BoB) in the north-eastern Indian Ocean, an area with a population of around 200 million, most of whom are partially or almost wholly dependent on the regions fisheries. Many of the activities taking place in the region result in marine pollution from unsustainable human activities in the region. While there is considerable scope to develop the region's natural resources for the socio-economic benefit of the region and to develop a sustainable blue economy, there are also many threats to the marine environment through exploitation of the region's hydrocarbon reserves, for example. It is, therefore, essential to effectively manage the region (currently done on a sector-by-sector basis) to gain economic benefits while reducing the threats facing the environment—a balance is needed between conservation and exploitation. However, as Alam explains, the legal regimes in the region for managing marine resources (conventions, agreements, declarations, programmes, for example) are fragmented and inadequate to allow for the development of MSP for sustainable use and marine pollution prevention in the BoB region. Having examined the concepts and practicalities of Blue Economy and MSP, both separately and together, the current management framework for the BoB is discussed in detail, including a range of agreements, action plans, and declarations already in place. While many of the tools needed for MSP are already in place, MSP as a management tool has not been implemented. Alam concludes that this is a vital step, either at a regional or country level, to ensure the sustainable management of the regions resources and to protect the marine environment, ecosystem, and living resources of the BoB; it might also facilitate cross-border cooperation among the coastal states economy in the BoB.

In Chap. 4, Munim and Saha (2021) examine green ports and sustainable shipping in Europe, with a focus on emissions from shipping and maritime activities, including air pollution from ship exhausts. Looking at the North Sea/Baltic Sea, Mediterranean Sea, and Black Sea regions of Europe, they assess green port and shipping practices and regulations and then propose a high-level conceptual framework for the implementation of those practices. They also detail the effects of GHG emissions on the environment and human health, and measures set out by the IMO to reduce emissions from the maritime sector by at least 50% by the year 2050 (against 2008 levels). Also considered are major local, national, and international regulations governing maritime transportation in the European region including, for example, European pollution prevention regulations and ship-shore pollution prevention measures. They then proceed to examine green port management practices, noting that while emissions from ports are low compared to shipping, there is also scope to reduce emissions from port activities, which would contribute to the IMO goal of reducing maritime emissions. Measures such as environmental pricing, adapting green technology, and improving supply chain collaboration are also identified as ways for ports to improve their green management practices. Similarly, with green shipping practices, technical solutions to improve vessel efficiency, increasing ship recycling, and energy efficiency evaluation are just some of the measures suggested to improve shipping practices. Munim and Saha identify that while some measures have already been implemented in selected companies, ports, countries, or regions, there still needs to be greater implementation and adoption of such measures across the port and shipping sectors. They, therefore, propose a conceptual framework for better implementing green port and shipping practices across all European ports. Key measures for maritime sustainability include sustainable shipping practices, internal environmental management, and environmental pricing. Within shipping companies, sustainable operations. High-level and large-scale implementation of such practices will, they conclude, lead to better environmental, economic, and social performance from ports and shipping companies. It will also contribute to meeting the challenges of the SDGs such as SDG 14—life below water—to conserve and more sustainably use maritime resources.

The chapters in Part II of this volume (Chaps. 5–9) are presented under the heading of 'Moving to a More Secure and Safe Maritime Regulatory Regime'.

Chapter 5 by Martini and Allnutt (2021) focuses on Maritime Transport and Sustainable Fisheries, two maritime activities that are highly interconnected and need solutions to help achieve SDG 14. In particular, the issue of Illegal, Unreported and Unregulated (IUU) fishing is examined in this chapter, as it has been identified as one of the main barriers to sustainable fishing practices (UN FAO 2020); and this issue poses threats to both for navigational safety and sustainable maritime transport. The chapter initially provides an overview and analysis of the existing international agreement on sustainable fisheries and on Port State Control (PSC), where through a number of regional agreements, foreign flag ships are inspected in national ports to verify that the condition of the ship and its equipment comply with the requirements and rules of the international maritime regulations of the IMO. The chapter also examines interactions between the IMO, the International Labour Organization (ILO), and the UN Food and Agriculture Organization (FAO) in deterring and combating IUU fishing and protecting fishermen's safety at sea, including international mandatory and non-legally binding measures. The chapter then examines barriers and analyses mechanisms, opportunities for high-level actions, and global and regional measures to help reduce IUU fishing. A "global, transdisciplinary approach lead by an interagency effort, and based on international collaborations", involving scientists and representatives from the shipping and fisheries industry is, the authors conclude, necessary to achieve "effective, science-based, implementable solutions". They also conclude that implementation of legally binding measures—including through national legislation—on fishing vessels will "enable legal and sustainable fishing practices [to be] conducted by fishermen operating in a safe environment and will significantly help to shape fisheries to fulfil several SDGs". In this respect they highlight: SDG 14 (life below water), SDG 2 (zero hunger); SDG 5 (gender equality); SDG 8 (decent work and economic growth), and SDG 17 (partnerships for the goals).

The theme of Chap. 6 by Skinner (2021) is Maritime Security: Adapting for Mid-century Challenges. This chapter examines the role that maritime security plays in contributing towards the UN SDGs for 2030—through consistent and sustained collaboration within international structures—through the UN, IMO, and regional bodies such as the European Union (EU), Arctic Council and Nordic Council, for example. Maritime security cooperation already exists, as in the case of combating of piracy in the Horn of Africa. In the future, as a result of climate change, new shipping routes or transit corridors may open up in areas such as the Arctic Eurasia or though Antarctic waters, while new energy, mineral, and other extractive industries may start to operate in previously undeveloped regions. This poses a risk to the environment from pollution, for example, oil spills from ships or oil extraction operations in remote regions, and could also create difficulties in responding to emergencies in those areas. The risks from unknown challenges, of which the Covid-19 pandemic and its' impact on the maritime industry is one example, emphasise the need for collaboration at multiple levels. This chapter examines such collaborative activities within the framework of the UN SDGs, particularly those contributing to a secure maritime sector, which include, but are not limited to: SDG 6—Clear Water and Sanitation, SDG 7—Affordable and Clean Energy, SDG 8—Economic Growth and Decent Work, SDG 9—Industry, Innovation, and Infrastructure, SDG 13—Climate Action, and SDG 14—Life Below Water. The chapter also highlights the difference between 'soft' security, where "a compliance or enforcement regime is based on specific international law in parallel most often by 'domestic legal' enforcement by sovereign nations, and 'hard' security which is refers to "naval combat, or more often posturing, which takes place under a very different set of parameters". While different, both 'soft' and 'hard' security actions can take place together, as in the example of countering pirate activities off the coast of Somalia. Having set out the different types of maritime security activities, measures at IMO and EU levels are examined in the broad area of benchmarking maritime security strategies. A key point in planning for maritime security moving forward is that the causes of issues are unpredictable and uncertain. In planning for future scenarios, it is, therefore, important to identify potential drivers and examine the potential outcomes for various scenarios. Identifying main drivers and threats from, for example, the impacts of climate change on shipping routes in the Arctic, or mineral extraction in the Antarctic, are two examples, where scenario planning has already taken place. Security issues discussed in this chapter include: geopolitics, for example, conflicts between countries such as German and Great Britain in World War I, placing sovereign interest over international law; developments within energy markets such as the change in transit routes posing a range of security problems; and the impact of Covid-19 on the shipping sector, including some regional reductions in CO_2 emissions. Security flashpoints over the decades to 2050 include competition for resources and sovereignty issues in the Baltic and Black Seas and the growing emergence of China as a dominant regional power in the South China Sea. However, the key point is that it is not possible to create a comprehensive list of threats since the future is unknowable. Changes over the decades from the 1920s onward were not predictable, nor are changes and threats at the current time. The main conclusion by Skinner is, therefore, that prudent planning to wisely husband the resources for maritime security may very well be needed to address unforeseen future events.

Chapter 7 by Dalgaard (2021) also examines aspects of maritime security through implementation of the International Shipping and Port Facility Security (ISPS) Code, developed by the IMO post the September 11, 2001 terrorist attacks on the USA. The ISPS Code was developed as a means of protecting both shipping and ports from such attacks while ensuring free trade without risk between contracting parties. The Code addresses areas such as cooperation between governments to assess and detect potential security threats to ships or port facilities, determining the roles and responsibilities for the various parties concerned with safeguarding maritime security, supporting the collation and exchange of maritime security information, providing a methodology for security assessments, and ensuring that adequate maritime security measures are in place on ships and in ports (IMO 2020). In this chapter, Dalgaard specifically examines Danish implementation of the ISPS Code, which he notes has added a significant bureaucratic burden at both a Danish and EU level on maritime transport and security. The chapter examines how the various requirements of the Code fit in within the Danish tactical security system, together with EU security measures. Danish implementation of the ISPS Code is carried out by a range of individuals, bodies, and agencies (including a Port Facility Security Officer (PFSO), local police, a range of Danish Ministries (e.g. Defence, Justice, Transport), and the Royal Danish Navy), each with specific roles, areas of operation, and level of authority. The chapter examines how security plans are developed in Danish ports and port facilities, including the EU and Danish legislative framework and the roles of the various agencies. It also evaluates the risk and consequences posed by a range of security threats, including global threats, and methods to test security systems and improve security in the face of such threats. Investment in security—infrastructure and annual running costs—is examined across the Danish ports sector. The experience of PFSOs is an important component of this chapter, since it introduces a practitioner perspective into the analysis of the ISPS Code. In this respect, of note is the comment that “The current ISPS system often seems too ambiguous in the minds of PFSO, the security personnel, and even less meaningful to the politicians and the citizens in general”. Considering how the ISPS Code is currently implemented and how more appropriate security measures might be used, Dalgaard concludes by noting that port security efforts can be inefficient, can place an unnecessary burden on limited resources, and can be ‘off-target’, that is, not implemented appropriately. Any system moving beyond the 2030 end of the SDG must, therefore, include measures against crime and accidents to contribute to both future economic sustainability and protect lives.

Chapter 8 by Edgerton (2021) examines Port and Maritime Security as key components in the sustainable development of the global maritime transportation system, highlighting the role of security by, for example, protecting natural resources and fisheries and minimising disruptions to vulnerable maritime supply chains. Edgerton indicates that “To promote resilience and sustainable development in the maritime domain … security efforts and initiatives will need to move beyond the current regulatory regime”, that is, the ISPS Code. Measures to incorporate protection and resilience of trade into security coordination include an expanded focus for the security of cargo, expanding the range of stakeholders (customs services, World Customs Organization (WCO)), using incentivised programs to enhance security, for example. Fisheries, often crucial to the economic stability or food security in a region, are considered to be particularly vulnerable and in need of specific enforcement of environmental and fisheries laws through an international maritime security approach. Resilience in maritime transportation systems is, Edgerton notes, vital to protecting critical infrastructure from a range of threats—natural, accidental, terrorist, or criminal—highlighting the need to maintain a rapid and global shipping supply chain, minimise delays in the system, and reduce stockpiling of resources. Topics assessed in relation to SD and the maritime domain include threats to maritime security, protection of marine resources, an enhanced focus on cargo security, limitations of the ISPS Code, and governance challenges (e.g. lack of a globally mandated security standard within the supply chain). Edgerton then outlines how maritime and port security can support SD in areas such as enforcing laws to protect the environment and natural resources, using security planning to build and enhance resilience within the supply chain, and ensuring freedom of the seas. Edgerton concludes that it is necessary to update regime maritime security and governance and regulation to reflect industry changes of decades and respond to potential future disruptions to the global economy, environment, and social sustainability.

The theme of Chap. 9 by Fantinato (2021) is Governance of International Sea Borders, including region approaches to maritime surveillance in the Mediterranean Sea region. This chapter focuses on how new threats in that region have resulted in a reshaped definition of maritime security and highlights the need for a high level of vigilance and enhanced security measures. Issues including cross-border crimes (terrorism, drug trafficking, weapons smuggling, and irregular migration) are considered detrimental to the EU and its member states. The EU's Maritime Security Strategy is based on collection of intelligence information, use of state-of-the-art technologies, sharing real-time information, and regional cooperation between EU member states and other Mediterranean Sea. This chapter focuses on the evolution of maritime surveillance strategies and technologies used in the Mediterranean, together with an array of assets employed in the governance of the external maritime borders of the EU. It identifies three operational activities, taking place in the region, and highlights an issue associated with those activities—the lack of a common platform, where data collected from those operations could be aggregated and analysed. It also assesses the different maritime surveillance activities taking place, where "EU interagency cooperation requires sharing human resources, air-naval assets and information to protect the EU maritime external borders and preserve Member States' interests across the Mediterranean through an approach based on integrated maritime surveillance". That approach makes use of satellites, unmanned aircraft, and maritime autonomous vehicles for maritime surveillance purposes. The chapter explores the nexus between maritime surveillance in the Mediterranean and sustainability in the governance of the EU external maritime borders. It discusses traditional surveillance techniques, presents the EU Maritime Security Strategy and its interplay with maritime surveillance for the region, introduces the concept of integrated maritime surveillance within sea borders management, examines new technologies being implemented in the field of maritime surveillance, and highlights how these technologies can contribute to a sustainable management of the EU external sea borders. The chapter concludes by highlighting the need for continued—and stronger—national, regional, and international cooperation in areas such as cross-border trafficking and other crimes. It also highlights that new technologies for maritime surveillance are greener, can contribute in the areas of maritime safety and security and detection of marine and air pollution, and illegal fishing, and can support economic development in the Mediterranean Sea region. One caveat is that new technologies are expensive and, therefore, the issues of affordability and availability must be considered and may be overcome by EU interagency coordination to avoid duplication of efforts and share data across the region.

The chapters in Part III of this volume (Chaps. 10–17) examine 'Improvements in Management/Technology of Best Practices for Sustainable Shipping'.

Chapter 10 by Aldosari (2021) examines international and regional efforts to prevent oil pollution and compares the Arabian Gulf Region, an area where there is growing concern about marine pollution, particularly oil-related pollution, with the North Sea, an area where oil and other pollution prevention measures have been in place for many years. Both are transnational regions bounded by economically interconnected countries, with the shared marine areas being of enormous strategic and economic significance, but also where pollution in the waters of one country poses a threat to the waters of others in the region. The analysis in this chapter focuses also on SDG 14, and particularly SDG 14.1, which recognises the importance of maritime transport in international trade and the global economy. Marine pollution, particularly from shipping, poses a significant threat to the marine environment. Pollution prevention measures are vital to ensure the protection of biodiversity and natural ecosystems while contributing to the sustainability of maritime transport. The chapter's comparative study of both the Arabia Gulf and North Sea regions examines international efforts to curb marine oil pollution prevention activities, particularly through regional conventions (IMO Conventions, UNCLOS). It then examines pollution prevention efforts in the Arabian Gulf (including regional measures), before contrasting it with the North Sea regional efforts (regional, EU), each of which is at a different level and with different levels of commitment currently to achieve a reduction in pollution from shipping. A comparative analysis of the regional efforts is presented, including how strategies and efforts have improved the sustainability of maritime transportation. It assesses how various measures link to SDGs—for example, how SDG 14c envisions high-level cooperation between states, something that is vital for successfully combating oil pollution (both accidental and non-accidental) in a region. Aldosari concludes that oil prevention activities and the SDGs play a significant role in improving the sustainability of maritime transportation and that a reduction in pollution from maritime transportation illustrates the effectiveness of those measures. It is, therefore, vital that the issue of the sustainability of maritime transportation features highly in future conventions and agreements.

Chapter 11 by Sharma et al. (2021) examines autonomous operations, digital technologies (virtual reality, augmented reality), and their implications for maritime education and training (MET). Developments such as autonomous shipping are changing maritime operations in significant ways while presenting a number of challenges and opportunities. Moving forward, MET needs to develop appropriate digital, information processing, and other non-technical skills (i.e. cognitive, social, and personal resource skills that complement technical skills). One of the most significant changes in maritime domain is that activities on ships are getting less labour intensive, crew sizes have reduced over years, and types of jobs have become more varied. In the future, there may be only minimal or even no crews on board, as ships are operated via remote control or become autonomous, although crew size will depend on level of automation and how far a ship's systems are able to make decisions by itself. Such changes may result in reduced demand for seafarers, particularly low- or medium-skilled workers, although there will continue to be manned ships. Autonomous ships will result in the need to re-train the workforce on a considerable scale. Sharma et al. assess the skills and competencies that will be needed of seafarers in the future, together with the MET requirements under the internationally agreed Standards of Training, Certification, & Watchkeeping (STCW). MET has already adapted to the use of digital technologies for education and training, using simulators onshore to train seafarers in various job functions, using distance learning solutions via mobile devices, and adopting various approaches (e.g. constructivist learning, game-based learning) to meet the need for changing skills. In this context, Sharma et al. highlight the "ongoing debate around the use of Virtual Reality (VR) and Augmented Reality (AR) for their potential application in MET". They conclude that to keep pace with technological changes in the maritime transport sector, global training and certification standards must also be revised and adapted, while MET institutes, where training is conducted, must be proactive "in building competence structures for seafarers to embrace this new era of ship operations and to stay ahead of competition".

Chapter 12 by Rayegani (2021) examines synergies between obligations and measures to reduce vessel-source underwater noise and GHG emissions. These are both areas where tools developed via IMO-led measures to increase energy efficiency of ships might also contribute to reducing both GHG emissions and underwater noise, which impact marine mammals, as could operational measures such as routeing systems and slow steaming (the latter discussed by Pastra et al. (2021) in Chap. 17 of this volume). Underwater noise, which is a stressor causing damage to marine ecosystems, can come from a range of sources including seaborne transportation, offshore renewable energy, and underwater construction. GHGs and rising CO_2 levels can contribute to warming waters and increased ocean acidification, which are linked with climate change. The links between SDG 13, which requires urgent action to deal with climate change, and SDG 14, which aims to conserve and sustainably use oceans, seas, and marine resources for SD, are analysed. The regulatory framework to deal with climate change and measures to tackle vessel-source underwater noise is assessed. In the former case, this includes an examination of measures taken under the UN Framework Convention on Climate Change (UNFCCC), signed in Rio de Janeiro in June 1992, and its various protocols (e.g. Kyoto Protocol of December 1997 and Paris Agreement of December 2015). In the latter case, this includes underwater noise as it relates to UNCLOS, as well as international instruments such as the IMO Underwater Nose Guidelines, for reducing noise and mitigating risks. Rayegani then addresses the interlinkages between the reduction of GHG emissions and underwater noise: design, construction of equipment that could contribute to such reductions; and operational measures and maintenance routines that could be used on older ships to achieve some reductions. In concluding this chapter, Rayegani identifies synergies and suggests, for example, that using measures created to attain other objectives such as reduction of GHG emissions can be implemented to reduce underwater noise and mitigate its associated risks.

Chapter 13 by Shan and Zhang (2021) focuses on the area of Sustainable Maritime Labour Governance and the role of transformative partnership in seafarers' welfare. In that context, seafarers' welfare is defined as "the health, happiness, and fortunes of seafarers and institutional protection or social efforts designed to promote physical health, material, and mental well-being". They examine the role played by port-based welfare facilities that provide seafarers with, for example, access to grocery stores and cafes, high-speed Internet, and affordable telephone lines, or somewhere to rest while on land. Many of these facilities operate independently, but the majority are part of regional or international NGOs, and many of these are charitable organisations. To ensure the sustainable development of such facilities, a comprehensive public-private partnership, together with resources from sovereign states, is needed, as set out under the 2006 Maritime Labour Convention. Shan and Desai identify that the importance of establishing port-based seafarers' welfare facilities was recognised as early as 1952; at the Joint Maritime Commission of the International Labour Organization, the legal framework under which facilities should be provided, including mandatory and non-mandatory standards for facilities, is examined. From that examination, Shan and Desai note that "public-private partnership plays a key role in regulating and operating port-based welfare facilities. In this governance partnership, the states, particularly port states, shipowners' and seafarers' organisations, are vital players in developing and maintaining port-based welfare facilities." However, they also indicate that levels of provision differ between countries and, in some countries, government funding is needed to support facilities and services. Shan and Desai conclude that maritime labour governance is a key component of ocean governance as seafarers are essential workers, ensuring timely and safe maritime transport. However, they note the ongoing problems for seafarers as their right to access decent welfare facilities may be compromised or sacrificed, as has occurred during the Covid-19 pandemic. Further efforts are, therefore, needed to increase collaborations between governments and NGOs and to ensure adequate funding for facilities.

Chapter 14 by Lancaster et al. (2021) examines underwater noise from shipping using a case study for the Arctic Ocean, an area where there is limited shipping activity and consequently little underwater noise pollution from human activities. However, this is likely to change as the region is opened up to industrial development, forecast to bring trillions of dollars into the region over the next 25 years. Also, with the opening up of trans-Arctic shipping routes as sea ice declines and the region becomes more accessible, there are a number of associated risks from increased shipping levels: oil pollution, ship strikes, introduction of alien species, disruption of migratory patterns of marine mammals, as well as underwater noise pollution, the main topic of this chapter The region and its indigenous communities are also under pressure from rapid environmental changes resulting from climate change—loss of sea ice, ocean warming, acidification, and changes in currents and stratification. Lancaster et al. provide an overview of current levels including changes over time resulting from a reduction in sea ice coverage. They then assess future trends from an extended open-water shipping season, a reduction in transit times, and shorter shipping routes when compared to current routes connecting the Atlantic with the Pacific Ocean and Indian Ocean. They then discuss the underwater soundscape of the Arctic region—sounds created by wind and rain, the movement of ice flows and pack ice, and biotic sources (sounds coming from marine mammals such as walruses, ringed seals, bearded seals, and polar bears together with whales or cetaceans such as beluga whales, narwhals, and bowhead whales). Many species use echolocation to navigate and find food or use underwater vocalisations to send out predator alerts or for mother-calf interactions. Increased levels of underwater noise can be very disruptive and is likely to have negative impacts on those Arctic species that use sound. An analysis of studies previously conducted shows that sound from ships can impact fish species, marine mammals, and whales. Lancaster et al. identify the need for effective regulation of underwater noise in the Arctic through improved monitoring, mitigation, and management activities with cooperation between Arctic states. The EU in its 2008 Marine Strategy Framework Directive defined underwater noise as a form of pollution, with levels of noise being required at levels that “do not adversely affect the marine environment in order to achieve Good Environmental Status”, as set out in a 2008 EU Directive (Directive 2008/56/EC). Monitoring is needed to provide baselines to compare how the ocean soundscape and underwater noise has changed over time. Mitigation measures such as redesigning, retrofitting, or better maintaining ships have been shown to be effective in reducing noise from ships, as has reducing the speed at which they travel. Stronger regulation, for example, through the EU’s 2008 Marine Strategy Framework Directive, the IMO’s Energy Efficiency Design Index setting out specific targets for ship design, and through or the IMO’s 2014 International Code for Ships Operating in Polar Waters (Polar Code; entered into force in 2017) could also result in stronger action in the Arctic, where, the authors conclude, there is an opportunity for a proactive, cost-effective approach to managing underwater noise pollution “that will safeguard Arctic species, ecosystems, and the people who depend on them”.

The theme of Chap. 15 by LeClerc et al. (2021) is Canadian Ports Sustainability and their strategic response to the disruptions and major challenges they faced as a result of the Covid-19 pandemic. The chapter considers the steps taken by Canadian ports, already actively engaged in environmental protection and actively working to improve the quality of life of their surrounding communities, to ensure resilience during the pandemic. It also examines how those ports, which are a responsibility of the Canadian federal government, have responded to the UN’s sustainability agenda and what potentially lies ahead in the post-Covid era. LeClerc et al. present an overview of the history of Canadian ports and Canadian Port Authorities (CPA), and how the UN SDGs relate to them. They examine the wide range of challenges facing those ports as they compete globally—infrastructure development, marine environmental protection, and involvement of First Nations and community engagement, for example. The regulatory regime under which ports operate (international through the IMO and national under the Canadian Marine Act and Port Authority Regulations) is examined, including how that regime relates to sustainable development and CPA involvement in international environmental collaboration. An assessment of Canadian port traffic pre- and post-Covid is presented, highlighting the challenges faced by ports to adapt and respond to the pandemic. LeClerc et al. assess that, in the end, those impacts were only minor, and the majority of ports continued to operate with virtually no disruptions and demonstrated resilience in the face of the pandemic. In light of that assessment, they examine the future for Canadian ports post the UN 2030 Agenda. Challenges highlighted by the authors include: development of an integrated transportation system to ensure sustainable growth; ensuring resilience within the ports industry to respond to climate change impacts (flooding, storm surges, sea level rise) and the need to invest in critical infrastructure; emissions reduction, both from ships and for all port activities; energy transition and energy clusters; and digitalisation across the entire maritime supply chain. Looking forward, they emphasise that Canadian ports and CPA are taking steps to meet those challenges, as well as respond to major crises such as that posed by Covid-19.

Chapter 16 by Ozturk (2021) presents an analysis of lessons learned from robotics and AI in a liability context. Pressures on the sustainability of maritime trade and ocean-based economic interests have led to the exploration of marine applications of robotics and AI, which have the potential to improve safety, increase efficiency, and take 'dull, dangerous, and dirty tasks' away from humans on board ships. The concepts of "Robotics" and "AI" are defined and their contribution to sustainability assessed. Ozturk indicates that one of their most significant marine applications is in autonomous surface vessels (ASVs) and autonomous underwater vessels (AUVs). Following an assessment of the current state of the art for such vessels, Ozturk examines the existing legal frameworks (International Conventions, domestic legislation) under which they operate, noting that "a significant part of the regulations that ASVs and AUVs will have to comply with … are based on the presumption that seafaring vessels are always human-operated, or manned". As one of the main types of maritime accident is a collision between two vehicles or a vehicle colliding with a stationary object, there are a number of shortcomings in the existing legal framework for liability as they relate to autonomous vehicles, which may, in some cases, be completely independent of human operators. EU models have been developed to identify the liability for other autonomous artificial agents (e.g. unmanned aerial vehicles), and it is suggested that these can be used to define the liability regime of autonomous marine vessels. Different types of liability are presented, and liability is then assessed within the prism of sustainability. Ozturk indicates that while ASVs and AUVs can directly help achieve elements of a number of SDGs, their lack of compliance with existing liability regimes can place heavy financial burdens on their manufacturers and users, limiting the use of such vehicles and slowing technological innovation. A balanced and consistent liability regime is considered essential for the economic viability of the maritime transport sector, and conclusions are presented about what such a regime should look like.

Chapter 17 by Pastra et al. (2021) considers the role of slow steaming in shipping and methods of CO_2 reduction, where 'slow steaming' is the practice of operating cargo ships at less than their maximum speed so as to match the vessel's speed with the time they are due to arrive and berth in a port. The chapter first outlines the different types of emissions, including GHGs, resulting from marine shipping, and the range of international measures in place to try and reduce such emissions. These measures include a 2018 Initial IMO Strategy on Ship GHG Emissions Reduction, a 2020 global sulphur cap to reduce maximum sulphur oxide content in marine fuels, and the 2013 EU strategy to integrate maritime transport emissions within EU GHG reduction actions. The slow steaming approach is examined, identifying both positive and potential negative impacts. Pastra et al. identify that there is a difference between the speed reduction, for example, reducing speed in bad weather, when transiting narrow straits and in areas where there are speed restrictions due to whale migration, and speed optimisation, where the most suitable speed for a voyage is calculated that will reduce fuel consumption but does not unduly extend the duration of that voyage. Economic factors can also have an effect. During strong economic periods, demand for trade increases, and society is willing to pay higher costs for faster goods transportation, with the result that ships are likely to operate at higher speeds. During poor economic periods, ships are likely to operate at slower speeds since a ship's income is constrained, and there is a need to reduce operational costs becomes crucial, with fuel being the highest operating cost. The result is that, in general, high freight rates induce high speeds, and high fuel costs induce slow speeds. From their analysis, Pastra et al. identify that "from an environmental point of view, the optimum speed is that of the lowest fuel consumption for the trip irrespective of economic considerations". The potential for 'speed limit' regulations to reduce ship speed and GHG emissions is examined, a number of countries and NGOs having put forward proposals to the IMO to impose strict speed limits for various vessel types. However, Pastra et al. identify a number of problems related to speed limits: that the calculated GHG emissions reductions are based on theory rather than on real life circumstance, so that the "CO_2 reduction could be … half or less than those stated in a study"; that more ships may be needed to satisfy world transport demand; that they favour old, inefficient ships by extending their useful lives; that new energy efficient ships use less than half the fuel of older vessels but will have to operate to the same speed limits as those inefficient ships; and that there is no incentive to retrofit energy saving technologies on older vessels. Speed limits are, they suggest, being abandoned by the IMO in support of "power limits", which reduce operational speeds in a way that favours efficient ships and promotes best operating practices. Pastra et al. then present an overview of the commercial perspective on slow steaming, including its impacts on supply chain management generally, from a port perspective, and the potential for bottlenecks in the supply chain. They conclude that while 'slow steaming' could result in emission reductions and fuel cost savings as ships travel at slower speeds, it may increase response times within the supply chain. An "economic" optional speed may not coincide with "environmental" optional speed, and there are a number of problems arising from the use of speed limits. Power limits are, they suggest, the best scenario to reduce operational speeds and to meet CO_2 reduction targets, in a way that is fairer to already efficient ships.

The chapters in Part IV of this volume (Chaps. 18–21) fall under the theme of Good Ocean Governance.

The topic of Chap. 18 by Echebarria Fernández (2021) is Maritime Governance and Small Island Developing States (SIDS) of the Wider Caribbean Region (WCR) in the era of climate change adaptation. This chapter analyses the readiness and preparedness of those SIDS to face the impacts of climate change and threats posed by marine pollution from anthropogenic sources. These impacts and threats include damage to marine ecosystems and biodiversity, adverse weather phenomena and sea level rise, and the economic and social implications for coastal and indigenous communities. The interrelated issues raised in this chapter are analysed through the 'guiding thread' of the UN SDGs and implementation of global and regional instruments. Global instruments include UNCLOS, together with the anticipated introduction of an internationally legally binding instrument on the conservation and sustainable use of biodiversity beyond national jurisdiction (BBNJ), negotiations for which commenced in 2017 under the aegis of a UN General Assembly intergovernmental conference; the anticipated final negotiating session has been postponed because of the Covid-19 pandemic. The main regional measure is 1983 Convention for the Protection and Development of the Marine Environment of the WCR

(Cartagena Convention) and its Protocols (1983 Protocol on Cooperation in Combating Oil Spills in the WCR, 1990 SPAW Protocol on Protected Areas and Wildlife, and the 1999 LBS Protocol on Pollution from Land-Based Sources and Activities). The particular issues facing SIDS, "a distinct group of developing countries facing specific social, economic, and environmental vulnerabilities", are then outlined. SIDS are highly dependent on international trade (around 95% of their transport is seaborne), and they have limited resources due to the limited availability of soil. They face challenges from sea level rise and extreme weather events and also from high transportation costs, low connectivity, and limited human, financial, and technical resources. Echebarria Fernández analyses the main challenges facing SIDS, particularly those in the WCR, as they relate to: climate change adaptation through a socio-ecological system model and environmental justice actions; climate adaptation legislation and treaties at international, regional, national, and local levels; and the practicalities of a Blue Economy strategy to fight marine pollution in the WCR through, for example, improved use and management of marine resources and waste minimisation approaches. Governance tools, including the IMO's role in preserving marine ecosystem, and regional institutions that address governance in the region are analysed, as are the main provisions of the Cartagena Convention and its protocols. Projects, plans, and initiatives to address climate change in the WCR are then presented. The impact of GHG emissions on SIDS, and measures to reduce GHG emissions from shipping, are then analysed; these include market-based measures, IMO global partnership projects to support technical cooperation, technology transfer, and energy efficiency measures, and development of a global sulphur cap. In his final remarks, Echebarria Fernández identifies that "marine adaptation requires most developed countries, economic integration organisations, …and national and local authorities to further assisting LDCs [Least Developed Countries] and SIDS in facing the most severe and adverse effects of climate change". He also indicates that funding, providing technology and technical transfer to states in the WCR will "provide better mitigation, adaptation, and resilience strategies for those countries", and that by doing so, "communities, including … SIDS, can foresee and enjoy a better future".

In Chap. 19, Pastra and Swoboda (2021) examine gender imbalance in the maritime sector through an analysis of women in the boardroom, on ships, and in ports. The maritime sector—both shipping and ports—is one of the most male-dominated sectors, with women representing only around 2% of seafarers in the global maritime workforce and 16.8% in the port industry globally. In addition, only a few women begin and complete a MET programme. Women's representation in the boardroom of shipping companies is low; one study found that only around 0.17% of executive leadership appointments went to women, another study indicating that across Greek-owned shipping companies between 2001 and 2017, only 4.86% of Directors were women. The need for gender diversity in the boardroom is examined, with research highlighting potential benefits of such diversity—improved financial and operational performance, a more risk averse approach in decision-making, and lower levels of fraud and financial manipulation. Women's participation in the shipping and ports sectors is assessed. Women seafarers face prejudice and discrimination in recruitment and employment, and also gender stereotypes, sexual harassment, and discrimination on board. Actions such as improving current working environments, more inclusive gender policy actions from key stakeholders, higher participation by women in MET, and clear discrimination and sexual harassment reporting instruments are all necessary to expand women's representation on board. In the ports sector, levels of participation are much higher. Women representation in ports was around 16.8% globally in 2018. A more detailed analysis showed that global average representation in port management positions was higher at around 34%, but women only represented 12.1% in operational roles and 5.1% in cargo handling. While women are employed in the ports sector significant barriers to full participation across all jobs in the sector remain. Improving the gender ratio of port employees in operational and managerial functions is considered "fundamental to promoting equality and women's empowerment and the competitiveness and efficiency of the industry". This requires improved gender-specific education and training to allow women to acquire the technical skills and capacities needed by high-level operational and decision-making positions, as well as promoting networking and relationship-building opportunities for women in the port industry to connect with each other. As port and maritime industries modernise their processes, operations, and management, Pastra and Swoboda provide recommendations on how to tackle under-representation of women in those sectors and boost gender equality to provide a more attractive, accessible, and empowering working environment for women.

Chapter 20 by Christodoulou and Echebarria Fernández (2021) provide a comprehensive review of Maritime Governance and IMO instruments focused on sustainability in light of the UN SDGs. The IMO has adopted a number of instruments to enhance safe and secure maritime transportation and reduce the risk of environmental pollution over decades. More recently, it has developed seven strategic directions (SD; e.g. SD 1 Improve implementation, SD 3 Respond to climate change, SD 6 Ensure regulatory effectiveness) within its Strategic Plan for 2018–2023. The SDs have been developed within the context of the UN SDGs. The broad range of IMO instruments within the areas of maritime safety and security, the marine environment (including oil pollution, chemical pollution, sewage and garbage, air pollution, and GHG emissions), the human element (human behaviour and psychological factors; covered by IMO instruments such as the Convention on STCW), and technical cooperation between the IMO and its member states are examined. For each area, the links between IMO instruments, the IMO SDs, and the UN SDGs are identified and assessed. In the case of maritime safety and security, where IMO measures include the SOLAS Convention, the ISPS Code (discussed by Dalgaard (2021) in Chap. 7 of this volume) and international codes relating to the carriage of cargoes and dangerous goods, the IMO's SDs 2, 3, and 5 on the integration of new and advancing technologies in the regulatory framework, the enhancement of global facilitation and security of global trade can be directly linked to SDGs 3, 8, 14, and 17—respectively good health and well-being, decent work and economic growth, life below water, and partnerships for the goals. Christodoulou and Echebarria Fernández then examine regional maritime governance, looking at best practice action from the EU, and assess EU legislation in the areas of maritime security and the marine environment, the EU's contribution to the 'human element', and EU legislation on technical cooperation. They conclude that both IMO and EU maritime governance instruments contribute to the SDGs although there may not be an explicit link between them. They further conclude that "the main challenge for the fulfilment of the SDGs in the maritime sector in a coherent way lies with the need to adapt the SDGs in the maritime context" that concrete goals and targets need to be developed for the maritime stakeholders and that capacity building and enhancing technical cooperation among IMO and EU Member States is needed to foster global implementation efforts for sustainable development.

Chapter 21 by Topping (2021) on Putting the Pieces Together for Sustainable Shipping brings together "the many pieces that need to be in place for a sustainable shipping sector that contributes to a global sustainable economy". This includes an examination of the role of international marine shipping in the global economy and its impacts on people's lives, both in the past, at the present time, and looking ahead to the future. Domestic and short sea shipping, that is, shipping between ports in one country or between ports in neighbouring countries, are analysed. In particular, the short sea shipping trade differs from marine shipping as vessels are designed to fit in local waterways (including freshwater channels), narrow channels, and areas with shallow depths and navigation hazards; they are also subject to a range of specific national laws. Topping then examines marine shipping in the context of small island states and remote regions. For small island states, they are highly dependent on marine shipping for the goods needed to support people's daily lives including materials, products, and equipment and for the export of products to generate income. For remote regions, and in the example of Inuit communities in remote Northern Canada, shipping is vital to deliver retail goods and also combat food insecurity in those communities. The risks posed by GHG emissions from ships are then examined, together with IMO measures to reduce those emissions, including the IMO's goal for a 50% reduction in those emissions by 2050, and how that goal connects to the challenge of balancing a growing economy, the need for decarbonisation. Topping assesses what shipping needs to do to achieve those targets, which may be through a range of approaches and development of new technologies. From a regulator perspective, he notes that the IMO is considering 15 possible short- and long-term regulatory measures to help achieve the 50% reduction goal. Each regulation would need to meet nine general principles, examples of which include being: "(1) effective in contributing to the reduction of total global GHG emissions, (5) based on sustainable environmental development without penalizing global trade and growth, and (6) based on a goal-based approach and not prescribe specific methods". Topping concludes that marine shipping will remain one of the most important global transport modes and that it has a role to play in helping shift the world to zero-carbon emission energy sources. He indicates that real progress is being made, both through regulation and technological solutions. However, these moves will take time, so measures to increase the efficiency of the current global fleet, including lower carbon fuels, will continue to be needed while zero emission technology is developed and adopted.

Finally, Chap. 22 by Carpenter et al. (2021) provides an overview of how the SDGs can be connected to the Maritime Domain, either directly or indirectly. They do so by examining the original UN 2030 Agenda for Sustainable Development, assessing each of the SDGs and their associated targets, and presenting examples of how these are directly relevant to the maritime domain (UN SD 2015). In addition, they highlight the importance placed on the oceans and their contribution to a shared future for humanity, for example, through poverty eradication, food security, maritime trade and transportation, and decent work and livelihoods (UN General Assembly 2017).

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Part I
Moving to the Green-Blue Economy

Chapter 2
Greening the Blue Economy: A Transdisciplinary Analysis

Mark J. Spalding, Angelica E. Braestrup, and Alexandra Refosco

Abstract A healthy ocean generates oxygen and precipitation to support all life on earth, even as it generates trillions of US dollars in global economic activity. The ocean economy is commonly defined as all economic activities related to the ocean, including activities that are harmful to the ocean and the life within. The subset of economic activities that are actively good for the ocean is the foundation of the *sustainable* blue economy. Incorporating sustainability actions into the maritime transportation sector is necessary to preserve the life support system, restore abundance in our global ocean, and help nations achieve the Sustainable Development Goals of the United Nations 2030 Agenda, especially SDG 14, Life Below Water. Achieving these and climate change mitigation goals requires transdisciplinary approaches—integrated actions across disciplines, sectors that transform every element of maritime transportation. Such actions include standardizing inspection and enforcement, promoting solutions to reduce greenhouse gases, designing and building greener ships, treating ballast water with low (or no) impact technology, installing safer onboard water treatment systems, greening port facilities, improving ship safety and emergency response capacity, making shipping quieter so the fish can think, operating to avoid whale strikes, and expanding maritime transportation sector engagement in oceanic data collection and monitoring. Some of these actions are already under way. Others are still in need of design and implementation. Together they form the basis for the sustainable blue economy that should define the future human relationship with the ocean.

Keywords Blue economy · Greening the blue economy · Sustainability · Maritime transportation

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1 Introduction

For millennia, our global ocean has served as the natural superhighway for trade, transportation, and communication. These physical services are in addition to the ocean's ecosystem services such as the generation of precipitation, food, and half of our oxygen that are necessary for the preservation of all life on earth. Thus, maritime activities must be conducted in such a way so as to limit harm to our life support system and restore abundance in our global ocean—even as they also support economic well-being. The future can be blue, abundant, and healthy if sustainable action is taken.

A green economy is one that restores and conserves biodiversity (UNEP 2011). It is low carbon, resource-efficient, socially equitable, and supports ecosystem services. Similarly, the blue economy focuses on the above principles in the context of coastal and marine resources. These resources are both assets to be used sustainably and natural infrastructure that can improve a region's resilience to natural disasters and climate change. There are opportunities to develop blue economy opportunities in the maritime transportation sector that are equitable, conserve ecosystems, restore abundance, and improve human lives and livelihoods. Taking action to incorporate these sustainable principles can be called "greening the blue economy."

The ocean economy is commonly defined as all economic activities related to the ocean, including activities that are harmful to the environment. Thus, a distinction must be made for the *sustainable* blue economy, which is the subset of economic activities that are actively good for the ocean (Spalding 2016). A parallel example is "green business," which is the subset of all business that intentionally pursues sustainable outcomes, reduces negative impacts, and increases positive effects. Recognizing how a healthy ocean supports diverse human activities and that short-term thinking may not support long-term economic health in the sector is the first step. The maritime transportation sector is due to be made more "green," and the choice must be made to take actions to make maritime transportation a part of the sustainable blue economy. In fact, maritime transportation can be a key positive player in the sustainable blue economy by making the right choices in fuel, design, technology, technology applications, human relations, and compliance.

Figure 2.1 shows the position of ships at any given time around the globe while also highlighting the frequency of travel along transportation routes. The red areas indicate high volume of ships on the route, yellow an average route, and dark blues indicate less frequently traveled routes. Also found on the map are markers that represent individual vessels. Green markers represent cargo vessels, red markers represent tankers, dark blue markers represent passenger vessels, yellow markers are high-speed craft, light blue markers are tugs and specialized craft, brown markers are fishing vessels, pink markers are pleasure craft, and gray markers are unspecified or unknown vessel types.

The International Maritime Organization convention (IMO) was approved in 1948 and came into force 10 years later (IMO 2020a). It was established "to provide machinery for cooperation among Governments in the field of governmental

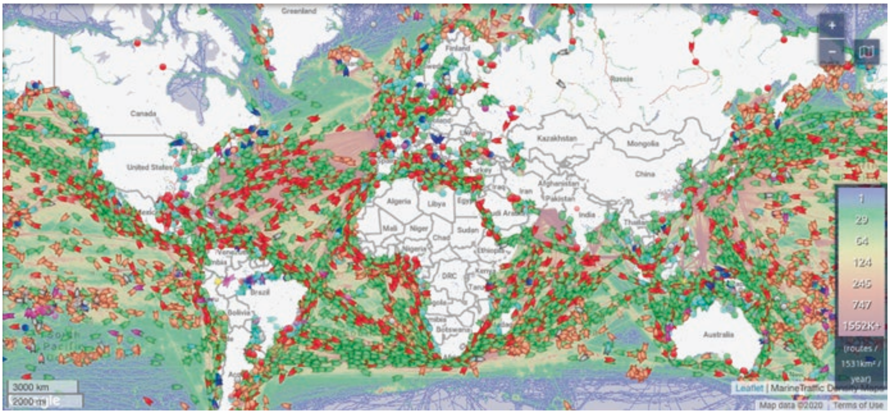

Fig. 2.1 Global shipping and transportation routes (Marine Traffic 2020). Map accessed 20 August 2020

regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation and prevention and control of marine pollution from ships" (IMO 2020a). The IMO and other ocean-related conventions represent the formal international agreement that the health of the ocean is a global concern, underpinning the health of all humanity.

The ocean environment is varied, vast, and largely not fully understood. It is not fully mapped. It is not fully explored. And it is full of species that have yet to be identified (Reubold and Earle 2013). At the same time, nearshore and high seas waters are bustling with human activity that directly affects the functioning of the ocean systems and the well-being of the diverse species within. The common goal of sustainability is to limit harm and restore abundance to the ocean environment.

Harm to the environment from marine transport can be divided into three categories: those effects which derive while in or close to port; those that derive from at sea operations; and those that derive from a ship's lifecycle, its building, maintenance, and dismantling. The effects include air pollution (both local and global), noise and vibrations (in and out of the water), habitat destruction, water pollution, and contributions to the overall effects of climate change and ocean acidification (Miola et al. 2020). There are those who challenge the concept of significant impact from the negative effects of any individual ship's transit or operations on the global ocean. However, the cumulative effects of thousands of ships in operation must be understood and addressed. At the same time, when the *MV Wakashio* ran aground on a coral reef on the southeast tip of Mauritius in July 2020, the resulting fuel spill from a single ship harmed the economic and environmental well-being of an entire nation. Such risk needs to be assessed and addressed.

Assessing the effects on coastal and marine environments from maritime transport activities starts with a synthesis of scientifically credible evidence to create a list of specific activities that cause harm. That list of harmful activities must be analyzed to look at what is being done (or has been done) to address any of those effects either voluntarily or through the IMO or through other regulatory efforts. What remains is the gap between those activities and designing actions that lead to integrating maritime transportation into a sustainable blue economy. For true sustainability, a truly blue economy, it is necessary to fill the gaps with actions that not only reduce these environmental harms, but also consider the health and well-being of the hundreds of thousands of people who play a role in marine transportation.

Thus, it is also necessary to reach all stakeholders in each part of the supply chain. These include traditional players in the ocean environment such as charterers, shipowners, shipyards, maritime industry workers and management, ports, and port operators and also include banks, ship finance and insurance providers, classification societies, equipment manufacturers, indigenous and local communities, and technology companies. The global maritime system spans from inland rivers, canals, and lakes to coastal ports and, finally, to the open ocean. Each business, every individual, has a stake in the physical services of the ocean and, inevitably, has a stake in its life support services.

Marine transportation is significantly more efficient per pound of cargo or passengers carried when considering energy used per mile traveled than car, train, or plane (World Shipping Council 2020a, b). However, due to the massive scale of global trade, ships are responsible for significant carbon dioxide emissions, especially in times of heightened global economic activity. There has been progress in reducing some shipping emissions through cleaner fuels, emissions controls systems, and other changes, all as the result of increased pressure from both consumers and investors within the shipping industry, effected through IMO actions, and as new regulations come on line, enforcement (Forum for the Future 2011). The IMO has also pledged a 50% reduction in all greenhouse gas emissions by 2050.

The expansion of maritime trade and the growth in the size of vessels—from cruise ships to the New Panamax ships—have had a corresponding effect on the size (and depth) of the shore-based infrastructure to support their operations (Kantharia 2019). The construction and maintenance of adequate shipping channels, ports, and other infrastructures have always had a significant coastal and nearshore effect on marine life and habitats. When there are significant changes in the size or type of vessels (e.g., the advent of Liquefied Natural Gas (LNG) carriers or new fuel requirements), there are many new consequences to be considered (Chakraborty 2020).

How that infrastructure is sited and maintained with minimal risk and maximum consideration to anticipated changes in ocean depth and weather patterns is part of the choices that must be made for greater sustainability and viability over decades. Shipping clients (and consumers) have to understand the full environmental costs of transporting people, goods, and bulk cargos. These are costs that need to be internalized for all trade by any mode. When they are, maritime transport can be sustainable and still be the most effective mode.

Currently, there is no comprehensive inshore-to-open ocean framework for a sustainable blue economy within maritime transportation. The development of a framework must incorporate economic and social policies that encourage the growth of the sustainable industries and the creation of jobs, where there are few. Sustainable growth allows the maritime transportation sector to be better able to recover from short-term disasters and mitigate some of the longer-term disruptions from climate change. At the regional and global level, the momentum behind the concept of the sustainable blue economy needs to be translated into action—and for that, there needs to be investment of intellectual, political, social, and financial capital through projects that are multisectoral, regional in scope, and span all aspects of the maritime transportation industry.

The world is changing. As ice melts in the Arctic, new sea routes open up in the environmentally fragile regions, north of Canada and Russia. The marine transportation sector must work to protect these fragile areas that are remote from pollution response teams and with conditions that make spills etc. nearly impossible to clean up. This can be done through the expansion of sustainable shipping practices (Hunt 2020). The Polar Code is one example of a framework that requires extra safety precautions and pollution prevention in anticipation of greater risk and potential harm (IMO undated).

Anticipating and acting rather than reacting when things go wrong is a key requirement of improving any sector's sustainability. Government and industry alike need to implement a wide range of maritime transportation "sustainability actions" so that the oceanic resources can meet the needs of today without compromising the needs of future generations. A transdisciplinary approach requires that actions to reduce the harm from the maritime transportation sector to fulfill two requirements. Every action must be viewed through the lens of doing no harm, and each sector that is engaged in performing those actions must use the same lens. Every action must also engage all the many disciplines—from policymaking to engineering to oceanography and other marine sciences to human safety and health—that are involved in the vast and complex realm of global maritime transportation.

2 Sustainability Actions

Historically, crossing the ocean involved only using renewable resources. Wood was the material of choice for ships, and wind was the power. Maritime transportation required only the vessel and an understanding of prevailing winds and currents—and ports from which to load or to off-load cargo and passengers. Speed and efficiency (move the most goods for the least cost) was always a factor—driving both design and practice. Once shipping became dependent on fossil fuels, the power was no longer free, and the drive to keep costs down meant that shipping became more and more unsustainable.

Operating the maritime transportation sector on a truly pro-ocean basis means a shift toward internalizing externalized costs, especially for those that represent harm to the ocean or to the people who work in the maritime transportation sector.

It means actively engaging in both long- and short-term strategies to adopt sustainability actions such as those described below. Many organizations within the maritime transportation sector are implementing elements of each of these actions—from ports to shippers to cruise lines and ferry operators. A level playing field would mean that all good actors operated under reasonable oversight and all bad actors were forced to change before continuing operations (Spalding 2016). This also means that the sector would be broadly supported in paying the initial costs for shifting to a more just, more sustainable, and more ocean-friendly operational mode. This is especially important when unanticipated large-scale disruptions occur, such as the sudden shutdown of an economy due to strife, pandemic, or other disasters.

Each of the following actions represents an area for improvement, innovation, and opportunity within maritime transportation. Each of the actions already has at least preliminary—if not fully—implemented technological, regulatory, or other solutions that form a platform from which to undertake the actions.

Sustainability Action 1: Standardize inspection and enforcement
Sustainability Action 2: Promote solutions to reduce greenhouse gases
Sustainability Action 3: Design and build greener ships
Sustainability Action 4: Treat ballast water with low (or no) impact technology
Sustainability Action 5: Install safer onboard water treatment systems
Sustainability Action 6: Green port facilities
Sustainability Action 7: Improve ship safety and emergency response capacity
Sustainability Action 8: Make shipping quieter so the fish can think
Sustainability Action 9: Operate to avoid whale strikes
Sustainability Action 10. Expand maritime transportation sector engagement in oceanic data collection and monitoring

In the following subsections, each of the above and possible strategies to implement those actions is offered as a means of reframing the conversation around best practices in the maritime transportation sector globally to support the health of the sector and the ocean on which all life depends.

2.1 Sustainability Action 1: Standardize Inspection and Enforcement

Global shipping activity requires global collaboration and compliance, and this is particularly true in the pursuit of a more sustainable maritime transport industry. For the most part, regulation of pollutants from maritime transport acknowledges that the vessels cause harm in transit and in port that is borne by coastal communities, the natural resources of the ocean, and the businesses that depend on them (e.g., capture fisheries, wildlife watching businesses, and so on). Addressing the harmful activities generally depends on agreeing to standards, implementing them, and enforcing them through inspection or interdiction.

Thus, the sustainability action can be described as taking advantage of new technologies to design new frameworks to strengthen international consistency and promotion of best practices for pollution prevention and compliance. This means that port authorities need sufficient resources to cooperate with other ports and strong enough national policies to enforce standards at their own ports to reduce the number of substandard ships and limit harm from all vessels.

Port State Control (PSC) is the inspection of foreign ships in national ports by marine authorities, to verify that the condition of any given vessel and its equipment is in compliance with international standards and confirm that the ship is operated under these rules (IMO 2020b). Most of the IMO's technical standards provide for inspection in foreign ports, to support flag state implementation of IMO regulations. In practice, foreign port inspection increases compliance because it limits the ability of ship operators to pick and choose ports based on inspection standards or flag states to promote substandard ships. Enforcement depends on this network of inspectors being consistent in their training and scope of authority (IMO 2020b).

The International Convention for the Prevention of Pollution from Ships (MARPOL) has updated its pollution prevention standards over the years (MARPOL, 73/78). Amendments have been added to include ship sewage disposal regulations, tighter regulations for protection against oil spills, and ship air pollution regulations. The MARPOL Annexes limit ship discharges by specific categories of pollutants: MARPOL Annex I (operational and cargo-related oil waste), Annex II (noxious liquid substances), Annex III (packaged harmful substances), Annex IV (sewage), Annex V (garbage), Annex VI (air pollution), and Annex VII (atmospheric pollution) (IMO 2020a). Each annex sets out requirements regarding the types and quantities of discharges that may occur, ship speed at the time of discharge, and required operating equipment, including waste filtering equipment.

The IMO has taken significant steps in addressing pollution at the international level but more can be done to standardize inspection requirements for ships by flagged nations. Enforcement varies by country and region, and there is significant room for improvement at the international level. There is no uniform global policing of MARPOL provisions through the IMO. Each individual signatory nation is responsible for determining its own inspection and enforcement policies. These do vary from jurisdiction to jurisdiction; all noncompliant vessels can expect civil, and possibly criminal, sanctions for violations of such provisions as the new sulfur provisions, in part, because of the port State Control framework.

In 1991, the IMO approved a resolution that addressed regional cooperation in the management of ships and shipping-related pollution through a proposed network of "MoU" organizations. Globally, nine regional organizations and one national organization (the United States) have been established to make inspection and enforcement more consistent—and to ensure that efforts focused on substandard ships and coordinated well enough to avoid repeated inspections.

In the United States of America (USA), this enforcement is carried out by the Coast Guard in partnership with other local, state, and federal agencies (U.S. Coast

Guard 2020). Thus, MARPOL implementation and enforcement are addressed through the combined efforts of the Coast Guard and the Environmental Protection Association (EPA). With respect to enforcement of vessel emissions under Annex VI, for example, the two agencies operate pursuant to a 2011 Memorandum of Understanding (MOU) (U.S. EPA 2011). Generally, while the Coast Guard takes the lead on conducting vessel inspections and responding to deficiencies in the first instance, including potential detentions, Notices of Violation (NOVs), and civil penalties, the Coast Guard may refer more serious violations to the EPA for enforcement action. The MOU applies specifically to Annex VI violations, and a revised protocol on referrals under Annex VI, dated March 2015, establishes specific protocols for referrals between the EPA and the Coast Guard.

In Europe, there are over 1000 individual ports, which handle around 90% of European Union external trade and around 40% of trade between EU countries (European Maritime Safety Agency (EMSA) 2020). This involves handling 3.5 billion tons of goods and 350 million passengers being transported on thousands of ships journeys each year. The EU Port State Control Directive was agreed to in 2009 (and has been amended), and it focuses on ensuring that maritime transport in EU member nations' waters operates in a safe and environmentally friendly way (EMSA 2020). EMSA provides technical support, inspection training standardization, and other services to help ensure that EU ports are operated consistently across the EU. Thus, it is hoped that consistent inspection and enforcement will result in greater compliance.

In Asia, 20 member states are parties to the "Tokyo MoU on Port State Control," which was established in 1994 (Tokyo MOU 2020). The Tokyo MoU was intended to "establish an effective port state control regime in the Asia-Pacific region through cooperation of its members and harmonization of their activities, to eliminate substandard shipping so as to promote maritime safety, to protect the marine environment, and to safeguard working and living conditions on board ships" (Tokyo MOU 2020).

Some two-dozen central and west African nations are part of the Abuja MoU organization, which was established in 1999. Its jurisdiction includes Mauritania, the Gambia, and Senegal and includes all coastal nations of South Africa. A separate MoU organization established in 1999 covers the Indian Ocean countries, including Australia. The remaining MoU organizations are the Black Sea MoU (2000), the Caribbean MoU (1996), the Mediterranean MoU (1997), the Riyadh MoU (2004), and the Vina del Mar Agreement (1992) (for further information on the various MoU regimes see IMO 2020b).

The COVID-19 pandemic presented a serious challenge to the PSC system as designed. The number of physical inspections of ships had to be reduced to protect the health of both seafarers and inspectors. A number of individual flag states provided exceptions to certificates and other waivers to permit the continued flow of necessary goods. In early April 2020, the IMO and MoU regional representatives met to address the dual challenge of being pragmatic and flexible while ensuring that new hazards did not emerge from inadequately policed maritime transportation activities. In a joint statement, the PSC regimes and IMO highlighted the unprecedented impact of the COVID-19 crisis, "The respective roles of flag States and port States to solve this crisis, in terms of supporting maritime trade, are paramount, and can also be significantly assisted by the industry. At the same time, the safety of life at sea, the protection of the marine environment and the respect of seafarers as key-workers must remain shared priorities" (IMO 2020b).

It is clear that, to ensure that bad actors do not take advantage of emergencies and that substandard ships are prevented from operating, flag states should be engaged in planning and preparation for such events. Port State Control organizations need operational regimes that actively prepare for adverse events, including pandemics, economic difficulties, or the effects of climate change such as intense storms and unpredictable weather patterns. It is possible that additional standards may need to be drafted and implemented that help the maritime transportation sector reduce risk with the accompanying flexibility to choose the best retrofits or other adaptations to meet them. Collaborating to ensure minimal harm from substandard polluters and support the critical supply chains in maritime transport operations means being prepared for adverse conditions and deliberate planning to defend each new positive development that supports ocean health.

2.2 Sustainability Action 2: Promote Solutions to Reduce Greenhouse Gas (GHG) and Other Atmospheric Pollutant Emissions Generated by the Maritime Transportation Sector

As noted, ocean and brown water transportation is considered an environmentally beneficial alternative to air or road transportation for good reason: shipping has a very high capacity to transport large volumes at a relatively low input of energy. At the same time, the cheapest fuels are generally the dirtiest to burn—making shipping one of the bigger air polluters. The effort to reduce fuel costs also can mean navigating shipping routes that increase the risk of groundings, cargo loss, and fuel spills, such as the Arctic passage.

As the agency that establishes and enforces standards for marine transportation, the IMO has been moving the sector toward cleaner operations since the first air pollution controls for ships in 2005. Beginning in January 1, 2020, ships operating anywhere outside those areas that already have stronger controls must comply with IMO's Sulphur 2020, the regulations that address air pollution from ship emissions. The 2020 regulations set limits on sulfur oxide (SO_x) and nitrogen oxides (NO_x) emissions from ship exhausts. Specifically, ships must use fuel that contains no more than 0.50% m/m (mass by mass) sulfur oxide, down from a previous limit of 3.5% m/m (MARPOL 2019). In practice, this requires that ships either transition to cleaner fuels or invest in exhaust gas cleaning systems, or more casually "scrubbers," that remove air pollutants from the exhaust from engines, auxiliary engines and boilers, and onshore and onboard marine vessels.

Some countries, such as the USA, were among the few designated Emission Control Areas (ECAs). Others include the Baltic Sea, the North Sea, and the US Caribbean. In ECA-designated areas, the allowable limits for particulate matter and sulfur dropped to 0.1% in 2015. As a result, vessels calling on US ports, including those in the Great Lakes, already were familiar, and largely compliant, with fuel requirements that exceed even the new IMO standards.

The IMO's policy is moving maritime transportation in the right direction, but consistent enforcement is required. That means that the Sulphur 2020 policy must be embraced by national governments, and as important, must also be embraced by ports and local governments who will be on the front lines of enforcement. A 2018 study found that cleaner marine fuels can reduce ship-related premature mortality and morbidity by 34% and 35%, respectively, and contribute to a significant reduction in childhood asthma. However, even low-sulfur marine fuels may still account for as many as 250,000 deaths a year and nearly 6.4 million cases of childhood asthma, even as climate effects are greatly reduced (Sofiev et al. 2018). Thus, striving for ever cleaner maritime transportation has additional benefits—and an equal commitment to cost-effectiveness must be made.

Individual port authorities have worked to address the problem of air pollution from ships in port. The New York Times Lisa Collins reported on the extent to which cruise ships pollute the ports where they dock. To wit: "A single cruise ship docked one day can emit as much diesel exhaust as 34,400 idling tractor-trailers, according to an independent analysis verified by the Environmental Protection Agency" (Collins 2019). That translates to 1200 tons of carbon dioxide, 25 tons of nitrous oxide and tons of hazardous particulate matter, and enough vanadium that its concentrations near cruise ship terminals in New York City that led to a $21 million investment in a "plug-in" station that allows ships to run all systems using shore power. Relatively few ships use the system in New York, but the use of plug-ins is required in some US cruise ship ports such as those in California and Seattle (Washington et al. 2020), and those in London, Sydney, and some ports in China. Overall, the cruise industry has been more focused on scrubber installation than in purchasing better fuel or in installing cleaner propulsion systems (Walker 2019).

Given IMO's longer-range emissions reduction goals for 2030 and 2050, the maritime transportation industry needs technological innovations, cost-effective strategies, and consistent regulatory enforcement to level the playing field and reduce its negative effects on air quality. For many companies, installing scrubbers is a gamble on fuel prices—deciding whether the expense and projected payback time of installing scrubbers will be greater or less than the gap between the price of cleaner fuel and that of the dirtier fuel over similar operating periods (Washington et al. 2020).

The 2020 abrupt economic slowdown due to the COVID 19 pandemic response brought about unprecedented reductions in maritime transport, including the cruise industry, and disrupted established trade patterns among countries. Drastic shifts in demand happened nearly overnight as countries strove to limit the spread of the virus through "stay at home" orders and shutting down all "nonessential" economic activities. Maritime transport was essential for maintaining supply chains of medical equipment, food, and other necessities and threatened at the same time by the sudden "pause" in the global economy. The calculus for how to abide by IMO Sulphur 2020 also changed.

Multiple bulk carrier companies announced that they were going to delay scrubber installation for at least a year for a variety of reasons, including a sudden closing of the gap between cost of higher quality fuel and the higher sulfur fuels, which reduced the incentive to install air scrubbers. As reported by S&P Global on 12 May 2020, "A deteriorating global economic situation, which has impacted the dry bulk segment heavily, has come at the same time as a diminishing spread between 3.5% sulfur fuel oil, which would require a scrubber to be used on board, and more expensive 0.5% sulfur fuel oil … According to calculations from Norwegian risk management company DNV GL, this increases the payback time from one year to about four years for open-loop scrubbers and six years for closed-loop scrubbers" (Washington et al. 2020).

At the same time, the cost of some shipping routes (e.g., through the Suez Canal) can shift preferred routes from the shortest to the less expensive longer routes (e.g., around the Cape) when fuel prices are low and speed is not of the essence, as was also seen in the spring of 2020 (Latarche 2020).

In terms of reducing worldwide carbon emissions, IMO's clean fuel regulations help but do not address the likely expansion of global maritime transport that will increase emissions over the next several decades nor can they anticipate all market conditions that affect the sector (Walker 2019). As additional steps are taken to reduce the negative effects of ships on the climate and air quality, all strategies need to be deployed on a timely basis. Those include operational changes to reduce emissions from ships, such as speed reduction and energy consumption optimization, adoption of greener propulsion modes (as discussed in the subsection on greener shipping), and encouraging nations to include measures relating to energy efficient vessels and energy transition in their Nationally Determined Contributions (NDCs) under the Paris Agreement.

2.3 Sustainability Action 3: Design and Build Greener Ships

As noted, shipping is an efficient mode of transportation of goods and people. Prioritizing cleaner and safer construction, operation, and final disposal is a necessary foundation for a more sustainable maritime transport sector. Each new generation of ships has brought innovations in efficiency, albeit with trade-offs such as when ships become substantially larger and require additional coastal infrastructure to support their operation and repair. Sustainability actions begin with the idea that ships must operate more efficiently with less pollution of air and water, but also ship design must anticipate what can go wrong as well as what happens in normal operations.

2.3.1 Energy Efficiency

There needs to be increased investment in solutions that are energy-efficient and favor ocean-friendly maritime transport. These include designing evermore accurate navigation for efficiency and safety, testing driverless or autonomous ships, reducing onboard energy consumption, expanding the use of hybrid power systems, using sustainable building materials, and end of life considerations. The good news for maritime transport is that the “true blue” options are evolving rapidly.

The shipping industry itself is embracing more efficient propulsion systems (Latarche 2020). As shipping aims to reduce emissions, engines will need to be supplemented by other power sources, meaning the engine itself may have a reduced footprint while the overall propulsion system delivers the same power output.

The incentive is clear. Carbon-neutral fuels are needed to help shipping meet the IMO 2050 target of halving total greenhouse gas emissions. However, these fuels will not be widely available before the 2030 deadline when IMO aims to have cut shipping’s carbon intensity by 40%, based on 2008 levels. Some engines “have already greatly reduced the emissions levels through their benchmark low-pressure dual-fuel technology, but to reach the future IMO targets, energy efficiency measures are also needed. The increasing use of electrical energy–potentially using batteries to store energy surplus efficiently produced by onboard sources like rotor sails or solar panels—is one way of cutting emissions” (Latarche 2020).

Reducing onboard energy use can improve a ship’s cruising range. As ships travel longer and farther between refueling stops, companies will reduce fuel consumption and save money. There are dozens of new designs that are being tested and implemented (Zeldovich 2020). In the fall of 2019, a ship design firm announced that its hybrid sail design would be integrated into the construction of a new cargo vessel. The 30 meter sails harness the wind to supplement propulsion and are expected to reduce fuel consumption and emissions by as much as 30%. Other designs for hybrid engines and solar power to improve vessel efficiency are also being deployed (Spross 2019).

In 2018, the first LNG-powered cruise ship was launched, thus eliminating sulfur emissions, and greatly reducing nitrogen oxide and particulate emissions as well (Hellenic Shipping News 2019). The cruise industry in general has been pursuing greener designs for operations at sea. Some cruise ships have integrated solar power to operate elevators, LED lights, and heating systems. Other cruise companies are looking ahead to incorporating biogas (fuel made from dead fish and other organic waste) as a fuel for their propulsion systems, reducing reliance on fossil fuels and improving emissions. All of these innovations are part of moving maritime transport to a more sustainable relationship with the ocean.

2.3.2 Life and Safety at Sea

The COVID 19 pandemic generated a new awareness of how vulnerable a ship full of people can be when contagious diseases are present. Not only were thousands of passengers and crew members sickened, but also, they were forced to change routes or stay at sea longer than planned in order to negotiate off-loading of passengers. Months later, more than 100,000 crew members were still stranded on their cruise ships after cruising shut down at the same time as many countries' borders (Dolven 2020). Scheduled crew changes on commercial shipping vessels suffered from similar delays and disruptions. So, what is the sustainability action in ship design?

One strategy might be to anticipate having passengers (and crew) limit their activity in public spaces to maintain social distances or fully quarantine in their rooms, if necessary. The ability to use UV light to disinfect surfaces, treat water, and improve air ventilation systems is one possibility. Designing water and solid waste management systems to provide more storage to avoid illegal dumping at sea is another possibility. Still another might be to focus on improving ventilation systems to ensure that they are not spreading disease. Ensuring that the ship's exhaust is as clean as possible can also help reduce the impact of emissions on people's lungs. Fundamentally, good design for human health and emergency operations is likely to be sustainable design.

2.3.3 Automation

Another trend is toward more automated operations—that is to say designing vessels that can be operated from shore or are fully autonomous. As with other autonomous vehicles, there needs to be considerations of liability and emergency backup systems and plans, as well as the potential for interactions with marine mammals, recreational, and small nearshore fishing vessels that are difficult to anticipate. At the same time, a smaller crew or no crew means that the design would not have to include spaces for humans to sleep and live, as well as work. Autonomy could also reduce energy costs associated with the needs of a human crew such as sanitation, food storage/preparation, laundry, entertainment systems, heating, cooling, and ventilation. Dedicated routes for autonomous vessels could improve fuel efficiency overall.

Autonomous ships are getting closer to commercial viability with the first real-world test on a Finnish ferry in January of 2019, and additional sea trials continuing (IMO 2020c). The first zero emission, fully autonomous container ship (the *Yara Birkeland*), is designed to begin its operations with a temporary human-operated bridge while it undergoes testing of its other systems. Instead of ballast, the battery packs will serve as permanent ballast. All operations are intended to be autonomous—from loading and unloading to berthing and leaving port (Latarche 2020).

The IMO is looking at ways to assess the relative safety and sustainability of autonomous ships, which it generally sees as an application that will be used for routes where there is little traffic and calm waters (IMO 2020c). The goal is to make autonomous ships safer and operate in ways that represent an improvement in human and environmental safety.

2.3.4 End of Life/End of Service

From the beginning of the design phase, sustainable marine transportation should consider what will be done with the ship and its constituent parts at the end of the useful life of its ships and other vessels. Sourcing sustainable materials is also important when considering the sustainability of maritime transport—in vessel construction, in freight operations, and in port design. All materials need to be evaluated for their relative benefits at every stage. Steel has traditionally been the material of choice for ships due to its low cost and durability, yet, steel adds significant weight leading to additional fuel consumption. Conversely, many small ships or parts used in ships that are increasingly being made out of petroleum-based plastics (including both fiber-reinforced and polyethylene) can provide lightweight parts reducing overall fuel cost, but the end of life treatment of this plastic can end up polluting the ocean for centuries to come.

Consideration of end of life includes ensuring that the materials used for all parts of ships can be reused or recycled and that those materials that cannot be reused or recycled should be avoided or minimally incorporated. Historically, a considerable percentage of each ship's hull, systems, and other contents could be reused or recycled. Those operations are an important part of the maritime transport sector. The goal is to consider the end stage, perhaps even beyond the reclamation of ship components that now occur legally in regulated shipyards and less so in the notoriously polluting and unsafe shipbreaking yards found in Bangladesh, for example (Rajamanickam 2018). Here is an area where the UN 2030 Agenda for Sustainable Development Goals (SDGs) would be to improve the operations of such yards to make the industry more equitable, while enhancing the options for reuse or recycling of ship components beginning with the design.

2.4 Sustainability Action 4: Treating Ballast Water with Low (or No) Impact Technology

Reballasting at sea is necessary for the safety and stabilization of ships but can increase the spread of invasive species if the ballast water is not treated (U.S. Department of Agriculture 2020). Ships load water for balance and stability when cargo holds are light, but this water can be contaminated by plants and animals when off-loaded the water spreads invasive species. Each year, the USA spends roughly $3 billion attempting to control aquatic invasive species (Congressional Research Service 2018a, b). As shipping and marine transport have spread, so has the introduction of nonnative species. This can cause havoc in a wide range of areas.

These biological invaders can harm local ecological systems, fishing, and tourism and must be studied holistically. The issue can be addressed by treating water before off-loading. Sailors and crew may not be aware or might not be concerned about environmental harm from invasive species without education on the subject. Therefore, programs need to incorporate education and consideration for the local realities of ship staffing in addition to physical water treatment.

The IMO established the *GloBallast Programme* to address and monitor the problem of invasive species. *The International Convention for the Control and Management of Ships' Ballast Water and Sediments* (BWMC) was adopted in 2004 to introduce global regulations to control the transfer of potentially invasive species (GloBallast 2020). It entered into force on 8 September 2017. This is a good example of an action that has considerable technology available for implementation and one that continues to provide an opportunity for addressing a problem (IMO 2017).

Ballast water can be treated sustainably through the use of UV light, which kills organisms in the water and has no lasting impact on the water, the use of filtration systems as water exits ballast tanks, the use of heat to sterilize the water, and in some instances, chemical methods. Chemical treatment methods should, however, be approached with caution as the handling and storage of the chemicals themselves may be carried out by crew members who may or may not have training on proper handling of hazardous material and could result in a different kind of pollution problem. Also, carrying enough chemicals adds more weight to a vessel increasing its carbon footprint. Thus, alternatives may be preferable.

To promote compliance, countries can require inspections at ports-of-call that include checking ballast treatment systems, and if they fail, ships could be turned away or face hefty fines to unload their goods; sanctions based on the ship's home-port can be inflicted to ensure international compliance. This relies on strong monitoring and self-interest at the port to verify compliance.

The IMO is also instituting new requirements (expected to become mandatory in 2022) that demand that individual ballast water treatment systems be tested when a ship is commissioned. This is intended to ensure that installation was proper and to ensure that ship owners have confidence in their compliance, at least at the start of the ship's operations (Alfa Laval 2020).

2.5 Sustainability Action 5: Making Onboard Water Treatment Systems Safer for People and the Ocean

Water is a necessity on ships for cooking, drinking, and personal hygiene for both passengers and crew. Water is also a known source of infectious disease transmission on board ships, and wastewater becomes a pollutant when dumped in the ocean (World Health Organization 2011). Because it is inefficient to keep sufficient supplies of fresh water on board, ships often have multiple water systems. The potable water supply used for cooking, ice, drinking, and other direct consumption uses is sometimes supported by secondary systems for sanitation and wash water that recycle and reuse water.

The use of chlorine dioxide (ClO_2) as a powerful biocide, disinfectant, and oxidizer is common for onboard water treatment (U.S. EPA 2019). Waste treatment varies by industry and ship type; some large cruise ships have implemented high-tech filtration systems and off-load waste only at port, while other ships simply dump waste overboard.

The use of certain chemicals can be effective in killing bacteria but also extremely harmful to the environment if dumped. Therefore, a treatment's environmental effects must be considered when recommending sustainable alternatives. Likewise, the water associated with scrubbers and other pollution control equipment also must be treated. Scrubbers to limit pollution emissions use seawater as part of a filtration system to remove toxins from a ship's engine and boiler exhaust, and the less expensive ones dump the used water back in the ocean. More expensive "closed-loop" systems retain the toxins for safer disposal in port (Sethi 2020). The majority of cruise ships plan to install (or have installed) the less-expensive scrubbers that dump the "wash water" directly, raising concerns about a pollution threat that could be particularly damaging when it is released in congested waters containing multiple ships (Turner 2019). Given the impact of events such as the COVID 19 pandemic and fuel price volatility, there are relatively few incentives to invest in closed-loop scrubber systems unless a more sustainable path is mandated.

For a truely blue economy, the safe management and handling of waste and wastewater must be prioritized. There are a number of nonchemical systems that can be applied at scale, based on current land-based systems. These include the use of UV light, cavitation, electromagnetic field, and filtration systems. These water treatment systems were primarily designed to conserve water, prevent sickness and pollution, and reduce costs and maintenance, all areas in which the marine transportation sector could benefit (U.S. General Services Administration 2019).

2.6 Sustainability Action 6: Greening Port Facilities

Shipping is a global phenomenon, where the vessels spend the majority of their time outside the jurisdiction of individual nation states. Ports play a significant role as the facilitators of global trade and primary point of contact and transfer for ships and their cargos. Ports are also an integrated part of a larger interactive coastal and ocean system in which ports facilities affect and are affected by their surrounding environment.

The environmental and public health effects of port activities include those from noise (e.g., ship engines, cargo handling machinery); particulates from bulk carrier loads (e.g., grain, coal, and sand); SO_x, NO_x, and CO_2 emissions from ship engines; and of course, the road and rail traffic to and from the port (OECD 2011). In addition, there are environmental issues related to dredging, waste disposal, dirty water discharge, runoff into harbor waters, and other in-port activities. Dredging to accommodate the Panamax ships is a particular area of concern because of its exponentially increased negative effects on marine habitats and water quality due to the necessary removal and disposal of large volumes of often toxic materials (OECD 2011).

Of equal concern is adequate consideration of how port operations and facilities will be affected by sea level rise and increasingly powerful storms. Authorities need to invest heavily in preparation. Ports must consider what areas can be protected at minimal cost, what areas can be adapted to higher sea levels, more storms, and increasingly acidic waters, and in what cases will communities need to be relocated to avoid adverse effects of port activities.

So, what are the sustainability actions for greening ports? One could consider the following:

- Pursuit of certifications for greening port activities
- Monitoring air and water quality to identify pollution sources and create solutions
- Reducing emissions from trucks, ships, and other sources
- Installing renewable energy capacity
- Limiting and capturing runoff from port facilities
- Inspecting vessels and enforcing wastewater discharge
- Planning for future conditions such as higher sea levels, including, especially, high tides and storm surges
- Ensuring that channels deepened for larger ships do not increase the effects of storm surge on the port or upstream
- Deciding which facilities need to be raised or moved (and can be)
- Assessing the options for loading and off-loading schedules around known tidal patterns
- Locating fuel, waste, and other storage facilities away from areas that are likely to be inundated
- Collaborating with local communities on emergency planning for evacuations, spills, groundings, or other consequences of storm surges
- Anticipating and integrating ports into both working waterfronts and as a public asset
- Ensuring that port activities do not pollute recreational areas such as beaches
- Monitoring and enforcing known entry and departure routes to limit impact on nearshore habitat
- Limiting the negative effects of dredging activities on water quality, critical habitat (e.g., mangroves, seagrass meadows, and marshes), and marine life

Again, the good news for those looking for viable examples of these kinds of sustainable actions is that a number of ports have made conscious efforts to improve operations to make them more sustainable, resulting in both greater efficiencies and lower pollution. Many of these strategies can, and should, be implemented in ports around the world to support improved sustainability in the sector and improved health and well-being in nearby communities.

Begun in 2014 and extended in 2019, Maritime Singapore's Green Initiative has three key elements all based on incentivizing greener ship operations: the Green Ship Program, the Green Port Program, and the Green Awareness Program (MPA Singapore 2019). The key element of the Green Ship Program is to reward shipowners for voluntarily exceeding IMO environmental standards by reducing port registration and annual tonnage fees for specific actions such as adopting LNG as a fuel. The Green Port Program reduces fees for ships that use LNG while in the Port of Singapore and for those who exceed the current IMO Energy Efficiency Design Index. The Green Awareness Program is an education and outreach program intended to greatly improve carbon reporting and internal carbon pricing as part of the overall effort to shift to lower carbon shipping.

The Port of Los Angeles is one of the largest air polluters in the Los Angeles area. Yet, it has made significant strides in "greening" its port through a number of programs. For example, the port now requires that ships plug into the local power grid while docked to reduce emissions caused by ships idling. In addition, shipping containers are now moved on tracks rather than trucks or heavy equipment, which also lowers air emissions (Our Daily Planet 2020). Additional greening investments by the port and the nearby Port of Long Beach are intended to make the ports more cost-effective and contribute to improved air and water quality for the benefit of both port employees and nearby communities.

In 2020, the Port of San Diego announced plans to install a solar microport grid project at the port's Tenth Avenue Marine Terminal. The project is expected to cut the port's energy costs significantly "while demonstrating integration of distributed energy resources—including solar, storage electric vehicles, and demand response" (GreenPort Magazine 2020a).

Ports play a role in supporting sustainability in other ways. For example, the Danish port of Esbjerg has supported the offshore wind industry since Denmark installed its first large-scale offshore wind farm (Horns Rev 1) in 2002, and as Horns Rev 2 (2009) and Horns Rev 3 (2019) came online. As installation of the projected 100 gigawatts of additional wind capacity in the North Sea by 2030 continues, the port expects to invest in new capacity to store, pre-assemble, and even manufacture the necessary components so as to reduce transportation costs and accompanying environmental effects (GreenPort Magazine 2020b).

Finally, the esthetics of a port can be a major draw of the ocean and, therefore, affect a locality's tourism and economy. The Port of Seattle announced that investing in sustainability was its path to recovery from the effects of the COVID 19 pandemic. Its proposed investments include the addition of a new 13.5 acre park on the Duwamish River to provide public access and aid in its habitat restoration goals. Scenic vistas may draw crowds, but there is also known economic benefit to communities that have clean ports, beaches, and waterways compared to those that are perceived to be dirty (JetBlue 2016). Therefore, local economies benefit when sustainable practices are adopted that keep the local environment clean.

Ports play a key role in the facilitation and monitoring of global maritime transport. Around the world, investment can and should be made to improve the operations of ports so as to improve the well-being of coastal communities, near-shore habitats, and the marine life that depends on them.

2.7 Sustainability Action 7: Improve Ship Safety and Emergency Response to Shipping Accidents

Long-distance shipping carries inherent risks—terrible weather conditions, collisions, failure to invest in maintenance and upgrades, and human error can all result in a ship leaking, grounding, or sinking, which in turn can cause significant environmental harm. The degree to which prevention, inspection, and response capacity can be anticipated or enhanced can reduce the degree to which such incidents cause significant harm.

The ability to deliver relevant information to shipowners, operators, and ports in real time is one key to reducing risk. A second is, of course, consistent inspection and repair of substandard ships as discussed earlier in this chapter. The third is sufficient response capacity.

Steps for greater sustainability to address these risks might include:

- Regular review and quick adoption of navigational and structural innovations that reduce risk
- Clearer assignment of liability for negative international consequences for cargo spills
- Increased response capacity, especially in more remote coastal areas near regular shipping lanes

Shipping accidents happen—but fortunately, they are relatively rare as a percentage of all shipping miles and volume. For example, more than 100 million containers are shipped on enormous vessels in normal years—yet, the industry projects that fewer than 1500 are lost each year on average (Schuler 2018). However, when accidents do happen, damage to resources can be significant. Even though salvors are required to be sensitive to the environmental impact of both a shipwreck and salvage operations, there can be serious damage during the process of removing a ship (and its contents) once grounded.

The unintentional release of ship cargoes causes their own suite of problems. For example, it is estimated that 250,000 tons of nurdles spill into the ocean every year (Eunomia 2016). Weighing roughly 25 mg apiece, nurdles are the tiny building blocks for nearly all plastic goods, from soft drink bottles to oil pipelines. A 2017 accident of Durban, South Africa, released containers spilling more than 54 tons of nurdles into the water—pollution that showed up in Australian waters more than a year later (Julissa et al. 2019). Better design and clearer liability for the consequences might ensure that potentially harmful cargoes such as this are not spilled. Better clean up and containment systems might also be adopted.

Liability to companies for oil spills is somewhat clearer and more easily determined. The 1989 grounding of the tanker *Exxon Valdez* and the lasting harm from the volume of oil spilled in Alaskan waters was one shipping incident which inspired greater attention to the construction and operation of large fuel carriers, as well as their operations and company liability.

Another significant accident was the December 2004 grounding of the *Selendang Ayu*, also in Alaskan waters, after the ship's engines failed. The rupture resulted in the release of about the ship's fuel—350,000 gallons of oil and diesel—as well as 132 million pounds of soybeans (NOAA 2019). The oil covered 86 miles of shoreline, killed thousands of birds and other animals, and the soybeans smothered the habitat on the coastal shore.

In both cases, the weather, the remote location, and the absence of response and containment capacity amplified the negative impact of the accident. And in both cases, the harm was not limited to the time of the incident but lasted for years.

Ship design and improved technology have enabled significant progress in reducing oil spills from vessels since 1989. In response to the *Exxon Valdez* accident, the IMO mandated that tankers are required to be double-hulled and over time has instituted additional measures, which addressed the potential source of pollution. Fuel oil, especially the so-called bunker fuel, used by other ships such as the *Selendang Ayu* is a particularly pernicious pollutant when released into marine environments. Emissions reduction efforts may well pay off by reducing the use of dirtier, if cheaper fuels, and thus reduce risk to marine environments in accidents as well.

Satellite tracking, improved navigation, and related technology have added a suite of tools to the goal of reducing risk to marine environments from marine transport. Consistent monitoring of shipping routes and tracking helps identify bad actors—flagging their activities for the appropriate authorities. Satellite tracking of major fishing vessels has already improved monitoring of no fishing zones and supported more targeted enforcement, and efforts are continuing to refine those efforts to be more cost-effective and timelier (Ship Technology 2018; Heffernan 2019). Additional monitoring of particularly hazardous routes such as that along the coast of Alaska, where the *Selendang Ayu* broke in half, might improve response time, especially if sufficient response capacity is in place at the nearest ports. Likewise, the loss of life and ships to collisions should be able to be reduced even further if the available technology is deployed properly.

Sufficient capacity to respond to harmful events is critical. One form of response is the ability to address new threats quickly within the existing regulatory framework. For example, the IMO Marine Environment Protection Committee (MEPC) can recognize Particularly Sensitive Sea Areas (PSSA) that require additional protective measures. Acknowledging the particular challenges of response to accidents and containment of pollutants in polar areas, the IMO is implementing the Polar Code, which entered into force in 2017 (IMO undated). The Polar Code covers the full range of design, construction, equipment, operational, training, search and rescue, and environmental protection issues for ships operating in the waters of both poles.

In recent decades, there have been significant improvements in global observation capacity to predict events that can disrupt navigation such as storms and tsunamis. Satellites continue to be used for the remote sensing of building storms over the ocean and for distributing information to response and shipping authorities—and that capacity needs to be expanded. There is concern about the loss in observation capacity due to economic downturns and events such as the COVID 19 pandemic, which may cause both a loss of investment and a loss of data collection because of the limitations on travel and the reliance on airplanes, ships, and observation buoys to collect and share data (Viglione 2020).

The vast majority of maritime transport occurs without incident—any harm is caused by ordinary operations, wilful misconduct, and / or disregard for IMO and other rules and regulations. As noted, part of sustainability requires thinking ahead to what can happen and investing in the capacity to prevent or respond. The cost of preparedness tends to be weighed against the present tense cost of operations rather than the cost of potential harm—figuring out how to embed precautionary actions into maritime transport is a sustainability action to reduce risk.

Human-caused disruption of the global climate means that the ocean currents and weather patterns around which maritime activities are designed will no longer be as stable or as predictable. Thus, every tool that can be deployed in support of safe navigation and reduced impact from incidents must be used to help the sector adapt safely. Additionally, integrated global positioning systems may reduce the number of lost or misdirected containers and lower associated operation costs (U.S. Global Positioning System 2006). Finally, as new technologies emerge, regulatory frameworks and response capabilities must also adapt.

2.8 Sustainability Action 8: Make the Ocean Quieter

Water transmits sound very effectively. In the absence of human activity, the ocean is not really a quiet place. It is filled with whale song and the low-frequency sounds of animals communicating across the water and under the water. Fish and dolphins are among the marine animals that use sound to navigate and find food (or avoid becoming food). Over time, the expansion of human activity in and on the ocean has generated more and more noise, to the detriment of the life within. Some types of noise hinder communication, others stress and can even kill ocean life.

Ship propellers and engines are one of the most pervasive sources of noise pollution in the ocean, impeding animal communication throughout (Glacier Bay National Park 2018). It is obvious that when a large ship passes close by, the noise that it generates will temporarily increase the sound levels at that location substantially. What is less well-known is that even in areas far from shipping lanes, the background sound level at low frequencies is dominated by noise from distant ships because low-frequency sound travels such long distances underwater (University of Rhode Island 2020).

Other sources of acute noise pollution stem from underwater drilling rigs, seismic surveys, dredging, and sensors. These activities can cause stress to fish, crabs, and other animals. Seismic surveys, in which air guns are used to explore for oil and gas beneath the seafloor, can also make significant contributions to the background sound levels at low frequencies. They have been shown to kill tiny zooplankton, the keystone of the food web, over half a mile away from survey sites (Jones 2019).

So, what are the sustainability actions to address noise? These include:

- Improving the navigation and operation of ships for better noise management
- Redesigning propulsion systems to make them quieter
- Expanding the use of quieter electric- and wind-powered vessels
- Investing in technology research, adoption, and implementation
- Continuing to refine the regulatory framework to reduce ocean noise even as human activity increases
- Limiting or eliminating seismic surveys in fragile areas (e.g. polar waters) so as to reduce the overall stressors on marine life and habitats
- Managing shipping in the context of migratory routes of marine animals to minimize noise in nursery areas, for example, during certain times each year
- Expanding monitoring of noise and its effects while engaging the maritime transport issues in developing solutions

Regulatory recognition of the noise pollution problem is growing. In 2014, the United Nations passed IMO MEPC.1/Circ. 833: *Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life*. Beginning in the design phases, new ships can incorporate propellers that reduce cavitation, install wake conditioning devices, and install air injection to the propeller. The process of decarbonization may encourage a switch to electric- and wind-powered vehicles, which will also reduce sound pollution (IMO 2014).

The most effective way to reduce noise pollution is by reducing the speed of ships and number of ships (Frankel and Gabriele 2017). As newer ships incorporate sound reduction technologies in their designs, the number of ships may be less of a problem than where and how they travel and for what purpose.

2.9 Sustainability Action 9: Operate to Avoid Whale Strikes

Just as shipping routes and practices have been established based on centuries of relatively predictable currents and weather patterns, so too have the migratory patterns of animals such as sea turtles, pelagic fish, and whales. Due to centuries of overfishing, whales are protected under multiple international agreements in order to avoid further risk of extinction. Unfortunately, paper protections do not prevent ship strikes of marine mammals that are usually fatal. From ferry routes to shipping channels, marine animals are constantly at risk of being in the wrong place at the wrong time.

Critically endangered North Atlantic right whales are vulnerable to ship collisions due to their slow speeds. Their migration route from Florida to Canada (and back) crosses major US East Coast shipping lanes, which are determined by the IMO. They are not the only north-south migratory species affected by east-west shipping routes. In the eastern Pacific, blue whales, gray whales, and humpbacks migrate from the south, where they bear their young to the north to feed seasonally as well.

As glaciers and sea ice melt, new shipping lanes are opening in the fragile Arctic ecosystem, increasing both the risk of harm and the chance of collision between marine animals and ships. Beyond the critical role that large marine mammals play in ecosystem health, marine animal fatalities tend to attract public attention in ways that do not benefit either ship owners or port operators.

So, what are the sustainability actions that might mitigate the threat of ship strikes?

- Understanding the migratory routes and patterns can help—but with warming waters and other effects of climate change, these might not be as predictable as one could hope for in anticipating potential conflicts
- Sonic pingers to warn animals and underwater sensors to warn ship operators of the presence of whales are part of the solution, although success has been mixed
- Slower speeds in key areas at appropriate times of year can also yield success
- Adjusting existing shipping routes based on careful collection of data and collaboration among shippers, maritime authorities, and scientists to implement those adjustments

Some areas have deployed other technologies as a way of reducing overall stressors and generating information about marine animal activity. Some scientists are deploying underwater unmanned remote vehicles to observe marine mammals with the goal of minimal disturbance, as long as standards are in place to manage the tens of thousands of underwater ROVs being shipped and deployed by amateurs, and to ensure the information relayed is reliable (Thaler et al. 2019). Citizens can also be engaged through apps and reporting systems that were developed to provide information to mariners and shipping companies (NOAA 2017). One example is through Whale Alert, a network of nonprofit organizations, government agencies, shipping, and technology companies dedicated to tracking whales in order to reduce lethal ship strikes (Conserve.IO 2020).

In 2008, scientists from the Smithsonian Tropical Research Institute in Panama began studying humpback whale migrations in the Gulf of Panama in order to reduce ship strikes in the food-rich area. Sixty whales were tagged from Ecuador to Costa Rica to compare their movements with the known pathways of 1000 ships (Guzman 2020). In just 2 weeks, more than 90% of the animals had had a close encounter with one of the ships. Working with the Panama Canal Authority, STRI devised a plan modeled on practices used in the USA and Europe known as a Traffic Separation Scheme, whereby ships would travel a certain distance apart (to give the whales room) and would keep their top speed at 10 knots or below during the August-November breeding season. The changes required international, national, and regional approval but were finally implemented in December 2014. Operationally, this change had relatively little effect, but for the humpback whales, it has made a significant difference.

A number of coastal nations have regulations protecting certain endangered marine animals within their jurisdiction, but at the international level, there are three main conventions that protect marine mammals. These include the 1946 International Whaling Convention, the Convention on International Trade in Endangered Species of wild Fauna and Flora (CITES), and the United Nations Convention on the Law of the Sea (UNCLOS) (International Whaling Commission 2020; CITES 1983; United Nations 1982). These call on signatories to work to conserve marine mammals and are the basis for the regulations that prohibit international trade in endangered animals. The IMO also has jurisdiction in the sense that it sets shipping routes and provides for the safe environmental operation of maritime transport. Additional measures may come into effect after the United Nations comes to agreement on protecting biodiversity beyond national jurisdiction (BBNJ), the 68% of the ocean that is also known as the high seas.

2.10 Sustainability Action 10: Expand Maritime Transportation Sector Engagement in Oceanic Data Collection and Monitoring

In 2019, over two dozen new species were discovered in the ocean. There are an incredible number of unknowns and uncertainty when it comes to the ocean, and more data is needed to guide sustainable policy and action. Engaging the maritime transport sector in learning more about the ocean, changes over time, and the life within is not a new idea. In fact, it is well-established. But, it is an area that can be greatly expanded to help the sector adapt to changing ocean conditions due to climate change and to support better understanding of the global ocean and how to restore its health.

All types of ships make routine weather and ocean observations that are shared internationally to support weather forecasting, safety at sea, and commercial ventures (e.g., energy, fisheries, and transportation) (Smith et al. 2019). Oceanographic research vessels provide an extremely versatile sampling platform from which highly sophisticated instruments can be deployed by national research facilities, navies, coast guards, universities, or private institutions. However, sampling from research vessels is uneven, sporadic, and can be subject to large seasonal biases, in part due to the expense of operating them (and a shortage of funding) and in part due to the need to fulfill highly specific research objectives.

Commercial ships have multiple advantages for researchers. Many run the same routes over and again, meaning that time, temperature, salinity, and other data can be collected with some consistency and the ability to understand short-term variations versus long-term trends. One example is ferry routes. Another is cruise ships.

Another is the regular shipping routes, both traditional and evolving as Arctic ice disappears, for example. The role ships play in atmospheric, oceanic, and biogeochemical observations is generally in measurements made near the ocean surface.

Regulation 5 of the Safety of Life at Sea Convention, 2002 (SOLAS), encapsulated in the title “Meteorological Forecasts and Warnings,” already specifies a system whereby consenting governments are encouraged to arrange for a selection of ships to be equipped with tested marine meteorological instruments and to take, record, and transmit meteorological observations that include atmospheric pressure, wind speed and direction, air temperature, relative humidity, and sea surface temperature (SST), as well as wave height and direction. The regulation further asks governments to encourage other ships to make, record, and transmit observations in a modified form, particularly in areas with sparse data.

While the near global coverage from satellite-based remote sensing helps overcome this, data from ships remain essential to support numerical weather prediction and operational forecasting including real-time storm conditions. Ship-based observations fill the gaps that satellites cannot (e.g., atmospheric pressure.). Beyond their use in numerical weather prediction, data from ships are also used operationally in the preparation of forecasts and warnings, including those for the Global Maritime Distress and Safety System, and to support the routeing of ships to avoid adverse weather and efficiently transport cargo (Smith et al. 2019).

Beyond the critical data already being collected, additional sensors may be integrated that relay additional data to scientists on shore. Ships can build systems that automatically gather water samples and pump water through to provide real-time monitoring and chemistry testing.

Some ships could also use a GPS network to tag large accumulations of microplastic, ghost fishing gear, and marine debris. The debris could either be picked up by authorities and nongovernmental organizations or collected by the shipping industry itself if an incentive program was created. However, it is important to consider that outfitting ships with collection and monitoring equipment can be very expensive and may require both extensive training and frequent maintenance—not to mention interfere with profit-making activities. At the same time, additional information may aid in designing regulatory regimes that benefit the sector and the ocean environment.

Science will not only benefit from increased data, but that data can be used to improve the marine transportation sector itself. A great opportunity exists with the United Nation’s Decade of Ocean Science for Sustainable Development to connect researchers and existing technology to fulfill sustainability needs and goals (United Nations 2019). The decade will run from 2021 to 2030 and hopes to promote applied, pragmatic science in support of sustainability and addresses the current data gaps to benefit all in the marine sphere (see Fig. 2.2). It will pursue the science we need for the ocean that we want to see at the end of the decade:

- A **clean ocean,** where sources of pollution are identified, reduced, or removed
- A **healthy and resilient ocean,** where marine ecosystems are understood and managed

Fig. 2.2 UN Decade of Ocean Science for Sustainable Development. (Courtesy of the Intergovernmental Oceanographic Commission of UNESCO)

- A **productive ocean** supporting sustainable food supply and a sustainable ocean economy
- A **predicted ocean,** where society understands and can respond to changing ocean conditions
- A **safe ocean,** where life and livelihoods are protected from ocean-related hazards
- An **accessible ocean** with open and equitable access to data, information, and technology and innovation
- An **inspiring and engaging ocean,** where society understands and values the ocean in relation to human well-being and sustainable development

3 Looking Ahead: Establish a Framework for Maritime Transportation Governance That Supports All Life on Earth

To arrive at the ocean we want, one that is healthy and abundant, shipping will need to improve. Sustainable shipping will require a strategy that crosses many disciplinary boundaries to use a more holistic approach. In fact, a successful transdisciplinary approach should be a prerequisite to the implementation of most, if not all, of the Sustainability Actions in this chapter because mankind needs to avoid unintended consequences that might come from siloed thinking. As the maritime sector approaches change, it must ensure it is thinking not just about cost per pound, per mile transport of goods, but also about how it is affected by (or affects) policy, science, socioeconomic equity, and esthetics. The maritime transportation sector must avoid cognitive entrenchment because the complexity of ocean systems and how they interact with all our broader concerns do not lend themselves to a single disciplinary specialist, instead a breadth of experience is invaluable. A transdisciplinary approach is a generalist's approach, someone trained in various disciplines, someone who uses that united knowledge to solve problems, including solutions for the threats to the ocean from shipping.

Restoring the health and abundance of the ocean is also a necessary step in achieving the United Nation's SDGs. The SDGs seek to balance social, economic, and environmental sustainability by 2030, something that can only be attained through the adaptation of new technologies and changes within industries. While Goal 14 deals with Life Below Water, an abundant ocean can positively affect multiple goals from reducing hunger (SDG 2) to climate actions (SDG 13) and economic growth (SDG 8). Incorporating sustainable or "green" activities into the "blue" marine sector is necessary to preserve the life support system and restore abundance in our global ocean, the ocean or blue economy. Without irony, a healthier and more abundant ocean is a rising tide that lifts all boats. In other words, many stakeholders will benefit from increased productivity that arises from ensuring abundance in the world's ocean.

The IMO has asserted that "most of the elements of the 2030 Agenda will only be realized with a sustainable transport sector supporting world trade and facilitating global economy" and lists how the maritime transportation sector relates to all 17 of the UN SDGs (International Maritime Organization 2020). Low-cost maritime transport of goods helps address poverty, inequality, and food security; fosters economic growth and creates jobs; and demands education of seafarers (SDGs 1–4, 8, and 10). IMO has programs to increase gender diversity, to continue to address clean water and sanitation, as well as to pursue maritime energy efficiency and low carbon shipping (SDGs 5–7, and 12–14). The maritime transportation sector can contribute to sustainable cities and innovation for the sector and the infrastructure it needs for port cities, as well as ship building and ship breaking communities (SDGs 9, 11). It can also be part of global efforts to halt illegal wildlife poaching and trafficking and can support governance, institutions, and partnerships to promote the SDGs (SDGs 15–17).

The Sustainability Actions in this chapter are those where the maritime transportation sector can change its behavior, improve its own relationship with the ocean rather than just being a supporting player in achieving the 2030 Agenda. Thus, we must describe a framework for maritime transportation governance that supports all life on earth.

From the establishment of MARPOL to the SDGs that underpin the United Nations 2030 Agenda, there are evermore policy elements to support the regulatory framework that are needed to provide consistent guidance to all of the maritime transportation sector while improving practices. The United Nations SDG 14 Life Below Water asks committed nations to "conserve and sustainably use the oceans, seas, and marine resources for sustainable development."

Fulfilling SDG 14 means changing maritime transportation practices, in addition to reducing the harm to the ocean from onshore activities. Connecting the existing international agreements to national policies means collaborative consideration of how to establish a comprehensive inshore-to-open ocean framework for a sustainable blue economy within maritime transportation. The development of a framework must incorporate economic and social policies that encourage the growth of the sustainable industries, invest in research and innovation, and anticipate shifts in where jobs are created to support these activities.

The foundation of consistency is enforcement. For maritime transportation that means monitoring of discharges from ports, vessels, and other infrastructures. It means consistent inspection standards and implementation—and will require assistance to poorer nations to improve their capacity. It means using a combination of satellites, other technologies, incentives, and punishments to identify bad actors and elevate the good ones. Good examples abound, which should make it easier. Political will to enforce and to invest may be harder to achieve.

Science based on data collection, monitoring, and evaluation can help find the sources of the issues and be used to determine the effectiveness of various solutions. Policy can be used to provide standardization, guidance for countries, and provide mechanisms for enforcement. Socioeconomic considerations can and should be used to determine population areas that may be particularly vulnerable or susceptible to increased climate variability.

There is considerable opportunity and innovation already underway. The efficiency of maritime transportation rests on millennia of adaptation and change. The goal is to design the next steps through the lens of doing good for the ocean.

The maritime transportation industry needs to recognize that restoration, protection, and enforcement are all economic activities that underpin other parts of the global economy and security. Policy agendas must be developed that simultaneously enhance ocean health and economic growth, in a manner consistent with principles of social equity, inclusion, and justice. Agendas that work toward improvement of human well-being and social equity, while also mitigating environmental risks and ecological scarcities, are agendas that support economic well-being for all sectors.

4 Concluding Remarks

Harmful human activities on, near, and in the ocean have reached the point where significant harm to biodiversity and ecosystems has already occurred and is still occurring—with an adverse effect on the critical ecosystem services the ocean provides. The most important one of those is the generation of oxygen—fundamental to virtually all life on earth and, therefore, priceless.

As ocean-based trade increases, so too does the environmental footprint of shipping and trade. Increased international trade has aided the spread of invasive species and diseases, pollution is increasing, the ocean is becoming more acidic, warmer, and deeper, and the effects are measurable (Ricciardi 2016). As noted earlier in this chapter, the overall efficiency of moving people and goods by ship means figuring out how to ensure that maritime transportation does the least harm possible, while becoming even more efficient. Ensuring that the maritime transportation sector operates as sustainably as possible should be a global priority.

Policy, science, socioeconomic equity, and esthetics are the four pillars that must be jointly considered when looking at the sustainability of maritime transportation—considerations that are built into the sustainability actions described above. Additional actions can capitalize on the considerable innovation that is already underway in all segments of maritime transportation. The industry needs both consistency to operate and incentives to innovate. The whole sector must be engaged in change—keeping in mind that most of the harmful effects of maritime transportation activities are borne by those who do not benefit from them. Pragmatically, that means recognizing that the existential threat to our ocean from climate change is part of a multitude of threats to safe and predictable shipping operations from the effects of climate change.

It is very simple. To support life on earth: we have to stop taking too much good stuff out of the ocean and stop dumping too much bad stuff in. A truely blue economy does not rest on growth for the sake of growth—it rests on restoring abundance, rebuilding ecosystem services, and matching need to capacity. Embedding sustainability into maritime transportation practices means fostering a more sustainable future globally.

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Chapter 3
Regional Marine Spatial Planning: A Tool for Greening Blue Economy in the Bay of Bengal

Asraful Alam

Abstract The Bay of Bengal (BoB) region is under severe threat of marine pollution because of unsustainable management of human activities for the exploration of marine resources. The emergence of the concept of Blue Economy fuels the coastal states to explore more marine resources that will cause much more marine pollution in the region. Therefore, a balance between the exploration and conservation of marine resources is essential for the prevention of unsustainable use and marine pollution. Marine Spatial Planning (MSP) may be a tool for the balance between exploration and conservation of the marine resources in the BoB region. This balance approach will also facilitate to develop a sustainable Blue Economy for the coastal states of the Bay region through sustainable management and use of the marine resources. However, the current regional legal arrangements for management of ocean resources of the BoB do not provide any explicit provisions for the development of MSP in the Bay region. The current regional conventions, agreements, declarations, organisations, programmes and plans have different provisions for management of the marine resources of the BoB. Those legal regimes have several provisions that are relevant and cover different aspects of MSP. However, the current regional arrangements for the management of marine resources are not adequate for the development of MSP for sustainable use and prevention of marine pollution in the BoB. This inadequacy has significantly impacted the objective of sustainable Blue Economy in the Bay region. A uniform agreement among the coastal states is essential to develop a regional MSP in the BoB region. Development of MSP in the BoB will be an effective tool for greening the Blue Economy by sustainable use and protection of the marine environment in the Bay region.

Keywords Marine spatial planning · Blue economy · Integrated management · Sustainable use · Marine pollution · Ecosystem approach

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1 Introduction

The Bay of Bengal (BoB) is an embayment of the northeastern Indian Ocean, important for maritime connectivity and natural resources in the Bay region. The Bay is positioned between India and Sri Lanka in the west, Bangladesh to the north, and Myanmar and the northern part of the Malay Peninsula to the east (see Fig. 3.1). The natural resources of the Bay play a significant role in the socio-economic development in the region. Approximately, 200 million people live along the BoB's coasts, and they are partially or wholly dependent on its fisheries (Pauly and Zeller 2017). About 90% of the international trade of the BoB region is carried by maritime transport (Plummer et al. 2016). Moreover, the BoB has become an important area for hydrocarbon reserves (Faruque 2012). The coastal states of the BoB have considerable opportunities to boost socio-economic benefits through the utilization

Fig. 3.1 Map of the Bay of Bengal. (Source: World Atlas, available at: https://www.worldatlas.com/aatlas/infopage/baybengal.htm)

of the Bay's natural resources. However, these natural resources are under severe threat due to over exploration, exploitation and marine pollution (Hassan and Haque 2015). Emergence of the concept of Blue Economy is likely to create even greater threats to the BoB. An effective management mechanism is essential to prevent or at least reduce these threats and to benefit from Blue Economy by sustainable use and prevention of marine pollution (Alam 2016).

The Bay is currently being managed sector-by-sector and by fragmented regulations of the coastal states (Bari 2017). The ongoing trend of management of marine resources sector-by-sector, with only fragmented regulations of the coastal states, is ineffective in achieving sustainable use while preventing marine pollution in the Bay (Verlaan 2006). The coastal states need a management mechanism with the objectives of sustainable use, conservation of marine living resources and protection of the marine environment. An ecosystem approach should be the basis of the management process. The management mechanism should also address the objectives of Goal 14 of the Sustainable Development Goals (SDGs) of the United Nations. Goal 14 makes a global commitment to protect life under water by the sustainable use and conservation of marine resources (United Nations 2016). Several coastal states of other regional seas have developed Marine Spatial Planning (MSP) to achieve sustainable use and conservation of marine resources (Ya 2016). MSP may be a very useful tool to achieve sustainable use and conservation of marine resources while preventing marine pollution in the BoB region (Alam 2019). Hassan and Haque establish the necessity of transboundary MSP in the BoB for sustainable use and conservation of marine resources (Hassan and Haque 2015). However, the paper does not analyse the current legal and institutional arrangements for management of the marine resources of the Bay from a Blue Economy perspective. The objective of this chapter is to close this gap by examining the current regional conventions, agreements, declarations, organisations, programmes and plans for management of the marine resources of the BoB. The chapter explores the prospects and challenges in developing a regional MSP to achieve a sustainable Blue Economy for the coastal states of the region. The chapter is based on a qualitative research approach with interdisciplinary strategies of legal, policy and management research. The findings of the chapter will facilitate understanding of the necessary legal reforms and institutional changes to develop a regional MSP for greening the Blue Economy in the region.

2 Blue Economy

The concept of 'Blue Economy' is a recent phenomenon, originating from the United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012 (United Nations 2014). The Conference focused on two themes: a framework for sustainable development and advancement of green economy. However, the coastal and developing countries were at the forefront and strongly argued for Blue Economy from the very beginning of the Conference. Consequently, the concept of

Blue Economy was recognised and included in the United Nations Conference on Environment and Development process, the Johannesburg Plan of implementation, and reaffirmed in the outcome document of the Rio + 20 Conference (United Nations 2014).

Despite the frequent use of the term 'Blue Economy' in global legal and policy documents, there has been no universally accepted definition of Blue Economy. According to the World Bank report, 'Blue Economy' refers to sustainable use of ocean resources for economic growth, improved livelihoods and jobs and healthy ocean ecosystem (World Bank 2017a). The concept refers to the economic activities that directly or indirectly take place in oceans, use outputs from oceans, and put goods and services into marine activities, and the contribution of those activities to economic growth, as well as social, cultural and environmental well-being (Roberts 2016). The goals of Blue Economy include improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities, endorsing low carbon, ensuring resource efficiency and social inclusion (Smith-Godfrey 2016).

Blue Economy has diverse components, including established traditional ocean industries, such as fisheries, tourism and maritime transport; also new and emerging activities, such as offshore renewable energy, aquaculture, seabed extractive activities and marine biotechnology and bioprospecting (World Bank 2017b). Blue Economy ties up a balance between development and environmental protection. Blue Economy seeks to promote economic growth, social inclusion and the preservation or improvement of livelihoods while at the same time ensuring environmental sustainability of the oceans and coastal areas commonly known as 'sustainable development' (World Bank 2017b).

Blue Economy is closely connected to the concept of sustainable development and the SDGs. While the SDGs are not legally binding, governments are expected to establish necessary frameworks for the achievement of the 17 Goals (United Nations 2016). Goal 14 of the SDGs, 'Life below water', aims for conservation and sustainable use of the oceans, seas and marine resources (United Nations 2016). Goal 14 aims to pursue sustainable use of marine resources. Goal 14 has two aspects: conservation of ocean and marine resources and sustainable use of ocean and marine resources. Goal 14 necessitates the exploring and exploiting of ocean resources in a sustainable manner, which maintains ocean conservation (WWF Global 2015). The targets of Goal 14 clearly reveal or show or require that ocean conservation should be achieved through the sustainable use of ocean resources. Therefore, sustainable use of ocean resources is the toolkit with which to achieve conservation of oceans under Goal 14.

Sustainable use of ocean resources requires that economic activity is conducted in balance with the long-term capacity of ocean ecosystems to support this activity and remain resilient and healthy (Goddard et al. 2010). Sustainable use of ocean resources and services essentially requires the use of ocean resources in a sustainable manner to ensure the long-term capacity of the ocean and protection of marine ecosystems. Clearly, exploration of marine resources and services will involve increased human activities in and around oceans and thus pose greater threats to natural ocean ecosystems. Oceans are threatened by marine and nutrient pollution, resource depletion and climate change, all caused primarily by human actions (UN Global Compact 2016). These threats place further pressure on the sustainable use of ocean resources. Therefore, an effective management tool is essential for sustainable use of the ocean activities for the exploration of marine resources and services. MSP is a recognised management tool to achieve sustainable use of the marine resources and services.

3 Marine Spatial Planning

MSP is a recognised tool for management of marine resources. MSP is a public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that are usually specified through a political process (Ehler and Douvere 2009). Three or more coastal states of a region may develop MSP for a regional or sub-regional ocean, which is called regional MSP. Moreover, two coastal states may enter into a joint MSP arrangement, which is popularly known as transboundary MSP.

MSP is a practical tool to create and establish a more rational use of marine resources and spaces to balance the demands for development and the need to protect the environment and to deliver social and economic outcomes in an open and planned way (IOC/UNESCO 2018). It provides an integrated process for sustainable management of human activities in the ocean through the allocation of space and control of activities to protect economic, environmental and social interests. It allows a high level of environmental protection and a wide range of human activities for exploring marine resources (Ehler 2008).

MSP is a significant departure from the sector-by-sector or use-by-use approach to integrated approach, which allows planners to consider various uses of oceans at the same time (Hassan 2013). It places emphasis on coordinated networks of national, regional and global institutions (Douvere and Ehler 2009). It brings a spatial dimension to the regulation of marine activities by establishing geographical patterns of sea uses within a given area (World Bank 2017a). As MSP provides sustainable management through an integrated mechanism for sustainable use of the marine resources and service, it has become an important issue for Blue Economy.

4 Blue Economy and Marine Spatial Planning

Sustainable use of ocean resources and services is a key component of Blue Economy. Blue Economy, predominantly, comprises the sustainable use of ocean resources (The Economist 2015). Blue Economy has introduced a new dimension in ocean management. It recognises that diverse ocean uses and marine ecosystem services are interconnected, and additional value can be gained from managing these uses and services jointly rather than separately (Burgess et al. 2018). Rapid growth of human activities in the ocean to boost Blue Economy is creating unsustainable threats to the marine environment. The various ocean energy technologies will potentially have significant adverse environmental impacts on the marine environment (Hussain et al. 2017). The mounting pressure on oceans due to the expansion of existing marine activities and new uses looks for new tools and approaches to foster a more rational and wiser use of ocean space (Douvere 2008). In this context, MSP is an effective tool for sustainable ocean management through rational use by balancing economic growth and environmental protection (Dominguez-Tejo et al. 2016). MSP provides a holistic ocean management for blue growth, which is analogous to the hypothesized advantages of ecosystem-based management. MSP has become an essential tool for identifying and utilizing marine spaces and for drawing up plans for sustainable ocean governance (Hassan and Haque 2015). The best feature of MSP is an integrated approach that allows planners to consider various uses of oceans along with consideration of environmental impacts in the ocean spaces (Davies et al. 2014).

Historically, economic activity in the oceans has been managed on a sectoral basis, with only limited coordination between ministries, regulatory bodies and industry when overseeing, among other things, overlap of property rights, shipping routes and fishing grounds (The Economist 2015). As a result, sector-by-sector management of ocean activities tended to create innumerous conflicts among the users and threatened economic development. In this case, MSP is the tool for promoting a more rational and integrated use of the oceans by mitigating inter- and intra-conflicts.

The concept of Integrated Coastal Zone Management (ICZM) emerged for integrated management of blue resources. However, the approach is found less effective for sustainable use of the blue resources and protection of the marine environment. In this case, MSP is found much effective for sustainable use of the blue resources and protection of the marine environment through sustainable management of the resources. MSP has a significant role in promoting a rationale use of ocean resources to overcome the various barriers to the development of the Blue Economy (Young 2015). Therefore, MSP can be a means to confirm sustainable use of ocean resource while benefitting from Blue Economy.

The Blue Economy Concept Paper of the World Bank provides the guidelines for responding to issues concerning the management of Blue Economy activities. The Concept Paper prescribes for the ecosystem approach to maintain the degree of interconnectivity and to protect the ocean ecosystems (United Nations 2014). It states that an ecosystem approach is required that factors in the restoration of biodiversity and renewable resources and proper management of resource extraction. Although acknowledging the need for an ecosystem approach in all aspects of Blue Economy, the Concept Paper does not prescribe a specific tool for the implementation of the ecosystem approach. In this context, MSP is an appropriate tool for the management of blue resources based on the ecosystem approach. MSP as an implementation tool for EBM, it demonstrates significant resilience and maintenance of marine biodiversity. For example, MSP in the Great Barrier Reef of Australia demonstrates application of an ecosystem approach in the management of a vast marine area (Hassan and Alam 2019).

Blue Economy aims to utilise ocean resources for the well-being of human beings. Services from the ocean should be maximised through multi-layer uses and services subject to protection of the marine environment. In this concern, MSP is the perfect tool to manage multi-layer uses of the ocean by 'separating conflicting uses through application of the various zones and determining the appropriateness of various activities' (Day 2002), maintaining a balanced approach between economic interest and environmental protection. MSP may facilitate the objectives and benefits of Blue Economy by providing a master plan for sustainable management of the blue resources by integrated management approach among the conflicting actors. Moreover, the ecosystem approach of MSP accelerates conservation of the marine ecosystem for sustainable ocean functioning.

5 The Current Management Framework for the Bay of Bengal

There are several regional conventions, agreements, declarations, organisations, programmes and plans that have different provisions for management of the marine resources of the BoB. The relevant provisions of those legal regimes are discussed below.

5.1 Bay of Bengal Program Inter-governmental Organization Agreement 2003

The Bay of Bengal Program Inter-Governmental Organization Agreement 2003 is a regional agreement established the Bay of Bengal Programme Inter-Governmental Organization (BoBP-IGO) to promote long-term utilisation of coastal fisheries (Ghosh and Lobo 2017). The Agreement was formally signed by the governments of Bangladesh, India and Sri Lanka at Chennai in April 2003 and subsequently by the Government of Maldives in May 2003 (BOBP-IGO 2019). The Agreement is an outcome of the BoBP of the Food and Agriculture Organization (FAO) of the United Nations. The primary objective of the Agreement is to establish cooperation among the member countries for sustainable coastal fishery development and management in the Bay region (BOBP-IGO 2019).

The Agreement provides necessary programmes and tools to achieve the objectives of sustainable coastal fisheries and management in the BoB. Article 4 of the Agreement outlines the programmes and tools required to facilitate the achievement of the preceding objectives. Article 4 of the Agreement provides that the first step towards the achievement of the objective is the implementation of programmes and activities immediately required for the sustainable development and management of coastal fisheries. However, the Agreement does not mention what the immediately required programmes and activities are and leave it to the contracting parties to identify and implement by mutually agreeing. The second step is to consolidate the establishment of an expanded network to share the responsibility of fisheries management, training and information exchange essential to coastal fisheries development in the region. The third step is to assist in the harmonisation of policy and legal framework necessary for sustainable development and management of coastal fisheries resources of the region. The fourth step is to establish a regional information system to provide appropriate information for development, planning, research and training.

5.2 Action Plan for the Protection and Management of the Marine and Coastal Environment of the South Asian Region 1995

The *Action Plan for the Protection and Management of the Marine and Coastal Environment of the South Asian Region* is a regional action plan to protect the regional marine environment adopted by the South Asia Co-operative Environment Programme (SACEP) in 1995. The SACEP was established in 1982 as the regional environmental hub to facilitate the introduction of the Regional Seas Programme to South Asia (SACEP). In 1984, SACEP developed 18 programmes, and the South Asian Sea Programme (SASP) is one of these. The five maritime countries signed the Action Plan (Bangladesh, India, Maldives, Pakistan and Sri Lanka) (SACEP). The Action Plan was adopted to promote and support the protection, management and enhancement of the environment in the region (SACEP).

The primary objective of the SACEP Action Plan is to protect and manage the marine environment and coastal ecosystem. Pollution by oil, noxious liquid substances in bulk, harmful substances, sewage, garbage, air pollution and ballast water are the major threats to the marine environment of the BoB (Sarma et al. 2015). The Action Plan, at section 3, recommends that the member states establish and enhance consultations and technical cooperation among the states, emphasise the economic and social importance of the resources of the marine and coastal environment and establish a regional cooperative network of activities concerning concrete projects of mutual interest for the whole region. Moreover, the Action Plan, at section 6, aims to ensure that the state parties work to prevent deterioration of the region's marine and coastal environment originating from activities within and outside the states of the region. The Action Plan is intended to promote policies and management practices for the protection and development of the marine and coastal environment on a national and regional level, including appropriate legislation at the national level.

The SACEP Action Plan, at Section 6(a), requires member states to strengthen and encourage, through increased regional collaboration, the activities of institutions within the region involved in the study of marine and coastal resources and ecosystems. Moreover, states should, under Section 6(d), improve training, technical assistance and exchange of scientific and statistical data at all levels and in all fields relating to the protection and development of the marine and coastal environment.

Article 7 of the SACEP Action Plan prescribes for more specific strategies to achieve its or these objectives. First, assessment and evaluation of the causes, magnitude and consequences of environmental problems, in particular, the assessment of marine pollution from sea-based sources, and the study of activities and social and economic factors that may influence or be influenced by environmental degradation. Second, promotion of methods and practices for the management of social and economic development activities that safeguard environmental quality and utilise the resources rationally on a sustainable basis. Third, promotion of national legislation, if necessary, for the protection and development of the marine and coastal environment, which will facilitate mutual collaboration and operational efficiency of the Action Plan, having due regard to the need for and suitability of such a framework. Fourth, strengthening of institutional machinery and adoption of financial arrangements required for the successful implementation of the Action Plan.

The Action Plan contains five main strategies for the protection and management of the marine environment and related coastal ecosystems of the region: environmental assessment, environmental management, environmental legislation and institutional arrangement and Integrated Coastal Zone Management (ICZM). Article 9 of the Action Plan provides for environmental impact assessment for the development of management plans to control the human activities with the potential to cause marine pollution. The states should strengthen their national capabilities in marine science and for monitoring and assessing the state of the marine and coastal environment and the conditions of living and non-living resources. The states should collaborate in establishing a coordinated regional marine pollution monitoring programme. The states should conduct survey and assessment of present social and economic activities, including development projects, which may have an impact on the quality of the marine and coastal environment. The states should arrange a comprehensive classification of coastal and marine habitats and mapping of critical habitats.

Environmental management is one of the primary strategies of the SACEP Action Plan. Article 10 of the Action Plan provides that sustainable and environmentally sound development depends upon the rational management of natural resources. The Action Plan requires the governments to adopt appropriate environmental management policies for strengthening of national and regional capabilities to prevent, control and combat marine pollution from sea-based sources and cooperation in implementing and enforcing existing international agreements related to it.

ICZM is one of the strategies of the SACEP Action Plan for the environmentally sound and sustainable development of marine and coastal areas in the region. Annex I of the Action Plan suggests many activities for the sound management of coastal areas. The first step of integrated management is the preparation of a comprehensive and integrated management plan. The authority concerned should conduct surveys and research on selected issues within the sectors of human and economic activities, analyse the natural systems, as well as the human and economic activities in coastal areas, assess the exposure to risk, for example, rise in sea level or other natural hazards and prepare a resource atlas.

5.3 SAARC Charter, Environment Action Plan and Convention on Cooperation on Environment

The South Asian Association for Regional Cooperation (SAARC) is a sub-regional organisation established by the *SAARC Charter* in 1985. The SAARC comprises eight member states: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. The objectives of SAARC are to promote the welfare of the peoples of South Asia and to improve their quality of life by accelerating economic growth, social progress and cultural development in the region.

According to the Preamble*, the SAARC Charter* is a record of commitment made by member states to mutual cooperation for regional solidarity. The states agreed to resolve common problems by joint action and enhanced cooperation within their respective political and economic systems. The preamble of the Charter shows that the states gave their commitment to regional cooperation as mutually beneficial, desirable and necessary for promoting the welfare and improving the quality of life of the peoples of the region. Moreover, the states reaffirmed their determination to promote cooperation within an institutional framework.

The *SAARC Environment Action Plan* 1997 was adopted by the third meeting of the SAARC and expressed concern for the deteriorating state of the environment, urging action to address these concerns. In the ninth SAARC Summit, the heads of states expressed the urgent need for implementation of the recommendations on the protection and preservation of the environment. In response to the decision of the heads of SAARC states, the *SAARC Environment Action Plan* was adopted. The primary objective of the Action Plan is to address regional environmental concerns.

The SAARC Convention on Cooperation on Environment was adopted in the sixteenth SAARC Summit in 2010. The member states adopted the Convention according to the decision of the twelfth SAARC Summit on the importance of an early and effective implementation of the SAARC Environment Plan of Action. The parties to the Convention recognise the necessity for sustainable management of the environment and natural resources, as prominent or highlighted or emphasised in the Preamble of the Convention documents. At the preamble, the parties to the Convention expressed their sincere commitment to cooperation to protect the environment. In Article II of the Convention, the parties agree to the areas of cooperation concerning the marine environment including biological diversity, coastal zone management, coral reef management, ecosystem management for sustainable livelihoods, global environmental issues, sea water quality management, water management and conservation, EIA studies and the impact of human activity.

5.4 Declaration on the Establishment of the Bangladesh-India-Myanmar-Sri Lanka-Thailand for Economic Cooperation (BIMSTEC) 1997

The regional states of the BoB adopted *the Declaration on the Establishment of the Bangladesh-India-Myanmar-Sri Lanka-Thailand for Economic Cooperation for Multi-Sectoral Technical and Economic Cooperation* (BIMSTEC) ('*Bangkok Declaration*') in 1997. BIMSTEC is a regional organisation comprising seven member states (Bangladesh, Bhutan, India, Nepal, Sri Lanka, Myanmar and Thailand) lying in the littoral and adjacent areas of the BoB, constituting a contiguous regional unity (BIMSTEC 2019). BIMSTEC has established a platform for intra-regional cooperation between SAARC and ASEAN members (BIMSTEC 2019). The organisation functions in accordance with the founding principles of BIMSTEC as laid down in the Bangkok Declaration (BIMSTEC 2019).

The objective of *the Bangkok Declaration* is to establish regional cooperation for collective benefits. The state parties adopted the Declaration for the purposes of mutual interests and common concerns among their countries. The Declaration, at para 3, emphasises active collaboration and mutual assistance on matters of common interest in the economic, social, technical and scientific fields. The Declaration, at para 6, also calls for maintenance of close and beneficial cooperation with existing international and regional organisations, which have similar aims and purposes. Moreover, the Declaration provides for an institutional arrangement to carry out the aims and purposes of the BIMSTEC.

The Declaration provided skeleton guidelines for regional cooperation for mutual benefit. However, the subsequent decisions of the BIMSTEC Ministerial Meeting reconfirmed their commitment for the specific aspects of fishery resources, environment and Blue Economy. The 6th Ministerial Meeting of BIMSTEC adopted three projects in the fisheries sectors in 2004 including the ecosystem-based fisheries management in the BoB. The project was completed in December 2007. Its overall objectives were to understand the physical and chemical oceanographic and hydrological conditions, to investigate the biological data of fishery economics in terms of species, abundance, distribution, maturity size, feeding, etc., to assess the potential of fishery resources and to improve understanding and collaboration among researchers of the member countries during on-board surveys. It was expected that the scientific data and information obtained from all sub-projects within the project would be highly beneficial for states bordering the BoB in order to eventually accord with the policy on sustainable utilisation of fishery resources and achieve effective fisheries management in the BoB.

In the 12th Joint Statement of the BIMSTEC Ministerial Meeting, the member states reaffirmed their commitment to continued cooperation for sustainable use of marine resources through effective conservation and management of resources in the BoB. Afterwards or following this, the 14th Ministerial Meeting of BIMSTEC focused on the cooperation for sustainable use of marine resources through effective conservation and management in the BoB.

In the 15th Ministerial Meeting in 2017, the member states stressed sustainable development of fisheries, including marine fisheries. Para XI of the Joint Statement of the Meeting says that the state parties recall the importance given by our leaders to sustainable development of fisheries in making a significant contribution towards ensuring food security and in improving the livelihood of the people of our region and agrees to constitute an Expert Group on Fisheries to prepare a plan of action. The 15th Meeting also confirmed deeper cooperation in the areas of Blue Economy with the objective of sustainable development. The Joint statement recalls the directives of the leaders during their retreat to explore ways to deepen cooperation in areas of Blue Economy with the objective of holistic sustainable development of the region and agree to constitute a Working Group to determine modalities in this regard. Moreover, the 15th Ministerial Meeting welcomed the initiative for a Blue Economy Workshop by Bangladesh in 2017.

6 The Management Framework, Blue Economy and Marine Spatial Planning in the Bay of Bengal

Blue Economy has opened up a new avenue for economic benefits for the coastal states but has also introduced threats of over exploration and marine pollution to the BoB. Therefore, the coastal states of the BoB must not ignore these threats while making plans to capitalise on the benefits of Blue Economy. Sustainable use and conservation of marine resources and prevention of marine pollution will help ensure real benefits from Blue Economy. Sustainable use and conservation of living resources are inherent elements of Blue Economy. Goal 14 of the SDGs requires an effective management system to achieve sustainable use and management of marine resources. MSP as a tool for EBM may provide this and facilitate sustainable use and management of marine resources of the BoB.

Blue Economy prescribes for the long-term capacity of ocean ecosystems to support this activity and still remain resilient and healthy. It is generally understood to be a long-term strategy aimed at supporting sustainable economic growth and preserving the environment (UNCTAD 2014). MSP is an appropriate way to maintain the long-time productivity of ocean resources and to protect them from overexploitation (Hassan and Haque 2015). It restricts their overexploitation and protects their natural productivity for better blue growth. Therefore, MSP may be an appropriate management tool to assess and incorporate the real value of ocean resources and to facilitate sustainable Blue Economy for the coastal states of the BoB. The coastal states of the BoB require legal and institutional frameworks in order to develop MSP in the region.

The Bay of Bengal Program Inter-Governmental Organisation Agreement (BOBP-IGO Agreement) does not incorporate MSP for the management of the fisheries resources in the Bay. However, the Agreement has several provisions that are relevant for the development of MSP among the coastal states of the BoB. The provisions of the Agreement for accumulation of necessary data, networking, institutional integration, harmonisation of policy and development of plans are relevant for MSP. Essential elements of the MSP process are legal and institutional frameworks, integration and coordination and implementation provided by the programme (Ehler and Douvere 2009). Regional or transboundary MSP will enhance integration and transboundary cooperation over common regional issues such as shipping and commercial fishing (Soininen and Hassan 2015). A transboundary MSP develops a shared vision of regional actors in assessing, evaluating and monitoring exploration and exploitation of marine resources of the BoB. MSP implements share governance, balancing of powers, institution and capacity building, along with sufficient stakeholders' participation and open and transparent dialogue (Gazzola and Onyango 2018).

The SACEP Action Plan does not incorporate MSP as a strategy to achieve the Plan's objectives. However, the Action Plan has several provisions that are relevant and applicable for the development of MSP. The implementation strategies of the Action Plan are analogous to the implementation process of MSP. The development of MSP will help the implementation of the strategy for environmental assessment. The assessment and evaluation of marine pollution from sea-based sources is identical to the monitoring and evaluation process of MSP. Monitoring and evaluation of the causes and consequences of environmental problems is an essential process for learning and improvement of the management under MSP (Ehler and Douvere 2009). The MSP process analyses the actual impact of the activities and social and economic factors that may influence the management of the natural resources (Halpern et al. 2012). MSP monitoring process examines the management of social and economic development activities that safeguard environmental quality and utilises resources rationally on a sustainable basis (Fang et al. 2019). Moreover, the MSP's ecosystem approach confirms or establishes or strengthens the assessment of present social and economic activities, including development projects that may have an impact on the quality of the marine and coastal environment (Carneiro 2013).

The provisions of the SACEP Action Plan for mapping and zoning for the classification of coastal and marine habitats, and the mapping of critical habitats, are relevant for the development of MSP. Zoning is an essential method or pathway or means to implement MSP (Crowder and Norse 2008). Moreover, the provisions for ICZM are relevant for MSP in the region. The development of MSP will facilitate integrated coastal environmental management. MSP is very well recognised or highly recommended for the integrated coastal management to ensure an environmentally sound use of marine resources and to prevent marine pollution through EBM (Shabtay et al. 2018).

The legal instruments under SAARC are very general and less focused on the marine environment and ocean governance. However, a series of cooperative action areas cover different aspects of the regional marine environment and ocean governance. MSP would concentrate on ensuring the commitment of the member states and the objectives of the *SAARC Charter* in the South Asian sub-region. Recognition of coastal environment and a proposal for establishing the Coastal Zone Management Centre are significant advances towards the development of MSP in the region.

Apart from these, the *SAARC Charter* provides a consistent and systematic institutional framework, based on the bottom-up approach, to implement the plans and programmes decided by the states. The commitment and the institutional framework under the Charter may be further extended to be implemented by regional or transboundary MSPs in this region. Regional and transboundary cooperation is in fact viewed as an essential element of MSP (Flannery et al. 2015). Regional MSP will allow greater integration and harmonisation between existing management frameworks in order to achieve sustainable Blue Economy. Transboundary MSP allows selection of the most appropriate sites for development in coastal areas (Maes 2008). Concerning the regional marine environment, the regional or transboundary MSP will be a useful tool to coordinate the management of ocean activities in the region (Hassan et al. 2015).

The *SAARC Action Plan* requires assessment of the environment to support the prudent management of the environment and will facilitate the implementation of the other components of the Action Plan. The development of MSP will provide effective assessment and sound management of the marine environment of this subregion. MSP offers a process of practical assessment and evaluation in order to identify the existing status of ocean resources for sustainable management (Manea et al. 2019). Moreover, the Action Plan requires legal instruments for the sustainable protection and conservation of the environment of the region. In this context, MSP would provide an efficient management mechanism by allocation and distribution of human activities in the ocean. The MSP process would avoid and reduce user conflicts and would be a means of sustainably managing the marine environment (Douvere 2008).

The *SAARC Action Plan* also requires national and regional institutional arrangements for the implementation of the Plan. MSP provides the process for engaging effectively in implementing the master plan (Filgueira et al. 2014). For example, institutions including supranational institutions under OSPAR and sub-national institutions such as the Severn Estuary Partnership (spanning England and Wales) have played a significant role in the implantation of regional MSP in that region (Flannery et al. 2015). A network of regional institutions is a key or useful agency for members to pass on what they have experienced in cross-border cooperation and to help develop good working relations (Leibenath et al. 2010).

Although the legal regimes under SAARC have less focus on ocean governance, the legal regimes under the BIMSTEC may play an important role in the development of MSP in the BoB. The legal instruments under the BIMSTEC do not employ MSP for the management of marine living resources of the region. However, BIMSTEC is an appropriate platform for regional cooperation among the member states for the development of MSP to achieve sustainable Blue Economy in the Bay.

The Bangkok Declaration established a foundation for collective action to promote sub-regional cooperation in the areas of marine resources including fisheries. The Declaration and subsequent decisions of the Ministerial Meeting impose an obligation on the member states to achieve sustainable development through effective conservation and management of the resources of the Bay. The member states have confirmed their commitment to sustainable use of fisheries resources, protection of the environment and mainstreaming Blue Economy. The development of MSP would foster obligation and commitment for sustainable marine fisheries, boosting Blue Economy and protection of the marine environment. MSP reduces the risk of unsustainable cumulative or aggregate effects on the marine environment while at the same time improving conservation and ecosystem health (Filgueira et al. 2014). It is an instrument for environmental protection, emphasising environmental sustainability with the goal of EBM (Hassan and Soinenen 2015). The use of the initial strategic projects under MSP can strengthen confidence in inter-jurisdictional working relations, eliminate obstacles to collaborative fact-finding and develop capacity among different actors within each nation (Uitto 2002).

The Bangkok Declaration and the decisions of the Ministerial Meetings prescribe for sustainable fisheries through a fisheries plan. The leaders of the states established an expert group on fisheries and a working group to determine the modalities for sustainable use of ocean resources. They recognised that sustainable fisheries would be a way to economic and social progress including livelihood for the people of the region. The development of the regional MSP can further fuel the process. The development of MSP will support managers and government officials to reconcile objectives for multiple uses of ocean space and resources (Agardy et al. 2011).

As part of the commitment to the sustainable use of marine resources through effective conservation and management, BIMSTEC adopted the Ecosystem-based Fisheries Management Programme. The Ecosystem-based Fisheries Programme requires the sustainable utilisation of fishery resources and effective fisheries management in the BoB. The concept of an ecosystem approach in the management of ocean resources has been matched with the MSP. MSP has achieved significant progress in the protection of valuable ecosystem services (Mackenzie et al. 2013). In many respects, MSP is a way to implement EBM using a framework to explicitly integrate the management of multiple human activities (Collie et al. 2013).

The above-mentioned provisions of the regional conventions, agreements and plans show that there are several provisions that cover several aspects of MSP. Moreover, the development of MSP will facilitate to achieve the objectives and goals of that regional legal regime. The provisions and the objectives of that legal regime may act as a persuasive value towards the development of a uniform regional agreement for the development of MSP for greening Blue Economy for the coastal states of the BoB.

7 Conclusion

Sustainable use, conservation of marine resources and protection of marine environment are three essential elements of Blue Economy. An effective management system focused on sustainable use and conservation of marine resources and environment is essential for the coastal states of the BoB to reap the benefits of Blue Economy. MSP is an appropriate management tool to facilitate sustainable use of blue resources and prevention of marine pollution in the BoB. MSP will enhance the management capacity of the coastal states to achieve the true benefits of Blue Economy. However, the regional conventions, agreements, declarations, plans and programmes do not employ MSP as a management tool to manage blue resources of the BoB. Absence of any explicit legal document for the development of MSP in the BoB is the main challenge for implementation of a regional or transboundary MSP in the BoB region.

Although there is no explicit legal document for MSP, there are many provisions under the current management framework that are relevant to the development of MSP in the BoB. The strategies for the implementation of *the BoB Inter-Governmental Organisation Agreement* are applicable to the development of MSP in the region. Similarly, the objectives, strategies and the major components of the SACEP Action Plan are pertinent to MSP. The requirements of assessment, evaluation, harmonisation and mapping of coastal habitats under the SACEP Action Plan are all applicable to the development of MSP. Moreover, the institutional arrangements under the SAARC may be a platform for the development of MSP among the member states for the purpose of sustainable development through Blue Economy. Establishment of the SAARC Regional Centre on Coastal Zone Management may be an essential step towards development of the regional or transboundary MSP in the region. Furthermore, the legal arrangements under the BIMSTEC are very or highly relevant and applicable to the development of MSP in the Bay region. *The Bangkok Declaration* and the Ecosystem-Based Fisheries Management Programme are closely applicable or highly pertinent to the development of MSP in the BoB. The fisheries survey and generated data are highly supportive of the development of MSP in the region.

Incorporation of explicit provisions for the development of MSP into the regional convention, agreement and action plan will be the primary initiative for the development of a regional or transboundary MSP in the BoB region. Moreover, necessary institutional frameworks, political good will and commitment to the SDGS are the preconditions for developing a regional or transboundary MSP in the BoB region. However, the coastal states may plan or arrange for the development of MSP within their own territorial waters, which may subsequently be extended to EEZ and the transnational arrangements.

Development of a regional or transboundary MSP will ensure sustainable management of the resources as well as protection of the marine environment of the BoB. The development of MSP in the region would protect the living resources, environment and ecosystems of the Bay. Besides, the development of regional MSP would facilitate cross-border cooperation among the coastal states in greening Blue Economy in the BoB.

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Chapter 4
Green Ports and Sustainable Shipping in the European Context

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Abstract Ship emissions and emissions from the maritime industry, in general, are of great concern to various stakeholders due to their adverse impacts on climate change and the local community. Countries within the Europe (and also around the world) are developing strategies, technologies, and drafting laws and regulations for mitigating environmental impacts of the maritime industry. Air pollution from ship exhausts has a negative impact on the surrounding area of the ports and coastal zones. This chapter provides an overview of the green port and sustainable shipping practices within the European maritime transport network, which can be divided into three maritime regions—the North and Baltic Seas, Mediterranean Sea and the Black Sea. For these regions, we present the green port and shipping practices and relevant regulations for environmentally sustainable shipping. Furthermore, we propose a high-level conceptual framework for the implementation of the green port and shipping practices. Finally, we discuss some future research directions.

Keywords Maritime transport · Green shipping · Green port · Shipping emission · European ports · Environmental sustainability

1 Introduction

Historically, the European nations are shipping nations. European cities in the Mediterranean Sea region were already popular seaborne trade destinations by the 375 BC. Due to its geographical position and industrial activities, maritime transport plays a vital role in the European economy. All European nations are connected via maritime transport, even those nations without a sea (e.g. Austria, Switzerland) are connected via inland waterways. Such a mature maritime transportation network

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within the Europe facilitates Short-Sea Shipping (SSS), which has emerged as a means of diverting the road congestion (Douet and Cappuccilli 2011) during the last two decades within Europe. Furthermore, maritime transport is the driving force of Europe's imports and exports to the international markets. The European Union (EU), which as of 2017 included the United Kingdom, had 329 key seaports, and 75% of its external and 36% of internal trades are carried out by the sea, while 32% of the world's fleet is controlled by companies within the EU (European Commission 2020a). Overall, almost 90% of Europe's international and 40% of intra-EU trade is seaborne, including 3.5 billion tonnes of goods and 350 million passengers being transported (European Commission 2020a). Despite the economic significance to the European continent, the maritime industry has adverse impacts on the natural environment that also affects human life.

During 2007–2012, maritime transport accounted for 2.8% of annual greenhouse gas (GHG) emissions (IMO 2015), which may seem negligible, but projected future growth is upward sloping. GHG emissions, which primarily include sulphur oxides (SO_x), particulate matter (PM) and nitrogen oxides (NO_x), from maritime transport account for 13% of total emissions from the transport industry within EU (European Commission 2020b). According to the 3rd International Maritime Organization (IMO) GHG study, CO_2 emissions, including GHGs from total maritime transport, was approximately 961 million tonnes in 2012 (IMO 2015). For the year 2011 in Europe, total ship-induced emissions of CO_2, NO_x, SO_x and $PM_{2.5}$ accounted for an estimated 121, 3.0, 1.2 and 0.2 million tonnes (Jalkanen et al. 2016). While measuring the impact of ports on surrounding city's air quality, Viana et al. (2014) found that the port activities contribute to 33% of NO_2, 43% of PM_{10} and 60% of SO_2 emissions at the city-port boundary. Hence, the negative impact of emissions from shipping on environmental cannot be ignored.

GHG emission affects the environment and causes air pollution, leading to negative impacts on human health. Within Europe, an estimated 301,000 deaths per year due to primary PM exposure ($PPM_{2.5}$) and 245,000 deaths due to secondary inorganic PM exposure (SIA) can be attributed to shipping emissions (Andersson et al. 2009). The overall health cost in Europe from shipping emissions is expected to increase from €58.4 billion (7%) in 2000 to €64.1 billion (12%) in 2020 (Brandt et al. 2013). Similarly, Maffii et al. (2007) estimated an €57 billion in total external costs from maritime transport (considering marine discharges into sea, GHG emissions and atmospheric emissions) for the EU fleet in 2006. More recently, Chatzinikolaou et al. (2015) estimated that the external health cost from ship air pollution calling at the Piraeus Port of Greece is about €26 million. Meanwhile, according to Brandt et al. (2013), the implementation of sulphur emission control areas was expected to reduce health cost in the North and Baltic Sea region by 36%, from €22 billion in 2000 to €14.1 billion in 2020. Apart from GHG emissions, oil spills, accidents and ballast water treatments remain a challenging environmental issue. Therefore, green port management and shipping practices are essential to reduce emission from shipping.

In an effort to reduce GHG emissions from ships, IMO aims to reduce total annual GHG emissions by at least 50% by 2050 in comparison to 2008 levels (IMO

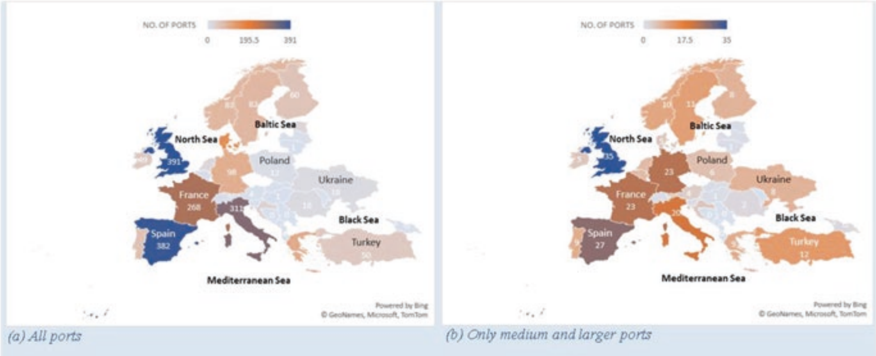

Fig. 4.1 Ports in European maritime regions *(number of ports including inland waterway ports based on satellite image, Source:* www.worldportsource.com*)*. (**a**) All ports. (**b**) Only medium and larger ports

2020h). In recent years, sustainable shipping concerns enhanced practices both on ships and at ports. Although the environmental impacts from shipping have been well-known for decades (e.g. pollution from oil spills and discharge), more of the adverse effects (e.g. toxicity of anti-fouling paints, movement of alien species through ballast water) have been revealed during recent years, and some of the negative impacts such as stress to underwater marine ecosystem due to propeller noise need further research. With growing concerns from both political leaders and the general public, European maritime bodies (regulators, ports and shipping companies) have increased their attention to maritime sustainability in recent decades.

In this chapter, first, we discuss the major local, national and international regulations governing maritime transportation in the European region. Based on satellite images, Fig. 4.1a presents the total numbers of ports including very small ports, while Fig. 4.1b presents only medium and larger ports within the European region. European countries with a higher total number of ports hosted comparatively larger ports than those with lower (correlation between number of ports in Fig. 4.1a, b = 0.901). Then, we present some of the key green port management and shipping practices implemented by European ports and shipping companies. For easiness, based on geographic locations, shipping pattern and regulatory practices, the European maritime territory can be categorised into three regions.

1.1 The North Sea and Baltic Sea Region

The busiest European ports, namely Rotterdam, Antwerp and Hamburg, are located in this region. This region is governed under an Emission Control Area (ECA), more precisely Sulphur Emission Control Area (SECA). ECAs were introduced across North America, Caribbean Sea, North Sea and Baltic Sea by the IMO to reduce

Table 4.1 European ECAs and their effective dates (IMO 2020k)

ECA	Emissions	Adopted	Entry into force	Effective
Baltic Sea	SO_x	Sep 16, 1997	May 19, 2005	May 19, 2006
Baltic Sea	NO_x	July 7, 2017	January 1, 2019	January 1, 2021
North Sea	SO_x	July 22, 2005	November 22, 2006	November 22, 2007
North Sea	NO_x	July 7, 2017	January 1, 2019	January 1, 2021

emissions of SO_x, NO_x and PM in designated areas (IMO 2020c). At the time of writing, the North Sea and Baltic Sea regions accounted for the reduction of only SO_x emissions to the air from shipping under the regulation 14 of MARPOL Annex VI but soon to be accounted for NO_x emission control (IMO 2020k, see Table 4.1). According to the revised MARPOL Annex VI, effective from January 1, 2020, sulphur limit in marine engine fuel has been reduced from 3.5% m/m to 0.50% m/m for areas outside ECAs and from 1.00% m/m to 0.10% m/m for ECAs (IMO 2020l). In addition, the Baltic Sea is defined as a special area under three other MARPOL Annexes—Annexes I, IV and V—which introduce further restrictive requirements to prevent pollution from oil, sewage and garbage, respectively (IMO 2020k). For further details of MARPOL, see Sect. 2.1.

1.2 The Mediterranean Sea Region

Historic shipping nations, namely Greece, France, Italy and Spain, are located in this region. Being a bounded sea, this region is vulnerable to pollution, particularly due to high traffic volume, sensitive shallow and deep-sea habitats (Abdulla 2008). There are more than 600 cities with a population of more than 10,000 along the Mediterranean coast, with about 175 million annual tourists (Abdulla 2008). For the year 2011, shipping activities in this region accounted for 40% and 49% of total CO_2 and SO_x emissions from the European shipping industry (Jalkanen et al. 2016). The same study reported that the combined shipping related CO_2 emissions from North Sea and Baltic Sea regions were almost the same (88%) as the total emissions from the Mediterranean Sea region. Moreover, shipping related SO_x emission in the Mediterranean Sea region was significantly higher than SECAs (Jalkanen et al. 2016). Hence, there is an ongoing debate among the stakeholder nations to introduce an ECA (Brewer 2020). Currently, this region is designated as special area under MARPOL Annex I (effective from October 2, 1983) and Annex V (effective from May 1, 2009) for pollution prevention from oil and garbage, respectively.

1.3 The Black Sea Region

This is a land-locked sea surrounded by mostly non-EU member states, namely Russia, Turkey and Ukraine. The Black Sea is regarded as one of the most polluted seas in Europe (Altaş and Büyükgüngör 2007). Europe's second-largest river, the Danube, transports a significant volume of land-based pollutants that enter the Black Sea every year (Galatchi and Tudor 2006). This region is also designated as special area for pollution prevention from oil and garbage under the MARPOL Annex I (effective from October 2, 1983) and Annex V (entry into force on December 31, 1988 but not in effect yet), respectively.

2 Maritime Regulation in the European Regions

At sea, international regulations by the IMO, European Commission (EC), vessels' flag state (port of registry) and classification society govern the environmental protection measures for the shipping industry. For coastal and port areas, local and/or national regulations apply in addition to the international rules. Here, we will first examine the international regulation for pollution prevention at sea and then the regulations by the EU and its stakeholders on environmental protection.

2.1 MARPOL in European Regions

The international regulation that has been continuously developed and widely used to control pollution at sea is MARPOL 73/78—the International Convention for the Prevention of Pollution from Ships, originally proposed in 1973, later modified by the protocol of 1978 (IMO 2020e). The Maritime Environment Protection Committee (MEPC) of IMO has been reviewing the MARPOL requirements to address any undercover challenges and to provide clarification. As a result, several amendments to the convention have been made over time.

MARPOL has six annexes, each of which specifies the pollution prevention measures at sea by ships. Further, they also have 'specified special areas' under each annex, considering sea traffic, oceanographically and ecological condition. Regulatory measures are stricter on these special areas with specific requirements under each Annex. Table 4.2 summarises the list of special areas within the European territory.

Table 4.2 Special areas within Europe under MARPOL 73/78 (IMO 2020k)

MARPOL Annex	Special areas within Europe	Key point
Annex I: Regulations for the Prevention of Pollution by Oil	Mediterranean Sea, Baltic Sea, Black Sea, Northwest European waters	Preventive measures such as 15 PPM on oily water separator, mandatory record keeping on oil record book, etc. to prevent oil pollution from operational processes and accidental discharge
Annex IV: Regulations for the Prevention of Pollution by Sewage from Ships	Baltic Sea	Prohibits discharge of sewage unless the ship is 'en route' and has an operational Sewage Treatment Plant (STP)
Annex V: Regulations for the Prevention of Pollution by Garbage from Ships	Mediterranean Sea, Baltic Sea, Black Sea, North Sea	Prohibits discharge of garbage including food waste more than 25 mm so that it does not comminute or ground
Annex VI: Regulations for the Prevention of Air Pollution from Ships	Baltic Sea, North Sea	Stricter regulations on fuel oil quality (SO_x, NO_x and PM); mandatory technical and operational energy efficiency measures (e.g. EEDI) to reduce GHG emissions from the ships

2.2 *European Pollution Prevention Regulations*

The EC imposes stricter regulations within its maritime territory, which comes through various directives such as Directive 2009/15/EC for inspection of vessels (see Sect. 2.2.1), Directive 2009/16/EC for Port State Control (PSC) (see Sect 2.2.2), Directive 2002/59/EC for monitoring vessels in the EU waters (see Sect. 2.2.3) and Directive 2000/59/EC on port reception facilities for ship-generated waste (see Sect. 2.2.4). The objective is protecting Europe with stricter safety rules preventing sub-standard shipping, minimising the risk of accidents and environmental impact from maritime transport. The EU's pollution prevention actions can be summarised from the following perspectives:

2.2.1 Classification Society

According to Lloyd's List, for the year of 2019, Europe hosts five out of the top ten classification societies of the world: DNV GL, Lloyd's Register, Bureau Veritas, RINA and the Russian Maritime Register of Shipping (RMRS). Excluding the RMRS, classification societies within the EU are governed by the Directive 2009/15/EC on 'common rules and standards for ship inspection and survey organisations and for relevant activities of maritime administration' (European Commission 2009a). The purpose is to allow only reliable and skilled bodies as 'recognised organisations' to carry out the statutory surveys and certification for the EU member states. These societies ensure technical standards of a ship for both the construction and maintenance operations. Periodical assessment of these societies by the EC ensures indirect monitoring of the safety condition of the ships operating in EU waters. Moreover, under the Directive 2009/15/EC, the classification societies can be authorised to conduct inspection and surveys related to compliance with the International Conventions (European Commission 2009a). Under the same directive, the classification societies are also authorised to issue ship certificates on behalf of a 'flag state', which is a member state of the EU.

2.2.2 Port State Control

Any ship calling to a foreign port other than their port of registry is subject to inspection by that port authority, commonly known as PSC. The purpose of these inspections is to ensure that the ship, its equipment, documentation and operation are complying with the applicable local, regional and international laws. The EU has its specific legislation on PSC, the PSC Directive 2009/16/EC (European Commission 2009b). This directive is an extension of the Paris Memorandum of Understanding (MoU) on PSC, an agreement among EU maritime member states, together with Norway, Iceland, Russia and Canada (EMSA 2020; Paris MoU 2020). Furthermore, Directive EU 2017/2110 amends Directive 2009/16/EC introducing mandatory inspections for the high-speed passenger and ro-ro vessels by EU flag states and PSC (EMSA 2020). The European Maritime Safety Agency (EMSA) has the technical responsibility to supervise the PSC activities within the EU. EMSA also operates its own database covering all the PSC inspection results to identify potential sub-classified vessels.

2.2.3 Maritime Surveillance

Due to its geographical position and strong consumers demand, European maritime territory has high vessel traffic, which possesses potential hazards for higher pollution from the ships. To address this issue, under Directive 2002/59/EC, the EU established a community vessel traffic monitoring and information system (European Commission 2002). The purpose of establishing the directive includes improving efficiency of maritime traffic, increasing maritime safety by enhancing the responsible authority's response on any incident or accident or potential hazards and preventing pollution by ships. Under Directive 2002/59/EC, all the ships calling at an EU port are responsible for notifying upon entering or leaving EU waters. Automatic Identification Systems (AIS) has played a significant role in the implementation of maritime surveillance within EU, and 'black boxes' or Voyage Data Recording (VDR) systems facilitated accident analysis and prevention (European Commission 2002).

2.2.4 Ship-Shore Pollution Prevention

To further support the pollution prevention measures under MARPOL and its Annexes, Directive 2000/59/EC on 'port reception facilities for ship-generated waste and cargo residues' provided a framework for EU ports to ensure adequate reception facilities to collect all kinds of ship-generated waste including oil, sewage, plastic, etc. (European Commission 2000). The Directive 2000/59/EC has been amended as Directive 2010/65/EU, which was later amended as Directive (EU) 2019/883 (European Commission 2019). Throughout those amendments, the aim was to constantly reduce marine pollution from ships by providing them with adequate reception facilities at the shore. For instance, the latest amendment, Directive EU 2019/883, included requirement of reception facilities at port for the newly introduced waste categories such as residues from exhaust gas cleaning systems that emerged due to the Annex VI of MARPOL.

3 Green Port Management Practices

In comparison to ships, emissions from ports are relatively low. Even emissions from ships at port is a major concern for local authorities. Being hubs in the global transportation networks, ports are the centre of high-energy concentration activities such as the loading-unloading of cargo from ships, moving them within port areas and management of the administrative building, locks and bridges. Thus, a reduction in emissions from port operations can contribute to IMO's goal of reducing emissions from maritime transport and develop a sustainable global community. According to Acciaro et al. (2014), port energy use can be categorized into three groups: (a) energy for direct port activities, (b) energy for powering ships at port and (c) other port-induced activities such as ship maintenance and repair works. While ports can adopt practices to reduce energy use, they can also take the initiative for greening their energy generation, particularly renewable energy-based solutions. European ports have been in the frontline for investing in sustainable energy generation based on solar technology (e.g. Amsterdam, Genoa, Antwerp), geothermal plants (e.g. Hamburg, Antwerp), wind (e.g. Hamburg, Rotterdam, Amsterdam), ocean energy (e.g. Leixoes, Naples) and hydrogen fuel (e.g. Valencia, Hamburg).

For the European port sector, there are mainly two institutional bodies driving green port practices. The first is the European Sea Ports Organization (ESPO),[1] and the second is the International Association of Ports and Harbors (IAPH).[2] While the first is dedicated to European ports, the latter plays a significant role, too. ESPO promotes environmental sustainability of European ports through its set of rules and code of conduct. Essentially, in 1997, a group of European ports initiated the

[1] See website at https://www.espo.be.

[2] See website at https://www.iaphworldports.org.

EcoPorts[3] environmental initiative—the first for the European post sector, and since 2011 fully integrated within the ESPO framework. As of May 2020, EcoPorts has 113 member ports in 22 countries, 52 of which are ISO certified (EcoPorts n.d.). Santos et al. (2016) found that the members of EcoPorts disclose their green practices in their official websites to a greater extent in comparison to non-members. Meanwhile, under the oversight of IAPH, the World Port Climate Initiative (WPCI) was initiated in 2008 by 55 of the world's major ports, in an effort to reduce GHG emissions within the port and surrounding areas. In 2010, WPCI initiated the Environmental Ship Index (ESI) that evaluates NO_x, SO_x and PM emissions from a ship with a score ranging from 0 to 100. Different ports around the world reward ships when they score above a specified threshold on the ESI. For example, the Port of Oslo in Norway offers a 10% discount on normal rates to ships with an ESI score between 30 and 40 and a 40% discount to ships with an ESI score higher than 40 (Port of Oslo 2020).

Despite the EcoPorts and WPCI initiatives, more needs to be done. According to ESPO (2019), the most important environmental priorities of its member ports are improving air quality, reducing energy consumption, contributing to climate change adaptation and reducing noise and work together with local communities. To better address these priorities, various Green Port Management (GPM) practices should be adopted by ports across the European region. Based on Munim et al. (2020b), we categorise and present some key GPM practices in Table 4.3. The adaptation of the presented GPM practices varies among ports in different European countries. Major ports in Belgium, Germany, Italy, Netherlands, Spain, the UK and Nordic countries are the front runners in adapting the majority of the GPM practices listed in Table 4.3.

4 Green Shipping Practices

Green Shipping Practices (GSPs) refer to environmental management practices by shipping companies to reduce waste, save resources and protect the marine environment. Almost all shipping companies use strategic planning to reduce their environmental footprint. European, particularly Northern European, shipping companies are often considered as pioneers in sustainable shipping practices.

There are specific regulations that define mandatory GSPs for shipping companies. Driven by internal factors, pioneer companies often commit beyond mandatory conditions laid down by regulations. According to the IMO (2020g), the key regulations governing the GSPs are:

- *MARPOL 73/78:* This convention regulates pollution preventions measures from a ship. Although proposed in 1973, it was not effective until 1983 due to approval issues. As mentioned earlier, it has six annexes that have become effective during

[3] See website at https://www.ecoports.com/.

Table 4.3 Key green port management practices

Green port practices	Measurement indicators
1. Internal environmental management (IEM)	• Continuous environmental monitoring and reporting
	• Implementing Energy Management Plan (EMP)
	• Achieving ESPO Code
	• Communicating with local government to improve sustainability
	• Training employees on sustainable practices
	• Allocating dedicated budgets for sustainable port performance
2. Sustainable port operations (SPO)	• Implementing lean operations
	• Adapting sustainable port operating system
	• Reconfiguring existing terminals
3. Environmental pricing (EP)	• Implementing dynamic pricing
	• Offering incentives to port users
	• Implementing penalty pricing
4. Adapting green technology (GT)	• Establishing cold ironing or onshore power supply (OPS)
	• Using energy efficient hardware and data centres
	• Continuously switching to cleaner port operation technologies
	• Using renewable or alternative energy generation
5. Supply chain collaboration (SCC)	• Collaboration with port operators to achieve environmental goals
	• Collaboration with other ports for GPM
	• Collaboration with shippers for GPM
	• Collaboration with shipping lines for GPM
	• Collaboration with other (hinterland) transport providers for GPM

Modified and adapted from Munim et al. (2020b)

the period 1983–2005. The first five annexes have established mandatory record--keeping procedures, such as oil record book, garbage management plan, etc. The sixth annex focuses more on the air quality. Under the 2010 amendment into MARPOL Annex VI, ECAs were established that have a limit of 0.10% m/m sulphur limit since January 1, 2015. Furthermore, effective from January 1, 2020, ships outside the ECAs also have a reduced sulphur limit of 0.50% m/m. In 2011, MARPOL amendments to Annex VI introduced the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP). For further information on EEDI and SEEMP, see IMO (2020d).

- *The Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), 1990:* This convention was adopted on November 30, 1990 (entered into force on May 13, 1995) to establish national and international co-ordination to prevent and act on oil pollution incidents. Under this convention, ships under the jurisdiction of participating parties must have an oil pollution emergency plan that includes reporting oil pollution related incidents to costal authorities, maintaining inventory of oil spill-combating equipment as well as helping others in the event of oil pollution emergency. Later in 2000, a similar protocol to the OPRC to deal with pollution from incidents involving hazardous and noxious substances (OPRC-HNS) was adopted. For further information on OPRC and OPRC-HNS, see IMO (2020f) and IMO (2020i), respectively.

- *International Convention on the Control of Harmful Anti-fouling Systems on Ships (AFS), 2001:* Anti-fouling paints are used to coat the underwater hull of ships to prevent attachment or growth of sea life such as microorganisms, algae or molluscs on the hull. Such sea life growth on the hull reduces operational performance of ships. As early as in 1970s, anti-fouling paints, particularly tributyltin-based, has been recognised as harmful (Andersson et al. 2016). The AFS convention prohibits harmful anti-fouling paint and systems to protect the marine environment from shipping operations. For more information on the AFS convention, see IMO (2020a).
- *International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM), 2004:* For steel-hulled vessels, ballast water plays an important role in stabilizing ships at sea, particularly when sailing unloaded. Meanwhile, ships loading ballast water in one part of the world and discharging it in another can transport alien spices across geographical locations—a threat to the marine ecosystem. To address this issue, the BWM convention (entry into force on September 8, 2017) introduced the ballast water management plan with mandatory record-keeping by means of ballast water record book to restrict harmful aquatic organisms from travelling through ship ballast. For detail on the BWM convention, see IMO (2020b).
- *The Hong Kong International Convention (HKC) for the Safe and Environmentally Sound Recycling of Ships, 2009:* Currently, no international regulation exists governing ship scrapping—a process that has severe environmental and health impacts. The HKC was developed in May 2009 and aimed to reduce any potential hazard to the environment and human health from ship recycling activities as well as improving safety. This convention implies that ships to be sent for recycling must carry a ship-specific inventory of hazardous materials that must be verified during initial, renewal and final surveys. Besides, use or installation of some listed hazardous materials in the appendix of the convention is restricted or prohibited at premises of participating parties. The HKC convention has not yet entered into force awaiting approval by at least 15 member states. For more information on the HKC convention, see IMO (2020j).
- *EU MRV Regulation 2015/757:* On April 29, 2015, to reduce CO_2 emission from ships' energy consumption, the EU proposed the Monitoring, Reporting and Verification (MRV) system to stimulate more energy-efficient shipping practices. According to this regulation, ships over 5000 gross tonnage calling at a port within the EU must have a detailed analysis of CO_2 emissions. For detail, see European Commission (2015).

Several guidelines have been developed to simplify the execution of these conventions. The principal objective of these conventions is monitoring and managing the harmful substances (i.e. marine and air pollutants) emitted from the ships. To get an overview of the GSPs by European shipping companies, in Table 4.4, we compare 'sustainability report' or GSPs reported in the Corporate Social Responsibility (CSR) report of the three major shipping companies of Europe, namely A. P. Moller-Maersk, MSC and CMA CGM, possessing the world's 1st, 2nd and 4th largest fleet, respectively.

Overall, the three largest shipping company has been taking strategic, technical and operational level sustainable initiatives. Among them, A. P. Moller-Maersk has been disclosing more information on their sustainability practices, which is rather rare but exemplary in the context of the shipping industry. We find A. P. Moller-Maersk as a pioneer in adopting sustainable shipping initiatives.

While Table 4.4 reported GSPs adapted by the three major European liner shipping companies, we present a generic form of key GSPs in Table 4.5 to guide other shipping companies that are lagging behind in taking sustainable shipping initiatives. Similar to the GPM practices in Table 4.3, the GSPs in Table 4.5 are categorised into five main factors: IEM, sustainable shipping operations (SSO), compliance for green shipping (COM), adapting GT and SCC. Table 4.5 reports the measurement indicators for each of these five GSPs. Majority of the measurement indicators are modified and adapted from Lai et al. (2013) and Munim et al. (2020b).

5 A Conceptual Framework for Maritime Sustainability

In the previous two sections, we have presented some major green port management and green shipping practices. The implementation of those practices varies significantly across shipping companies, ports, countries and regions (Munim et al. 2020b; Santos et al. 2016). While there are some front runners, to achieve maximum environmental sustainability in the maritime transportation sector, greater adaptation and implementation of the green port concept and shipping adjustments are required. Hence, we propose a conceptual framework for better implementation of green port and shipping practices across all European ports. Figure 4.2 presents the conceptual framework.

The implementation of sustainable practices can vary depending on a shipping company's corporate structure or a port's governance model. For ports, some port managers believe that public ports implement a higher degree of green practices, while some port managers believe that private involvement in a landlord port model induces higher implementation (Munim et al. 2020b). Interestingly, both propositions seem to be true within the European context. For example, Norwegian ports are mainly governed by public authorities and implemented many of the green practices listed in Table 4.3. Landlord ports such as Antwerp, Hamburg and Rotterdam are the leaders in implementing and innovating green practices. Besides, private

Table 4.4 GSPs by three major European carriers (*based on data available on the company's website)*

Aspect	A.P. Moller-Maersk	MSC	CMA CGM
Annual sustainability reporting	Yes	Yes	No
CO_2 emission	Aiming net zero CO_2 emission by 2050, reduced CO_2 emissions by 41.8% between 2008 and 2019	Reduced 13% in CO_2 emissions per transport work in 2015–2018	Targeted a reduction of 30% CO_2 per TEU transported by 2025, already reduced by 50% between 2005 and 2015
Sustainable Development Goals (SDGs)	Five SDGs are highlighted: decent work and economic growth (SDG 8), industry, innovation and infrastructure (9), responsible consumption and production (12), Climate action (13) and partnership for the goal (17)	Focused on life below water (SDG-14) and focused on life on Land (15) are key concerns for MSC's sustainability actions	In December 2019, CMA CGM joins the United Nations global corporate sustainability initiative, a technical network having nine sustainable principles in an aim of preserving the ocean
Technical solutions to improve vessels efficiency	→ Emission conversations and calculation → High-capacity vessels (Triple-E vessels could improve CO_2 efficiency by 50%) → Waste heat recovery system with an electronically controlled engine	→ Air lubricating system → Anti-fouling paint → Bow modification → Cold ironing (shore-based power) → Capacity boost → Hull cleaning → Propeller and rudder retrofit	→ Retrofitting bulbous bow, → Twisted leading edge rudder, → LNG fuelled new vessels, → Ballast water treatment system, → Antifouling paint.
Participation in global environmental initiatives and platforms	→ The Ocean clean-up project → The getting to zero coalition (which aims to decarbonising global shipping by 2050, deployment of zero--emissions vessels by 2030) → Ocean-Going Vessel (OGV) Energy Efficiency Measurement Demonstration Project ('TAP Project)	→ Cargo Incident Notification System (CINS) → Business for Social Responsibility (BSR) → North American Maritime Environment Protection Association (NAMEPA) → United for wildlife (addressing the unyielding conservation contests, prevention of extinction of endangered species)	→ Business Action Platform for the Ocean → Charte Bleue--Armateurs de France for Safety at Sea (French charter promoting prevention and management of pollution risks, reduction of GHG and effective waste management) → WPCI → Clean Cargo Working Group (CCWG)

(continued)

Table 4.4 (continued)

Aspect	A.P. Moller-Maersk	MSC	CMA CGM
Ship recycling following HKC 2009	Yes	Yes	Yes
Energy efficiency evaluation	Voyage Efficiency System (VES)	Energy Efficiency Operational Indicator (EEOI)	EEDI

Table 4.5 Key green shipping practices

Green shipping practices	Measurement indicators
1. Internal environmental management (IEM)[a]	• Senior management support for GSP
	• Mid-level management support for GSP
	• Cross-departmental support for GSP
	• Company policies in support of environmental protection
	• Existence of environmental management systems (e.g. ISI 14001)
	• Corporate environmental sustainability report
2. Sustainable shipping operations (SSO)[b]	• Implementation of VES
	• Implementation of EEOI
	• Implementation of EEDI
	• Handling shipping documents electronically[a]
3. Compliance for green shipping (COM)[a]	• Compliance with conventions to reduce environmental degradation[b]
	• Compliance for energy saving shipping equipment design
	• Compliance for shipping equipment reuse
4. Adapting green technology (GT)[b]	• Continuously replacing vessel fleet with new low-emitting vessels
	• Continuously switching to low-GHG-emitting fuel alternatives
	• Retrofitting vessel equipment for reduced environmental impacts
5. Supply chain collaboration (SCC)[c]	• Collaboration with shippers to achieve environmental goals
	• Collaboration with other shipping lines for GSP
	• Collaboration with ports for GSP
	• Collaboration with other (hinterland) transport providers for GSP
	• Collaboration with ship equipment suppliers for GSP[a]

[a]Modified and adapted from Lai et al. (2013)
[b]Proposed by authors
[c]Modified and adapted from Munim et al. 2020b)

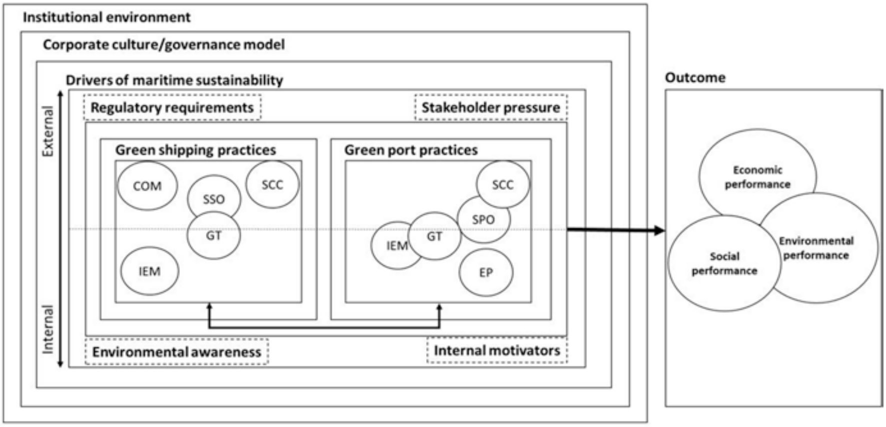

Fig. 4.2 Conceptual framework for maritime sustainability**.** (*COM* Compliance for green shipping, *SSO* Sustainable shipping practices, *IEM* Internal environmental management, *GT* Adapting green technology, *SPO* Sustainable port operations, *EP* Environmental Pricing, *SCC* Supply chain collaboration)

ports from the UK, for example, the Port of Felixstowe, are also early adopters of green practices. As for shipping companies, it is likely that the largest ones are the large-scale adopters of green practices driven by the four drivers in the conceptual framework, while the smaller companies are most likely only complying with the regulatory requirements. At a higher level, the institutional framework of the host country of a shipping company or port has an impact on the sustainable practice implementation (Lai et al. 2011). In some countries, the institutional frameworks facilitate the process (e.g. Germany), while in some, it hinders (e.g. Italy) (Acciaro et al. 2014).

Overall, higher implementation of the green port and shipping practices leads to better performance of shipping companies or ports in terms of economic, environmental and social performances (Lun et al. 2016). The improved economic performance includes cost savings from sustainable port operations and growth opportunities due to greener image. Environmental benefits include a reduction in GHG emissions, fuel consumption and waste discharge. Social improvements include higher satisfaction levels for employees, customers, an improved image and greater support from the local community. Therefore, a higher degree of implementation of green measures potentially allows for easier compliance with regulatory authorities.

6 Conclusions and Future Research Directions

This chapter presents an overview of the green port and sustainable shipping practices within the European maritime regions. While GSPs are highly driven by regulatory frameworks such as the IMO and EU, green port practices are mostly driven by CSR frameworks under sustainability initiatives such as EcoPorts and WPCI. Considering the European ports, we present a list of green port practices in Table 4.3, a list of sustainable shipping practices based on the websites of three of Europe's largest shipping companies in Table 4.4 and a generic list of GSPs in Table 4.5. The proposed conceptual framework in Fig. 4.2 critically reflects on institutional frameworks of host countries of ports and shipping companies, as well as firm-level corporate or governance structure.

The 17 United Nations SDGs call for actions globally to protect the planet and improve quality of life on earth (United Nations 2015). While several SDGs are indirectly related to maritime, the SDG 14—life below water—dedicated to the need for conservation and sustainable use of maritime resources. While the IMO attempts to account for the SDGs by means of imposing stricter regulations, for example, Directive (EU) 2019/883, to achieve greater maritime sustainability beyond the SDGs, much more needs to be done. The interrelationship of the institutional environment, corporate structure or governance model, drivers and practices of maritime sustainability needs further investigation. To achieve the most from the green port and sustainable shipping practices, large-scale implementation is required across ports and shipping companies of all sizes and types. Shipping companies willing to adopt sustainability practices beyond regulatory requirements should consider adapting GSPs reported in Tables 4.4 and 4.5. Similarly, port authorities that are eager to adopt green practices should consider GPM practices in Table 4.3.

Finally, the three main pillars of a greener maritime industry are technological advancement, regulations and increasing awareness (Andersson et al. 2016). Recently, major European ports and shipping companies have been scrutinising digital technologies and circular economy potentials for achieving environmental sustainability to a greater extent. Electric autonomous ships are being developed with the potential for zero CO_2 emissions—and are expecting to launch commercially within a decade or so (Munim 2019). Moreover, in the short run, shipping companies should aim for making a transition from heavy fuel oil to comparatively less harmful alternatives such as liquid natural gas (Wang and Notteboom 2014), and in the long run, adaptation of low-emission fuel alternatives such as biofuels or hydrogen fuel are likely to happen. In addition, there exists enormous possibilities of big data and AI applications in reducing emissions from the maritime industry (Munim et al. 2020a), for example, optimising fuel or energy consumption from ships using machine learning algorithms. As of regulations, the implementation of NO_x ECAs in the Baltic Sea and North Sea region (effective for ships constructed on or after January 1, 2021) is likely to reduce air pollution and related external health costs significantly (Åström et al. 2018). And, as can be seen in Fig. 4.2 already, environmental awareness of ports and shipping companies as well as their stakeholder is a major driver of GPM practices and GSPs.

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Part II
Moving to a More Secure and Safe Maritime Regulatory Regime

Chapter 5
Maritime Transport and Sustainable Fisheries: Breaking the Silos

Natalia Martini and Sandra Rita Allnutt

Abstract Sustainable maritime transport and sustainable fisheries are two global transboundary phenomena, which are highly interconnected and need simultaneous tackling to generate solutions, which could effectively lead towards the implementation of the Sustainable Development Goal on life under water (SDG 14). Illegal, Unreported and Unregulated (IUU) fishing has been identified as the main barrier to sustainable fishing practices (http://www.fao.org/3/y3274e/y3274e06.htm) and has important implications for navigational safety and sustainable maritime transport. This chapter provides an overview and analysis of the global effort to deter IUU fishing by strengthening Ports States Measures, Port State Control regimes, and increasing maritime safety for fishing vessels. This chapter also identifies barrier and analyses mechanisms, measures, and opportunities for high-level actions, which can help to progress towards achieving this goal; it addresses IUU fishing and the maritime sustainable aspects linked to fisheries, such as sea-based marine plastic litter, which include fishing gears (including abandoned, lost or otherwise discarded fishing gear (ALDFGs) and Drifting Fish Aggregation Devices (DFADs)). The conclusion highlights the common high-level actions for fisheries and shipping, which aim at strengthening the existing ocean governance mechanisms. The effective implementation of the identified key legally binding instruments (FAO's Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA), 2009; STCW-F Convention on the training of fishers; IMO's Cape Town Agreement on the safety of fishing vessels (estimated entry in force 2023); ILO C188; MARPOL Annex V (its annex on garbage); 1996 Protocol and the London Convention 1972 cover deliberately disposed unwanted waste from ship including fishing gears) would significantly help to shape fisheries and ship-

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ping to fulfil SDG14. Suggestions are provided to improve ocean governance and strengthen regional compliance through a more effective use of Regional Fisheries Management Organizations (RFMOs) and Port Sates Measures, as well as the enhanced use of public–private partnerships for capacity buildings projects, and the use of trans-disciplinary multi-stakeholder platforms, which generate science-based solutions.

Keywords Sustainable maritime transport and fisheries · IUU fishing · Port State Measures · Sea-based marine plastic litter · Fishing gears including ALDFGs

1 Overview of the Global Efforts for Sustainable Fisheries and Maritime Transport

This section provides an overview and analysis on the existing international agreement on sustainable fisheries and on the Port State Control (PSC) regime. Illegal, Unreported and Unregulated (IUU) fishing has been identified as the main barrier to sustainable fishing practices and has important implications for navigational safety and sustainable maritime transport. As such, Sect. 1.2 focuses on the global approaches to deter IUU fishing and to increase maritime safety for fishing vessels.

1.1 The Global Effort for Sustainable Fisheries and Port State Control

Since the adoption of the 1982 United Nations Convention on the Law of the Sea (UNCLOS), several international agreements were developed to promote sustainable fishing. The *UN Agreement on straddling stocks and highly migratory fish stocks* (1995) implemented the UNCLOS provisions related to conservation and management of these stocks. The UN system also had a key role to play in combating destructive fishing practices, which damage fragile habitats, in particular seamounts and cold-water corals.

Under the Food and Agriculture Organization (FAO), the following agreements have been adopted: the *Agreement on compliance with conservation and management measures* (1993), the *Code of Conduct for Responsible Fisheries* (1995), and the UN General Assembly adopted resolution 61/105 (2007). In particular, the 1995 UN Stocks Fish Agreement played a crucial role. This treaty had recognised the potential for Port States to contribute to fisheries conservation and management; in this context, the treaty emphasised the sovereignty of States in their ports, provided that parties have the duty and right to take non-discriminatory measures to promote the effectiveness of regional and global conservation and management measures. Moreover, this treaty called on Port States to inspect vessels in their ports and prohibit landings and transshipments when the catch undermines the effectiveness of conservation and management measures, in accordance with national regulations. Under this instrument, several Regional Fisheries Management Organisations (RFMOs) have adopted Port State Measures (PSMs) in accordance with these provisions. Further to this, in 2001, FAO adopted the non-legally binding *International Plan of Action to Prevent, Deter, and Eliminate Illegal, Unreported and Unregulated Fishing* (IPOA-IUU). The IPOA-IUU expanded significantly on the 1995 UN Fish Stocks Agreement and required fishing vessels to give notice of entry, request authorisation to enter, and submit to inspections (Harrison et al. 2017). The 2001 FAO IPOA-IUU had served as a platform to build a legally binding instrument: the FAO 2009 Agreement on Port States Measures (PSMA). PMSA entered into force in 2016, and there are currently 87 Parties to this agreement (see FAO Undated). This legally binding instrument deters and eliminates IUU fishing by preventing IUU vessels from using ports and landing their catches; it applies only to fishing vessels entering a Port of a States, which is different to their Flag States (Table 5.1).

In the maritime sector, the International Maritime Organization (IMO) supported the establishment of the PSC regime. PSC is the inspection of foreign flagships in national ports to verify that the condition of the ship and its equipment comply with the requirements and rules of the international maritime regulations of the IMO. PSC is a system designed to target substandard vessels with the primary objective to eliminate unsafe shipping and prevent damage to the marine environment from

Table 5.1 List of the legal binding instruments for fisheries management and PSC to deter and fight IUU fishing and list of the PSC MoUs

UN Agency	Legally binding instrument	Scope
FAO	UN Stocks Fish Agreement Entry into force 2001 (under UNCLOS)	Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks 1995. Port States to contribute to fisheries conservation and management
FAO	2009 Agreement on Port States Measures (PSMA) Entry into force 2016	Deters and eliminates IUU fishing by preventing IUU vessels from using ports and landing their catches
UN Agency	**Memoranda of Understanding**	**Scope: Regional PSC regime**
IMO	Paris MoU	Europe and the north Atlantic
IMO	Tokyo MoU	Asia-Pacific region
IMO	*Acuerdo de Viña del Mar*	Latin America
IMO	Caribbean MoU	Caribbean
IMO	Abuja MoU	West and Central Africa
IMO	Black Sea MoU	Black Sea region
IMO	Mediterranean MoU	The Mediterranean
IMO	Indian Ocean MoU	The Indian Ocean
IMO	Riyadh MoU	Gulf Region
IMO	US Coast Guard MoU	The USA

ships. This objective could be best achieved by the coordination of port states, which are all based on the provisions of several widely accepted international maritime conventions. Therefore, in Paris, in January 1982, the Paris MoU on PSC was adopted and signed by the maritime authorities of 14 states. The Paris MoU has been in operation since July 1982. Since then, the IMO has supported the establishment of eight other regional PSC regimes, achieving a global maritime network of nine regional voluntary agreements on PSC—Memoranda of Understanding (or MoUs) and the United States Coast Guard maintain the tenth PSC regime (UK P&I Club, Pandi 1998) (Table.5.1).

Despite this international and interagency effort, within the maritime and the fisheries sectors, the FAO reported that unsustainable fishing methods, and in particular IUU fishing, are responsible for annual catches of up to 26 million tonnes, for a value of up to USD 23.5 billion (Agnew et al. 2009),[1] but most importantly, these practices undermine efforts to ensure sustainable fisheries and responsible fish stock management worldwide. IUU fishing, jointly with the overexploitation of fishing stocks, both in areas under national jurisdiction and in the high seas, has been identified as the main barriers to sustainable fishing practices, as IUU fishing is fundamentally opposed to the goals and principles of the Code of Conduct for Responsible Fisheries (FAO 2000). Moreover, IUU fishing has important implications for the navigational safety of fishing vessels (Burroughs and Mazurek 2019) and can create barriers for sustainable maritime transport. Therefore, it is increasingly evident that such a complex phenomenon can only be effectively tackled with a trans-disciplinary approach aiming at shaping fisheries and shipping simultaneously.

1.2 Interagency Cooperation: A Global Approach to Deter IUU Fishing and Increase Maritime Safety

On a global level, the IMO, the International Labour Organization (ILO), and the FAO play a major role in deterring and combating IUU fishing and in protecting fishermen's safety at sea. The collaboration has led to the development of Fishing Vessel Safety Code and Voluntary Guidelines (see non-legally binding instruments in Table 5.2) for vessels smaller than 24 m, which operate in national waters or within countries' exclusive economic zones and are subject to any national safety regulations.

The interagencies collaboration between the IMO, the ILO, and the FAO has also led to the creation of the Joint FAO/ILO/IMO Working Group on IUU fishing (JWG). This JWG provides an instrumental platform to develop effective policy solutions and non-mandatory instruments, to generate ideas to amend existing international agreements, as well as to enable an early engagement of key stakeholders

[1] For further details see FAO (2016), http://www.fao.org/news/story/en/item/414494/icode.

Table 5.2 Overview of international legally binding instruments and non-mandatory instruments, which cover maritime safety, including safety of fishing vessels and help in the fight against IUU fishing

UN Agency	International legally binding instruments	Status	Scope
IMO	International Convention for the Safety of Life at Sea (SOLAS), 1974.	In force 1980	It specifies minimum standards for the construction, equipment, and operation of ships, compatible with their safety. It does not cover fishing vessels. SOLAS provides the legal basis for the mandatory IMO ship identification number scheme for commercial vessels • 2013 Resolution A.1078 (28) allows voluntary application of this scheme also to fishing vessels of 100 gross tonnage (GT) and above • 2017 Resolution A.1117(30) extends the voluntary scheme to all motorised inboard fishing vessels of less than 100 GT up to12 m LOA
IMO	Cape Town Agreement (CTA), 2012	Not yet in force	It outlines safety standards for commercial fishing vessels and provides detailed regulations, which Parties must adopt to protect fishing crews and observers. CTA covers safety of fishing vessels of 24 m in length and above. Once in force, it will be mandatory for fishing vessels, covered by CTA, to have an IMO ship identification number
IMO	The International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel, 1995 (STCW-F 1995)	In force 2012	It sets the certification and minimum training requirements for crews of seagoing fishing vessels of 24 m in length and above
ILO	Work in Fishing Convention 2007 (ILO C188)	In force 2017	It sets out binding requirements relating to work on board fishing vessels, including occupational safety and health, medical care at sea, and ashore, rest periods, written work agreements, and social security protection. It also aims to ensure that fishing vessels provide decent living conditions for fishers on board
UN Agencies	**Non-mandatory instruments**		**Fishing Vessel Safety Code and Voluntary Guidelines**
FAO/ ILO/IMO	Code of Safety for Fishermen and Fishing Vessels, 2005		

(continued)

Table 5.2 (continued)

UN Agency	International legally binding instruments	Status	Scope
FAO/ ILO/IMO	Revised Voluntary Guidelines for the design, construction, and equipment of small fishing vessels, 2005		
FAO/ ILO/IMO	Safety recommendations for decked fishing vessels of less than 12 m in length and undecked fishing vessel		
FAO/ ILO/IMO	Implementation Guidelines on Part B of the Code		
FAO/ ILO/IMO	Voluntary Guidelines and the Safety Recommendations (Implementation Guidelines)		

in this international process. The JWG has worked regularly, and its latest session was held in October 2019.

Prior to this, with the aim to increase navigational safety for fishing vessels, in 2012, the IMO adopted the Cape Town Agreement on fishing vessels safety (CTA). The CTA outlines safety standards for commercial fishing vessels and provides detailed regulations that countries party to the agreement must adopt to protect fishing crews and observers (see Table 5.2). The CTA will enter into force once 22 States have ratified it, with a total of 3600 fishing vessels 24 m or longer, and it will apply to fishing vessels 24 m and longer, carry out commercial fishing operations on the high seas, or outside their national waters. Once in force, the CTA and the provision of the 1993 Torremolinos Protocol will provide a mandatory global regime for fishing vessels safety and will also provide an essential instrument to deter and fight IUU fishing. In October 2019, with the view to increase ratification, with the aim to achieving the entry into force, the IMO organised a Ministerial Conference in Torremolinos during which the Torremolinos Declaration was signed: 48 States committed themselves to work towards ratification and the entry into force in 2023. The Conference resolution 1 adopted the Torremolinos Statement on the CTA of 2012, relating to fishing vessel safety and combating IUU fishing (IMO 2019). The Statement emphasises the importance of the CTA, urges States to take actions to prevent, deter, and eliminate IUU fishing, and encourages the implementation of the International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel, 1995 (STCWF 1995) on training of fishing vessel personnel, as well as encouraging interagency cooperation between FAO, ILO, and IMO (Table 5.2).

To make the most of the momentum, the latest session of the JWG, its fourth session, was held in Torremolinos, in Spain, in 2019, back-to-back with the IMO Ministerial Conference. The IMO, FAO, and ILO, in collaboration with the key stakeholders, attended this meeting and developed several recommendations to strengthen the interagency collaboration and increase the efficiency of the fight

Table 5.3 Voluntary measures to fight IUU fishing and to increase traceability of fishing vessels

UN agency	Voluntary measures	Scope/content
FAO	Global Records of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels (GRFV)	Database used to identify a specific vessel beyond 24 m length and above 100 GT (e.g. recording vessel's name), flag, length, GT, type of fisheries, and type of gear
IMO	IMO number schemes 2017 Resolution A.1117(30)	Unique identifiers for the voluntary application of this scheme to fishing vessels of 100 GT and to all motorised inboard fishing vessels of less than 100 GT up to12 m LOA

against IUU fishing. The JWG recommended to IMO to lead the development of guidelines for the implementation of the CTA of 2012 and better define their scope and content to assist the competent authorities to establish an effective compliance regime.

The JWG carried out an analysis of the development and implementation of the relevant global legal framework[2] and the related voluntary guidelines to date. For further details, see non-legally binding instruments in Table 5.2. It was noticed that progress was made towards strengthening the effectiveness of the global legal framework addressing safety of navigation and IUU fishing; however, the JWG recommended that the three UN agencies should increase coordination and information sharing for port inspections procedures at a national level for the merchant and fishing sector; the three agencies were also encouraged to develop international guidelines based on the current international instruments on fishing operations, personnel, and vessels to enhance the harmonisation of these procedures.

Moreover, during the JWG, the agencies exchanged updates and further investigated the joint use of the FAO Global Records of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels (GRFV), and the IMO ship identification number scheme (PEW 2017) (Table 5.3). These are two voluntary measures, which help to identify a specific fishing vessel and vessel-related activities uniquely. The GRFV collects information from Port States and RFMOs to identify a specific vessel beyond 24 m length and above 100 GT (e.g. recording vessel's name, flag, length, and GT) along with its function, but it also has modules on performance, the type of fisheries practiced, as well as on the type of gear on board; all these information, once collected in the record, can greatly help to combat IUU fishing and enable the effective implementation of the PSMA (Joint FAO/ILO/IMO WG 2019a).

The IMO ship identification number was first introduced under the International Convention for the Safety of Life at Sea (SOLAS: see legally binding instruments

[2] ILO's Work in Fishing Convention 2007 (ILO C188); FAO's Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA), 2009; STCW-F Convention on the training of fishers; IMO's Cape Town Agreement on the safety of fishing vessels (not yet in force); the MARPOL Convention on prevention of pollution ships, including its annexes on garbage, sewage, and air pollution, also applies to fishing vessels as well as to cargo and passenger vessels..

in Table 5.2), as a mandatory measure, for commercial vessels (cargo ships above 300 GT and passenger ships above 100 GT) with the aim to enhance ship safety and security; in 2013, the IMO adopted Assembly resolution A.1078(28), which allowed the voluntary application of the scheme to fishing vessels of 100 GT and above, in addition to merchant ships. More recently, in 2017, the IMO Assembly adopted resolution A.1117(30), extending this scheme to ships of 100 GT, including fishing vessels of steel and non-steel hull construction; passenger ships of less than 100 GT, high-speed passenger craft, and mobile offshore drilling units engaged on international voyages (SOLAS regulation V/19-1); and to all motorised inboard fishing vessels of less than 100 GT down to a size limit of 12 m in length overall (LOA) authorised to operate outside waters under the national jurisdiction of the Flag State. During the JWG, it was recognised that the allocation of IMO numbers to fishing vessels, in support of the of GRFV, will enable the integration of these two schemes, and the three UN Agencies, in collaboration with RFMOs, should consider taking appropriate actions for the effective allocation of this number.

During the latest session, the JWG's emphasis on the importance of continuing cooperation on labour and fisheries was also discussed. It was recognised that the work carried out by the IMO and the ILO on abandonment, and fair treatment of seafarers, should be extended to include fishers; the FAO was encouraged to further promote fisheries' observer safety globally by reviewing available information and existing national and regional measures on the safety, security, and working and living conditions of fisheries' observers under existing observer programmes (Joint FAO/ILO/IMO WG 2019b).

Furthermore, the JWG and the UN Agencies recognised the importance of enhancing cooperation and dialogue on environmental issues associated with fisheries, such as marine debris, which include abandoned, lost or otherwise discarded fishing gear (ALDFG) (Joint FAO/ILO/IMO WG 2019c). The IMO international environmental agreements cover fishing gear and ship-generated marine litter and can play a crucial role in the development of international environmental regulatory regime, which enables sustainable maritime and fisheries practices. To this extent, IMO has designed an action plan and action list to address sea-based sources of marine plastic litter and has encouraged interagency dialogue collaboration with the FAO and the ILO to tackle this issue effectively. Environmental issues associated with fisheries are discussed in more detail in the next section of this chapter.

2 The Way Forward: How to Break the Silos

This section identifies barrier and analyses mechanisms and opportunities for high-level actions and measures, which can help to progress towards achieving this goal. IUU fishing and the maritime sustainable aspects linked to fisheries are addressed in separate sections, whereas, the conclusion highlights the common high-level approaches towards solutions.

2.1 Fighting IUU Fishing: Enhanced Global Cooperation, Strengthened Ocean Governance, and Improved Regional Compliance

The 2015 UN Sustainable Development Goal 14 (SDG 14) included SDG 14.4 on overfishing and IUU fishing and destructive fishing practices. This sub-goal was envisaged to be implemented by the end of 2020. Regardless of the international effort to tackle this phenomenon, the fight against IUU fishing is still underway. It is increasingly evident that it is deeply linked to other transboundary sustainable industry practices, such as shipping and that, therefore, further international and national work is needed to achieve effective implementation of SDG 14 and its sub-goal 14.4.

The effort to strengthen existing ocean governance mechanisms should continue through enhanced global cooperation, coupled with improved regional compliance. At the global level, the entry into force of the CTA will provide an international legally binding instrument on the safety of fishing vessels 24 m or longer and will protect fishing crews and observers carrying out commercial fisheries operations outside national waters and in the high seas; its entry into force will also make the IMO ship identification number scheme mandatory for the fishing vessels covered under this convention. Simultaneously, the increased rate of ratification of the FAO Agreement on PSMA, its adoption, and its effective implementation will ensure that only legally fished catches are landed in ports. Moreover, the ILO's Work in Fishing Convention 2007 (ILO C188) and the CTA, once in force and implemented, would have complementary regulations, which can all be checked during port inspections under PSMA, providing a coordinated framework, which can strengthen the effectiveness of PSCs and enhance international cooperation against IUU fishing.

Nevertheless, there are a few gaps in global ocean governance that would still need to be tackled to progress further with the implementation of SDG 14. Gaps and opportunities for actions are analysed at global and regional level.

Global: the effective implementation of PSMA and CTA is essential to successfully fight IUU fishing, improve PSC, and promote sustainable maritime transport. To this extent, the establishment and the management of robust and extensive capacity building programmes for each of these instruments is an important step to succeed, as these frameworks are designed to identify barriers at an early stage of the processes. The FAO capacity building programme for PMSA has already identified three key elements, which need to be in place for an effective implementation, at national level: the policy and legal framework, institutional capacity, and the availability of resources for the operational procedure. These can become barriers if they are not adequately developed. Therefore, strengthening the regional and national level of means and competencies for operational procedures is essential to carry out a coordinated and cost-effective Monitoring Control Surveillance (MCS) operation to combat IUU fishing through PSMs. In order to achieve this goal, the FAO and the IMO, in collaboration with other international bodies such the Global Environmental

Facility (GEF), could design and establish new public–private partnerships, which would be able to provide the necessary resources to address these barriers.

Regional: Several of these gaps in ocean governance can be better addressed at a regional level through the RFMOs[3] (RFMOs; see for example European Commission 2020; EJF et al. 2019), which are intergovernmental fisheries organisations with authority to establish fisheries conservation and management measures on the high seas.

RFMOs play a critical role in the global system of fisheries governance because they are the most effective body to achieve cooperation between and among fishing nations, which is essential for the conservation and effective management of international fisheries. RFMOs can promote compliance and facilitate enforcement, with the effective monitoring of vessel activities (i.e. Vessel Monitoring Systems (VMS) for all vessel sizes) (ISSF 2018), with a publication of lists of licenced vessels, and by tracking the compliance with conservation management measures. RFMOs can also play a key role in enhancing compliance using more effective schemes for vessel identification by, for example, coupling the IMO shipping identification number with other national unique vessel identifier (UVI) schemes for non-IMO compliance vessels. All these measures would enable RFMOs to draw more accurate authorised vessel lists, which would greatly help towards the creation of a more comprehensive record of licenced vessels, enhancing traceability of fishing vessel operations and consequently addressing, more effectively, the fight against IUU fishing. Moreover, RFMOs could adopt transboundary policies on monitoring and enforcement, which include the high seas, such as best practices of joint inspections programmes (OECD 2018; IMO 2019) (e.g. inter-RFMO collaborations), as well as establish collaborative schemes between themselves and the relevant Regional Agreements on PSCs to combat IUU fishing (e.g. MoUs), fisheries-related crimes, and crimes associated with fisheries.

RFMOs are also better placed to help managing illegal and unregulated small fishing practices. Small-scale and artisanal fisheries are usually carried out with smaller vessels and can contribute to IUU fishing activities (Moenieba and Witboo 2019). Therefore, specific effort should be focused to manage them, with the overall aim to improve stock assessments and their use in fishery management, as the same fish species or the same fish stock can be harvested by different fishing methods and gears. At present, the IMO number eligibility scheme includes voluntary application for all motorised fishing vessels of less than 100 GT and greater than 12 m operating outside national jurisdiction, which does not cover vessels below 12 m LOA, operating outside or inside national waters. Ultimately, small-scale and artisanal fisheries are not covered under international agreements and, therefore, need to be regulated, managed, and monitored through Coastal State and Flag State collaborations and at a regional level through the use of another UVI (i.e. national UVI) as well as through the strengthening of RFMOs' governance.

[3] At present there are 6 tuna RFMOs and 11 non-tuna RFMOs.

2.2 Enhancing Sustainable Maritime Transport and SDG 14's Implementation: Environmental Issues Related to Fisheries and Sea-Based Marine Plastic Litter

The inadequate use, discharge, and disposal of fishing gear at sea is another barrier to sustainable fishing and ship safety, and it is often related to IUU fishing (MacFadyen et al. 2009; Richardson et al. 2019).

The ALDFGs is a transboundary environmental problem. The FAO estimated that at least 640,000 tonnes of fishing gear is lost each year and that fishing gear makes up 10% of all marine debris (Gilman et al. 2016). It was established that 46% of all the plastic found in the Great Pacific Garbage Patch is thought to be fishing nets (Lebreton et al. 2018), and there is an increasing concern over the Drifting Fish Aggregation Devices (DFADs), lost and discharged by various types of purse seine fleets (Gilman et al. 2018). At present, there is a lack of information on the full extent of these ever-growing phenomena, their impacts, and their composition and fate, as well as on the composition of these devices (i.e. ALDFG; DFADs). Several IMO international environmental instruments cover the use of fishing gear from ships*:* operational ship generated waste, including fishing gear, is covered under MARPOL Annex V (Regulations for the Prevention of Pollution by Garbage from Ships), and deliberately disposed, unwanted waste from ships, including fishing gear, is covered under the London Convention 1972 and London Protocol 1996 (LC-LP).

The IMO is committed to supporting the implementation of SDG 14, in 2017, with the establishment of a comprehensive legal framework around fishing activities. This framework included the entry into force of international instruments, such as the CTA, the implementation of the STWC-F Convention, jointly with the enhancement of existing regulations to tackle the inadequate use, discharge, and disposal of fishing gear at sea. Moreover, IMO recognised the importance of introducing new measures to reduce and prevent marine plastic litter entering the oceans through ship-based activities (IMO 2017a). Consequently, IMO committed to the development of an Action Plan on marine plastic litter to address, prevent, and significantly reduce marine pollution by 2025, which was adopted in 2018. The Action Plan covers macro-plastics and microplastics and builds on existing policy and regulatory frameworks while identifying opportunities to enhance these frameworks and introducing new supporting measures to address the issue of marine plastic litter from ships.

The IMO Marine Environment Protection Committee (MEPC), in collaboration with FAO, is leading the discussion addressing the IMO Action Plan on marine litter through the joint MEPC LC/LP Working Group, which is formed by experts who are delegates for IMO MEPC and LC/LP meetings. The Action Plan proposes: to undertake an independent study on marine plastic litter from ships; to analyse the availability and adequacy of port reception facilities (PRFs); in cooperation with FAO, to consider making the marking of fishing gear mandatory while promoting the reporting of the loss of fishing gear and facilitating the delivery of retrieved fishing gears to shore facilities; to review provisions related to the training of fishing vessel personnel and familiarisation of seafarers to increase awareness of the impact of marine plastic litter; to consider the establishment of a compulsory mechanism to declare loss of containers at sea and identify a number of losses (IMO 2018); to enhance public awareness; and to strengthen the international cooperation, in particular with FAO and UN Environment. Moreover, IMO has engaged with UN Environment in the Global Partnership on Marine Litter (GPML), the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea (ICP), and the United Nations Environment Assembly (UNEA).

IMO international environmental instruments cover fishing gears and ship-generated marine plastic litter under MARPOL Annex V[4] and under the London Convention 1972 and London Protocol 1996 (LC-LP); these treaties can play a crucial role in the development of international environmental regulatory regime, which enables sustainable maritime and fisheries practices. MARPOL Annex V (IMO 2017b) covers operational ship-generated waste, including fishing gear (IMO 2012a, b, 2016, 2017b), and provides the obligation for adequate PRFs, whereas, the London Convention 1972 and London Protocol 1996[5] (LC-LP) cover deliberately disposed, unwanted waste from ships, including fishing gears (macro-plastics), and regulates sewage sludge and dredged material disposals, which are the important waste streams for marine plastic litter (microplastics) (IMO 2017c).

Further to the requirements of the IMO Action Plan on marine plastic litter, MARPOL Annex V has been considered for amendments (IMO 2016) to regulation 10.6 and 10.7, which, respectively address the issue of reporting all types of losses or discharged fishing gear, and the issue of direct notification from Parties to IMO for the loss or discharge of fishing gear (IMO 2020); the main objective is to make the reporting requirement for lost fishing gear mandatory and enable both Flag States and the Coastal States to report directly to IMO, with the ultimate aim to reduce this source of ship-based waste at sea.

Effective policy decisions are based on scientific knowledge and evidence. To this extent, the Action Plan proposed to undertake an independent study on sea-based sources of marine litter, which includes litter originating from the fishing and shipping industries, and in particular, ALDFG, as, at present, there is a lack of understanding of the sources, of the extent of these phenomena and their impacts on marine habitats and ecosystems. In particular, ALDFG seems to be more harmful than other types and sources of marine debris, specifically in relation to 'ghost fishing', the entanglement of marine species and as a navigational hazard to safety at sea.

[4] MARPOL 73/78 Annex V, Prevention of Pollution by Garbage from Ships: Annex V, which came into force on 31.12.1988, contains requirements relating to the disposal of all types of food, household, and operational waste that have accumulated aboard ships during operation.

[5] The IMO Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, the London Convention (LC), is one of the first global conventions to protect the marine environment from human activities (entered in force in 1975). For further details see http://www.imo.org/en/OurWork/Environment/LCLP/Pages/default.aspx.

To carry out this study, the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) was tasked to set up a Working Group (GESAMP WG 43 on Sea-Based Sources on Marine Litter) to undertake this work. The first work stream consists of an overarching scoping study on all sources of sea-based litter (e.g. fishing, aquaculture, shipping and boating, ocean dumping, offshore oil and gas exploration) to help identify priority areas for interventions in support of the measures for the Action Plan, with more emphasis on fisheries and shipping. The second workstream addresses all sea-based sources of marine litter while focusing on ALDFG, as this is the primary source and needs urgent addressing, as specified already by IMO and FAO, and requires further science-based evidence (e.g. distribution and hotspots, quantification of environmental and social-economic impacts, identifying gaps in knowledge) to shape focused interventions and design effective solutions (Joint FAO/ILO/IMO WG 2019d).

3 Conclusions

The process of breaking the silos requires a global, trans-disciplinary approach led by an interagency effort, based on international collaborations; the early involvement of scientists and representatives from the shipping and fisheries industry is recommended to design effective, science-based, implementable solutions. Interagency collaborations can play a key role throughout these processes.

The effective implementation of the key legally binding instruments,[6] on fishing vessel safety and PSMs, will enable legal and sustainable fishing practices conducted by fishermen operating in a safe environment and will significantly help to shape fisheries to fulfil several Sustainable Development Goals: SDG 14 (life under water), SDG 2 (zero hunger), SDG 5 (gender equality), SDG 8 (decent work and economic growth), and SDG 17 (partnerships for the goals). The existing instruments, legally binding and non-binding, provide the framework to progress towards achieving sustainability in fisheries and maritime transport, but there is a need to enhance effective transposition into national legislation and to strengthen regional compliance; in particular, RFMOs could play a crucial role in enhancing international collaboration, Port State ratification, and implementation of the PSMA, especially under an international body to overseas their performances.

The effective implementation of these trans-disciplinary instruments would be greatly strengthened by the use of extensive capacity building activities, which enable an early identification of barriers, raise awareness among national fisheries authorities, regional fisheries bodies and fishing and shipping industry, and,

[6] FAO's Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA), 2009; STCW-F Convention on the training of fishers; IMO's Cape Town Agreement on the safety of fishing vessels (estimated entry in force 2023); ILO C188; MARPOL Annex V (its annex on garbage); 1996 Protocol and the London Convention 1972 cover deliberately disposed, unwanted waste from ship including fishing gears.

ultimately, enhanced effective implementation and compliance. Capacity building initiatives should be strengthened; at present, IUU fishing is addressed by the PMSA capacity development programme, which is focusing on effective implementation of PSMs and complementary monitoring, control, and surveillance (MCS) operations and on measures and tools to combat IUU fishing; consistently, a capacity-building framework should be designed for sea-based litter on how to manage the source and improve PRFs for derelict gear, as well as address the marking of fishing gear; moreover, other capacity-building projects could encourage ALDFG to address license conditions. To this extent, establishing public–private partnerships for the management of sea-generated litter and the ALDFG removal should be considered.

The IMO, FAO, and UNDP, under the Global Environment Facility (GEF), have worked towards building partnerships to assist developing countries in reducing sea-based sources of marine litter (e.g. Glolitter Partnership: see Safety4Sea.com 2019). The establishment of multiple public–private partnerships for the effective implementation of international environmental agreements should be enhanced. In this context, RFMOs can play an essential role in tailoring and implementing more stringent approaches into regional and national realities. Moreover, the IMO, in collaboration with FAO, is actively seeking to build an international, trans-disciplinary, intergovernmental platform to enhance dialogue and promote the exchange of scientific data, ideas, and best practices. Within this platform, policymakers and key stakeholders can interact and jointly tackle IUU fishing and sea-based sources of marine plastic litter, which includes fishing gear. The aim is to create more effective evidence-based policies, to review regularly and strengthen the existing international voluntary and regulatory framework to minimise the impacts, manage the issues, identify gaps, and better regulate these phenomena. To this extent, the trans-disciplinary work carried out by the FAO/ILO/IMO JWG on IUU fishing and other related matters has been placed side by side with the work of the joint MEPC LC/LP Working Group, in collaboration with FAO, addressing the IMO Action Plan on marine litter and the GESAMP scientific working group (WG43) on sea-based sources of marine litter. The overall aim is to address, prevent, and significantly reduce these sources of marine pollution by 2025.

The combination of these trans-disciplinary processes, together with the measures identified and the high-level actions suggested in this chapter, should enable the international community to progress significantly towards achieving sustainable maritime transport and fisheries by 2030.

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Chapter 6
Maritime Security: Adapting for Mid-century Challenges

Jon A. Skinner

Abstract Maritime security can be expected to continue to develop and mature global and regional objectives and is a critical component to advance many of the United Nations (UN) Sustainable Development Goals (SDGs) for 2030. However, there are unknowns, impossible to properly prioritise in advance, that will surely appear. The Covid-19 impact on the maritime industry and broader global economy, at the time of this writing in 2020, is stark and omnipresent. Historically, geopolitics has been a major game changer, but in absence of an outright war, there has been a strong continuing trend to harmonise maritime security in international waters for well over a century. Climate change over the next 30 years may open new routes in previously ice-bound waters. Developments in new energy, mineral and other extractive industries in previously undeveloped regions are expected to drive new offshore and transit corridors bringing greater environmental risk, especially oil spill and emergency response challenges to regions sparse in infrastructure and response resources, such as the Arctic and the Antarctic littorals. The pace of this change, however, will most likely continue to be driven by market forces, often non-linear—which will challenge planners. Husbanding sufficient human and economic capital in reserve is prudent. Strategic thinkers on maritime security objectives should embrace the multi-causality of global challenges and remain nimble enough not to be entrapped by their assumptions.

Keywords Maritime security · Hard power · Soft power · Climate change · Multi-causality · Scenario planning

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1 Introduction

Maritime security will benefit from consistent and sustained collaboration within international structures and forums to advance its planning objectives and mature its institutions. This is the assumption, if not the isolated and pristine-dependent variable, "strategic planners" must embrace to advance the United Nations (UN) Sustainable Development Goals (SDG) for 2030 and is the expectation. However, there are unknowns. Though perhaps too conveniently timely and, therefore, with a potential for distorted context, the shock of the Covid-19 pandemic is an all too obvious example. Historically, geopolitics has perhaps most consistently been a major game changer, but in the absence of outright war among major military and commercial powers, there has been a strong continuing trend to harmonise maritime security in international waters by a very broad collaboration of nations, many in no way otherwise aligned, for example, counter piracy off the Horn of Africa. Climate change over the next 30 years may open new routes in previously ice-bound waters, especially in Arctic Eurasia, though Antarctic waters may also begin to see significant new regulatory and enforcement challenges. Developments in new energy, and mineral and other extractive industries in previously undeveloped regions are expected to drive new offshore and transit corridors bringing greater environmental risk, especially oil spill and emergency response challenges to regions sparse in infrastructure and response resources, such as the Arctic littoral and the Antarctic and sub-Antarctic. The pace of this change, however, will most likely continue to be driven by market forces, often non-linear—which will challenge planners. This chapter will delineate current maritime security strategic thinking and emphasise the multi-causality of global changes, with a focus on the viability and certitude of assumptions.

2 Collaborative Maritime Security

Collaborative maritime security is supported by a framework of international law with institutional guidance from the UN and its affiliated institutions, most specifically the International Maritime Organization (IMO). Regional organisations also play a very substantial role and include the Arctic Council, Nordic Council and the European Union (EU) in their respective, often overlapping, geographic regions. Collaborative "hard" vs. "soft" security is generally an exercise by States of unilateral naval power. There are, however, significant contributions by navies to support soft security functions, such as policing, safety and environmental law enforcement—unilaterally, within formal alliances, as well as more hoc or temporal cooperation.

2.1 United Nations Sustainable Development Goals for 2030

The focus of this chapter is on strategic planning for "global" maritime security, which has an objective outside, though hopefully generally parallel with, specific State or regional intra-governmental goal. It is illustrative to note the high number of the 17 UN SDGs (drafted in 2015) for 2030, which rely significantly and clearly on a secure maritime sector for advancement, especially SDG 6 Clear Water and Sanitation, SDG 7 Affordable and Clean Energy, SDG 8 Economic Growth and Decent Work, SDG 9 Industry, Innovation and Infrastructure, SDG Sustainable Cities and Communities, SDG 13 Climate Action and SDG 14 Life Below Water (plastic refuse) (UNEP 2015). It is also worth noting early that there is inherent friction in meeting these objectives as implementing policies that are not foundationally mutually supportive. Affordable energy, economic growth and policies to reduce greenhouse gases (GHGs) do not leap together into effective synergistic policies but are likely to require a very complex, coordinated and sustained effort.

2.2 Maritime Security and the International Regulatory Governance

The following major international shipping conventions, adopted by the IMO,[1] reinforced by sovereign domestic laws, impact primarily "soft" security and by charter and design must take into account the interests of 173 member countries (and the Cook Islands) (European Union 2020).

- International Convention for the Safety of Life at Sea (SOLAS) sets safety standards for ships.
- International Convention for the Prevention of Pollution from Ships (MARPOL) sets international standards to prevent ship-borne pollution.
- From a security perspective, the United Nations Convention on the Law of the Sea (UNCLOS) in which 167 countries have joined has gone a long way to codifying international common law. Its most noteworthy exception, the US, which has not ratified it, nonetheless generally abides by its provisions, and its ratification is supported by both the US Navy and Coast Guard.
- Convention on the International Regulations for Preventing Collisions at Sea (COLREGS) standardises rights of way.
- The International Ship and Port Facility Security Code (ISPS) provides the security regulations for ships and ports (post 911 guidance and standardisation effort).
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) provides a standard for maritime training.

[1] For a more detailed examination of the various Conventions mentioned see the chapter by Christodoulou and Dalgåard which appears as Chap. 20 in this volume.

2.3 Collaborative Hard Security

In general, by definition, "security" in the context of international maritime collaboration implies "soft" security, or more specifically, a compliance or enforcement regime based on specific international law in parallel, most often by "domestic legal" enforcement by sovereign nations. Hard security by contrast refers to naval combat, or more often posturing, a very different set of parameters and one more often governed by unilateral or alliance-fettered objectives.

This is not always the case, however, as demonstrated by the multi-layered response to pirate activity off the coast of Somalia in the last dozen years, for example. In that sizable and highly significant action alliances, coalitions and unilateral sovereign state navies have cooperated and at times collaborated in and out of structured security parameters.

At most, these actions are tactical (reactional and incident driven) and, at best, only approach operational levels of planning such as at the counter piracy Shared Awareness and Deconfliction (SHADE) meetings in Bahrain (Combined Maritime Forces 2020).[2] In fact, the enabler of these multifaceted maritime coordinated actions in the Gulf of Aden and in the Indian Ocean is the absence of an articulated or even "implied" holistic strategy (Iran, Pakistan, China, NATO, the EU and almost every other nation that had merchant ships or cargos transiting the Horn of Africa have been engaged in these security operations). However, it would perhaps be an overstatement to generalise that this well over a decade-long maritime security cooperative engagement, among a very diverse group of participants, is a future trend absent the unique geographic details and highly specific concerns.

3 Benchmarking Maritime Security Strategies

For this discussion, the emphasis is on planning and collaboration by intra-governmental institutions and forums with mandates for maritime security, such as the IMO with a charter of enhancing global maritime security and intra-governmental regional institutions such as the EU. A maritime "strategy" implies a coherent multifaceted approach with multiple methods, usually to achieve an overriding objective larger than specific incidents.

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[2] The chair for this biannual conference rotates between the CMF (Combined Maritime Forces) and EU Naval Force—Somalia (EU NAVFOR) (Rider 2018).

3.1 IMO

The IMO adopted, in 2018, an initial strategy to reduce GHGs 50% by the year 2050 (IMO 2018). The "threat" driving this strategy is climate change. The anticipated worsening trajectory of the impact of GHG in the atmosphere has been observable for some years.

The collective impact of GHG from the shipping industry is not of a decisive magnitude (3% of all global inputs) to mitigate the global "threat" but is significant in a collective sense (speculatively, it could rise to as much as 10% of the global GHG emissions) (Cushman 2018; Transportenvironment.org 2020). Additional supporting measures by the IMO include significantly enhanced energy efficiency requirements and the Global Maritime Energy Efficiency Partnership (GloMEEP). These programs seek to build capacity for adopting GHG mitigating measures in Developing and Least Developed Countries (LDCs) (IMO 2020).

3.2 European Union

For the EU, maritime strategy *"is understood as a state of affairs of the global maritime domain, in which international law and national law are enforced, freedom of navigation is guaranteed and citizens, infrastructure and transport, the environment and marine resources are protected"* (European Union 2014). Maritime interests are delineated as prevention of conflicts and the rule of law, protection of EU people and infrastructure, maritime external border control, global supply chain safety and steps to curb illegal or "pirate" fishing. Identified transnational threats highlighted include territorial disputes (especially in the South China Sea), piracy, weapons proliferation, terrorism, organised crime, pollution, natural disasters and climate change.

Fundamentally these measures are designed to address the above specified threats with an emphasis on a coordinated approach in international relations, EU maritime global visibility, a regional response capacity, preparedness and include UNCLOS dispute-settling mechanisms. Information sharing is also highlighted along with enhanced maritime awareness and surveillance capacity (European Union 2014). It should be noted that sharing of maritime awareness and surveillance with international institutions can be, especially, challenging as many of the assets with the capacity to execute these missions operate primarily within navies and air forces whose primary task and focus is on specific member state defence priorities—or rather—hard security vs. soft security objectives.

An EU analysis focused on the North Sea region but with a global outlook implies that the major driver for future shipping changes in the behaviour patterns of owners and operators is clearly market driven. Ships have steadily increased in size as the global merchant fleet has been modernising to optimise changing patterns of consumer demand though this has been limited somewhat by a lag in the ability of ports to meet the increased capacity of the newer larger vessels. Short sea shipping (coastal and/or inland) has been a means to adjust this capacity disparity within the EU (European Union 2020).

Clearly, the planning efforts of the IMO and EU emphasise "soft security" in the maritime domain with measures and strategic institutional plans to guide policy formation and implementation. They are not, and rightfully so, designed to assess and significantly alter the global economic or political status quo. The threat addressed that most closely approaches the grand strategies of the major sovereign states is climate change.

4 Embracing Multi-causality

Identifying the independent or causal variable is the foundation of the scientific method. The challenge for applying, in a macro sense, that method directly to maritime security planning is that the future is not going to be a laboratory. Nor will it follow any rules. Case studies of historical events and forecasting or linear projections have a place in preparatory analysis but also can be less than neutral if they do not consider the very uncertainty with which they influence and support planning. At worse, they can allow for the lack of contingency planning to address a "Black Swan" event; one which has a very low probability of happening, but which can have dramatic impact (Taleb 2010).

This is not the place to provide an analysis of whether the Covid-19 impacts to the maritime industry is, or is not, a good example (though investors in the cruise ship industry very likely believe so). But it can be, and is reasonable to suggest, that the scale of the tertiary shock to the maritime industry, global trade and energy markets was not on the forefront of planning as little as 3 months before this writing (though pandemics and their capacity to uproot civilizations are foundational to civilization itself) (McNeill 1977).

The larger point, for projecting a future on which to "plan" for, is that it is best to "embrace" uncertainty rather than obfuscate. A tool to consider is scenario planning methods, which are not as overly reliant on quantitative methods for macro-analysis (quantitative methods though can greatly enhance the "micro" subsets of useful data). The objective is to identify drivers and assess how they might interact within a complex system to produce plausible outcomes.

Scenario futures are not forecasting or linear projections of the future. Rather, they are used to best prepare future decisions makers for uncertainties. It is clear that *"[a] scenario focus on developing and differentiating drivers and how they are interconnected in a complex system, will produce structurally different futures … conceived through a process of causal rather than probabilistic thinking*" (Van der Heijden 2005, 27).

5 Identifying the Main Drivers and Threats

From a maritime security perspective what should planners anticipate for 2050? The best answer to the unanswerable is that it is unlikely to be a tight linear continuation of current trends. Admittedly that answer is not very helpful. More useful would be to make some necessary assumptions to assist preparation for unexpected developments or contingencies, which at their best allow the flexibility to have utility for multiple variations of the coming 2050. Deep changes to global trade patterns have and will have highly volatile security implications. This is particularly true when changes to shipping routes, means or functions outpace existing regulatory regime and infrastructure. For example, the rapid rise in Arctic and Antarctic adventure tourism voyages has stressed soft security reasonability and infrastructure (Ren and Chimirri 2018).

Historically, global aggregate shipping fluctuations are a derivative of market demand for goods, 90% of which are currently borne by shipping; therefore, it is a common and well-grounded planning assumption that there is a causal relationship between the global economy and sea borne commerce (European Union 2020; Berti 2020). Also, highly significant from both a "soft" and "hard" security perspective is the tertiary effects of climate change and the opening up of new and longer seasonal sea route patterns in the Arctic, as well as potentially in Antarctic waters that challenge the existing security regulatory regime. This is particularly true of hydrocarbon development in frontier maritime regions but also for a host of other growing extractive industries that provide the mineral and rare-earth components necessary for many alternative energies (European Union 2020).

The Arctic Council's seminal *Arctic Marine Shipping Assessment 2009 Report* identified in its findings that Arctic natural resource development and, especially, global commodities prices for hydrocarbons and minerals were driving much of the expansion in Arctic transit routes (Arctic Council 2009). Other studies on expanding development and shipping on maritime frontiers, also using scenario method tools for analysis, identify the continuing significance of hard power geopolitics, shifts in global trade and commodity markets (particularly oil and gas) (Skinner 2016). These are good assumptions for security planning. They should be anticipated and planned for. Seismic geopolitical shifts (war) could also change the rules of the maritime security regime as could vagaries of climate change.

6 Geopolitics and Breaking the Rules

Historically, when security transitions to "defence" or rises to naval action, the international legal regime is often disregarded, and sovereign interests override strict adherence to international law—but this does not always, or even generally, equate to complete disregard, as is often assumed. For example, both Germany and Great Britain did indeed create new rules for themselves during the First World War that suited their own interest on the high seas, but particularly in the German case, the decision to do so was long-deterred by the feared repercussions of breaking from existent international common law, for example, violation of US neutrality in the North Atlantic. The suspension and then resumption of unrestricted submarine warfare were at the very highest levels of German strategy, and its timing and execution were one of the key determinates of its ultimate failure to secure regime survival (Wolford 2019).

7 Energy Markets and Maritime Security

Planning or attempting to manage future global trade patterns in a holistic sense is a task outside the charter and capacity of any maritime security institution. In fact, it can be argued in a geopolitical lens that historic hegemonic superpowers themselves, at their height and greatest reach, have at most only highly influenced global trade. By contrast, a narrower focus on global energy markets can be especially useful for 2050 maritime planners for two reason: it is tightly correlated to achieving "strategic" objectives of the international community with emphasis in this chapter on the IMO, EU and UN SDGs for 2030; and it is a highly significant, perhaps the most significant driver of change in transit routes to adjust to industrial extractive industries. As routes change in turn, the regulatory security regime must adjust. Physical risks are aggravated by infrastructure deficiency, poor communications, incomplete charting, unreliable navigational aids and difficulty of Search and Rescue. Insurance is an important component of shipping costs as well but minor when compared to capital, crew, or fuel (Peter 2019).

7.1 The Geopolitics of Oil and Gas

For a century, the geopolitics of energy has been synonymous with the geopolitics of oil and gas. Near-term price of hydrocarbons influences investment development decisions. Markets and profit matter. However, the very long timelines to progress from exploration to profitable production that is necessary for these massive industrial projects require strategic analysis. Like security planners, the gamble for the energy industry is on assessing the future market decades away, as well as the nature of the coming global political-economic system; not the current price of a barrel of oil. However, geopolitics and the global energy economy is continually changing and not necessarily in a linear or evolutionary manner.

The international order predominant since the end of World War II has faced mounting challenges that have included the collapse of the Soviet Union and the end of the Cold War (Yergin 2011). One of the central enablers and drivers of these significant shifts has been and continues to be energy, and still, its central component, the oil and gas sector. Much of the global hydrocarbon resource that has been easy to access, produce and transport has already been consumed. Though there is certainly very little likelihood that known reserves cannot sustain even a growing global economy to 2050 and beyond, the technologies and resources necessary will increase, and therefore, its relative cost.

7.2 Scenarios and Back-Casting

While forecasting scenarios envisage growth in renewable energy, none anticipate a revolution in which renewable energy surpasses consumption of any of the fossil fuels though back-casting scenarios posit a more promising future, a radically different energy mix, where utilization of renewables eventually surpasses fossil fuels. In this context, it should be noted that back-casting is a planning method that does not analyse current trends rather it goes backward in time from a policy objective, such as the Paris Accord's CO_2 reduction target years, and then develops scenarios with bundles of policies that could reasonably achieve that objective.

As a transition to renewable energy accelerates in the scenarios, new trade patterns and routes could develop around those materials critical to renewable energy technologies. For example, rare-earth elements are widely used in clean energy technologies, including solar panels and wind turbines. Though rare-earth elements are found in many regions, they are usually in non-marketable concentrations. Currently, almost all mining, production and processing take place in China. Change in extractive industry regions for lithium, cobalt and indium, also widely used in clean energy technologies, could also change trade patterns and shipping corridors. Renewable energy is already a game changer for Chile, Jordan, Morocco and several island states in terms of energy security (O'Sullivan et al. 2017).

8 The Covid-19 Pandemics Impact on 2050 CO_2 Emission Goals

The shipping sector and its growth are routinely impacted by financial crises, such as in in 2008, as well as pandemics. Clearly, the current (August 2020) economic Covid-19 downturn has produced dramatic regional reductions in CO_2 emissions to visible effect. However, the long-term impact is very much uncertain. Economies and energy have typically rebounded in the past from severe economic downturns. Populations, distinct from their leadership, however, tend to gravitate to "dirty" and cheap fuels (hydrocarbons) in times of crisis, which will challenge planned shifts to cleaner but still currently more expensive fuels (particularly for transportation) (Victor 2020).

9 Security Flashpoints 2050

There are a number of potential security flashpoints that have been identified for the next few decades. These include areas such as:

- The Arctic and Antarctic littorals: Climate change is projected to continue to extend summer sailing season, and these regions will likely continue to see new exploratory and production activity for hydrocarbons and other minerals and rare-earth commodities—highly variable on market demand.
- The Baltic and Black Seas: Potential for continued sovereignty friction and competition for both land and sea (above and below surface) resources, dependent on US, Russia and NATO relations.
- Alliance between China and Russia? Such an alliance could create major shifts in the global political arena, not only regional security regimes. However, for historical context, arguably it was misreading the likelihood of such an occurrence that was the major driver for the failed US engagement in the Vietnam War.
- The degree of China's emergence as a dominant regional power in the South China Sea: Already a factor in sovereignty claims regionally, it could potentially also have game changing influence on transit routes and resource extraction in the Indian Ocean and East Asian waters.

It is important to note that this is not an exhaustive, authoritative or prioritised listing. In fact, this chapter hopefully has underscored that such a list cannot be subjectively developed with useful validity. Rather, it is a contribution to stimulate thought. It suggests perhaps that a scenario workshop of maritime security stakeholders from a wide spectrum, addressing these concerns, might make a useful contribution to the problem set and enhance strategic planning.

10 Conclusion

In 1920s and early 1930s, along with war plan "Orange", in preparation for a potential war with Japan, the USA also created a "Red" war plan and conducted staff drills for war with the British Empire. There was even a Red-Orange series of plans for taking on Japan and Britain in a coalition (Ross 1997). The point being that events that played out in the Pacific only 10 years later in WWII were very far from a planning "certainty" or even considered a probability. Nonetheless, broadly developed capacity in ships, training, planning, and especially sustained operations served the US Navy well in the hard power challenge of WWII.

Looking from the present back 30 years to the early nineties, as distant in time today as 2050, the emergence of a much-improved Chinese regional military power prepared to challenge the USA, the dominant naval power in the South China Sea, was not seen as any more likely by strategic planners than either India or Japan's future capabilities (Tritten and Stockton 1992). In conclusion, this chapter urges prudent planning to wisely husband the resources for maritime security that may very well be needed to address the unforeseen.

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Chapter 7
ISPS Code Implementation: Overkill and Off-Target

Johnny Dalgaard

Abstract As a supply chain security measure, the International Ship and Port Facility Security (ISPS) Code promulgated by the International Maritime Organization (IMO) is overall a well thought through system. It provides a structure to support ocean governance for maritime transport, security for the environment, and security for the member states (MS). However, from a Danish perspective, as well perhaps from a European Union (EU) MS viewpoint, it has added a significant bureaucratic burden. From a pragmatic prism, appropriate, adequate, and efficient security can be successfully accomplished without such a heavy bureaucratic burden. This chapter contains an overview and provides a qualitative, analytical examination of ISPS frameworks in Danish Ports and facilities based on Port Facility Security Officers (PFSO).

Keywords ISPS · Terrorism · Security · Lack of proportionality · KIS: Keep it simple

1 Introduction

When it comes to international maritime security, the ISPS Code (see IMO 2020a) is required to be implemented through domestic regulation, with diverse specific measures optimised for different regions and MS unique requirements. Three examples of this are that: (a) in Denmark there is no Recognised Security Organization (RSO) (until 31 March 2021 with initiatives ongoing), (b) in Norway there is an RSO, and (c) in Greenland there are no requirements for port security, but only for securing port facilities. In large parts of the world, the rules are administrated as intended by the IMO in 2004, for example, in Greenland.

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According to the general description found in the ISPS Code, the Code primarily serves the purpose of protecting the maritime sector against criminal acts of all kinds. There is, however, a widespread consensus that the international acceptance and implementation of the ISPS Code is directly linked to the aim of supporting the United States of America (USA) through protection against terror (IMO 2020a). The origins of the ISPS Code began with the ambition of securing the "world community against terrorism while simultaneously supporting the development of international trade and economic growth". Thus, a supplement to the ISPS Code was made as an appendix to the Convention for the Safety of Life at Sea, 1974 (SOLAS) (IMO 2020a). The aim was to create a secure and closed system for international shipping traffic for the merchant fleet and to ensure that goods could be transported between countries agreeing to implement the ISPS Code.

President George W. Bush stated in a speech to the American Congress on September 21, 2001 that many countries had already offered sympathy and support to the country following the terrorist attacks of September 11, 2001, which left all countries facing a choice: "Every nation, in every region, now has a decision to make. Either you are with us, or you are with the terrorists" (9–11 commission report 2004). The ISPS Code, IMO annex to the SOLAS Convention (see IMO 2020a), was the UN's answer to this demand from the American president.

The ISPS Code secured free trade without risk to the contracting countries and without the risk of export or import effects that could damage the receiving country, shipping, and secured international trade.

The scope of the ISPS Code according to Section 1.2—Objectives are numerous:

1. To establish an international framework involving co-operation between contracting governments, government agencies, local administrations, and the shipping and port industries to detect security threats and take preventive measures against security incidents affecting ships or port facilities used in international trade.
2. To establish the respective roles and responsibilities of the contracting governments, government agencies, local administrations, and the shipping and port industries, at the national and international level for ensuring maritime security.
3. To ensure the early and efficient collection and exchange of security-related information.
4. To provide a methodology for security assessments to have in place plans and procedures to react to changing security levels.
5. To ensure confidence that adequate and proportionate maritime security measures are in place (IMO 2020a).

The IMO's ISPS Code delineates a wide range of activities to optimise security. From the outset, the rules are global and do not differentiate among countries. The activities may seem logical and required in some environments and countries while appearing less obvious in others. Significant differences include, for example, that the US Coast Guard has legal authority for patrolling, preventing, and investigating crimes at sea. In Denmark, on the other hand, the Navy is one of three types of maritime defence policy, which includes a small group of sailing police units and the

Home Guard, which all patrol at sea. The Navy primarily monitors sovereignty violations while the police and Home Guard carry out certification checks and intervene in emergency offenses at sea when a crime has been committed or reported.

As the EU is a union of more than two dozen European countries, the ISPS Code requires compliance to the code for passenger—and cargos ships over 500 Gross Ton (GT) that cross borders between two MS. This differs from ships in domestic use, for example, within the USA, from San Francisco to a port in Alaska, where the application of the ISPS Code for security is not required, as it is domestic handling of cargo ships.

It is axiomatic that ISPS provides a structured system, which diverges sharply with the Danish tactical security system, which is also administratively burdensome; that system is reviewed below, starting in Sect. 2.1.

In a world of limited resources, where there is an increasing focus on climate change and environmental issues, it is important to further understand maximising the value of all resources, including resources engaged in security activities, and to consider the purpose of resource consumption and use. This is a fundamental premise of the UN's Sustainable Development Goals (SDGs) that were adopted by all member states in 2015 (United Nations 2020a). Against this backdrop, this chapter provides a critical analysis of ISPS frameworks from a Danish ports' and facilities context, considering the work of Port Facility Security Officers (PFSOs).

2 ISPS Code Implementation in EU and Danish Legislation

In general, EU countries, including Denmark, comply with ISPS Code on security matters in port facilities as well as in ports. The ISPS Code, both parts A and B, regulates "facilities" with regards to security measures, for example, Port Facility Security Assessment (PFSA) and Port Facility Security Plan (PFSP). EU Regulation (REG) No. 725/2004 regulates the security of port facilities, while EU Directive (DIR) 2005/65/EC regulates the security of ports. "Ports" as an object to secure. They are not defined in the ISPS Code but are defined in EU legislation. "Port facilities" are defined in REG 725/2004 and "ports" are defined in DIR 2005/65.

The following two rule sets given by the EU are fundamental to Danish legislation:

Current Legislation for Ship and Port Facility Security According to ISPS in Denmark:

REGULATION (EC) No 725/2004 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 31 March 2004 on enhancing ship and port facility security.

Current Legislation for Port Security According to ISPS in Denmark

DIRECTIVE 2005/65/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 October 2005 on enhancing port security.

Figure 7.1 illustrates the implementation of the ISPS Code in European and Danish legislation regarding ports:

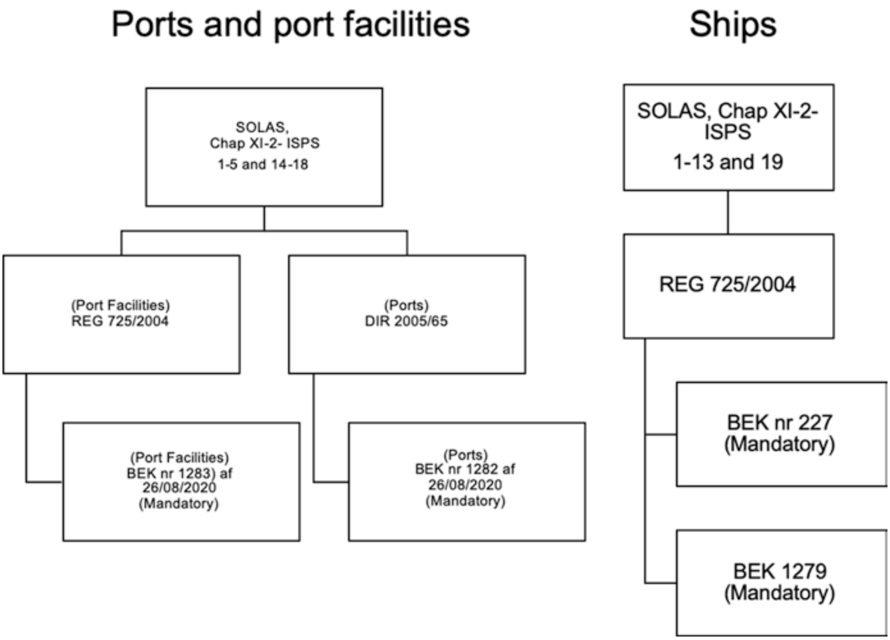

Fig. 7.1 ISPS Code implementation in Danish legislation

2.1 Danish Implementation

The Danish implementation of the ISPS Code for both port and ship security is carried out by a range of individuals, bodies, and agencies. Port Security Assessments (PSAs) and Port Facility Security Assessments (PFSA) are prepared by the PSO for ports and PFSO for portfacilities and from 31 March 2021 also by RSO and local police. Then they are approved by the Ministry of Transport, Construction, and Housing (TBST). Port Security Plan (PSP) and PFSP are prepared by PFSO and approved by the TBST. But since implementation of BEK 1282, PSP may not be made by the same organisation, that makes the PSA. It must be made by "anyone else", IE a random person, the port or another RSO. To most of us, this is completly irrational. Sea territory is monitored and patrolled by the Royal Danish Navy. Criminal activities at sea are handled by the local police in co-operation with the Home Guard. The Port Security Officer (PSO) controls the port's own administrative areas on land and sea but has no patrol outside the facilities and at sea, and the PSOs authority over these areas is unclear, as the port areas on land are patrolled by the Danish police and the areas at sea are monitored by the Royal Danish Navy.

Ship Security Assessments (SSA) and Ship Security Plans (SSP) are prepared by the Company Security Officer (CSO) and Ship Security Officer (SSO) and approved by the Danish Maritime Authority (DMA). Inspections of ships can be carried out by DMA or on behalf of DMA by Paris MOU. Figure 7.2 illustrates the range of authorities and companies involved in Danish implementation of ISPS requirements.

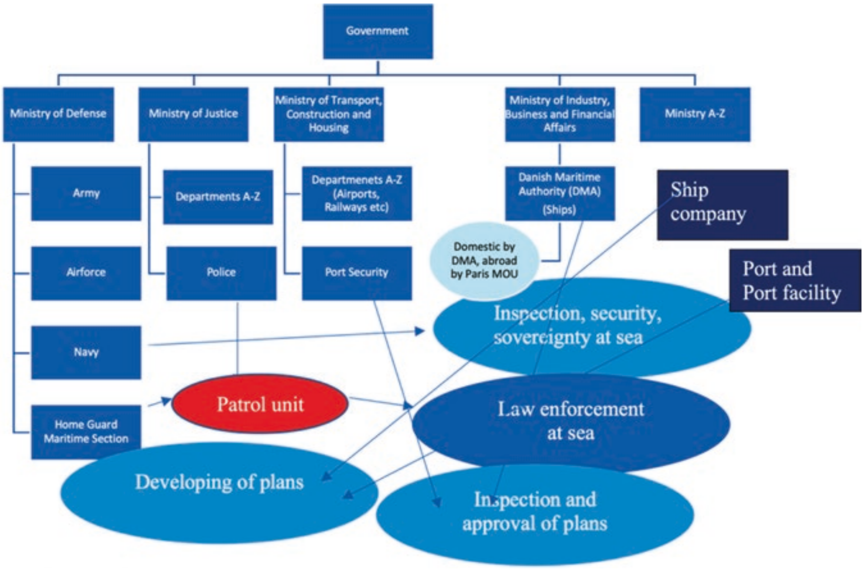

Fig. 7.2 Involved administrative and tactical authorities and companies in Danish implementation. (Source: Authors own work)

2.2 *Tactical Danish Method*

To work with the two plan sets PSA and PSP and PFSA and PFSP, it is helpful to define what is a port and what is a port facility. The definition of a port facility is given by the IMO in the ISPS Code, while ports are defined as everything else in a port's administrative area. According to EU legislation, it must have prepared a PSA and a PSP.

The procedure for making a PSA and a PSP is that the police and an RSO, legislation from October 1st, 2020, develop a PSA. Then the TBST has 3 months to either approve or reject it. If it is rejected, a corrected PSA is made and submitted to the TBST. When approved, there must be made a PSP, which can be made by anyone, but the RSO who made the PSA, regardless of capability or skills.

The procedure for making a PFSA and a PFSP is nearly the same as making a PSA and a PSP. The PFSA is made by the police and a RSO, due to legislation from the October 1st, 2020. Then the TBST has 3 months to either approve or reject it. If it is rejected, a corrected PFSA is made and submitted to the TBST. When approved, there must be made a PFSP, which can be made by anyone.

The above-described procedure is perhaps not used in all countries within the European Union (EU), but the procedures embedded in the legislation apply in a similar fashion to all MS (Fig. 7.3).

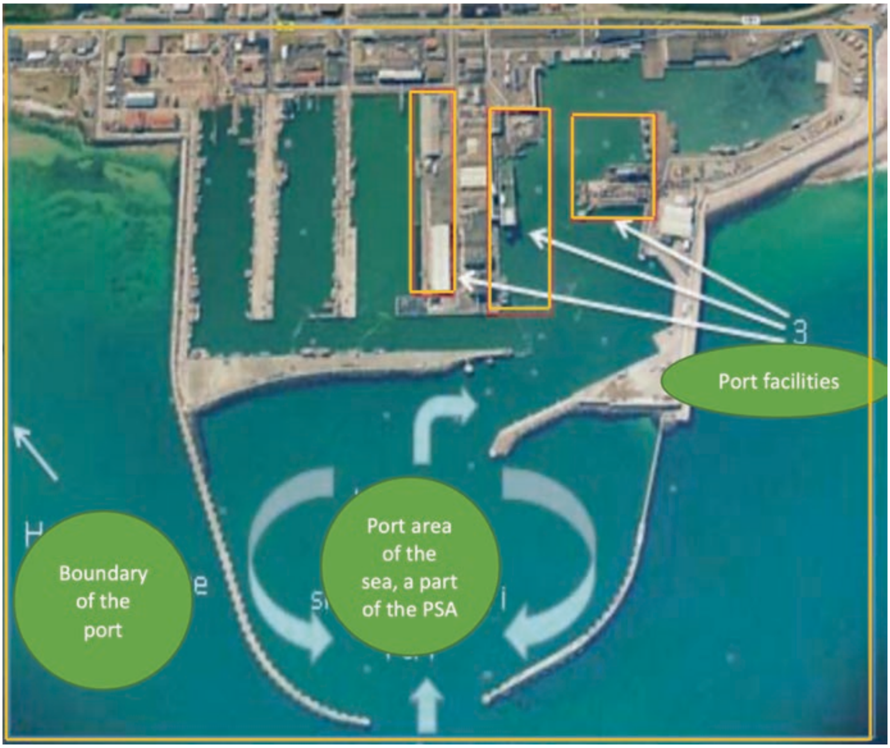

Fig. 7.3 Distinction between port and port facility. (Source: TBST 2020, translated by Dalgaard)

3 Development of Plans

Due to legislation and guidance from TBST, there is a practice of making plans, which has developed since 2004, and has been described in legislation, which is often renewed. The latest is from 2020, where BEK 1461 was renewed in BEK 1282, and BEK 1462 was renewed in BEK 1283.

3.1 Ports and Port Facilities

According to EU DIR 2005/65/EU, a port must have an approved PSA for activities to be permitted for handling ISPS Code-regulated ship activities. PSAs are developed by RSO (before in BEK 1461, it was the port) and the local police. When the framework is made, it is either approved or rejected by the Ministry of Transport, Construction, and Housing. If rejected, the work starts over again. If approved (before in BEK 1461, it was the port), the port is responsible for making a PSP.

When the PSP is approved, the port is ready for activities, according to ISPS Code. The PSP is the security plan for securing everything at the port except the port facility. As the PSP does not cover security for the port facility, a PFSA must also be conducted. The process of making a PFSA follows the same structure. When the framework is made by the local police and a RSO (before in BEK 1461, it was the PFSO), it is either approved or rejected by the TBST. If rejected, the work starts over again. If approved, the port facility is responsible for making a PFSP. Upon approval, the port facility is ready for ISPS activities.

The validity of the PSA, PSP, PFSA, and PFSP is 5 years. A complete renewal is required every fifth year, regardless of whether the structure at the port is changed or not. Additionally, a port and a port facility must have a renewed set of plans before initiating a change of the structure or purpose of the activities on the facility. In the ISPS Code, the 5-year term is mentioned in part A, section 19, which sets out mandatory regulations for ships. For port facilities, it is only required for the PFSAs to be periodically reviewed and updated. They must, however, still take into "account of changing threats and/or minor changes in the port facility and shall always be reviewed and updated when major changes to the port facility take place".

The ISPS Code in itself does not provide information about the mandatory renewal every fifth year. The EU has, nevertheless, made a rule on renewals, the plinth of which is S. 6 of Article 3 of REG 725/2004:

> *Notwithstanding the provisions of paragraph 15.4 of Part A of the ISPS Code, the periodic review of the port facility security assessments provided for in paragraph 1.16 of Part B of the ISPS Code shall be carried out at the latest five years after the assessments were carried out or last reviewed.*

In Denmark, the above requirement of the EU made its way into Danish legislation and has been implemented as a mandatory complete renewal of the plan every fifth year. This provides an economic and administrative burden for the port and the port facility. The fact that the ports and port facilities must make a new PSA and a new PFSA, followed by a new PSP and a new PFSP within 5 years even when the port structure and a port facility structure remain completely unchanged (the same location, the same owner, the same purpose, the same security, etc.) makes the legislation somewhat redundant and unnecessary. It provides no additional value to security and acts as a pure bureaucratic burden with unfortunate economic and administrative consequences.

Four examples of some of the administrative burdens are discussed below:

The *first* is based on the fact that a PSA requires a vulnerability assessment of the public roads in the port's administrative area and a security plan that describes activities to secure these.

In Denmark, it is the police who patrol public roads, both owned by public administration and private owners, and thus also those that are in a port. It is also the police who investigate crimes of any kind in the area of both the port and the port facility. For this reason, it is completely irrelevant what conclusions the PSO conducts concerning the PSA and PSP, as it is the police who maintain law and order in these places.

The *second*, another administrative burden is that ports in connection with the preparation of the PSA must involve the local police. The police allocate appropriate resources for participating in these assignments, and a PSA is prepared by the PSO, the police, and a Danish version of the RSO. At a meeting at the port or port facility, they assess the vulnerability. The RSO then issues a PSA, which is sent for approval to the police, who makes sure that their contribution to the vulnerability assessment has been incorporated into the PSA. Once the police have approved their contribution to the PSA, it is sent to TBST for final approval.

Despite the police's approved vulnerability assessment, TBST may refuse to approve it. This means that one Danish administrative authority under a ministry may reject the approval of another Danish administrative authority under another ministry. The same system is used for PFSA and PFSP.

The *third* example is an example of unequal administrative practice from TBST, where each traffic inspector may have his or her preferences for factors that may result in the rejection or approval of a PFSA. There are examples of a vulnerability assessment having been refused an approval on the grounds, among other things, that cranes used for loading and unloading ships at the port facility were not vulnerability assessed in PFSA. Even though they never left the port facility. Compared to PFSA at other similar port facilities, this has not previously been a requirement for the vulnerability assessment.

Concerning the ISPS Code, part A, section 15.3, number 6 and 15.10, number 2, vulnerability assessment of transport systems should be carried out, but if you look at the scope of the ISPS Code, cf. IMO (SOLAS XI-2 and the ISPS Code—see IMO 2020a), only a security aspect is mentioned and not an aspect regarding the port's general operation of ships.

The *fourth* and last example is the redundant administrative burden for a port, which is also a port facility. If a port is the same as a port facility and there is an approved PFSP for the facility, TBST still requires the port to make a PSA. Of course, this work adds no additional security to maritime security—or the national security, as the security and vulnerability assessment has been carried out in connection with the preparation of the PFSP. This is underlined by the fact that there is an administrative relief in this case, as the port can be exempted from drawing up a PSP.

3.2 Ship Security Assessment (SSA)

SSA and SSP ensure that there is interaction with PFSP according to the ISPS Code. By securing ships and port facilities in the same system, it is possible to have a combined effort against threats to port facilities and ships. Port facilities and ships can change their security procedure simultaneously in the event of a threat, and they can change threat levels simultaneously. At the same time, a ship's security plan can be changed without affecting the entire port facility, as a shipping company may be exposed to a threat and, therefore, changes the level of security in all shipping companies, no matter where in the world they are.

The fact that the fishing fleet was not included in the described safeguarding of the world shipping community is in many ways surprising. It is hypothesised that the IMO-estimated fishing vessels do not have the same capacity to transport and exchange risky elements as does the merchant fleet. However, it is safe to assert that if the world community aims to secure the transport system at sea, all sailing traffic should be included.

For example, when drawing a parallel to terrorism, the great efforts made against organised groups that previously practiced terrorism have made them change the character into becoming "NIKE" terrorists, as the lone wolves who carry out terror on their own are called by the British Security Service, MI5, and Danish Security and Intelligence Service (the secret service of the Danish Police) "PET". NIKE refers to a type of terror carried out based on the mindset, "Just Do It".

Terror targets and methods are explained in an article published in *Inspire Magazine* online in the period from 2010 to 2017 (Jihadology 2020), which provides instructions on tactical terrorist acts that can be carried out individually by single people in different countries. Therefore, the nature of terrorism has changed from being worldwide-organised attacks led by terrorist groups and in the 1970s Brigade Rosse (Red Brigade) of Italy, the Popular Front for the Liberation Palestine (PFLP). From around 2010 to the present time, terrorism has been characterised by what has been identified as Nike terrorists. Examples of such terrorism are single people using larger vehicles (Nice, 2016, Berlin, 2016, Stockholm, 2017) or weapons (Norway, 2011, Denmark, 2015) to attack at crowds or smaller groups of people (France, 2015) working autonomously to carry out terror attacks.

It seems that trends in terrorism have shown that it most often occurs where it is easiest to cause fear among people or loss of human life or values. Concerning maritime security, it would be natural for terrorists wishing to use maritime transport to transport effects that could be used for terrorism to use fishing vessels for this purpose, as fishing vessels, quite incomprehensibly, are not part of the ISPS/maritime security. For further information on maritime security, see IMO (2020b).

3.2.1 Security

In Denmark, the vulnerability analysis goes through the vulnerabilities in a port or port facility in the paradigm "Risk" and "Consequence", where the following definitions, set out in Table 7.1, are chosen:

However, there is currently no structured consideration of the likelihood of anyone being able and willing to attack a port facility. Moreover, the "Intent", which is defined by "PET", is defined as the accessible means (personnel, technology, equipment, etc.) combined with the ability (training, skills, logistics, etc.) to use these means to the fullest in a potential attack and to employ a certain capacity against a certain target or group of targets (Assessment of the terror threat to Denmark, 2020). What is also missing is that there are no structured considerations of whether the

Table 7.1 Definitions, "Probability: Consequence"

Probability	Low	Moderate	High
Definition	There are very few people or groups that have both the resources and motivation to realise the hedging incident, and the existing hedging measures are deemed sufficient to address this	There are some individuals or groups who have both the resources and motivation to realise the security incident, but due to existing security measures, it is considered possible to partially counter these events	There are individuals and groups with both resources and motivation to realise the security incident, and the existing security measures are not considered to be able to address these events
Consequence	**Moderate**	**High**	**Catastrophic**
Definition	The incident does not result in loss of life or personal injury, small financial loss, small environmental damage, or loss of reputation	Significant personal injury or possibly loss of human life, major regional consequences for the economy, long-term destruction of part of an ecosystem over a larger area or greater loss of reputation	Large losses of human life or extensive damage, major national or international consequences for the economy, complete destruction of several parts of an ecosystem over a larger area, or major loss of reputation

Source: Vulnerability Assessment, TBST 2020, translated by Johnny Dalgaard

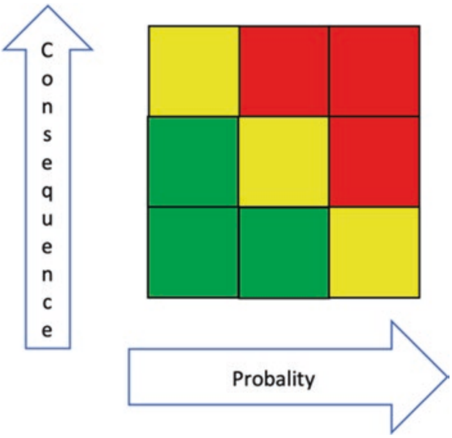

Fig. 7.4 Risk evaluation. (Source: Risk Evaluation, TBST 2020, translated by Johnny Dalgaard)

threat is local to the individual port facility and city or global towards a target in another city (where the analysed port facility is just part of the transport chain to facilitate a terrorist attack elsewhere in the chain of connected port facilities and countries). The structure of such risk evaluation is illustrated in Fig. 7.4.

The consequence of this approach is that one must take every theoretical threat described in the ISPS Code into consideration when assessing the port and the port facility. Even though it is not a local but a global threat.

Another aspect that is important to examine is how to evaluate the consequences of malfunctioning ISPS security measures. When assuming that cargo can potentially be altered or tampered with, and a ship can unwillingly be used to transport many dangerous objects (e.g. weapons, explosives, or biological material) to attack populations anywhere in the world, the question that comes into play is: how would it ever be possible to calculate the consequence? If the answer to that question is yes, does this analysis of consequences also answer the question as whether the terrorists will be able to attack the ports in Haifa, Rotterdam, or any given location in Europe? This would subsequently lead to the question as to how many would be injured and die, what would the casualty, loss of values, and harm of the environment at sea be?

As mentioned above, the SSA must be approved by the TBST, and after that, the port facility has to make the PFSP, addressing the threats in the PFSA. Thereafter, the PFSP is either rejected or approved by the TBST.

From a practitioner perspective, it seems appropriate to define this as a complete waste of time and effort, and though it seems not to harm the environment, all resources are used without a reasonable return on investment.

4 Nature of Security

At a closed-door meeting in an advisory board in the administration of ISPS Code under the TBST, the chairman stated: "when there has been an accident, there is too little security, but when nothing happens, there is too much".

That is indeed the nature of security. In general, security arrangements are not something you would buy, unless you had to secure your belongings or property from theft or vandalism. The inevitable question is proportionality in risk assessment: who would buy a lock to their house if they could spend the money on something else?

It has been suggested that safety (and security) is not only an aspect of human rights, it is a fundamental human need (Maslow 1943; Herzberg 1959). In principle, the concept of safety can be narrowed down to a question of perception as "feeling safe" does not necessarily correspond to being safe or vice versa: You can feel safe while being unsafe, just as you can feel unsafe while being safe.

In 2016, 79 people with American citizenship were killed worldwide in actions related to terror. From 1995 to 2016, a total of 3658 American citizens were killed in actions related to terror (START 2017). This number also contains the loss of human lives in the attacks of September 11, 2001. By contrast, on average, approximately 40,000 people died from motor vehicle related accidents in the USA per year in the years from 2000 to 2018 (Overview 2020).

4.1 Acceptance of Risk, Example Iraq Vs. USA

As indicated above, there is a high acceptance of death related to traffic accidents, while there is zero-tolerance for deaths related to terror. Stating this, there are circumstances where the zero-tolerance towards terror-related deaths appears, to a great degree, to be dependent on the population targeted by the terrorists. Since 2003, a total of 208,103 Iraqi civilians have been killed in violent attacks (Iraq Body Count 2020). If combatants are added to this number, this amounts to 288,000 people (Iraq Body Count 2020). Despite such a massive loss of life, with deaths occurring daily, these terror acts get no or little attention in the worldwide political and media landscape.

According to the Gun Violence Archive (2020), the usage of guns in the USA is deemed to be accepted and that every year, an average of approximately 11,000 people are killed in firearm assaults. The acceptance of death related to firearms seems to be very high in the USA, and the total number of deaths related to all kinds of gun violence was in 2019 39,473 individuals (The Gun Violence Archive). Since 2001, when the numbers were added, approximately 209,000 people have been killed in firearm assaults without resulting in any significant regulative change of "gun laws" and no sign of the number of deaths to decrease. In 2018, approximately 18,000 citizens were killed this way.

Furthermore, according to the Gun Violence Archive (2020), in the USA, there were 340 mass shootings in 2018, and each year, some 11,000 people are killed in firearm assaults.

In the light of the above-given examples, it is fair to argue that it is not the number of lost lives that determines the effort and legislation invested in saving lives and on enhancing security.

As previously identified, the ISPS Code represents a coordinated desire to involve the maritime industry in the protection of the world community from international terrorism after the events of September 11. However, if the true aim for the world community was to save civilian lives, many more civilian lives could be saved with legislation against gun violence or traffic accidents. That is why the ISPS Code, in its present structure and emphasis, can potentially be considered as costly overkill, off-target and not a wise use of resources.

4.2 Consequence and Risk of Exposal

The risk of "exposal" is defined as the likeness of getting caught and convicted or killed in the attempt of an attack, planning, performing, or as a result of an investigation. The consequence is a penalty after the perpetrator is caught and detained concerning the same activity.

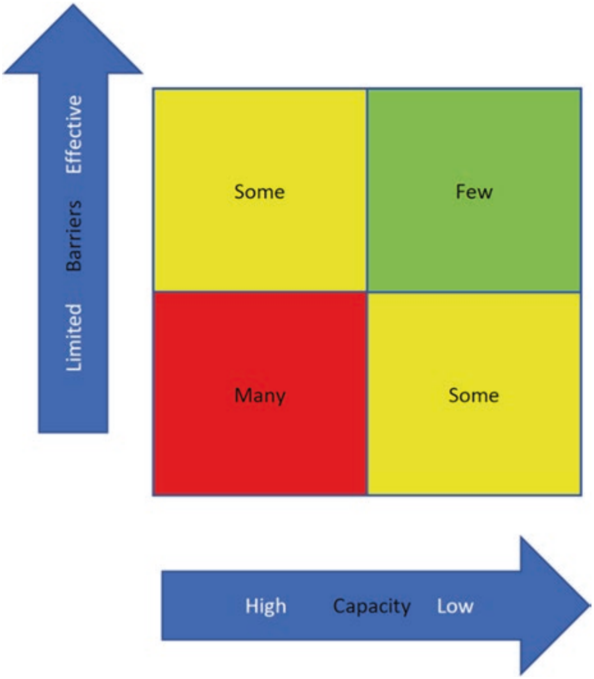

Fig. 7.5 Risk willing environment matrix. (Source: Authors own work)

Figure 7.5 sets out a risk willing environment matrix. From this matrix, if there are low consequences and low risk of exposal, then there is a higher risk of an attack resulting in more insecurity. On the other hand, if the risk of exposal is high, and the consequence is also high, then the object is secure and the risk is low.

In Denmark, the penalty for conducting an act of terror is prison and quite often lifetime imprisonment (Danish Penalty Code § 114) (see Danish Penalty Code 2019). This also applies as the penalty for abetment in a terror attack (Danish Penalty Code § 114, cf. § 21). The risk of being wounded or killed during the execution of a terror attack is also considered a risk probability. Case in point, in 2015 when the terrorist Omar Abdel Hamid El-Hussein was killed by the police in a manhunt after killing civil victims and injuring six armed police officers (Dagblad 2020).

From this figure, combining the paradigm, "Risk of Exposal" and "Consequence", results in defining "intent".

In short, the lower the risk of exposal and consequence, the more likely terrorists are to execute an attack, and the higher the risk and consequence, the more secure society is from terror attacks.

4.3 Red Teaming

"Red Teaming" is a way to test the security system at a facility. By trying to successfully overcome security, one gains knowledge of the effectiveness of the existing security and suggests areas where improvement of security is required.

In Denmark, a large number of "red team attacks", as part of drills, both in ports and other facilities, including facilities being highly secured, are conducted each year. From those "red team" attacks, it has become understood that it is very easy to bypass security and gain access to a facility of any kind. The conclusion of the easiness of breaking security measures at a facility is that security is a perception, a feeling, and, perhaps, even an illusion. Security is primarily effective due to the expected consequence and the risk of being exposed.

The success of "red team" operations does not provide a true picture of the possibility of breaching a security system, as the consequence of exposal is only an unsuccessful mission with little to no risk of criminal consequence such as life imprisonment in Denmark or the risk of the death penalty in other countries. Here, the "consequence" is keeping terrorists from attacking an object, as very few people are willing to risk the harsh penalties that security breaches entail about terrorism.

4.4 Barriers and Capacity

Capacity is a definition developed by the Danish Security and Intelligence Service, "PET" (PET 2020). A capacity is defined as the accessible means (personnel, technology, equipment, etc.) combined with the ability (training, skills, logistics, etc.) to use these means to the fullest in a potential attack (PET 2020).

The barriers are all the means offered by society to resist terror. Factors such as economic potential, social relations, the individual's possibilities of success, and the protection of an object are all barriers (CERTA 2016).

When the capacity is low, and the barriers are high, the likeness of an attack is low and the attacks are few, but if an organisation or an individual has high capacity, and the barriers are limited, the risk of an attack is high.

4.5 A Thesis of How to Assess Potential Terrorists

According to definitions from "Assessment of the Terror Threat against Denmark, (PET 2020), these are the following definitions of intent and capacity:

- Intent: will/intent to employ a certain capacity against a certain target or group of targets.
- Capacity: the accessible means (personnel, technology, equipment, etc.) combined with the ability (training, skills, logistics, etc.) to use these means to the fullest in a potential attack.

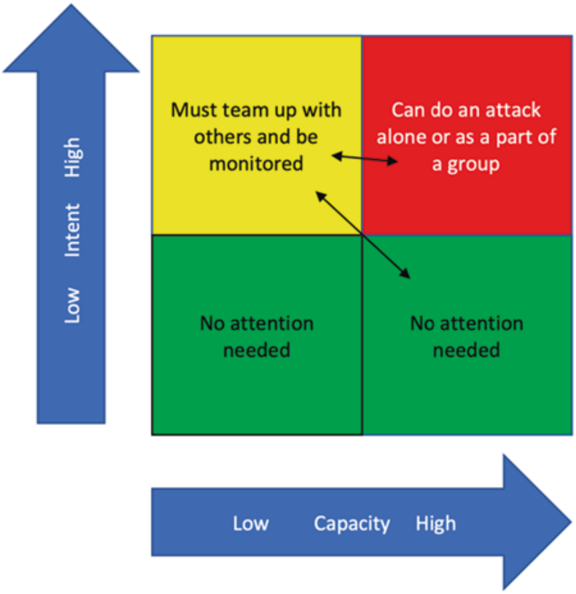

Fig. 7.6 Assessment of potential terrorists. (Source: Authors own work)

When combining intent and capacity, it must be the case that the combination of low intention and low capacity does not pose a threat. High capacity combined with high intention but low capacity requires a person or group without intention, voluntarily or forcibly, to cooperate with others with high intention, but individuals or groups with high intention and high capacity are immediate potential terrorists.

This can be described in the matrix at Fig. 7.6.

5 Combining Consequence and Risk of Exposal with Barriers and Capacity

When combining the two introduced matrixes, one will obtain an overarching picture of how to make effective security to counter terrorism. This is illustrated in Fig. 7.7.

The ISPS Code is a part of enhancing "risk of exposal" and "barriers". The procedures of securing a port facility with patrolling and the three security levels, for example, provide a way of making it easier to determine an attack because there is a much greater chance to identify an attack as there are far fewer people without a legal purpose within the port facility than if it was open to public admittance.

Other important measures are mass surveillance of the population, both physically, with CCTV, and by logging data on the Internet. The reduction of personal liberty to visit physical and virtual places makes it much easier for authorities to

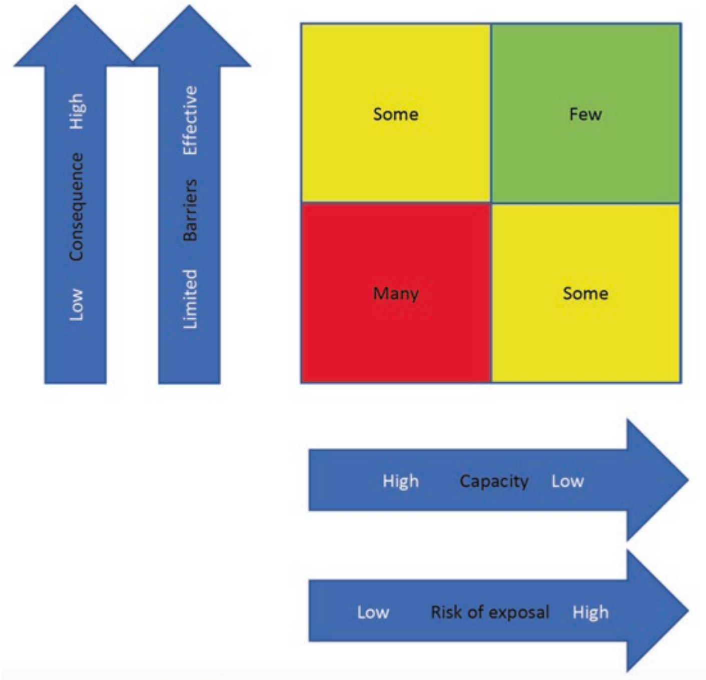

Fig. 7.7 Risk of attack. (Source: Authors own work)

discover any personal or virtual interest in potential targets and planning of a terror attack. All persons refrain from visiting physical or virtual places if their visit is only a result of curiosity, and the few visitors, for instance, on Islamic terror-related online places, are easy to discover for the authorities. Therefore, mass surveillance eliminates nearly all traffic but the relevant interesting traffic and, therefore, the few visitors are easier to eliminate.

5.1 Evaluation of the Efficiency in Perspective on "Return on Investment"

The effectiveness of the security requirements of the ISPS Code to prevent terrorism worldwide is undocumented. Consequently, it must be estimated that it has contributed to reducing terrorism on a global scale. Therefore, it is interesting to investigate what was the impact of terrorism before the introduction of the ISPS Code. This is now covered by security activities based on the introduction of the ISPS Code in 2004. However, one must assume that during the transition period from 2001 to the final implementation of the ISPS Code around 2005 and 2006, there has been an increased security preparedness in the world that has reduced the desire to engage in organised crime with a more governmental focus on securing facilities.

Searching the Internet for acts of terror at sea does not yield any results. However, there is a memorable terrorist activity, namely the cruise ship *Achille Lauro*, on October 7, 1985, when "Palestinian Liberation Front" hijacked the ship and killed a 69-year-old American citizen with Jewish ethnicity. Other relevant activities that are on the verge of living up to the definition of terrorism are the many pirate hijackings of cargo ships around East and West Africa.

If we consider general information found on general and wide search at the Internet, the hijacking of ships with hijackers from Somalia started in 2005, which is close after the introduction of the ISPS Code. There have been frequent hijackings of ships in this geographic area until 2020. Piracy now also appears in West Africa at the Gulf of Guinea as well as in Southeast Asia. One could argue that there would have been more international terrorism targeting ships, ports, and port facilities, and use of ships to transport effects to carry out terrorism around the world without the ISPS Code.

The effect of the ISPS Code, like any other preventive work, is impossible to measure or estimate precisely. Based on the conclusion of "Combining Consequence and Risk of Exposure with Barriers and Capacity" (Fig. 7.7), it would seem logical to state that the ISPS Code has reduced potential terrorists' motivation to use the maritime sector as a means to carry out terrorist acts. However, it must also be mentioned that the Danish authorities have specifically stated that there are no threats to Danish ports in several risk analyses, published from 2003 to 2020 (PET 2020), which may seem paradoxical in the light of the fact that Denmark in the same period has been at the second-highest threat level (PET 2020). The reason behind the high threat level is the threat of Islamist terror, which could well have been aimed at ports, port facilities, or the use of the maritime sector as a starting point for terrorism.

At this juncture, it can be concluded that one cannot reasonably precisely estimate a measurable positive effect of the introduction of the ISPS Code, only qualitative assessments.

The financial costs of introducing the ISPS Code worldwide have not been calculated ("Notat, Danske Havne" 2013). In Denmark, the industry organisation "Danish Ports", "Organization of Danish Ports" in 2013, estimated the following for the 83 ports to comply with the EU rules and the 211 port facilities that were located at the same ports, but also had to be secured, according to the ISPS Code for all 294 "port structures":

- Investment in infrastructure between 2004 and 2013 for all ports and port facilities:
  - DKK 45,000,000 equivalent to US $ 69,000,000 or € 60,000,000.
- In addition to this, the annual operating cost is:
  - DKK 60,000,000 equivalent to US $ 9,400,000 or € 8,000,000.

Based on the above, it is difficult to calculate the price per port and port facility since the individual ports and port facilities in complexity, size, and scope may be very different, but just for the sake of argument, one could calculate the price per port or facility to the following for all 294 “port structures”:

- Investment in infrastructure between 2004 and 2013 per port and port facility is:
  - DKK 1,530,612, US 235,478, € 204,000.

In addition to this, the annual operating cost is: DKK 204,000, US $ 31,400, € 27,200.

Citizens have been deprived of freedom as a result of restrictions on the right to move freely at port facilities, and the consequences of increased physical and virtual traffic surveillance can by no means be settled. It is, nevertheless, clear that mass surveillance causes behavioural changes in those monitored as well as potential abuse by those having access to the data generated by the mass surveillance (Foucault 1997).

6 Security as Part of Sustainable Development Goals (SDG)

Based on the available data, it is not possible to demonstrate that the ISPS Code has helped to protect the world community against terrorism. However, it can be demonstrated that the acceptance of the sudden loss of human life is very low when the grounds are terrorism but that the acceptance of the loss of human life based on other things such as road accidents and liberal gun laws cannot be seen in radically targeted efforts and structural changes to reduce these death rates.

Further, it can be shown that the financial costs of the implementation of the ISPS Code have been very high in Denmark and that the global investment must have been a not insignificant multiple of the Danish investment, but certainly not in the ratio of 1:1, as Denmark has traditionally been very little secured against criminal acts and terrorism in which against more totalitarian states must already be assumed to have had significant costs in regulating the free movement of inhabitants.

It is not established, but seems rational to assume, that human costs in the form of loss of freedom have been inflicted on the population of several countries as a result of mass surveillance.

In marketing, when pricing, one often uses the formula: Perceived value/price > = 1. When assessing whether the ISPS Code has had a value concerning Return on Investment (ROI), the answer must be negative in the light of the findings. It has indeed been overkill and off-target when looking holistically at its breadth and scope. Do we need to establish an international framework involving co-operation between contracting governments, government agencies, local administrations and the shipping, and port industries to detect security threats and take preventive measures against security incidents affecting ships or port facilities used in international trade? The answer is: Yes, IMO and EU have in place a system to monitor the ports, port facilities, passenger, and cargo ships.

A synoptic overview of the current system as well as consultation with concerned officials also provides answers to the following questions:

> Do we have to establish the respective roles and responsibilities of the contracting governments, government agencies, local administrations, and the shipping and port industries at the national and international level for ensuring maritime security?
>
> *Yes, the bureaucratic governmental and tactical system has been implemented.*
>
> Do we ensure the early and efficient collection and exchange of security-related information?
>
> *Yes, the bureaucratic governmental and tactical system has been implemented.*
>
> Do we provide a methodology for security assessments to have in place plans and procedures to react to changing security levels?
>
> *Yes, the bureaucratic governmental and tactical system has been implemented.*
>
> Do we ensure confidence that adequate and proportionate maritime security measures are in place?
>
> *Yes, the bureaucratic governmental and tactical system has been implemented.*
>
> However, the remaining question is: Could we spend the money and efforts in a better manner, both regarding to the SDG and keeping the sea secure?

7 Towards a Better Security to Support SDGs and Beyond

The previous sections describe how the ISPS Code is implemented in Denmark through EU legislation that is generally applicable in all member states.

From the analysis set out in the previous sections, it would appear that there is no clear and definable value for money in the current ISPS Code implementation, and the security risks in the ISPS Code supply chain are not comprehensive. For example, cargo is not necessarily secure before entering a port, and at security level one, nearly no cargo is examined despite security level one being the standard security level in all ports. In Denmark, security levels two and three have been set under ten times since 2004. The number is unofficial because the exact number is not to be exposed, which is announced by TBST.

Since the purpose of the UN 2030 Agenda for Sustainable Development is to minimise resource consumption, according to SDG 12 (Responsible consumption and Production), it will make sense to investigate how to adapt the resources to this in a more purposeful way.

If the world community maintains port facilities as a means of securing the world against terror and optimises it according to the Goal 12 of the SDGs, the ISPS Code could be changed in the direction described beneath.

Instead of the current description of the ISPS Code with the mandatory activities according to section A and the guidance in section B, the security should be carried out in the light of adequate security in the specific sending and receiving port facilities, wherever it is in the world. As it is now, the ship must keep a record of the last ten visited ports. In the light of ROI, the risk is not to know the last ten embarked ports. The appropriate question to answer is what it carries from one port facility to another? Therefore, the security measures must address that cargo loaded in one port is delivered correctly to the recipient, whether it is dangerous or harmless cargo.

As the figures in Sect. 7.1 suggest, the assessment will be tactical, simple, and logical.

7.1 Appropriate Security Measures

Appropriate security measures should be carried out, looking at four different situations (Fig. 7.8):

1. Local Threat: Is the port facility or the city, where the port is situated, objects for terror. If no, no measures are required.
2. Global Threat: Is there a global threat, where the port facility could be used for transportation of means of mass destruction. If so, the object to secure is "Dangerous cargo".
3. Dangerous Cargo: Cargo, stores, and goods with the potential or purpose of mass destruction should be secured in every way possible.
4. Harmless Goods: If not tampered, it should not be subject to security, according to local or global security, but only secured against theft, etc. If tampered, it should be restored by the port or authorities and categorised as "Dangerous cargo".

The security procedures concerning the above measures are the following:

1. Local Threat: Local authorities make adequate security.
2. Global Threat: Proper security measures should be carried out based on a risk assessment between the port facility and the receiving port facility. The threat and the arranged security could be reported to a system, which could be GISIS until the threat is terminated.
3. Dangerous Cargo: Proper security measures should be carried out based on a risk assessment between the port facility and the receiving port facility. The threat and the arranged security could be reported to a system, which could be GISIS until the threat is terminated.
4. Harmless Goods: requires no security activities.

Fig. 7.8 Matrix to appropriate security. (Source: Authors own work)

Fig. 7.9 Dual port security. (Source: Authors own work)

If the proposed procedure was used, it might only be necessary to take security measures for the type of cargo as shown in Fig. 7.9:

Implementing this system would only require the ability to identify risk elements and surveillance of reported risks in the system, where the security risks are reported.

As this method always provides aligned security measures, but also adequately and individually arranged, based on a structured analysis in each situation, this system would be just as efficient as the current system if not more efficient. The current ISPS system often seems too ambiguous the minds of PFSO, the security personnel, and even less meaning to the politicians and the citizens in general.

7.2 Sustainable Development Goal 14 Combined with Goal 17

The first 16 SDGs could all benefit from a simple and secure security system, especially SDG 14 (Life below water), which is explicitly connected to the maritime sector. Most importantly, security aligns in a befitting manner with SDG 17, that is, partnerships for the goals. For further information on the 17 goals, see United Nations (2020b).

Resources better spent (SDG 12, responsible consumption, and production) would have a direct positive impact on SDG 1 (no poverty), SDG 2 (no hunger), and SDG 16 (peace and justice). The question is: Would it have a negative impact, directly or indirectly, on any of the goals? The answer is that it will not harm any of the goals. Rather, it would have an indirect positive impact on the first 16 goals. Those indirect positive impacts would be on SDG 3 related to good health and well--being and SDG 6 related to clean water and sanitation. If there is any impact, it would be less pollution, fewer chemicals in the human body, etc. and in turn, supporting the other goals if not neutral to these.

Currently, a fundamental question, and perhaps the obvious "low-hanging fruit", is whether the EU be considered as an MS regarding the ISPS Code. In doing so, without any further legislation, shipping of cargo within EU countries would not need to be secured according to the ISPS Code or EU legislation. It would only have to be secured when being transported between the EU and countries outside of the EU. The amount of resources saved this way is hard to assess, but given the amounts spent in Denmark between 2004 and 2013, and the annual spend amount, there would certainly be important resource-savings made, supporting the implementation of goals and targets with regards to the SDGs.

8 Conclusion

When looking beyond 2030 and after the expiration of SDGs—with a focus on preserving and conserving the eco-system and marine environment—while still making efficient use of the sea as a means of transportation for both passengers and cargo—it is clear that the system must include measures against crime and accidents.

The very clear definition of "sustainable development", that is, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (The Explorer 2020), is completely in line with the requirement of the ISPS Code and is the direct reason why security must be accurate and sufficient. When requirements demand implementing security arrangements that are redundant, there is an unnecessary and wasteful strain on limited resources. This inefficiency drains current resources and may well compromise the ability of future generations to meet their own needs. The same applies to security arrangements that are "off target" in nature. If security measures are not implemented in an appropriate manner, it could result in the endangerment of many lives while putting pressure on future economic sustainability. Clearly, this should be a high consideration as we move forward to 2030 and beyond.

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Chapter 8
Port and Maritime Security and Sustainability

Michael Edgerton

Abstract Maritime and port security are key components in the sustainable development of the global maritime transportation system. Security supports sustainable development by enhancing system resilience and minimizing potential disruptions which could negatively impact the economic development, environmental conditions, and social stability of affected countries and communities. Further, maritime security efforts to protect natural resources and fisheries are critical to the sustainability of the world's oceans and, in some cases, contribute directly to the stability of national governments and regions. Current approaches to maritime and port security do not necessarily reflect either the importance of maritime security to sustainability, or vulnerability of the maritime supply chain to disruption. The focus on ports and ships as targets, coupled with the lack of a global standard for cargo security or information security, potentially makes the maritime shipping industry vulnerable to disruption which, in turn, can negatively impact global sustainability.

Keywords Port security · Maritime security · Fisheries · Governance · Resilience to climate change

1 Introduction

Maritime and port security are key components in the sustainable development of the global maritime transportation system. Security supports sustainable development by enhancing system resilience and minimizing potential disruptions which could, in turn, negatively impact the economic development, environmental conditions, and social stability of affected countries and communities.

To promote resilience and sustainable development in the maritime domain and ports, security efforts and initiatives will need to move beyond the current regulatory regime which is focused on the International Ship and Port Security (ISPS)

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Code. The ISPS Code was developed by the International Maritime Organization (IMO), a specialized agency of the United Nations after the terrorist attacks of September 11, 2001 and consists of a non-prescriptive, outcomes-based set of requirements for both vessel and port security.

The focus of the Code, as outlined by the IMO (undated) is on ports and ships as targets of terrorist attack and less on ports and vessels as the conduits of security threats. Further, the Code has not been significantly revised since is implementation and does not include specific requirements regarding cybersecurity or information security. This is being addressed for shipping through modifications to Safety Management Systems but not being addressed internationally for seaports. Finally, there is no global mechanism to assure the implementation internationally and each country is responsible for self-reporting compliance of their respective vessel fleets and ports. Further information and guidance can be found on the IMO website at: http://www.imo.org/en/OurWork/Security/Guide_to_Maritime_Security/Pages/SOLAS-XI-2%20ISPS%20Code.aspx.

The international community will need to incorporate protection and resilience of trade into security coordination. This includes an expanded focus for the security of cargo, in addition to the current ISPS Code focus on ships and ports, for example the need for designated personnel dealing specifically with security matters, and will likely involve an expanded set of stakeholders including customs services as well as international organizations such as the World Customs Organization (WCO). While there currently are voluntary and incentivized cargo and trade security programs, there is no globally accepted and mandated code similar to the ISPS Code. Examples of incentivized programs include the Authorized Economic Operator (AEO) concept developed by the WCO, whereby shippers and ports can obtain streamlined access to other participating countries by demonstrating enhanced security. Therefore, there are opportunities to integrate supply chain security initiatives into existing maritime security regimes which will contribute to greater resilience and confidence in the security of the system.

There are some programs developed by individual nations that have applicability as well such as the Container Security Initiative (CSI) which was initiated by U.S. Customs and Border Protection (CBP) on a bilateral basis with participating ports and countries. CSI allows for US CBP officers to be deployed to container ports outside the United States where container cargo bound for the U.S. is loaded. The CBP officers work in partnership with host nation customs and security officials to electronically screen and in some cases, physically examine targeted cargoes before they are loaded on ships bound for the U.S. The U.S. offers reciprocity by allowing partner nations the option of deploying their customs officers to U.S. ports that load cargo for host nation ports as well.

Additionally, there are opportunities to incorporate trade resumption and resilience planning into existing safety and security risk management programs to minimize the impact of trade disruptions on vulnerable communities. This approach would be both scalable and risk based, allowing for the prioritization of trade resumption based on national and regional requirements.

Finally, the protection of natural resources, including fisheries, is crucial to the stability of regions and contributes to the sustainability of populations and economies. In particularly vulnerable or unstable areas, the enforcement of environmental and fisheries laws requires an international maritime security approach.

2 Defining Sustainability and Resilience

According to the United Nations (UN), sustainable development has been defined as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development calls for concerted efforts towards building an inclusive, sustainable and resilient future for people and planet. For sustainable development to be achieved, it is crucial to harmonize three core elements: economic growth, social inclusion and environmental protection. These elements are interconnected, and all are crucial for the well-being of individuals and societies."*

Resilience is the capability to absorb undesirable or unexpected events with minimal impact and to quickly recover operations. The UN Office for Disaster Risk Reduction (UNDRR undated) defines resilience as, "*The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures."*

These definitions link resilience to the ability to sustain operations and activities in a manner in which they can resist negative external forces and maintain a level of benefit to the users without excessive degradation.

3 Sustainable Development, Disruption, and the Maritime Domain

By addressing the resilience of maritime transportation systems as a critical part of the strategy to protect critical infrastructure, the vulnerabilities and possible consequences of natural disasters, accidents, terrorist or criminal activity can be effectively managed and mitigated. This approach further enhances and supports economic, social, and environmental sustainability by minimizing the impact and "down time" of the maritime transportation system, which is predicated on the ability to treat risk by managing changes in consequence and vulnerability. Further, resilience is focused on maintaining the ability of the protected system to continue operations in all but the most extreme conditions.

Examples of resiliency measures in transportation systems include flexible and alternative transportation routes, nontraditional hubs that are not normally used for maritime commerce but could be used if necessary, to assure the flow of commerce and relief supplies. Further, in anticipation of severed or reduced communication, there is a need to plan ahead for the empowerment of local decision-makers, identification of alternate operating sites for management, risk-based approach to the deployment of security resources, regulatory flexibility in emergencies, and the identification and where possible, the pre-staging of critical supplies.

Sustainable economic development is reliant on the ability of global commerce to move rapidly and efficiently. This has become more apparent in recent decades as global shipping moves toward an environment of "Just-in-Time" delivery. This means that the global supply chain is increasingly sensitive to disruption as industries seek to reduce the costs of stockpiling products and the associated warehousing costs.

3.1 Threats to Maritime Security

Threats to maritime security and stability include terrorism, crime, and state (i.e. naval) conflict. Crime and criminal activity have been present in ports and on the high seas throughout history. Criminal activity may include smuggling, theft, environmental crimes, the violation of fisheries laws and regulations, and the violation of international embargoes. Threats from nation-states include the potential for incursions in territorial waters and exclusive economic zones to exploit or seize (or deprive other nations') natural resources, claims to disputed territory, or the deprivation of access to shipping lanes or ports. Terrorist threats can include the targeting of ships and ports for attack or the exploitation of the maritime transportation system as a conduit for the smuggling of people, weapons, money, or other contraband.

3.2 Protection of Marine Resources

The protection of marine resources has direct implications to the resilience of societies, economies, and the environment for several reasons. In many countries, fisheries, the extraction industries (oil and minerals), aquaculture, and tourism, are all dependent on sustainable and environmentally responsible policies to protect marine resources in order to ensure these industries remain viable for long periods of time. A failure to protect marine resources can lead to political instability and insecurity.

3.2.1 Piracy as a Result of Resource Unavailability

Additionally, the issue of maritime piracy, which is basically a form of criminal activity, is unique because of its occurrence in areas of the high seas that are not subject to any nation's territorial jurisdiction. Further, piracy thrives in areas where the rule of law is weak or non-existent. This lack of effective governance is often accompanied with unbridled exploitation of natural resources, including fisheries, and energy sources which also negatively affects economic sustainability. The most high-profile example of the lack of sustainable fisheries and coastal areas leading to the rise of piracy is the case of Somalia. Somali fishermen were pushed out of the richest fishing areas by foreign fishing fleets that had larger, more efficient ships and operations. Faced with a loss of livelihood and lack of any effective government to address foreign incursions, the fishermen allied themselves with local militias, who filled the vacuum in governance, and embarked on ship hijacking for ransom (Kantharia 2019).

For near-term solutions, piracy can be combated through the application of military or maritime law enforcement power, but this approach provides only temporary relief to ships and their crews and does not solve the larger, systemic issues that allow piracy to thrive (Williams and Pressley 2013). Examples include the deployment of multinational naval forces to the Horn of Africa region to provide escorts to merchant shipping and to combat piracy. The effect over time reduced the attacks on shipping but since the causes of piracy are not being meaningfully addressed, the departure of those naval forces will likely result in a resurgence of pirate activity. Those causes and systemic issues include building governance capacity in the affected regions, ensuring the targeted and effective delivery of international aid in the form of training, equipment, and sustainment, as well as strengthening the rule of law and providing economic alternatives to piracy.

3.3 Enhancing the Focus on Cargo Security

Since September 11, 2001 (more commonly known as 9/11), when there were coordinated attacks on the US by terrorists, the focus on port and vessel security has largely, but not exclusively, been framed by the implementation of the ISPS Code. Due to the anticipated and continued increase in global cargo volume as well as the focus on "Just-in-Time" delivery of goods, the focus of port and vessel security in the future will likely shift to a focus on ports and ships as conduits within the supply chain rather than being only targets. This will be due to an increasing concern for the safe and secure movement of cargo. "Just-in-Time" delivery is a supply chain concept to reduce warehousing and storage requirements for cargo. In some cases, there is also a reduction in "moves" within a supply chain thereby eliminating some transfers among logistics providers. The concept is intended to reduce costs but has the additional effect of increasing the sensitivity of supply chains to disruption as they are reliant on timely deliveries.

The factors that will contribute to the shift from port and vessel security to cargo and supply chain security include:

- Port and ship security requirements are well established through the ISPS Code, but the Code focuses on ships and ports as terrorist targets not as conduits of illicit activity, cargo theft, or movement of contraband including the potential introduction of Weapons of Mass Destruction;
- As global trade continues to increase at very rapid levels, there is more cargo in the system;
- There is an increasing reliance on "Just-in-Time" delivery which makes the global supply chain highly sensitive to disruption with greater potential impacts; and.
- The movement of cargo is also increasingly dependent on large amounts of financial, personal, and cargo information moving digitally, which increases the risks of converged security challenges (cyber, physical, and operational).

3.4 Limitations of the ISPS Code

The ISPS Code was introduced after the terrorist attacks of 9/11 and came into force worldwide in 2004. Because of the focus at the time on the protection of critical infrastructure, the Code was designed to emphasize the prevention of terrorist attacks on ports and ships rather than the use of ports and ships as conduits of illegal activity, contraband, or persons. While addressing access control and some cargo issues, the focus on cargo security was minimal. To address cargo security issues, US Customs and Border Protection (CBP) initiated additional programs to focus on cargo security to include the positioning of CBP staff at the largest container ports around the world, under the aegis of the US CSI, to serve as liaisons and to coordinate the screening of US-bound cargo as well as the expansion of incentivized, voluntary cargo security programs such as Customs-Trade Partnership Against Terrorism, which is the US implementation of the WCO's Authorized Economic Operator (AEO) program.

Further, the ISPS code was implemented before the rapid advancements in information technology, the internet, and the shipping industry and therefore, did not address cybersecurity in any detail. The Code makes reference to the protection of information but does not specify any standards or requirements.

Thus, the ISPS Code, while still relevant and very effective in protecting ships and ports from attack, is not designed to fully address cargo security issues and emerging cybersecurity challenges associated with the industry.

3.5 Expansion of Global Trade

Global trade continues to expand at an extremely rapid rate. The United Nations Conference on Trade and Development (UNCTAD), in its Review of Maritime Transport 2019 (UNCTAD 2020), shows the yearly increase in global maritime trade as increasing 2.7% between 2017 and 2018. With the exception of a slight decrease in trade in 2009 as a result of the global recession, trade has nearly doubled since 2000. UNCTAD projects trade to continue to increase around 3.5% per year through 2024. The expansion of trade will continue to drive increased cargo throughput in ports around the world which could result in greater potential disruption of the supply chain.

As many ports are located within cities, the real estate constraints of existing ports in some regions are fairly significant. This has resulted in a global increase in the development of new ports in areas where land is more plentiful as well as the expansion of existing ports through the creation of inland container yards that are not physically adjacent to the port. These developments create both security opportunities and security challenges. The construction of new ports provides the opportunity for security (physical, operational, and cyber) to be designed into new projects. Properly planned and executed, this approach can provide security efficiencies that can contribute to the overall efficiency of a new port. For existing ports, the increase in moving cargo to off-port inland storage areas complicates cargo and supply chain security within port regions, by adding additional movements within a port network. This requires additional measures of tracking, information-flow, and physical security that previously may not have been necessary.

3.6 "Just-in-Time" Delivery and the Sensitivity of Global Trade

Just-in-Time delivery of products continues to drive changes in shipping and supply chain management. Since its inception in the 1950s and 1960s in the Japanese auto industry, the concept of retaining minimal inventory by retailers or manufacturers has continued to mature and expand to many more industries. The result is the reduction in large warehousing operations and an increase in regional, smaller warehouses where small inventories are kept for short periods of time. Therefore, the concept of "Just-in-Time" delivery relies on the continued functionality of its associated supply chain to ensure the delivery of goods and parts when necessary. A disruption of any part of the supply chain, whether due to physical threats or risks, shutdowns due to labor strikes, or a lack of trust in the integrity of the supply chain can have an extremely disruptive effects on industries, markets and economies. A recent example of the impact of disruption on supply chains, albeit not for security reasons, is the Covid-19 pandemic. According to Burnson (2020), as a result of the shutdown of production and seaports in China, US west coast ports such as Los Angeles and Oakland initially saw reductions in container volume of up to 30%.

While estimates vary, a potential shutdown of ports on the West Coast of the US is estimated to have a financial impact of anywhere from several hundred million US dollars per day to one billion dollars. Further, shipping was disrupted in other geographic locations as ships were stuck at anchor off US ports while other ships delayed departures from Asian and European ports until the labor dispute was resolved. A study performed by Inforum (Interindustry Forecasting at the University of Maryland) in 2014 projected that the potential economic impact of a 10-day shutdown of U.S. west coast ports would result in 169,000 jobs being disrupted, a reduction in the Gross Domestic Product of 0.12% and a daily cost to the U.S. economy of $2.1 billion dollars per day (Interforum 2019).

3.7 The Convergence of Operational, Physical, and Digital Security

The maritime industry, like other industries, is in the throes of adapting to the Digital Age. For shipping and ports, cybersecurity has several distinct characteristics. Cybersecurity is important to the Operating Technologies (OT) within ports and shipping companies as it can have a direct effect on the ability for those elements of the industry to perform. This includes systems such as Supervisory Control and Data Acquisition (SCADA), other Industrial Control Systems, security scanning and access control systems, ship navigational and propulsion systems.

Additionally, the shipping industry is rich in data that could be valuable to criminals or terrorists. This includes personal and human resources data, financial data (such as contracts, banking details, and money transfers), cargo data (including cargo contents, destinations, shipper and consignee information, and cargo seal numbers, etc.), and other logistics and business operations systems. In the well-known case of the Port of Antwerp, Belgium, Robertson and Riley (2015) indicate that criminals were able to access information systems in the port, including the Terminal Operating System for 2 years beginning in 2011 and were able to use the information they obtained to target cargo for narcotics trafficking and to facilitate cargo theft.

3.8 A Challenge of Governance

A significant challenge to the likely shift to an emphasis on cargo or supply chain security is the lack of a globally accepted and mandated standard. There are a number of standards and codes that provide some governance to supply chain security programs, but none of them are mandatory. Further, there is no industry standard governing cyber security.

Common supply chain security programs, codes and standards include the World Customs Organization's SAFE Framework (WCO undated), the International Standards Organization's ISO 28000 series (ISO 2007), and numerous national and regional programs such as the US Customs-Trade Partnership Against Terrorism (CTPAT) (US Customs and Border Protection undated) and the European Union's Authorized Economic Operator (AEO) program (European Union undated). All of these programs have common features that include a focus on the vetting and reliable behavior of participants. Unlike the ISPS code, which focuses on physical and operational issues, most supply chain security programs require that there be a history of complaint behavior by participants before full acceptance into the programs. Further, participants must have well established security policies in place, including processes to protect the integrity of data that is shared with government regulators.

While the ISPS code is mandatory for ports and ships that trade internationally, supply chain programs are not mandatory and are incentivized by the promise of expedited entry into target markets and minimized inspections by participating customs agencies. In reality, the level of expedited access appears to vary, with some programs being perceived as more beneficial to participants than others.

Additionally, there is no global cybersecurity standard or requirement for ports or shipping. The IMO intends to require that cybersecurity be included as a component in the Safety Management System of ships starting in January 2021 but there is no similar global effort for ports (see IMO 2017). Further, by including the cybersecurity requirements in the Safety Management System, the focus is likely to be on the potential risks for cyber-attacks or compromise to vessel operating systems rather than the protection of sensitive data.

Therefore, cybersecurity in ports remains largely ungoverned, except for the efforts of some national governments and the growing interest by insurers to establish baselines of cyber- and information security before underwriting insurance policies. For example, the US Coast Guard has developed an approach to cybersecurity that will involve cybersecurity being included in the development and approval of Facility Security Plans (US Coast Guard 2020). These national level efforts, however, do not equate to a globally accepted approach to maritime supply chain and cargo security.

3.9 Maritime Security and Resilience

Considering the characteristics and developments noted previously, which include increased trade, greater sensitivity to disruption, the convergence of cyber, physical, and operational security, and a lack of global governance beyond the ISPS Code, it is likely that there will be a shift in port and maritime security from ports and ships as targets to a supply chain approach where ports and ships are conveyances and conduits. This approach would be directly supportive of efforts to build sustainable economies that also support responsible social and environmental policies.

Specific areas of emphasis and focus can include:

- Focus on infrastructure, ships and ports as facilitators, conduits, and conveyances of cargo, goods and people. This requires a shift in thinking away from the current emphasis on ships and ports as potential targets of possible attack or compromise;
- The realization that information and data in the maritime industry is as important as the infrastructure. This includes the potential for cyber-attacks and compromise that may target navigation systems, operating technology or industrial control systems but also the potential and equally important potential compromise and manipulation of data to facilitate the trafficking of contraband, cargo theft or financial crimes;
- In order to address these converged risks in a comprehensive and industry-wide manner, port cybersecurity standards or requirements should be developed and included in the development of supply chain security standards that should be globally accepted and enforced. These supply chain security requirements should be developed and promulgated by a respected, international organization with some sort of official status as an Intergovernmental Organization (preferably within the UN system) and should be required to be implemented along the same lines as the ISPS Code with the commitment of all signatory countries to implement and enforce the new Code. If the IMO is not the appropriate organization for port and supply chain security standards, then other potential candidates could include the World Trade Organization or World Customs Organization; and.
- Maritime industry port and vessel operators need to organize themselves to reflect the changing requirements of the Digital Age. The roles of the PFSO and the IT Director will need to be aligned in some form in order to ensure a unity of effort across all facets of security within the organization. Further, this effort will require high visibility in top management and staffing and position descriptions will need to adjust to reflect the need to provide senior leadership expertise in cyber security and cargo security.

3.10 Protecting the Sea Lines of Communication

Both maritime trade routes and the chokepoints through which some of the trade routes flow comprise what naval strategists' term, Sea Lines of Communication (SLOCs). This term, while not invented by the US naval strategist Alfred Thayer Mahan, was promoted by him in his important work, "The Influence of Sea Power Upon History", as a fundamental reason for the US Navy to expand into a global presence. He posited that ensuring the viability of SLOCs was in the vital national interest of the United States as most of our trade was borne on ships in international trade (Global Security undated). Therefore, the fundamental theory of SLOCs and their importance, remains applicable to maritime security today, particularly regarding the threat posed by modern piracy and non-state actors. SLOCs may be vitally important, even among nations in economic, political, or military competition and can rarely be considered vital for only one nation or bloc of nations. An example of this complexity is found in the trade routes that pass through the Straits of Hormuz.

The Straits of Hormuz form a chokepoint through which over 20 percent of the world's seaborne oil is moved (US Energy Information Administration 2019). Key consumers of oil coming through the Straits include Japan, China, and the US. While China and the US are perceived as international rivals, their economies are interdependent on each other in many sectors and they both need oil form the Arabian Gulf region, thereby ensuring that they both have a vested interest in ensuring the Straits remain open for shipping.

4 How Maritime and Port Security Can Support Sustainable Development

Resilient societies are dependent on sustainable economic, social, and environmental development. Due to the unique nature of the maritime domain as vital to both transportation and natural resources that support sustainable development, the security of ports and maritime approaches and territory has a vital role in the support of sustainable activities.

Specifically, the following are key areas where maritime security activities can support sustainable development:

- Enforcement of laws protecting the environment and natural resources. There are several important international treaties and conventions that govern environmental protection and the protection of resource in or under the sea. Further, many countries have additional legislation that governs the protection of resources. These may include more stringent pollution prevention requirements and fisheries protection laws. These are enforced with varying degrees of efficacy.
- Using security plans and regulations to build and enhance resilience. The measures mandated by the ISPS Code and supply chain security initiatives to secure ports from terrorist attack and other illegal activity contribute to the ability of a port area or ship to minimize the impact of a disruptive event. The plans typically include measures to enhance security during periods of heightened threat as well as response measures to be taken in response to emergencies.
- Ensuring freedom of the seas. A key function of naval and coast guard forces is to ensure that a nation's ability to ship cargo is not inhibited by nation-states or other parties. Further, security forces may be necessary to deter or respond to attempts by other parties to encroach on natural resources or pollute the maritime territory or Exclusive Economic Zone of a country.

Economic, social, and environmental sustainability are intertwined with the ability of countries and regions to ensure that access to maritime resources and transportation systems are unencumbered and managed responsibly. Maritime security measures, whether regulatory, or operational are critically important to the sustainability of societies that depend on the sea. Therefore, maritime security governance and regulation should be updated and refined to reflect changes in the industry over the last decades that have both increased the importance of maritime transportation as well as its fragility and the potential impact that disruptions may have on global economic, environmental, and social sustainability.

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Chapter 9
Governance of International Sea Borders: Regional Approaches and Sustainable Solutions for Maritime Surveillance in the Mediterranean Sea

Marco Fantinato

Abstract Over the past two decades the emergence of new threats in the Mediterranean Sea contributed to reshaping the definition of maritime security while also underlining the need to enhance maritime situational awareness for authorities and stakeholders involved in sea borders management within the European Union. Considering that more than 70% of the European Union's external borders are maritime and that the Mediterranean represents a crossroad between continents, maintaining a high level of vigilance in this regional basin is of the utmost importance. Cross-border crimes in the Mediterranean such as terrorism, weapons smuggling, drug-trafficking and irregular migration have an intrinsic transnational nature and are detrimental to the European Union and its Member States' economic interests. Therefore, collecting and providing solid intelligence at sea lies at the core of the European Union's Maritime Security Strategy. This not only requires using state-of-the-art technologies in the maritime domain but also calls for a stronger regional and international cooperation between European Union Member States and other Mediterranean partners, as well as sharing real-time information. Against this background, this chapter focuses on the evolution of maritime surveillance strategies and technologies used in the Mediterranean and the array of assets employed in the governance of the external maritime borders of the European Union. Further, opportunities for combining conventional surveillance operations at sea with more sustainable approaches in the Mediterranean are also explored.

Keywords Maritime surveillance · European Union external maritime borders · Sea borders management · Surveillance technologies and sustainability

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1 Introduction

More than 50% of the gross domestic product of the European Union (EU) is in maritime regions (EU Commission 2014) and this means that EU Member States (hereinafter Member States) have strategic interests that span across the global maritime domain (see Fig. 9.1).

The Global Blue Economy is set to grow faster than general economy, possibly doubling by 2030 (EIB 2018). In particular, the intra-Mediterranean maritime trade flows account for nearly 25% of the global traffic volume (UFM 2017). These aspects clearly underscore the need to enhance the Mediterranean situational awareness picture for all the stakeholders concerned. Identifying and responding to maritime security challenges is one of the EU priorities and surveillance activities conducted in the Mediterranean are crucial for both the EU and its Member States.

Currently, in the Mediterranean Sea, the following operations are active: (1) Operation Sea Guardian under the command of NATO; (2) Operation EUNAVFOR-Med Irini under the aegis of the EU External Action Service (EEAS); and (3) Joint Operation Themis under the technical coordination of the European Border and Coast Guard agency. Although these three operations have different remits, they all use air-naval assets to collect intelligence in the Mediterranean, each within its respective mandate. Agreements are in place to share and exchange information relevant for the maritime domain, however, there is no common platform where data collected by these three different organisations can be aggregated and comprehensively analysed. NATO and EEAS operations in the Mediterranean are military mis-

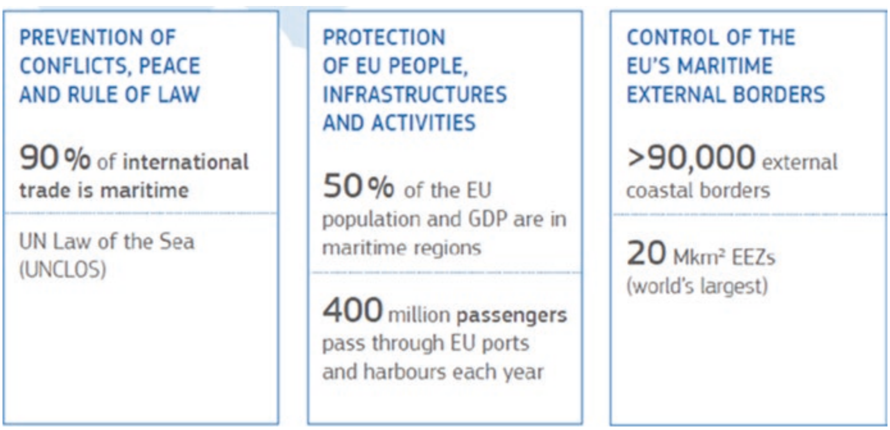

Fig. 9.1 EU maritime interests. (Source: European Maritime Security Strategy 2014)

sions regulated respectively by the North Atlantic Treaty[1] and by Council of the EU's decision 472/2020.[2]

Maritime surveillance activities under the aegis of European Border and Coast Guard mainly see the participation of coast guards and law enforcement actors and are governed by EU Regulation 1896/2019.[3] These three missions have different chain of commands and operational structures and do not share air-naval assets nor personnel. While NATO and EEAS mission deal with maritime security and defence and their personnel have military powers, European Border and Coast Guard officials are responsible for border control and use law enforcement powers. The scope of this chapter is limited to joint operations carried out in the Mediterranean under the technical coordination of EU agencies and does not cover NATO or EEAS military missions.

From traditional air-naval operations carried out by single Member States at sea, we are witnessing a gradual but progressive transition towards joint and multipurpose maritime operations conducted under the aegis of EU specialised agencies such as the European Border and Coast Guard agency (EBCG), the European Maritime Safety Agency (EMSA) and the European Fisheries Control Agency (EFCA). In 2017, these three agencies signed a Tripartite Working Arrangement to enhance cooperation on coast guard functions. Coast guard functions include tasks related to maritime safety, security, search and rescue, border control, fisheries control, customs control, general law enforcement and environmental protection. This EU interagency cooperation requires sharing human resources, air-naval assets and information to protect the EU maritime external borders and preserve Member States' interests across the Mediterranean through an approach based on integrated maritime surveillance. Technologies such as satellites used for maritime surveillance purposes, unmanned aircraft systems and maritime autonomous vehicles are playing a decisive role in this sector. These systems represent more effective, cost-efficient and sustainable solutions to detect unlawful activities at sea compared to conventional air-naval assets traditionally employed during surveillance and interdiction maritime operations in the Mediterranean.

For this chapter, the relationship between maritime surveillance and sustainability is to be understood as using multipurpose technologies at sea that are able to

[1] In accordance with Warsaw Summit Communiqué of 9 July 2016, paragraph 91, NATO transitioned from Operation Active Endeavour, an Article 5 maritime operation in the Mediterranean that contributed to fighting terrorism, to a non-Article 5 'Operation Sea Guardian', able to perform the full range of maritime security tasks.

[2] Pursuant to Council of the EU Decision 472/2020, Article 1, EUNAVFOR-Med is a military crisis management operation preventing arms trafficking and the illicit export of petroleum from Libya. Further, the operation provides assistance in the training of Libyan Coast Guard and Navy while contributing to combat human smuggling and trafficking.

[3] EU Regulation 1896/2019 establishes, inter alia, that the EBCG can provide increased technical and operational assistance to Member States by coordinating operational activities at the EU external sea borders. Within Joint Operation Themis, hosted by Italy, this translates into controlling illegal immigration, tackling cross-border crime and enhancing European cooperation on coast guard functions in the central Mediterranean region through a cross-sectoral approach.

efficiently detect illicit activities at sea while optimising the deployment of conventional air-naval assets and minimising the impact on the environment. The aim of this chapter is to explore the nexus between maritime surveillance in the Mediterranean and sustainability in the governance of the EU external maritime borders. Section 2 discusses traditional surveillance techniques at sea and conventional air-naval assets. Section 3 presents the EU Maritime Security Strategy and its interplay with maritime surveillance in the Mediterranean. Section 4 introduces the concept of integrated maritime surveillance within sea borders management of the EU. Section 5 delves into the new technologies being implemented in the field of maritime surveillance. Section 6 highlights how these technologies can contribute to a sustainable management of the EU external sea borders. Finally, Section 7 offers the concluding remarks.

2 Traditional Maritime Surveillance Operations and Conventional Techniques Within Maritime Spaces Defined by the UNCLOS

Before the 1982 United Nations Convention on the Law of the Sea (UNCLOS), maritime surveillance mainly referred to patrolling activities performed by coastal States' authorities within their territorial sea. Under this scenario, coastal patrol vessels and coastal radars were sufficient to conduct surveillance of these areas up to a limit of 12 nautical miles (nm) from national coasts. After the UNCLOS came into force, the Convention regulated a variety of maritime spaces whereby coastal States could exercise different degrees of sovereignty (Graziani and Leanza 2014). These spaces, according to UNCLOS, are the following:

1. Territorial sea—*territorial sea extends up to 12 nm (nautical miles) from the baselines established by the Convention. In this area, coastal States exercise full sovereignty.*
2. Contiguous zone—*the contiguous zone is a maritime area that may not extend beyond 24 nm from the baselines. In this area, jurisdictional powers of coastal States are limited to prevent infringement of their customs, fiscal, immigration or sanitary laws and regulations*.
3. Exclusive economic zone (EEZ) —*the exclusive economic zone is an area where coastal States possess sovereign rights only for the purpose of exploring, exploiting, conserving and managing the natural resources of the seabed, including the waters superjacent to the seabed and its subsoil. The exclusive economic zone shall not extend beyond 200 nm from the baselines*.
4. The high seas—*the high seas refer to an indefinite geographical area that comprises all maritime spaces subtracted from coastal States' jurisdictions*.

The Convention also addresses straits used for international navigation, archipelagic States and the continental shelf, however, these spaces are outside the scope of this chapter.

Along with the extension of maritime areas under the jurisdiction of coastal States, the codification of these maritime spaces contributed to a gradual erosion of the freedom of navigation principle originally applicable on the high seas (Conforti 1975; Bevilacqua 2017). Since the EEZ extended traditional surveillance activities of coastal States from 12 nm up to 200 nm from national coasts, technological developments that facilitated the exploitation of maritime resources in these extended areas have also warranted claims that coastal States' economic and environmental interests required protection (Klein 2011). These coastal States' prerogatives have thereby broadened the notion of maritime security fostering the phenomenon of 'creeping jurisdiction'[4] in the maritime environment (Kaye 2006; Fantinato 2017).

Coastal States were thus confronted with the need of extending the scope of their patrolling activities at sea by using offshore patrol vessels and radar systems that could cover well beyond the line of sight from their national coasts. Being the Mediterranean a semi-enclosed sea where there is no point whose distance from a coast is more than 200 nm, some challenges in extending surveillance activities in the maritime spaces defined by UNCLOS were faced by Mediterranean coastal States (Scovazzi 1994; Treves 2012).

Since the investments to purchase air-naval assets with higher performance and longer endurance, as well as upgrading the architecture of maritime coastal radars, were an excessive burden placed on developing countries, EU coastal States in the Mediterranean strengthened their presence by patrolling the high seas in this basin. On the one hand, this served to make up for the relaxed sea borders controls that North African maritime authorities performed owing to the lack of resources. On the other, it aimed at preserving Member States' strategic and economic interests as 90% of the total maritime freight traffic in the Mediterranean is directed towards Northern ports (UNEP 2010). Therefore, over the years, maritime surveillance of the high seas in the Mediterranean has become instrumental to protect EU coastal States' economic interests. This increased scope of maritime surveillance activities brought about the need for EU coastal States to employ different and versatile air-naval assets to cover wider regions of the high seas (Cataldi 2016). Consequently, air-naval operations conducted by EU coastal States traditionally see the participation of aircraft, equipped with special sensors (maritime radars, FLIRs and optical cameras) and specifically designed for maritime patrolling purposes (longer endurance and long-range detection), whose task is to fly at high altitudes to gather intelligence over a wider portion of sea (Angeloni and Senese 2005). In this regard,

[4] In the law of the sea, the expression 'creeping jurisdiction' indicates the gradual extension of coastal States' jurisdiction offshore throughout the course of the twentieth century. Emerging transnational threats in the Mediterranean have contributed to 'early detection' and 'pre-frontier' monitoring activities in sea borders surveillance while promoting the extension of coastal States' enforcement powers over maritime spaces normally governed by the freedom of navigation regime.

'early detection' remains one of the cornerstones of maritime surveillance that allows authorities to reposition air-naval assets deployed at sea to effectively monitor and, where appropriate, intercept any suspicious target of interest. Fixed-wings aircraft are mainly responsible for 'early detection' and 'pre-frontier'[5] monitoring activities over the high seas. The earlier a target is detected, the better authorities can respond to the threat it poses by increasing their operational readiness (Helal and Hassan 2017).

If a suspicious target is acquired in pre-frontier areas, the information collected by the aircraft is passed on to an offshore patrol vessel (OPV) navigating on the high seas and acting as an operations room at sea. Both the aircraft and the OPV continue to shadow[6] the suspected target while constantly updating the control room on land (Antonucci et al. 2016). When a suspected target enters the contiguous zone, coastal patrol vessels (CPB) are informed. If the target enters territorial sea, fast-intercepting boats (FIB) and helicopters are alerted. In most of the cases, EU coastal States prefer to intercept a target within their territorial sea in order to exercise the full spectrum of their enforcement powers (Leanza 2008; Klein 2011). If a non-cooperative target were to be intercepted, usually, authorities would engage the suspected boat when it is approaching national coasts. This operational technique fulfils two objectives: (1) allows CPBs to position themselves behind the target and prevent it heads back towards the high seas to escape unpunished; and (2) permits FIBs to engage the target in a smaller portion of sea (Antonucci et al. 2016). The final part of the pursuit is always accompanied by a helicopter that is responsible for recording the 'chain of events' leading to intercepting and stopping the suspected vessel (relevant for judicial purposes), providing assistance to the FIBs chasing after the target, and ensuring the protection of the crew during the pursuit. If the suspected boat were to land ashore, trying to flee from the pursuing authorities at sea, the helicopter would normally follow the fugitives and guide land patrols coordinated by the operations room on land to finally apprehend the suspects (Fantinato 2017).

Traditional maritime surveillance operations using conventional air-naval assets, such as the one described above, are routinely performed in the Mediterranean (Frontex 2014). The number of human resources and air-naval assets needed for such an operation is remarkable and entails significant costs. Flight hours and maritime engine hours not only are expensive, but they also have a considerable impact on the environment (EEA 2016). Furthermore, not all the air-naval operations in the Mediterranean are intelligence-driven, and quite often, air-naval assets such as OPVs, CPBs, FIBs, aircraft and helicopters perform regular and overlapping patrolling missions merely for reconnaissance and deterring purposes (EEAS 2012; GMF

[5] Pursuant to EU Regulation n. 1896/2019 on the European Border and Coast Guard, Article 2(13), "pre-frontier area" means the geographical area beyond the EU external borders which is relevant for the management of these external borders through risk analysis and situational awareness.

[6] In maritime surveillance, the verb "to shadow" means to follow a target without being detected. This operational procedure can be executed by maintaining the target within line of sight or by following the target's movements through maritime radars, forward-looking infrared systems (FLIRs) and/or optical sensors.

2018). These operations, which represent the majority of standard maritime surveillance activities in the Mediterranean, add up to the operational costs and environmental impacts ingenerated by intelligence-driven air-naval operations. Further, these conventional maritime operations are traditionally carried out by single Member States without cooperating with neighbouring EU and non-EU States. Nonetheless, threats faced by Member States in the Mediterranean usually require an improved transnational and trans-sectoral approach, particularly in the high seas (EU Commission 2010). This calls for a stronger regional and international cooperation among Member States and between Member States and non-EU Mediterranean partners. In addition, advances in maritime surveillance technology have clearly shown the efficiency of alternative solutions such as satellites and unmanned aircraft and autonomous maritime vehicles. These sustainable and cost-effective solutions, however, are not always available or affordable at national level.

For these reasons, in order to reduce the costs of maritime patrolling borne by single Member States and increase regional/international cooperation in the Mediterranean, the Council of the EU started to discuss the potential of EU inter-agency cooperation, space-based technologies and unmanned vehicles deployed under the coordination of EBCG, EMSA and EFCA (Council of the EU 2018). The effective implementation of these systems could significantly improve the performances of maritime surveillance activities by relying upon more advanced technologies and increased regional/international cooperation in the field of information sharing. At the same time, these technological developments could minimise the impact on the maritime environment and reduce costs thanks to the rapid increase in the affordability of data acquisition, storage and processing infrastructure of these systems (Tu et al. 2016).

3 The Interplay Between EU Maritime Security Policies and Surveillance Activities in the Mediterranean Sea

Illegal activities perpetrated at sea by non-state actors exploit the weaknesses of fragmented local, regional and global maritime governance systems (Council of the EU 2014). In this area, the EU has shown a strong political will to effectively respond to maritime security threats at and from the sea, tackle the root causes of cross-border trafficking and restore the confidence in the Schengen area and in the management of the EU external maritime borders (Fantinato 2020). Therefore, in 2014, an EU Maritime Security Strategy (EUMSS) was adopted to address potential threats that undermine the security of sea borders, ports and offshore installations, protect sea borne trade and optimise the use of the maritime domain's potential for growth and jobs, while safeguarding the marine environment. Based on a functional integrity approach, this strategy does not affect the respective competences of the EU and its Member States. Likewise, it shall be implemented without prejudice to Member States' jurisdictional powers over maritime zones regulated by

UNCLOS. Furthermore, the strategy builds upon existing policies and legal procedures without establishing supra-national structures, developing new legislation or placing additional obligations and administrative burdens upon Member States.

In line with the EU Commission policy documents, 'maritime security' across the EU borders entails the overall good governance of the maritime domain and the effective management of its external sea borders (EU Commission 2014). According to Hawkes (1989), "*a successful maritime security strategy creates the preconditions to provide a timely and accurate warning of an impending threat and offers the response for removing or neutralising that threat by repelling, capturing or eliminating the perpetrators*". On the other hand, the EU Military Committee defined 'maritime surveillance' as the systematic and continuous observation in the global maritime domain, in order to: (1) achieve effective maritime situational awareness over activities at sea impacting on maritime security; and (2) facilitate sound decision-making (EEAS 2012). It is a comprehensive process that implies knowledge, understanding, preventing and managing events related to the maritime domain which could affect maritime safety and maritime security, law enforcement, defence, border control, protection of the marine environment and fisheries control (Council of the EU 2014).

An effective maritime surveillance is more than simply gathering intelligence at sea. It is a holistic process that builds upon knowledge and understanding of all occurrences in the maritime environment. 'Knowledge' presupposes acquiring and tracking data and 'understanding' requires fusing and analysing the information collected. The information collected are then categorised and disseminated to stakeholders concerned in accordance with their respective operational interests and institutional competences. Both knowledge and understanding lay the foundations of any maritime surveillance system and together they contribute to enhance the maritime situational awareness picture of relevant authorities (Helal and Hassan 2017). This leads to an increased effectiveness in the planning and conduct of surveillance operations that optimise the use of resources (both human capital and air-naval assets) and minimise operational costs as well as the environmental impact on the maritime domain. In the governance of the external sea borders of the EU, knowledge and understanding are strategic to inform decision-making processes in the maritime surveillance sector. Maritime surveillance within the EU aims at: (1) offering complimentary information that assist decision-makers in the response to maritime threats; and (2) providing horizontal analyses that highlight trends and behaviours that support EU policymakers. Given its geographical features (Scovazzi 1994) and the peculiarity of the geopolitical context of non-EU neighbouring partners, maritime surveillance activities in the Mediterranean are complex and multifaceted. However, they are functional to the objectives set forth by the EUMSS by ensuring an early warning and providing a proactive response and remain key enablers for successful maritime security operations at the EU external sea borders (EEAS 2012).

4 The Management of the External Sea Borders in the EU and the Concept of Integrated Maritime Surveillance

Recent geopolitical regional changes, such as the instability in Libya and its repercussions on neighbouring non-EU States, contributed to an upsurge in the smuggling of arms and irregular migration in the Mediterranean (NATO 2019). This led to an increased interest in advanced maritime surveillance applications to detect these phenomena. Against this backdrop, a number of national and multinational initiatives were launched in the area of surveillance to gain knowledge of all the activities relevant to EU maritime security. During the last 5 years, 'knowing what is happening at sea' through a constant and effective monitoring activity in the Mediterranean gained momentum. Hence, the action plan of the EUMSS was revised in 2018, with the aim of enhancing maritime awareness for all the actors involved and better follow-up to the emerging maritime threats. This update was needed to take into account the new political priorities in a rapidly changing maritime security environment such as the Mediterranean, a strategical area that continues to represent a regional basin of particular significance for the EU maritime security (Council of the EU 2018). The strategy addresses five sea regions within the EU (Atlantic Ocean, Baltic Sea, Black Sea, Mediterranean Sea and North Sea); however, the scope of this analysis is centred only on the Mediterranean area.

Pursuant to EU primary law, specifically by Articles 4(2) of the Treaty on European Union (TEU) and 72 of the Treaty on the Functioning of the European Union (TFEU), the responsibility to maintain law and order and safeguard internal security lies with Member States (Salvadego 2017). Likewise, border surveillance activities fall into the sphere of Member States' primary responsibilities (Council of the EU 2014). For this reason, Member States have different structures and organisations responsible for safeguarding national and European maritime security interests and protecting against transnational threats at sea. In the area of maritime patrolling, some Member States rely on civilian authorities; others entrust coast guards or law enforcement agencies with specific competences at sea; others use military forces; and others share responsibility between civilian and military administrations. Within the EU, more than 400 civilian and military authorities in the Member States are responsible for maritime surveillance (Drent et al. 2013). Nevertheless, as per article 77 TFEU, the EU Parliament and Council can adopt measures necessary for the gradual establishment of an integrated management system for the external borders of the EU. While Member States' naval forces, coast guards and law enforcement agencies operating at sea can individually contribute to deterring and combating unlawful activities in specific regions, EU specialised agencies' technical coordination and the EU engagement with all the international partners facing the Mediterranean are key for the promotion of rules-based and sustainable governance of the EU external sea borders.

Along this line of reasoning, Article 7 of the EU Regulation 1896/2019 on the EBCG introduced an interesting provision. Although Member States shall retain primary responsibility for the management of their sections of external borders, integrated border management (including integrated maritime surveillance) shall be implemented as a ‘shared responsibility’ (Salvadego 2017; Fink 2018; Fantinato 2020). This mutual responsibility rests upon the EBCG and Member States’ national authorities responsible for border management, including coast guards to the extent that they carry out maritime border surveillance operations. In accordance with the principle of subsidiarity and proportionality, an integrated border management concept, including the implementation of integrated maritime surveillance services, was developed at the EU level. The ‘principle of subsidiarity’ and the ‘principle of proportionality’ are enshrined in article 5 TEU. The former ensures that the EU does not take action (except in the areas that fall within its exclusive competence), unless it is more effective than action taken at national, regional or local level. The latter requires that any action taken by the EU should not go beyond what is strictly necessary to achieve the objectives set forth by EU Treaties.

Integrating maritime surveillance ultimately aims at establishing a network allowing different public actors such as military administrations, coast guards, law enforcement agencies, traffic monitoring, pollution prevention, fisheries, and border control authorities, to improve communications to efficiently cope with real-time events at sea. In this field, several initiatives were promoted with the aim of creating a comprehensive maritime awareness picture, both at national and EU level, to exchange intelligence, *modi operandi* and best practices, taking into account not only the ‘need to know’ but also the ‘need to share’ information (EU Commission 2010).

In this regard, EMSA operates a suite of systems that process and distribute data on vessel traffic reports (SafeSeaNet), oil-spills detection through satellite monitoring (CleanSeaNet) and port state control (Thetis). The agency hosts a platform called SafeSeaNet Ecosystem that can integrate different layers of information and combine data from different internal and external sources. Intelligence information collected by these systems are fused and analysed by EMSA’s officials and then shared with Member States. The analysis offered to Member States’ maritime authorities is tailored to user requirements (EMSA 2020). Likewise, EBCG supervises Eurosur, where the agency’s officials use this information-exchange framework to fuse and analyse data to improve the surveillance of the external borders of the EU (including sea borders). This system collects information from National Coordination Centres (NCCs) located in Member States creating a common European picture. These data are sent directly to European and national officers deployed on the field to increase their operational awareness and reaction capabilities in the management of EU external borders (EBCG 2020). Similarly, EFCA operates a system called Marsurv service where Member States can access to collect information related to fisheries control. This platform provides a real-time maritime awareness operational picture fusing and correlating information from Vessel Monitoring System (VMS), automatic identification systems (AIS) and long-range identification and tracking (LRIT) position reports. The service also includes a tool for behaviour analysis, risk assessment and classification of possible non-compliant targets of interest. These data are transmitted by the agency’s officials to fisheries monitoring centres in Member States for follow-up actions.

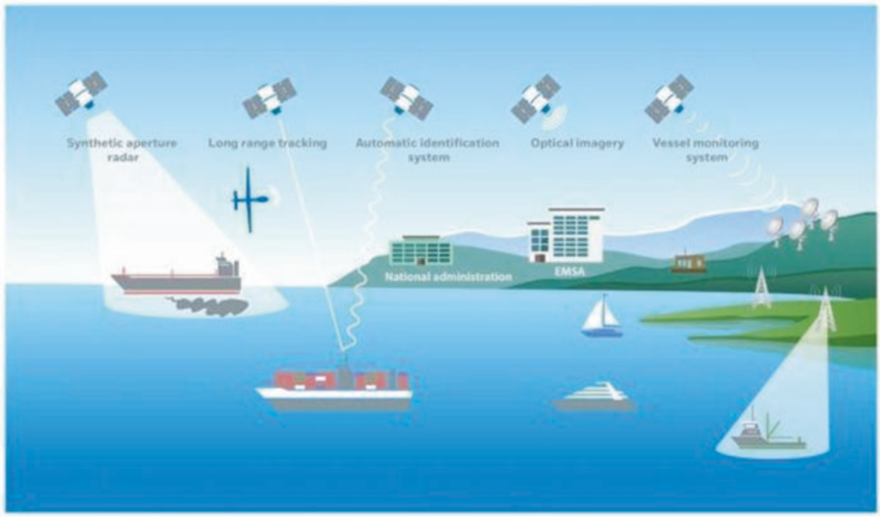

Fig. 9.2 Integrated maritime surveillance in the EU. (Source: EMSA 2014)

The aim of these three different platforms is to provide joint, secure and faster methods to exchange data and increase the operational response by Member States. Under the framework of coast guard functions cooperation, the three EU agencies collaborate with each other by sharing information where relevant. This interagency pool of data caters for Member States' different needs and strategic interests across the Mediterranean while avoiding duplication of efforts and preventing overlapping of infrastructures and additional costs. Sharing intelligence among all the stakeholders involved in the maritime environment makes surveillance activities cheaper and more effective. The essence of this integrated approach is to make maritime surveillance sustainable through strengthening interagency cooperation at the EU level, developing cost-effective solutions and exploiting all available resources for the patrolling of the Mediterranean Sea (Council of the EU 2018). Integrated maritime surveillance services (see Fig. 9.2) are therefore one example of how technologies can serve sustainability in maritime surveillance while ensuring a safer, more secure and cleaner maritime environment (EMSA 2020).

5 EU InterAgency Cooperation and the Development of Sustainable Technologies to Detect Unlawful Activities in the Mediterranean Sea

A variety of technologies were tested and successfully implemented in the Mediterranean under the framework of EU interagency cooperation. This paragraph investigates the following systems used for maritime surveillance purposes:

Copernicus Maritime Surveillance (CMS) services, Unmanned Aircraft Systems (UAS) and Maritime Autonomous Vehicles (MAV).

5.1 Copernicus Maritime Surveillance Service

The system can provide satellite images relevant for fisheries control, customs, law enforcement and marine pollution monitoring authorities upon request. Earth observation (EO) data collected from European satellites 'Sentinel' are combined with a wide range of other information, originating from different internal and external sources, and distributed under the framework of EU interagency cooperation. The CMS data fusion component provides a comprehensive overview of potential suspicious activities at sea, enabling a more in-depth analysis for decision-makers involved in the maritime surveillance environment. Based on user needs, the integration of these data may include vessel identification, GPS information and the detection of anomalous behaviour patterns of the target of interest. EO products are collected by Synthetic Aperture Radar (SAR) sensors or by optical sensors of the satellite, depending on the type of monitoring activity required at sea. SAR sensors are an active surveillance system that emits microwaves towards the Earth and records the way they are reflected back at the receiver. Optical sensors are a passive surveillance system that examines the Earth's surface across a varied spectrum of electromagnetic radiation frequency (Lohmann et al. 2004). While SAR sensors can be used to identify targets of interest through clouds and ensure night-time detection and tracking, optical sensors do not offer this possibility since they rely upon sun's illumination and thermal radiation. Optics sensors, however, allow satellites to gather high-resolution imagery despite the fact that these very detailed images are usually large and very expensive (Lele 2017).

CMS was successfully used by Member States' authorities and by EBCG, EMSA and EFCA during joint operations carried out in the Mediterranean under the EU interagency cooperation framework. In this regard, end users highlighted some of the limitations that CMS currently has and provided some feedback accordingly. Among the lessons learned identified in the ex-post evaluation of this satellite-based maritime surveillance technology, users remarked that there is a growing need for real-time availability of EO products. Currently, the images collected by the satellites can be delivered only twice per day depending on the orbit of the satellite. This clearly does not suit the operational requirements needed for maritime rescue and law enforcement activities, where the dynamics of the events are quite fast (EMSA 2016).

Likewise, in the area of cross-border trafficking, tasking requests to maritime authorities are often received at short notice. This requires the tasking of CMS within few hours and the delivery of data in near real time (less than 30 min). Currently, the time from tasking EO products to the delivery of processed images is too long to be efficiently used for law enforcement and maritime rescue (DG GROW 2017). Further, current EO technology is still far from being able to provide very high-resolution acquisitions. This renders satellite imagery useless in the identification of smaller targets such as skiffs used for unlawful activities at sea (irregular migration, drug-trafficking and smuggling of arms). Conversely, satellites turned out to be very useful to investigate marine pollution over wider portions of sea and correlate suspected vessels to oil-spills for prosecution purposes. In this area, however, some challenges remain as to privacy and data protection issues of the information collected by satellites. Some authors contend that satellite images acquired by CMS might infringe privacy and raise questions about data protection and confidentiality rules that are applicable in respect of commercial vessels (Aloisio 2018; Santos and Rapp 2019). Nonetheless, overall, while CMS can be regarded as an added value for the surveillance of maritime spaces such as the high seas and the EEZ, from the perspective of Member States' maritime authorities, there is an increasing need for higher resolution images, faster delivery and processing of EO products and higher frequency of acquisitions (PwC 2019).

5.2 Unmanned Aircraft Systems

Unmanned Aircraft Systems (UAS) are a relatively new phenomenon in the maritime surveillance domain. UAS are equipped with maritime radars, optical sensors and FLIRs. They are also able to receive AIS signals from ships that enable the aircraft to detect, identify and categorise vessels of interest according to user needs (EMSA 2017). In the area of maritime rescue activities, compared to manned aircraft and vessels, UAS can be used to enhance searching capabilities over wider maritime areas due to longer endurance and faster response times. UAS can also operate in harsher weather conditions than manned aircraft and vessels reducing the risks related to the personnel on board. UAS can also perform searching operations in places far from shore with reduced or no communication coverage. In addition, regarding marine pollution, UAS can be equipped with sensors capable of detecting pollution by ships at sea, confirm an oil-spill originally detected by CMS services, as well as collecting water and pollution samples for analysis and prosecution purposes (EMSA 2017). Moreover, UAS can be also equipped with gas sensors and used as 'sniffers' to measure the amount of SOx versus the CO_2 in a ship's plume navigating in Emission Control Areas (ECAs) and other European waters. Members States' authorities can use this service to verify the compliance with the limits of sulphur in marine fuels set by EU Directive 802/2016 (Sulphur Directive). In accordance with that Directive, from 1 January 2015, Member States have to ensure that ships in the Baltic, North Sea, and English Channel use fuels with a sulphur content less than 0.10%. These maritime spaces are called SOx-Emission Control Areas (SECAs). In all other areas, from 1 January 2020, the maximum sulphur content of marine fuels was diminished from 3.5% to 0.5%, in order to reduce air pollution and protect health and the environment.

These systems have a higher flexibility since they can be used for persistent and systematic monitoring activities without incurring the limitations of manned aircraft regarding flight crew fatigue and mandatory crew rest periods. In fact, UAS are operated from a ground station where personnel work in shifts to ensure continuous surveillance activities. From a fisheries control's standpoint, due to the UAS endurance, range and covert capabilities, these systems can be used to detect vessels undertaking fishing in restricted zones. Similarly, the law enforcement community can benefit from these services to perform constant monitoring of illicit activities at sea thanks to the longer endurance and range that UAS can afford (EMSA 2017). Compared to satellite operations performed by CMS services, UAS offer the possibility to stream live video feeds as opposed to the 'snapshot mode' provided by satellites. Further, these systems can operate at all times, during day and night. On the other hand, due to the need to re-task the sensor and alignment with the next suitable orbit/overpass, satellites often have a lead-time being in position over the area of operations (GMV 2017). Moreover, unmanned aircraft can be equipped with dedicated sensors that are currently unavailable for satellites or manned vessels and therefore UAS can gather additional and more precise information than satellites.

According to a benefit analysis of UAS operations in the maritime domain, end users expressed some concerns about certain aspects regarding the usage of these systems. At the beginning, the main limitation concerning the implementation of UAS operations was related to the regulatory aspects connected to obtain the 'permit to fly' in non-segregated airspaces. In this area, the previous lack of an EU Regulation determined that Member States had different legal frameworks that applied to these operations (GMV 2017). Against this scenario, the EU Commission Delegated Regulation 945/2019 and EU Commission Implementing Regulation 947/2019 introduced pan-European rules on UAS that will standardise procedures across all Member States from 31 December 2020 (EU Commission 2019). EU Regulation 947/2019 originally established the entry into force of common rules as of 1 July 2020. However, due the outbreak of COVID-19, this term was postponed to 31 December 2020 after the adoption of EU Regulation 746/2020.[7]

An unsolved issue remains the protection of data collected by UAS (photos and videos) as well as sharing information on the location of commercial vessels that are subject to confidentiality rules. In fact, although unmanned aircraft systems deployed within the EU interagency framework are placed under the command and control of Member States' authorities, UAS are provided by private contractors. This means that such companies offer these services providing civilian UAS operators that control the aircraft and additional personnel operating in the ground station where they receive, manage, and share the information collected with the authorities requesting these services. Some authors expressed concerns with respect to private security contractors involved in maritime surveillance operations with a particular focus on data protection, legal ambiguities and the potential for loss of government control over sub-contracted activities (Saner et al. 2019; Novotný 2020).

[7] Further information on EU Regulation 746/2020 is available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0746&from=EN

Another question raised by UAS end users is linked to upholding the integrity of the 'chain of evidence' in a court of law without a legally mandated official on board the aircraft (GMV 2017). In this area, national and European legislation regimes do not expressly cover UAS data elicitation and distribution conditions. At the same time, aviation safety considerations also need to be taken into account. Considering that UAS operations might also require entering in non-segregated airspaces, a key priority remains to ensure that unmanned aircraft stay clear of other airspace users. To this end, technological developments are under way to equip UAS with sense-and-avoid devices to allow these aircraft to detect and evade obstacles autonomously (SESAR 2020). Finally, other authors argued that security concerns exist regarding the possibility of malicious interferences with the UAS operations through frequency jamming (Huttunen 2019; Zhi et al. 2020). Despite the limitations highlighted above, overall, UAS provide an increased operational flexibility when compared to other maritime surveillance systems or manned air-naval assets. In addition, their employment in the Mediterranean Sea under the EU interagency framework certainly offers major financial benefits to Member States requesting these services (GMV 2017).

5.3 Maritime Autonomous Vehicles

Over the past few years, substantial research and significant development has been performed in the area of Maritime Autonomous Vehicles (MAV). This definition includes autonomous vehicles operating below, above and on the water while using a different degree of automation (Felski and Zwolak 2020). These systems have been tested in military environment in the field of maritime awareness, mine countermeasures and anti-submarine warfare (NATO 2020). However, there is a growing interest on MAV to be used also for maritime search and rescue, marine pollution, and law enforcement operations against smuggling of migrants and drug-trafficking by sea (Kraska 2010; Klein 2019; Bauk et al. 2019). At the time of writing, there are no information on such vehicles being currently employed under the EU interagency cooperation framework. Nevertheless, having due regard to the operational capabilities and the level of flexibility that these systems can offer, there are strong indicators that these autonomous technologies will be implemented, in the near future, during maritime operations carried out under the technical coordination of EU agencies (EDA 2018; DG-EXPO 2020; NATO 2020).

Although ongoing discussions at the IMO level are exploring the potential of fully autonomous maritime surface ships (MASS) for commercial purposes (IMO 2017), from an EU maritime surveillance's perspective, a certain degree of control is always needed when performing search and rescue at sea, marine pollution and maritime law enforcement operations. In addition, since the underwater domain remains unexplored by satellites, unmanned aircraft and conventional manned air-naval assets, vehicles operating beneath the surface of the water might represent a cost-efficient and sustainable solution to fill the existing operational gaps of the EU maritime patrolling activities conducted in the Mediterranean. Therefore, this section focuses on Unmanned Underwater Vehicles (UUV) remotely controlled, either from the ground or from another manned ship, and used for maritime surveillance activities executed by States' authorities in the Mediterranean.

Since the underwater domain has been so far neglected at EU level, non-State actors started to use subsurface craft to perpetrate illicit activities at sea such as drug-trafficking. In November 2019, Spanish authorities intercepted the first 'narco-submarine' ever caught in European waters while it was carrying three tonnes of cocaine. According to investigators, the 22-m-long submersible vessel had been operating for years between Colombia and Europe (El País 2019). In light of these recent developments, it can be said that undersea threats are expected to become more challenging and they might acquire a prominent role also in the Mediterranean. Underwater patrolling using UUV can directly contribute to higher resilience and enhanced awareness in the maritime environment (EDA 2018). In a similar fashion to UAS, UUV have a broader range of operations and possess a longer endurance compared to manned vessels. Likewise, they can also be employed in tasks in high threat environments or contaminated areas where the use of manned ships would constitute an unacceptable risk for the crew on board. For instance, this might apply if UUV were to be used in marine pollution operations to identify the pollutant and measure the extension and depth of a waste discharge at sea (Hafeez et al. 2018).

On the other hand, from a security standpoint, UUV that are remotely controlled, either from the ground or from another manned ship, might be targeted by malicious interferences such as frequency jamming that would hamper their normal surveillance operations (Chadwick 2020). Furthermore, some experts highlighted that software errors might question the safety of patrolling activities of unmanned ships (Dreyer and Oltedal 2019). In order to address both potential cybersecurity attacks and possible technical failures, these vehicles should be equipped with redundant navigational systems and recovery devices that allow the UUV to transition from a normal operational mode to an abnormal operations status. This, in turn, would enable the UUV to enter into a safer navigation mode commonly referred to as a 'minimum risk condition' that mitigates the hazards for the safety of navigation (DNV-GL 2020). Nevertheless, the main limitation of these systems remains the lack of a regulatory framework. In this regard, some authors argued that international law of the sea might accommodate unmanned maritime vehicles as well (Kraska 2010; McLaughlin 2011), including in the context of maritime law enforcement operations (Klein 2019). In fact, if the UUV is remotely controlled (rather than fully autonomous) and under the command of an officer, it may fit under the definition of 'warship' pursuant to Article 29 UNCLOS. Article 29 refers to a warship as: "*a ship belonging to the armed forces of a State bearing the external marks distinguishing such ships of its nationality, under the command of an officer duly commissioned by the government of the State and whose name appears in the appropriate service list or its equivalent, and manned by a crew which is under regular armed forces discipline*".

This status grants UUV sovereign rights and related immunities of the flag State operating the system. However, should these systems be operated by private contractors, this definition would not be applicable, and some jurisdictional challenges might emerge in the performance of law enforcement activities (i.e. right of hot pursuit). Article 111(1) UNCLOS establishes that: "*The hot pursuit of a foreign ship may be undertaken when the competent authorities of the coastal State have good reason to believe that the ship has violated the laws and regulations of that State*".

In fact, according to Article 111(5) UNCLOS, the right of hot pursuit may be exercised only by warships and UUV operated by private contractors do not qualify as such. Due to these legal challenges that might arise at sea, during EU interagency operations in the Mediterranean, it might be expected that UUV used for maritime law enforcement will be operated by Member States' authorities. Overall, apart from the regulatory challenges that these systems might present, UUV offer clear advantages in the detection and measurement of oil-spills as well as in the identification and tracking of underwater vehicles involved in smuggling of goods and drug-trafficking. At the time of writing additional lessons learned, or best practices provided by end users, are not yet available.

CMS, UAS and UUV are three innovations that will be further improved for maritime surveillance operations in the Mediterranean. Their provision under the EU interagency cooperation framework makes them available and affordable for Member States requesting the service. Each technology offers some advantages, presents some technical limitations and its use can be maximised according to Member States' needs. CMS is effective in detecting oil-spills and illegal fishing, UAS ensure extended range, longer endurance and covert capabilities that can be used both in search and rescue and law enforcement, and UUV can fill the operational surveillance gaps of the underwater domain. On the other hand, CMS does not provide a high frequency of image acquisitions, UAS can be affected by malicious interferences and UUV still lack a proper legal framework. Nonetheless, these technologies have key capabilities that could definitely enhance the efficiency of maritime surveillance activities. However, in order to optimise their employment, the operations of these systems should be harmonised, with the existing technologies already in use during maritime patrolling activities in the Mediterranean. To this end, Standard Operating Procedures (SOPs) should be developed in accordance with the best practices identified by end users.

6 Exploring the Nexus Between Maritime Surveillance Activities in the Mediterranean and Sustainable Approaches

The keys for the harmonisation of this array of technologies under the EU interagency cooperation framework in the Mediterranean are flexibility, interoperability and complementarity. These three aspects, combined together, directly contribute to make maritime surveillance sustainable, efficient, cost-effective and target focused. Flexibility, interoperability and complementarity not only refer to a new operational concept of maritime surveillance in the Mediterranean, they also encompass three requirements that CMS, UAS and UUV shall possess to be effectively used at the EU external sea borders. The connection between these three elements and sustainability will be discussed below.

6.1 Flexibility

From conventional maritime operations conducted by single Member States in the Mediterranean, the EU transitioned to joint operations carried out under the aegis of EBCG. Member States started to contribute to common maritime surveillance activities in the Mediterranean by providing assets and personnel under the coordination of the EBCG. These operations, however, in accordance with the agency's main task and competences, were mostly focused on border management. In 2017, after the signature of the Tripartite Working Arrangement, EBCG, EMSA and EFCA committed to strengthen their cooperation in the area of coast guard functions which include maritime safety, security, search and rescue, border control, fisheries control, customs control, general law enforcement and environmental protection. Since the EU expenditure for joint operations in 2016 surpassed 100 million euros per year (EBCG 2016), this agreement introduced the concept of Multi-purpose Maritime Operations (MMOs). The MMOs approach requires joint operations conducted under the EBCG to become more flexible. In this context, 'flexibility' entails undertaking multiple tasks concurrently, availability for rapid re-tasking, adaptability of operations in accordance with the dynamics of an evolving scenario. A flexible maritime mission calls for flexible sea borders surveillance technologies.

The extensive presence of the EBCG at EU maritime external borders makes the agency an ideal platform to facilitate this multipurpose cooperation across Member States operating in maritime surveillance while increasing the support of the three EU agencies in the Mediterranean, each within its respective mandate. Against this operational scenario, assets deployed under the aegis of the EBCG also collect information related to fisheries control (relevant for EFCA) and marine pollution (relevant for EMSA). Likewise, unmanned aircraft employed by EMSA can be used by EFCA for fishery control, by the EBCG for border surveillance and by Member States' authorities in their respective areas of competence. This operational concept gives maritime surveillance activities a higher degree of flexibility by using dual and multi-use technologies such as CMS, UAS and UUV. At the same time, it ensures considerable savings within the budget allocated by the EU in the area of maritime security.

The concept of MMOs was tested in June 2019 during a naval exercise performed in the Italian waters called COASTEX19. Under the operational coordination of the Italian Coast Guard and technical supervision of the three EU agencies, 11 naval assets, three aircraft and three boarding teams interacted in a complex scenario that simulated activities to combat illegal fishing, identify pollution, detect illegal trafficking and perform search and rescue operations. Although satellites and unmanned vehicles were not used during this naval drill, COASTEX19 demonstrated how EU specialised agencies and Member States can benefit from these synergies in the Mediterranean (EFCA 2019). This exercise served also as a European test-bed to show that flexibility within maritime operations is not only concretely possible but also highly desirable.

6.2 Interoperability

In the area of EU MMOs, 'interoperability' means the degree to which different intelligence platforms and surveillance systems can interact together. Interoperability also means that different maritime authorities are able to exchange data among themselves. This concept implies that the intelligence gathered by diverse actors through various maritime surveillance systems can be fed to a central database where data are fused, analysed and presented to all maritime users and stakeholders concerned. This whole information-exchange process also addresses possible compatibility issues in terms of technical design and software architecture. Currently, under the EU interagency framework, there are multiple platforms where maritime intelligence information are collected, fused and analysed. These systems are SafeSeaNet (EMSA), Eurosur (EBCG) and Marsurv (EFCA) providing relevant information to Member States, each within the respective agency's mandate. In addition to these systems, Member States also rely on their national platforms where they collect intelligence for several purposes and do not necessarily share this information with EU agencies or other Member States' maritime authorities. This clearly creates a fragmentation of the information available thus hindering maritime awareness and thwarting responsiveness capacity across the Mediterranean. To this end, under the coordination of EMSA, Member States' maritime authorities are implementing a programme called CISE (Common Information Sharing Environment). In 2010, the EU Commission defined a roadmap for the adoption of this system that has now reached its transitional phase (2019–2021).

The aim of this platform is to allow for increased information exchange among all the authorities responsible for surveillance in the EU maritime domain. The CISE will complement existing databases by streamlining intelligence flows into a comprehensive European platform where Member States can transmit, receive and analyse data related to maritime surveillance. Different information layers, covering all coast guard functions, will be fused into one common picture providing a wider framework to increase maritime situational awareness. Individual or multiple layers can be selectively aggregated according to user needs (see Fig. 9.3). When CISE reaches its full implementation in 2022, it will enable seamless and reliable information sharing between existing and future surveillance systems and networks. While the information exchange among the three EU agencies and between the EU agencies and Member States is mandatory, the framework of communications within and among Member States is voluntary.

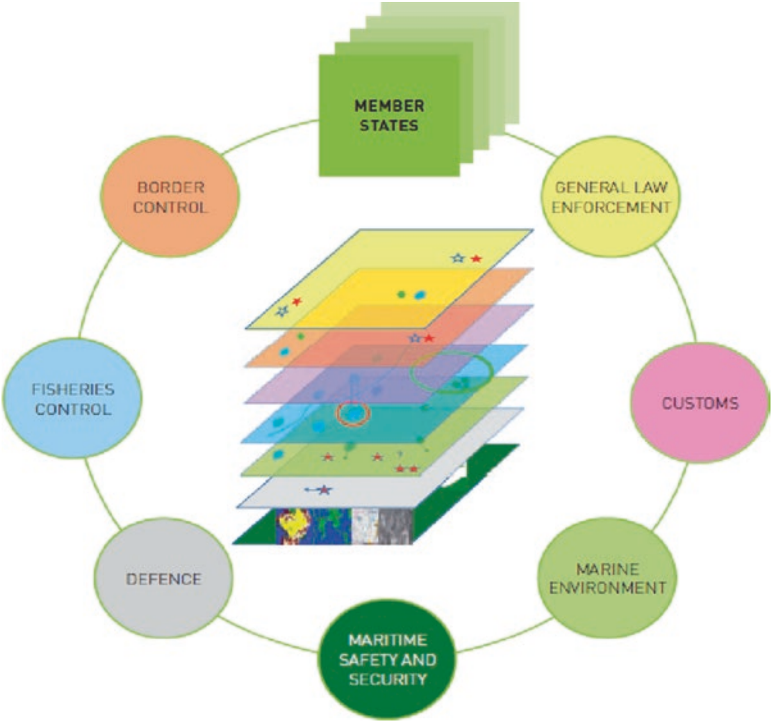

Fig. 9.3 Different layers of the EU CISE programme's maritime picture. (Source: EU Commission 2010)

The EU CISE programme also includes another voluntary framework for intelligence exchange between law enforcement and military operations. This will further enrich the European maritime picture by merging data coming from NATO and EEAS military operations. This operational approach will strengthen information-based risk-analysis techniques, maximise the use of sources currently not exploited, increase responsiveness capacity of Member States and ultimately lead to sustainable and cheaper maritime surveillance within the EU.

6.3 Complementarity

The term 'complementarity' in MMOs refers to surveillance technologies' potential of working usefully together. No single maritime surveillance technology can be employed alone in the Mediterranean. Each system presents some benefits, but at the same time, it also has some intrinsic limitations, often due to their technical design and software architecture. Further, advanced technologies such as CMS, UAS or UUV cannot and will not substitute conventional air-naval assets or boarding teams during certain type of activities at sea (e.g. law enforcement and search and rescue operations). In fact, these three systems not only complement each other, together, they also complement maritime surveillance activities of manned air-naval assets. A clear example of a possible integration among UAS, UUV and conventional manned systems during joint operations at the EU external sea borders is the EU-funded COMPASS2020 project. This programme aims at demonstrating the advantages of combining the use of manned and unmanned technologies in maritime surveillance. In particular, this project intends to show how UAS and UUV, respectively providing aerial and underwater coverage, can extend searching capabilities of manned air-naval assets and lead to an increased situational awareness of all the actors cooperating in the maritime domain. Although this programme does not contemplate the use of satellites, at the end of 2020, the project will offer some lessons learned about the integration of these unmanned technologies with conventional air-naval assets deployed for maritime surveillance. The outcomes of COMPASS2020 might reveal how these operational solutions can be further improved and fine-tuned to increase sustainability, cost-effectiveness and reliability of maritime patrolling operations (DGAM 2020).

While interoperability addresses compatibility issues of intelligence platforms and maritime surveillance systems, complementarity explores the advantages of using multiple technologies together while optimising the use of all available resources, including manned air-naval assets. The added value of the complementarity of these systems is that together they can provide a comprehensive maritime picture that includes space, aerial, maritime and underwater coverage. In addition, the main benefit of the concept of complementarity is that an integrated use of satellites, unmanned aircraft and underwater systems provides a solid intelligence-based and risk-analysis background. This, in turn, will inform decision-making processes prior to the deployment of conventional manned air-naval assets at sea. Therefore, the complementary use of maritime technologies such as CMS, UAS and UUV will lead to better planning of intelligence-driven operations, in order to optimise the use of traditional air-naval assets while minimising the impact on the maritime environment.

7 Concluding Remarks

The nature and variety of threats faced by Member States in the Mediterranean Sea pose a risk to European citizens and can be detrimental to the EU's and its Member States' strategic and economic interests. Maritime surveillance operations in this regional basin are instrumental to ensure the protection of these interests. In order to provide timely, appropriate and effective responses to these maritime threats, Member States depend on building a common situational awareness picture that is functional, up-to-date and reliable. Maritime surveillance is essential for creating such a comprehensive maritime awareness.

Historically, national maritime pictures relied on the intelligence gathered by conventional air-naval assets such as aircraft, helicopters, OPVs, CPBs and FIBs. Often, these assets are employed in patrolling missions primarily aimed at reconnaissance and deterrence. The number of human resources and air-naval assets needed to gather intelligence at sea is noteworthy and demands substantial funding. Flight hours and maritime engine hours not only affect Member States' national budgets; they also affect maritime environment. These conventional air-naval operations are normally carried out by single Member States without exchanging information with neighbouring EU and non-EU States, thus creating duplications and overlaps at sea.

Nonetheless, cross-border trafficking and other crimes perpetrated in the Mediterranean are intrinsically transnational and require stronger national, regional and international cooperation, within and among Member States, among EU agencies and with other non-EU Mediterranean partners. Promoting coordination and further developing these synergies, both at regional an international level, are key aspects to perform systematic and persistent maritime surveillance activities. An increased cooperation framework promotes solidarity and fosters mutual support when coping with common maritime security challenges in the Mediterranean. Against this backdrop, the use of advanced technologies for maritime patrolling, such as satellites, unmanned aircraft, and underwater maritime vehicles, not only offers sustainable and efficient alternatives but also has the potential to minimise the impact on the environment during maritime surveillance. The nexus between maritime surveillance and sustainability in the Mediterranean is therefore twofold. On the one hand, these new technologies are greener and can support maritime safety and security, including the detection of marine/air pollution and illegal fishing to make the use of Mediterranean sustainable. On the other, these systems also contribute to better planning of intelligence-driven operations that will eventually optimise the deployment of traditional air-naval assets at sea while reducing their impact on the maritime environment.

However, these advanced maritime surveillance systems are not always available or affordable at national level. MMOs carried out under the EU interagency coordination offer an ideal platform for Member States to use these contemporary technologies to bridge operational and geographical gaps in the patrolling of the Mediterranean. Under this supra-national framework, all intelligence gathered by different actors through various means of surveillance will be aggregated into a common European picture that will enhance maritime situational awareness across all Member States. In this regard, the framework of MMOs coupled with the EU CISE programme could be viable strategies to address the duplication of efforts in monitoring activities and the fragmentation of intelligence information at sea. Overall, this comprehensive approach will ultimately contribute to safer, more secure and cleaner seas. Sustainable maritime surveillance operations are therefore key preconditions for an effective governance of the EU external sea borders. In this area, the use of flexible, interoperable and complementary technologies should be encouraged to ensure the safety of maritime transport and support the economic development in the Mediterranean Sea.

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Part III
Improvements in Management/Technology of Best Practices for Sustainable Shipping

Chapter 10
The Applicability of the International and Regional Efforts to Prevent Oil Pollution: Comparative Analysis Between the Arabian Gulf Region and the North Sea

Khalid R. Aldosari

Abstract Marine pollution in the Arabian Gulf is increasingly becoming a big concern for Arabian Gulf countries. To date, the solutions deployed have been slow, and sometimes ineffective, in reducing the occurrence of both intentional and unintentional marine pollution. Today, the region is still marred by runaway marine pollution despite years of regional and local prevention efforts. This chapter analyses the pollution situation in the Arabian Gulf through a comparative analysis of the North Sea and the Arabian Gulf. The regions share common oil-related pollution issues. However, the Arabian Gulf still lags in terms of implementation. This analysis shows that ineffective cooperation is the main reason holding back the Arabian Gulf countries. This chapter illustrates that cooperation, as envisaged by SDGs 14 and 17, can be a critical factor in the success of regional and international agreements and conventions. Moreover, it is argued that pollution prevention efforts can significantly improve the sustainability of maritime transport.

Keywords Marine pollution · Arabian Gulf · Transboundary pollution · Maritime transport · SDG · North Sea · International Law · Conventions · Oil spills

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1 Introduction

This chapter seeks to investigate the applicability of international law in cases of marine pollution events in the Arabian Gulf. This is realised through a comparative examination of marine pollution prevention efforts in the Arabian Gulf and the North Sea. The North Sea and the Arabian Gulf share unique sets of circumstances in terms of oil exploration and tanker activities. The comparative study of both areas can outline extant inefficiencies in pollution prevention activities. By highlighting the inefficiencies of regional conventions, this chapter will outline the gaps in relation to the implementation of regional conventions and international law as well as the overarching objective of SDG 14 that relates to pollution prevention initiatives. To this end, this chapter seeks to investigate the role of the SDG 14 and other oil pollution prevention activities in ensuring the sustainability of maritime transport from an Arabian Gulf perspective.

For both the Arabian Gulf and the North Sea, marine pollution has been an existential threat to the biodiversity and natural ecosystems. Because of the discovery of oil and subsequent export activities like transportation, these regions have suffered tremendously from preventable activities associated with oil such as dredging, loading of oil, emptying of ballast tanks, exploration, prospecting, and manufacturing (Spellman 2017). Moreover, there have been a lot of oil pollution incidents from collision, explosions, and installation of oil exploration devices.

Like the North Sea, the Arabian Gulf is a transnational area separating economically interconnected countries. Apart from being a shared territory of local countries, the two regions are of enormous strategic and economic significance. Both the Arabian Gulf and the North Sea have therefore received huge international attention (Legrenzi and Lawson 2017). Locally, the Arabian Gulf region includes Qatar, Oman, Bahrain, United Arab Emirates, Kuwait, and Saudi Arabia. All countries that are a part of the Arabian Gulf have huge crude oil reserves and are renowned exporters of petroleum products. This makes the area prone to marine pollution. For decades, the most common form of pollution in the Arabian Gulf has been a mix of intentional and unintentional oil pollution. On the other hand, the North Sea connects five oil rich European countries. These include Denmark, Norway, United Kingdom, Germany, and Netherlands. Although the entire region has oil reserves, a significant volume of the reserves lies in the United Kingdom and Norway.

Because of the shared location in both regions, pollution caused by one country is bound to affect the other countries in one way or another. The effects and the by-products of oil pollution and particulate matter have the ability to cross international borders. For this reason, the issue concerned with marine oil pollution has been a subject of both national and international legal interest. Since oil exploration activities started much earlier in the North Sea compared to the Arabian Gulf, most of the early conventions were focused on problems in the North Sea (Baschek et al. 2015). However, and as will be illustrated below, these conventions would later be used in other areas facing similar issues, like the Arabian Gulf.

Today, most of the efforts to reduce regional oil pollution are coordinated by international bodies like the IMO (International Maritime Organization) and the UN (United Nations). The threats faced by oceans have also been a major international concern for global leaders (Carpenter 2011). Much recently, the UN developed Sustainable Development Goals (SDGs) (2015–2030) (Sosa-Nunez 2017).[1] Relevant to this research, the Ocean SDG (SDG14) includes targets related to the conservation and sustainable use of oceans, seas, and marine resources. As will be discussed below, there also exist regional efforts to curb the threats posed by marine oil pollution.

Apart from reducing pollution, both regional and international oil pollution prevention efforts have improved the sustainability of maritime transport for the two regions. In particular, issues regarding maritime transport feature highly in international agendas such as SDG 14. For example, SDG 14.1 recognises the importance of maritime transport in international trade and the global economy. As such, the section seeks to reduce all kinds of marine pollution that are linked to maritime transportation. Indeed, maritime transport plays a key role in global economic development. Unsustainable forms of maritime transport may therefore, hinder the achievement of pollution prevention goals (UN-Habitat 2015). There also exist international conventions that contain provisions aimed at reducing the environmental effects of maritime transportation such as the United Nations Convention on the Law of the Sea (UNCLOS, also known as the Law of the Sea Convention—LOSC).[2]

2 International Efforts to Curb Marine Oil Pollution

Most of the international agreements and conventions designed to tackle marine oil pollution were developed from problems experienced in the North Sea, the Arabian Gulf and other oil producing regions. An understanding of these efforts is crucial in examining the history and the interrelatedness of both the problems and solutions associated with marine oil explorations. International oil pollution prevention efforts also laid the foundation for the development of regional agreements and conventions.

Notably, the development of pollution prevention conventions has been the driving force behind the need to curb the threat posed by pollution as a result of maritime transport activities. In fact, most of the earlier treaties aimed at curbing oil pollution were created to specifically prevent marine pollution (Nathan 2017).

The two regions also emphasise the need for sustainability in marine exploration activities. Since both areas are reliant on maritime transportation, the comparative

[1] For further information see https://www.undp.org/content/undp/en/home/sustainable-development-goals.html

[2] For further information see: https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf

analysis shows the inherent linkages between oil pollution prevention efforts, the SDGs, and the sustainability of maritime transportation. In recent years, the establishment of the SDGs has had a positive impact on different maritime policies in both regions. For example, SDG 8, which applies in both regions, calls for a general consideration of sustainability in all economic undertakings, including maritime transportation. Indeed, the conventions and agreements established in the North Sea and the Arabian Gulf have in the long run improved the sustainability of maritime transportation.

2.1 Importance of UNCLOS in Marine Pollution Prevention

State responsibility on matters regarding marine pollution has undergone significant developments in the last few decades. Over the years, there have been developments of critical principles that today determine the principles of marine environment law (Johansson and Donner 2015). These principles today determine the responsibility as well as the liability of coastal states on key issues regarding environmental protection and the rights of coastal states (Johansson and Donner 2015).

The general obligation of states on matters pertaining to marine pollution is contained in Article 192 and 194. In particular, Part XII of UNCLOS contains provisions that direct states to preserve and protect the marine environment (Johansson and Donner 2015). The section outlines the responsibility of states in instances of vessel pollution and the right of states to exploit natural resources within their boundaries. Article 194 is the central provision that outlines the responsibility of states in the protection of biodiversity and the fragile marine ecosystem (Johansson and Donner 2015). Most experts regard UNCLOS as a holistic provision that can be used to address the complex range of issues that may emanate from the use of marine resources.

The two key jurisdictions in matters pertaining state responsibilities include the flag state jurisdiction and the coastal state jurisdiction. Relevant to this research, these jurisdictions provide frameworks that are used in the determination of the extent of regional conventions and in the determination of the territorial sovereignty of states. In Article 211 (2), there are provisions that bind all flag states to constitute laws that are in alignment with the core conventions of UNCLOS (Johansson and Donner 2015). In particular, states are obligated to formulate laws that parallel those contained in international conventions. Under Article 2 (1) and 211 (3), coastal states reserve the right to create regulations regarding matters relating to marine pollution (Johansson and Donner 2015). These states can also create legislations that limit the freedom of flag states.

As discussed above, all states are obligated to ensure the safety of its citizen and the environment in all economic activities including the transportation and extraction of oil. According to SDG 14, UNCLOS, and the numerous international conventions against marine pollution, states are obligated not to cause pollution in the seas as affected states may seek legal redress under international law (IMO 1991). In particular, state responsibility stipulates that any breach of any form of environmental state responsibility may lead to legal action such as compensation.

In marine pollution, state responsibility also determines the level of breach and the consequences of a particular breach. According to stipulations set by the International Law Commission (ILC), a state may also be responsible for certain acts of pollution if it fails to control the entities that cause pollution (Johansson and Donner 2015).

2.2 Summary of International Conventions

Oil pollution has resulted in adverse effects to marine ecosystem and surrounding biological systems. On the other hand, oil has been an essential resource for the global economy. Today, oil pollution regulation and compensation is one of the most analysed areas by legal scholars and academicians (Nathan 2017). Internationally, the Civil Liability Convention (CLC) is the body tasked with regulations of issues surrounding compensation and liability regarding oil pollution (Nathan 2017). However, experts have questioned whether the body protects against marine pollution, especially in high risk areas like the Arabian Gulf.

Other than the CLC, a wide range of pollution prevention initiatives, regimes, agreements, and conventions have been developed. Notably, the development of pollution prevention conventions has been the driving force behind the need to curb the threat posed by pollution as a result of maritime transport activities. In fact, most of the earlier treaties aimed at curbing oil pollution were created to specifically prevent marine pollution (Nathan 2017).

International Convention for Prevention of Oil Pollution of the Sea by Oil (OILPOL) is one of the earlier treaties related to oil pollution. Developed in 1954, OILPOL was a product of the first conference on marine oil pollution organised by the United Kingdom. OILPOL came into force in 1958. Subsequently, the secretariat function of OILPOL was transferred to the IMO in the same year. Other oil pollution prevention conventions that followed included International Convention for the Prevention of Pollution from Ships (MARPOL), Civil Liability for Oil Pollution Convention (CL convention), International Convention on Civil liability for Bunker Oil Pollution (the Bunker convention), the International Convention regarding Intervention in Cases of High Sea Pollution (Intervention convention), and International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC). These conventions are summarised in Table 10.1).

Table 10.1 List of International Oil Pollution Prevention Conventions

Name of convention	Brief summary	Link for further information
International convention for prevention of oil pollution of the sea by oil (OILPOL)	OILPOL was established in 1954 but was amended in the years 1962, 1969, and 1971. Amendment of OILPOL came with the addition and deletion of important issues that addresses several aspects of pollution resulting from ocean machinery such as ships. The main objective of the convention was to address crude oil pollution	http://www.imo.org/en/OurWork/Environment/PollutionPrevention/OilPollution/Pages/Background.aspx
International convention for the prevention of pollution from ships (MARPOL 73/78)	The international convention for the prevention of pollution from ships (MARPOL 73/78) convention came into force in 1978. The pollution addressed all forms of pollution that posed a risk to the ocean	http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx#:~:text=%E2%80%8B%E2%80%8B%E2%80%8BThe%20International,2%20November%201973%20at%20IMO
Civil liability for oil pollution convention (CL convention)	The Convention on Civil liability for Oil Pollution was established in 1965. The convention came into force in 1975 (IMO 1991). The main objective of the CL convention was to create a mechanism that could facilitate the process of liability compensation in the event of marine oil pollution	http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Civil-Liability-for-Oil-Pollution-Damage-(CLC).aspx
International convention on civil liability for Bunker oil pollution (the Bunker convention)	The international convention on civil liability for Bunker oil pollution (the Bunker convention), also called the Bunker oil convention, this protocol provides a framework for the determination of liability that occurs as a result of bunkering operations	http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Civil-Liability-for-Bunker-Oil-Pollution-Damage-(BUNKER).aspx
International convention regarding intervention in cases of High Sea pollution (the intervention convention)	The International Convention on Oil Pollution Preparedness, Response and Co-operation, known as the OPRC Convention (IMO 1990), is the largest international agreement on oil spill response cooperation	http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-Relating-to-Intervention-on-the-High-Seas-in-Cases-of-Oil-Pollution-Casualties.aspx

(continued)

Table 10.1 (continued)

Name of convention	Brief summary	Link for further information
International convention on oil pollution preparedness, response and co-operation (OPRC)	Developed in July 1989 the OPRC was a convention designed to establish a global framework for collaboration of efforts geared towards preventing marine pollution. The convention requires member countries to cooperate with each other in when designing measures to prevent marine pollution	http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Oil-Pollution-Preparedness,-Response-and-Co-operation-(OPRC).aspx
CLC and FUND	The CLC refers to the civil liability for oil pollution damage convention of 1969. The convention entered into force in 1975. The main objective of the convention was to ensure adequate compensation for victims of intentional and non-intentional oil pollution FUND refers to the international convention on the establishment of an International Fund for Compensation for oil pollution damage of 1971. The FUND convention was created to address the shortfalls of the CLC	http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-the-Establishment-of-an-International-Fund-for-Compensation-for-Oil-Pollution-Damage-(FUND).aspx

A number of key international conventions are identified that are relevant to the issue of marine pollution, maritime transportation, and environmental law in general. However, there are still questions surrounding the effectiveness of these conventions.

2.3 Section Summary and Critical Analysis

Marine oil pollution prevention activities in both the Arabian Gulf and the North Sea are designed in the context of international law and general international oil prevention conventions. This section has identified the key international conventions that are relevant to the issue of marine pollution, maritime transportation, and environmental law in general. The early marine oil prevention activities were developed in response to international oil pollution disasters. These were periodically modified to tackle emerging regional issues in both the North Sea and the Arabian Gulf.

3 Arabian Gulf Regional Marine Pollution Prevention Efforts

The Arabian Gulf sits in a strategic location given the proximity to international networks. The Gulf is part of the larger Arabian Sea and borders 8 countries: Kuwait, Iraq, Qatar, Bahrain, United Arab Emirates, Saudi Arabia, Oman and Iran. Moreover, the Gulf covers a surface of approximately 239,000 km^2 and has a water volume of about 8630 km^3 (Le Quesne et al. 2018). Figure 10.1 shows the Arabian Gulf countries.

Countries within the Arabian Gulf region developed different conventions, treaties, and agreements. In order to organise these efforts, they established the Gulf Cooperation Council Secretariat (GCC). The Gulf Cooperation Council Secretariat (GCC) is a secretariat office based in Riyadh.[3] The primary role of the secretariat is to oversee information exchange, assessment, training, and to facilitate regional coordination of efforts geared towards the protection of the environment (Alturki 2015). The Gulf Cooperation Council Secretariat (GCC) consists of the executive secretary who is appointed by the members of the council. The secretariat office works as a centre of coordination and also a source of information. Other functions

Fig. 10.1 The Arabian Gulf Region. (Source: GCC 2020 https://www.gcc-sg.org)

[3] For further information see: https://www.gcc-sg.org/en-us/Pages/default.aspx

of the secretariat are the preparation of invitations and relaying of critical information. The secretariat also oversees the distribution of member's laws regarding transboundary movements.

The GCC also enters into agreements and treaties that bind member states. For instance, in 2017, the GCC entered into an agreement with the UN to address pressing environmental issues faced by the GCC countries. The agreement proposed a new way of dealing with chemical wastes (Alturki 2015). The agreement also contains guidelines for the management of dredging activities. The agreement reinforces the resolve of the GCC in promoting growth and enabling sustainable development.

3.1 Summary of Regional Conventions to Curb Oil Marine Pollution

With a view to preventing marine pollution, the Arabian Gulf countries developed different conventions. These conventions have been effective in the reduction of all forms of marine pollution, including those caused by maritime transportation. These include Regional Organization for the Protection of the Marine Environment (ROPME), Regional Clean Sea Organization (RESCO), Council of Arab Ministers Responsible for Environment (CAMRE), and United Nations Environment Programme Regional Office for West Asia (UNEP/ROWA). The conventions were mainly developed to coordinate, manage, and oil pollution prevention activities in the Arabian Gulf. These conventions, treaties, and agreements are summarised in Table 10.2.

From a general prism, the conventions are designed to assist in preventing all forms of marine pollution. Others contain provisions that guard against specific types of pollution. For instance, ROPME led to the development of the KAP which contains provisions that directly benefit maritime transportation (Nathan 2017). Specifically, KAP provides regional guidance on key aspects such as oceanography of oil transportation routes, GIS and remote sensing studies, and investigations on the effect of oil pollution.

3.2 Section Summary and Critical Analysis

Regional efforts have played a significant role in the improvement of maritime transportation activities in the Arabian Gulf region. In particular, maritime transportation has benefited from improved coordination management of pollution prevention activities. Today, countries in the Arabian Gulf can effectively monitor and respond to threats against sustainable maritime transportation.

Although there has been a lot of development in the area of pollution conventions, the desired effectiveness and compliance level is yet to be realised. Although

Table 10.2 List of Arabian Gulf Oil Pollution Prevention Conventions

Name of convention	Brief summary	Link for further information
Regional Organization for the Protection of the Marine Environment (ROPME)	The Regional Organization for the Protection of the Marine Environment (ROPME) is situated in the capital of Kuwait. The main function of ROPME is to oversee and implement monitoring activities in the coastal marine environment of the Arabian Gulf (Comark 1999). Among other responsibilities, ROPME assembles and de-ploys resources that aid the protection and development of coastal states such as Iran, Kuwait, Iraq, Saudi Arabia, United Arab Emirates, and Qatar (Comark 1999). The first regional conference sponsored by ROPME was called the Conference of Plenipotentiaries. The conference was held in April 1978 and includes an action plan that charts a way forward for the protection and development of marine resources in coastal states (Comark 1999). The plan protects against pollution by oil and other affluent substances	http://ropme.org/home.clx
The Regional Clean Sea Organization (RECSO)	The Regional Clean Sea Organization (RECSO) is a cooperative organisation for countries in the oil industry. The Regional Clean Sea Organization (RECSO) is based in Dubai. The primary objective of RECSO is to protect the marine resources of member states from oil pollution. The cooperative function on the concept of mutual aid. RECSO was formed in 1972 by 13 members (Legrenzi and Lawson 2017). At the time of the formation, the oil companies in the countries felt a need for the protection of the environment from oil pollution	http://www.recso.org/#:~:text=in%20your%20browser.-,About%20Us,concept%20of%20%22mutual%20aid%22
Council of Arab Ministers Responsible for Environment (CAMRE)	The Council of Arab Ministers Responsible for Environment (CAMRE) is an organisation under the League of Arab States. CAMRE has a mandate of issuing decisions regarding the protection of the environment. CAMRE is the policy making arm of the League of Arab States (Freije 2014). Through CAMRE, the league of Arab states responds to the global environment agenda and policies issued by the UN	https://sustainabledevelopment.un.org/index.php?page=view&nr=127&type=13&menu=35

it is difficult to measure the effectiveness of adopted regional conventions, it is important that the agreements contain clauses that can be used to measure compliance and the sustainability of maritime transportation.

The issues of marine pollution from maritime transportation still face Arabian Gulf countries. It is therefore critical that clauses that measure compliance are introduced to the treaties. Today, agreements such as ROPME and CAMRE lack compliance measurement mechanisms. Because of lacklustre compliance, the Arabian Gulf lags behind regions like the North Sea in terms of marine pollution prevention. Although OILPOL and MARPOL have been instrumental in the protection against marine pollution, and most Gulf States are signatory to the international conventions, research shows that the agreements are less effective in preventing large marine pollution from oil activities. For instance, pollution of the magnitude witnessed in the Gulf War, should have been preventable if Gulf States acted in the interest of the environment, and within existing conventions like OILPOL, which envisioned such issues. Therefore, it is essential to see how regional areas translate the benefits of these agreements to the ground.

In furtherance of the foregoing, the following section incorporates a brief analysis of regional agreements and conventions developed to protect the North Sea from runaway oil pollution.

4 North Sea Regional Marine Pollution Prevention Efforts

The North Sea has several similarities with the Arabian Gulf, especially in terms of commercial activity and resulting threats posed by intentional and unintentional pollution. Like the Arabian Gulf, the North Sea area is also the primary area for oil and natural gas production since the 1960s (Baschek et al. 2015). Most oil installations in the North Sea northeast side of the United Kingdom and the southwest part of Norway. European Union report showed there were around 161 oil installations and 326 gas installations in the North Sea (Baschek et al. 2015). The Arabian Gulf, being the bigger of the two, produces one quarter of the world's oil. The Arabian Gulf also holds 35% of the natural gas deposits in the world (Fig. 10.2).

4.1 Regional Efforts Towards Marine Pollution Prevention

The North Sea area has a wide range of initiatives aimed at protecting the area from oil pollution associated with maritime transportation. These include protection from oil leakages, oil tanker spills, and leakages from gas installations. Over the decades, there have been significant developments of the frameworks designed to protect the North Sea from oil pollution. Development of marine protection frameworks has involved treaties, agreements, and conventions (ITOPF 2002). The first convention aimed at charting a way forward was held at Bremen in 1984. Other conventions

Fig. 10.2 The North Sea Region. (Source: Baschek et al. 2015)

include the OSPAR convention, the Bonn Agreement, and conventions stipulated by the International Maritime Organization (IMO) such as MARPOL (IMO 2001). There have also been measures designed by the European Union (EU) to curb activities associated with marine pollution. For instance, there was an EU directive on port reception facilities (Baschek et al. 2015). The directive significantly reduced the amount of oil pollution caused by port reception activities.

The EU is also behind the establishment of the European Maritime Safety Agency (EMSA) (see Table 10.3). The primary objective of the agency is to protect the North Sea from pollution that may be caused by operational activities. The agency uses services such as CleanSeaNet (CSN) to monitor pollution activities (Baschek et al. 2015). The EU has also taken environment protection measures under the auspices the Helsinki Convention. The convention plays a significant role in air surveillance in cooperation with the Bonn Agreement (see Table 10.3). Moreover, The BEWARE project of the North Sea was formed under the provisions set by the Bonn Agreement (see Table 10.3).

Table 10.3 List of North Sea Oil Pollution Prevention Conventions

Name of convention	Brief summary	Link for further information
The Bonn Agreement	The Bonn Agreement is an agreement by North Sea states aimed at preventing illegal oil spills. The agreement came into force in 1969 and includes all the North Sea States (Carpenter 2011). The primary objective of the Bonn Agreement is to protect the North Sea from oil pollution and accidents	https://www.bonnagreement.org/
The BEWARE Project	The purpose of the BEWARE project is to conduct marine pollution risk assessment through a common methodology (Baschek et al. 2015). Through the BEWARE project, member states get a comprehensive understanding of the risks posed by accidents marine pollution in the North Sea region	https://www.bonnagreement.org/site/assets/files/17082/be-aware_ii_summary_report.pdf
Aerial Surveillance Agreements	MANCHEPLAN between France and the United Kingdom, the DenGerNeth plan between Denmark, Germany and the Netherlands, and the NORBRITPLAN between Norway and the United Kingdom	https://www.bonnagreement.org/about/history
The European Maritime Safety Agency (EMSA) and CleanSeaNet Activities	Oil pollution prevention activities in the North Sea area are also coordinated under the European Maritime Safety Agency (EMSA). The European Maritime Safety Agency (EMSA) is the main body that facilitates coordination of environmental protection activities between countries in the European Union. The CleanSeaNet activities are also conducted under EMSA (Al Fartoosi 2013)	http://emsa.europa.eu/component/flexicontent/download/2102/121/23.html

4.2 Sources of Oil Pollution in the North Sea

Oil pollution entering the North Sea from oil and gas production and exploration has been a primary concern from European countries for a long time. The problem of pollution was first brought to the attention of European governments in the 1960s. In 1967, the North Sea witnessed the *Torrey Canyon* oil spill. The oil spill led to 119,000 tonnes spill of crude oil (Baschek et al. 2015). The oil spill worsened due to tides and winds in the North Sea which spread the oil widely and contaminated the beaches in France and United Kingdom. Today, the *Torrey Canyon* oil spill is still the biggest oil spill in the world. The *Torrey Canyon* led to the formation of MARPOL in 1973 and the International Convention on Civil Liability for Oil Pollution Damage in 1969 (IMO 2001).

As discussed above, there are many sources of pollution in the North Sea. Oil entering the marine environment can come from a wide range of sources such as seeps from underground erosion of sediments, leakages from oil combustion engines, atmospheric deposits from incomplete fuel combustion (Baschek et al. 2015). The effects of these solutions are known to be disastrous in the long term. The negative effects of oil spills in these areas are also worsened by the weather conditions in the North Sea such as strong winds, sunlight, and high temperatures. The North Sea also experiences spells of cold weather, which reduces the dispersion speed of oil (Baschek et al. 2015).

Refined petroleum products and crude oil is also known to enter the waters of the North Sea through accidental oil spills. These products include vegetable oils, fish oils, and animal oils. In 1993, the estimated amount of vegetable oil entering the North Sea was found to be between 7000 and 15,000 tonnes annually (IMO 2001). However, the largest estimated source of pollution in the North Sea was natural seeps that are estimated to be more than 600,000 tonnes a year (Baschek et al. 2015). Of the 600,000 seeps, researchers estimate that 186,000 tonnes came from oil sludge during routine operations. On the other hand, seeps as a result from the operation of oil tankers are estimated to be about 158,000 tonnes annually (IMO 2001). Extant research shows that oil spills that are as a result of oil and gas installations account for only 5% of the total oil pollution in the North Sea (Baschek et al. 2015).

Over the decade there has been a reduced level of pollution in the North Sea. Aerial surveillance (see Table 10.3) conducted under the Bonn agreement shows a sharp reduction in oil spills since the 1980s (IMO 2001). Data from the Bonn agreement is also consistent with surveillance imagery reported by the EMSA CSN. North Sea states also contribute effectively to monitoring of oil pollution.

4.3 Section Summary and Critical Analysis

Analysis of the regional pollution prevention efforts in the North Sea illustrates the importance of conventions in reducing marine pollution. Indeed, major international conventions like MARPOL and UNCLOS have become models for regional conventions. This shows that the conventions work. They should therefore be completely adopted by regional states. Urgent implementation of pollution prevention measures is also necessary for conventions to work.

In the North Sea, one of the biggest factors that stands out is the close cooperation between flag states and coastal states on issues involving marine pollution. From the analysis of the North Sea region, it is clear that cooperation can boost adherence to regional and international conventions. Cooperation, as outlined in SDG 17, would also decreases the likelihood of regional wars.

Based on the above, the following section makes an in-depth comparison between North Sea and the Arabian Gulf in the context of regional oil pollution prevention efforts.

5 Comparative Analysis Between the Arabian Gulf and North Sea Marine Pollution Prevention Activities

This section seeks to conduct a comparative analysis of the regional efforts aimed at preventing oil pollution in the Arabian Gulf and in the North Sea. In particular, the section analyses how the efforts have improved the sustainability of maritime transportation.

Both the Arabian Gulf and the North Sea area encounter high traffic as a result of high maritime transportation activities. Over the years, these activities have led to the development of different pollution prevention efforts aimed at improving the sustainability of maritime transportation. Notably, the regions are also subject to similar international conventions. Despite these similarities, the two regions exhibit differences in the sustainability of maritime transportation.

There are a lot of similarities in the way pollution prevention efforts are conducted in the North Sea and in the Arabian Gulf. In the early stages of oil pollution in the Arabian Gulf, most regional prevention activities were modelled from prevention activities in the North Sea (Al-Azab 2005). This is mainly because of the involvement of Britain in the early stages of oil extraction in the Arabian Gulf. In later years however, there has been a policy divergence in the way authorities in Arabian Gulf deal with marine pollution.

One of the most notable differences between North Sea countries and Arabian Gulf countries is the level of cooperation. It can be argued that the cooperation level in the North Sea is better compared to cooperation in the Arabian Gulf. Since the discovery of oil in the North Sea, European coastal states have recognised the need to cooperate in order to prevent oil pollution.

As early as 1960s, North Sea coastal and Flag states began initiating policies to protect the North Sea area from pollution. According to Carpenter (2018), pollution prevention efforts in the North Sea started late in the 1960s through frameworks such as international agreements, regional conventions, and education. The creation of the International Convention for the Pollution of the Sea by Oil (OILPOL) in 1954 was one of the earliest supported by North Sea states in the efforts to prevent marine pollution by oil tankers. OILPOL was followed by conventions such as Bonn Agreement in 1969 and the Oslo convention in 1972 (Carpenter 2018). The Bonn Agreement in 1969 ushered in a period of cooperation in North Sea states that is still visible today. The agreement pioneered surveillance and monitoring efforts that has helped to prevent oil pollution in the region. According to Carpenter (2018), surveillance data provided by the Bonn Agreement is used to identify pollution trends in the North Sea region and in specific countries.

Cooperation is also evident from the formation of the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR). OSPAR was established in 1972 (Al Fartoosi 2013). The countries in the North Sea also pushed for the development of MARPOL (IMO 2001). In the Arabian Gulf, countries were reluctant to enter into international agreements.

Unlike pollution prevention efforts in the Arabian Gulf, prevention efforts in the North Sea have been successful. According to Carpenter (2018), most of the objectives set out in the 1984 International Conference on the Protection of the North Sea have been achieved. These include a regional ban on waste incineration and dumping, ban on dumping by offshore installations, and cessation of hazardous substance dumping. The success of pollution prevention efforts in the North Sea can be attributed to several factors. High levels of cooperation, frequent meetings between states, political commitments, and willingness of member states ministers to participate in anti-pollution efforts, advocacy from NGOs, and comprehensive plans (Carpenter 2018).

However, the same cannot be said about countries in the Arabian Gulf. Reports by researchers like Al-Azab (2005) show a low level of cooperation between countries party to conventions and agreements. There is also a difference between North Sea and Arabian Gulf countries in terms of source of pollution. One of the biggest historical sources of pollution in the Arabian Gulf is intentional pollution caused by wars. For example, the Gulf war between 1990 and 1991 is one of the biggest sources of pollution, the Gulf War oil spill which occurred in 1991 (Alzahrani and Alqasmi 2013). Although the North Sea Area has had cases of oil spills like the Ekofisik oil field spill in 1977, the magnitudes of such spills have been very small compared to the Gulf War oil spill. Evidently, the inherent conflict in the Gulf region adds to the difficulty in cooperation between different states in efforts to prevent oil pollution.

6 The Relation Between Oil Pollution Conventions, the SDGs, and Marine Transportation

As observed from both the Arabian Gulf and North Sea, there exist strong linkages between oil pollution prevention efforts, the SDGs, and the sustainability of maritime transportation. The fundamental objectives of the SDGs rely on the attainment of sustainable maritime transportation goals. Different goals and targets of the SDG link to different sustainability goals that are dependent of maritime transportation. These linkages have led to a wide range of policy implications for maritime transportations. For example, SDG 8 outlines the need for sustained, inclusive and sustainable economic growth. In this context, sustainable maritime transportation can facilitate sustainable economic growth.

Because of conventions like the SDGs and the efforts of the IMO, the sustainability of maritime transportation has improved. As will be illustrated below, there has been consistent reduction in oil spills from tankers in the last few decades.

While maritime transportation has grown over the last decade, oil pollution from tankers has reduced. The reduction shows the effectiveness of efforts by the IMO, the SDGs, and other conventions.

6.1 SDGs and Maritime Transportation

Sustainable maritime transport is one of the biggest policy objectives of pollution prevention activities. Policy makers and regional governments are increasingly recognising the critical role of maritime transport in addressing the challenges associated with marine pollution. According to Benamara et al. (2019), a safe and secure maritime transportation system can significantly improve the achievement of economically efficient, environmentally sound, and socially equitable economic development. To address the need for sustainable maritime transportation, conventions like the SDG and others by the IMO contain provisions that guide shipping activities in Oceans.

As a component of the global economy, maritime transportation is considered a lifeline for global development. Almost every country in the world depends on maritime transportation. According to UNCTAD (2018), maritime transportation is responsible for transporting over 80% of international merchandise and goods. Other than sustaining international trade, maritime transportation facilitates the productivity of other economic sectors. These include equipment manufacturing, fisheries, energy, and auxiliary services such as insurance, brokering, and banking.

6.2 Overview of the SDGs Role in Maritime Transportation

All the 17 goals are characterised by an objective that is directly associated with the environment and the global social structure. Most debates around the world today specifically target the achievement of SDGs. All the 17 goals and the 169 targets are designed to work synergistically in the effort towards redirecting humanity towards sustainable development (Le Blanc et al. 2017) (Fig. 10.3).

6.3 Linkages Between SDG 14, 17, and Transboundary Pollution

One of the most notable impacts of the SDGs is the increase in collaboration between states in efforts against oil pollution, especially SDG 14 and SDG 17. In particular, SDG 14c envisions a high level of cooperation between states in their realisation of the goals set by UNCLOS. Important to note that targets like the SDG 14 are having an immense positive impact on international transboundary law (Houghton 2014). The old years where conventions and agreements would only be used for relations is waning fast. Today, international maritime law is multilayered and structured, with provisions for redress in case of transboundary pollution. As witnessed from regional cooperation in the Arabian Gulf and the North Sea, states have been today compelled to institute tailored regulatory approaches that to contain any form of oil pollution.

It can be argued that the motivation behind the development of SDG 14 can be channelled to address the problem of transboundary pollution. Due to the heightened level of oil activities in the North Sea and the Arabian Gulf and increased

Fig. 10.3 Summary of SDGs. (Source: UNESCO 2019 https://www.en.unesco.org)

occurrence of transboundary pollution, it is critical to point out the different ways through which possible pollution incidents can be tackled by regional regulations and conventions (Houghton 2014). Technically, the targets set by SDG 14 should provide a form of safeguard-guidance against oil pollution. However, it is still unclear how regional bodies such as the GCC can effectively use such goals to prevent oil pollution.

Oil pollution in international waters is known to transcend international borders. As such, different conventions include provisions that can be used to tackle transboundary pollution. Oil extraction in deep seas between international boundaries is known to cause transboundary pollution (Sosa-Nunez 2017). Transboundary pollution, therefore, occurs when oil spills in the waters of one specific country and moves from that country and causes damages in a bordering country. Transboundary oil is a common source of international disputes since oil spills from one country can cause ecosystem degradation inside the borders of a different country (Sosa-Nunez 2017). Today laws relating to transboundary movement of oil spills are not only preventive but also punitive (Vikas and Dwarakish 2015). The laws stipulate punitive measures that can be directed to countries that cause transboundary movement of oil spills.

6.4 Transboundary Pollution in Accidental and Non-Accidental Oil Pollution

Although oil pollution is often regarded as a regional concern, it has global consequences. There are three key aspects of oil pollution that require international cooperation as envisaged in SDG14 in conjunction with SDG 17. One key aspect of international oil pollution that requires cooperation is the long-range effect of pollution from one country to another. Second, as discussed above, it can be argued that the knowledge of the effect of oil pollution in one region can be transferred to another. For instance, similar oil pollution challenges face countries in the North Sea and the Arabian Gulf. Third, implications of policy developed in one country or region on countries in other regions. Therefore, this chapter argues that international cooperation is critical in the efforts towards prevention of marine pollution.

As discussed in previous sections, maritime accidents have previously challenged the effectiveness of regional and international law. In particular, risks of transboundary pollution have been found to be higher in the Arabian Gulf and the North Sea. Researchers like Al Fartoosi (2013) have pointed out the ineffectiveness of the laws in dealing with transboundary oil spills.

Accidental and non-accidental oil pollution is usually the result of the activities of oil companies. Oil companies face a wide range of challenges during extraction and transportation of oil. The complexities involved in these activities make it very difficult to monitor and manage oil pollution activities. Oil spills in Oceans can either be intentional or accidental. Accidental oil pollution occurs as a result of mechanical or human errors and is beyond the control of humans. On the other hand, intentional or non-accidental incidents occur as a result of intentional actions or may result from sabotage—deliberate plans to pollute the environment. An example of intentional oil pollution is the pollution that occurred during the Gulf War.

Extant research shows that accidental oil spills can be significantly reduced by applying proper engineering techniques in oil tankers and other oil transportation devices (IMO 2001). Today, oil companies also use automatic identification systems. Such systems are used to monitor the condition of underground oil pipelines. According to UNCLOS, flag states and coastal states are responsible in instituting measures that prevent accidental oil spills (Al Fartoosi 2013). Intentional pollution is also prohibited under provisions of MARPOL 73/78.

The current section argues that a high level of regional and international cooperation is required to address the challenges presented by oil pollution, whether at a regional or international level. As envisioned by SGD 17 and SDG 14, countries need to collaborate both at a scientific and policy level (Le Blanc et al. 2017). These include development of agreement and conventions that increase synergies and alignment with SDG14.

The benefits of cooperation have been recognised in other areas of pollution like transboundary air pollution. Through convention such as UNECE Convention on Long-range Transboundary Air Pollution, global leaders cooperate on a regional basis to tackle the problems of air pollution (Le Blanc et al. 2017). It is therefore critical for countries to cooperate on a regional basis in the fight against oil pollution.

7 Conclusion

As illustrated previously, the sustainability of maritime transportation features highly in the SDGs and in a wide range of conventions aimed at reducing marine pollution. As a key enabler of the global economy, most regional and international bodies view sustainable maritime transportation as a critical component of sustainable development. For historically vulnerable areas like the Arabian Gulf and the North Sea, regional cooperation and establishment and adherence to international convention has significantly improve the sustainability of maritime transportation.

Like all other regional areas such as the North Sea, the Arabian Gulf states have not been left behind in the development of regional laws that reflect international environmental laws. Notably, one of the most preventable sources of maritime pollution is pollution from shipping activities. Because of these efforts, pollution in the region has been on a downward trend. It is therefore clear that accomplishment of regional conventions has the potential to significantly reduce the occurrence of pollution activities. This research has established that the strength in the use of international agreements can be derived from implementation of regional agreements that are aligned with international agreements.

One key objective of this chapter was to conduct a comparative analysis between marine pollution occurrences in the Arabian Gulf and in the North Sea. From the analysis so conducted, it is concluded that the Arabian Gulf requires more proactive engagement in terms of regional cooperation and partnerships given that the *status quo* is somewhat less than effective when compared to other regions. Although the objective of the regional treaties in the Arabian Gulf and the North Sea are similar, the countries in these regions have varying levels of commitment towards the achievement of the agreements. It is therefore critical for regional governments to devise strategies for partnerships as an important part of regional agreements.

Research indicates that international and regional partnership was one of the main factors behind the establishment of both UNCLOS and SDG 14. In fact, SDG 17 lays out a form of mechanism for countries to partner towards the achievement of regional and international objectives. Unfortunately, it can be argued that the lack of close cooperation between countries in the Arabian Gulf created major obstacles in achieving the objectives of regional and international conventions. To prevent such issues in the future, regional bodies like the GCC should prioritise cooperation and partnerships as key strategies in the prevention of marine pollution. Specifically, the outcomes of this research point to the importance of cooperation and partnerships as outline by both UNCLOS and the SDGs.

The comparative analysis of the laws of the North Sea and Arabian Gulf shows the effect of globalisation on international law. Traditional environmental laws such as MARPOL 73/78 that focus on relations between countries are fast being boosted by new multilayered conventions and agreements such as the SDGs. Most regional states today are undertaking multilayered approaches that borrow from international environmental law. These conventions have a wide range of objectives such as increasing surveillance and conducting risk assessment on pollution activities.

Today, regional cooperation on matters relating to maritime transportation and oil pollution have become a basic yet critical part of international law and the global economy. Despite the existence of widely known international environmental initiatives such as SDGs, it can be argued that the success of international law is dependent on the success of regional instruments designed to curb marine pollution. As analysed above, the success of international conventions is also dependent on the values of the countries in question. Because of its role in the global economy, organisations like UNCTAD and the IMO have been at the forefront of creating awareness for the need of maritime transportation sustainability (Chintoan-Uta and Silva 2017). However, very few studies have conducted a comparative analysis of the effectiveness of regional agreements and conventions. Moreover, aspects of maritime transportation such as international civil liability are relatively new. The comparative analysis and the discussion of the role of UNCLOS and the SDGs provide a good background for future research.

It is evident that oil prevention activities and the SDGs play a significant role in improving the sustainability of maritime transportation. The reducing rate of pollution due to maritime transportation shows the effectiveness of the implementation of the SDGs and other conventions and agreements such as the Paris Agreement. Because it is the most efficient means of international transportation, maritime transportation is the backbone of world trade. As international trade grows, the issue of the sustainability of maritime transportation is expected to feature highly in future conventions and agreements.

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Chapter 11
Implications of Automation and Digitalization for Maritime Education and Training

Amit Sharma, Tae-Eun Kim, and Salman Nazir

Abstract Due to steady advancement and implementation of digitalization and automation technology, autonomous operations are slowly pervading all transportation sectors. In maritime sector, the industry and regulatory bodies are in active debate regarding the implementation mechanism, the operational, regulatory and safety aspects of such changes. The introduction of autonomous shipping in various degrees will have an impact on the fundamental ways various maritime operations are conducted. A change in work processes and roles within the sector would mean that the associated education and training for the seafarers will have to be adapted to meet the novel competence demands. In this chapter, we will discuss the maritime autonomous operations on the basis of prevailing trends in the maritime sector and their implications for Maritime Education and Training (MET). The directions and perceived solutions that can potentially aid in preparing for challenges and opportunities autonomous operations would entail will be elaborated upon. This chapter examines how digital technologies are changing the approach towards education and training, specifically with relation to maritime domain. The need to cultivate appropriate digital skills, information processing skills as well as other nontechnical skills is also highlighted. The aim is to provide a conceptual roadmap that shed lights on some of the ongoing developments occurring with respect to Maritime Education and Training.

Keywords Maritime operations · Autonomous ships · Maritime education and training · Digital technology

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1 Introduction

The maritime industry is often considered as old as human civilisation itself (Stopford 2009). Some of the earliest remains of the seagoing boats are found in the Persian Gulf dating back to sixth/fifth millennia BC (Carter 2006). These remains reveal a system of maritime exchange occurring in the nearby towns using ships. Over the years, ships expanded both in size and their voyage scope. They were able to transit bigger water bodies; ultimately culminating with the ability to cross large expanses of water bodies such as seas and oceans. Such changes correspondingly impacted the trade and transportation patterns all over the world. The ships steadily evolved over the years as well, as a result of change in basic technology. The shipping industry has witnessed the “Age of sail” where ships utilised sails as a means of propulsion (Carter and Carter 2010), steam powered ships (Griffiths 1997) and finally contemporary ships, utilising several modes (diesel/electric/nuclear) of propulsion; as well as modern navigational technology for their operations.

The current shipping industry is often termed as the “backbone” of the global economy; being responsible of 80–85% of the global trade (UNCTAD 2019). It has indispensable role at the moment in our society, as being responsible for the access of majority of goods which we need in day-to-day life. The personnel responsible for ensuring safe execution of maritime operations, traditionally have had a very challenging role to perform. The maritime industry has relied on their knowledge and competence for transferring variety of cargoes, often valuable products, on an equally if not more valuable assets—ships. However, it is worth noting that due to the advancement of shipping technology over the years, there has been a concurrent and noticeable trend in shipping, i.e. the utilisation of fewer manpower onboard. The involvement of human element onboard ships is getting less labour intensive and more challenging in terms of the cognitive demands on crew members (Mallam et al. 2019). The size of crew has steadily reduced over the years and their job functions increasingly diversified. For the future operations of maritime industry, we are now looking at the possibility of deployment of ships that are remotely controlled and highly autonomous in nature with presence of bare minimum or no crew members onboard.

2 Maritime Autonomous Ship Operations

Maritime industry stands at crossroads of technological development and at a verge on transition into next generation of shipping that would be characterised as consisting of vessels that are remotely controlled and autonomous in nature. In continuation of the ongoing trends of digitalisation and automation in various transport domains, maritime industry is looking at the possibility of introducing autonomous ships in various stages of their development cycle, throughout the coming years. The International Maritime Organization (IMO), has defined four degrees of

	Level of autonomy	*Human presence*	*Operational control*	*Human role*
Degree 1	Ship with automated processes and decision support	Yes	Seaferers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control	Supervision and operation
Degree 2	Remotely-controlled with seafarere on board	Yes	The ship is controlled and operated from another location. Seafarers are availabel on board to take control and to operate the shipboard systems and functions	Backup to manoeuvre, supervise the systems
Degree 3	Remotely-controlled without seafareres on board	No	The ship is controlled and operated from another location. There are no seafarers on board	Monitoring and remote control
Degree 4	Fully autonomous	No	The operating system of the ship is able to make decisions and determines actions by itself	Monitoring and emergency management

Fig. 11.1 The various degrees of autonomous operations as defined by IMO, adapted from Kim et al. (2019, p. 583)

autonomous operations from Degree 1, having human presence onboard and operating with decision support systems to Degree 4 representing a completely autonomous vessel, as illustrated in Fig. 11.1.

As evident in this framework, the autonomous ships in this context do not necessarily mean “unmanned” ships. The transition to “unmanned” ships in the future is going to be in incremental stages with increasing number of functions handed over to automation agents. The IMO has also commenced a regulatory scoping exercise for Maritime Autonomous Surface Ships (MASS) MSC 98 (2017). The primary reasons for the introduction of autonomous shipping has been argued as—reduction in emissions, improving efficiency and cost effectiveness, as well as improving safety by reduction in so called human error. However, as noted by many researchers (Komianos 2018; Kooij et al. 2018; Mallam et al. 2019; Porathe 2019), the promises regarding safety in operations particularly deserve cautious optimism. There are many operational, regulatory, and quality challenges influencing safety that are yet to be solved. Introduction of autonomous ships are likely to initiate a myriad of interaction between a “regular” manned ship and an “autonomous” ship with varying degrees of dynamic human control over the vessel (Porathe 2019).

Furthermore, the role of humans will evolve, as the need arises for novel competences requirements for operating such vessels (Sharma et al. 2019).

According to a report published by World Maritime University (WMU), the introduction of highly automated ships could lead to a slump in the global demand for seafarers from the current projections, by the year 2040 (WMU 2019). Further, the workers with low/medium skills and routine task intensive work are exposed to risk of losing their jobs to the highly skilled category of workers. To adequately cater to the changes in the maritime industry and corresponding change in competence requirements, it will require efforts to retrain the workforce in a considerable scale. In addition, the regulatory framework awarding the seafarers with Certificate of Competency (CoC) will require corresponding revisitation (Sharma et al. 2019).

The Standards of Training, Certification, & Watchkeeping (STCW 1978) as amended is the international convention that lays down the minimum competence requirements that the seafarers need to demonstrate before the flag state can issue them the CoC (IMO 2017). The flag state in this context is every nation signatory to the STCW 1978 as amaended, which ensures that the Maritime Education and Training (MET) institute adhere to the competence requirements stipulated in the convention. Such system, not without its own challenges in terms of subjective interpretation of the regulations, is an effort towards ensuring uniform compliance. The STCW convention and code have been subject to periodic revisions (for example in 1995 and 2010), taking into account the contemporary changes occurring in the shipping domain. It is already under speculation that, to cater for this new era of autonomous maritime operations and associated novel competence demands, the STCW convention and code will have to be revised accordingly (Sharma et al. 2019). Not only will the existing competence requirements for seafarers onboard change in light of autonomous operations framework, but it might also be necessary to cater for entirely new roles emerging due to such developments—for example Shore/Remote Control Centre Operators (Lutzhoft et al. 2019).

The technical skills required in autonomous operations will partly be a function of the technology in use. In addition, there is growing recognition of the importance of generic "soft skills" in modern complex socio-technical systems. These skills, often termed as "Non-technical skills" are defined as the *"the cognitive, social, and personal resource skills that complement technical skills, and contribute to safe and efficient task performance"* (Flin et al. 2008, p.1).

3 Future Competencies of Seafarers

Consider a hypothetical futuristic scenario with autonomous maritime operations as illustrated in Fig. 11.2 below. Vessels with various degrees of autonomous operations will mean that there have to be differential operational approaches, and even varying competence and skills, required in such operations. For seafarers present on an autonomous ship operating at degree 2 level of automation, they have a supervisory role in operations, but might be required to assess and evaluate the navigational

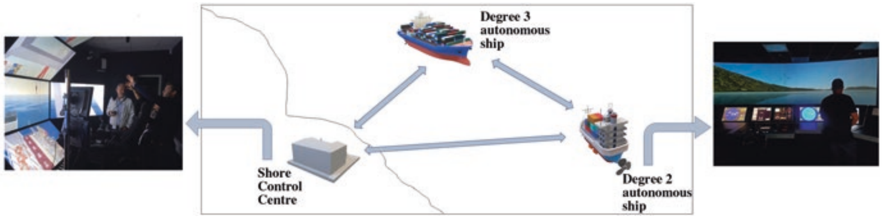

Fig. 11.2 Interaction between autonomous ships and shore control centre (copyrights with authors)

scenario at relatively short notice, should the need arise to take over the functions. For a vessel operating in degree 3 mode, as per the definition, it might even be the case that no seafarer is present onboard. However, such ships will be controlled from a remote or shore control centre. The operators of such a ship may or may not be a "seafarer" as we know them today. In addition, such operations may even lack the benefits offered by relatively enhanced situational awareness due to the actual presence on a ship as in degree 2 operations. It might also be the case that the operators responsible for a degree 3 ship are monitoring/controlling multiple ships and, therefore, they need to be aware of relatively specific information element parameters from multiple ships. These ships will also need to interact with one another, as well as with the shore control centre, using standard communication protocols. The future competence requirements in such scenarios will therefore take on new dimensions based on the evolving maritime operations.

The competence requirements and associated certification of seafarers are carried out as per STCW regulations describing the Knowledge, Understanding and Proficiency (KUPs) requirements for each position for merchant shipping. There has been an ongoing debate regarding the relevancy and suitability of existing STCW requirements for future maritime operations. The challenge regarding uniform application exists as each member state signatory to STCW interprets differently the terms and provisions given in it.

According to a recent survey carried out by Lloyd's Maritime Academy (Safety4Sea, 2019), about 67% of the respondents felt that there is a considerable skill gap present in maritime domain. The developments with regard to autonomous maritime operations can further exacerbate these challenges. Due to the fundamentally different nature of job functions for the seafarers in autonomous ships, not all KUPs as listed at present in the competency tables will be required. The functions that will be automated, or carried out by automation agents, will correspondingly not be relevant anymore.

In relation to this, Sharma et al. (2019) carried out an exploratory study regarding the suitability of Table A-II/1, which lists the competence requirements of navigators in an operational role, for hypothetical Degree 2 autonomous operations. The study consisted of a survey, where a number of maritime professionals were asked to rate the relevance of each of the KUPs in the table for the scenario as mentioned above. The respondents indicated that the competences related to the emergency management functions will be highly relevant as routine tasks will become more and more automated. The role of human operators in such a scenario will be more inclined towards handling of nonroutine or emergency events. Further, the need for inclusion of novel KUPs might arise in light of more supervisory roles for the seafarers in autonomous operations. The report by Norwegian Shipowners Association (2018) predicts that competences related to ICT, data processing, and cyber technology will be in high demand in the coming decade.

The importance of training seafarers in nontechnical skills such as teamwork, leadership, communication etc. has increasingly been recognised in the past few years by the maritime stakeholders. This is evident by the recent revisions in the STCW regulations to explicitly include provisions regarding their demonstration (Sellberg and Lundin 2018). Numerous accident analyses and case studies have illustrated the role of nontechnical skills in contributing to the maritime causalities (Barnett et al. 2006). In this regard, it is important that not only are the seafarers equipped with adequate technical skills, taking into account the developments with regards to technology, but they also possess relevant nontechnical skills for functioning efficiently as an individual as well as a team member amidst the evolving working environment.

As of now the framework and focus towards including nontechnical skills in training and assessment for seafarer seems underdeveloped and unstandardised. Fjeld et al. (2018) carried out a systematic review of studies which focused on nontechnical skills for bridge officers in maritime industry. They identified five nontechnical skills which were the focus in associated literature review, namely—(1) Situation Awareness (2) Decision-making (3) Workload management (4) Communication and (5) Leadership.

The first three skills belong to the category of "cognitive" skills and the latter two skills are termed as "interpersonal" or "social" skills. Fjeld et al. (2018) stated that in the research literature there is insufficient exploration of these skills in enough detail to formulate meaningful guidelines for maritime industry. For example, the studies focusing on "decision-making" usually focus on naturalistic decision-making forms and less or almost no focus on analytic and procedure-based decision-making forms. Further, there appears to be imbalance between research articles focusing on cognitive skills, in contrast to those focusing on interpersonal skills for bridge officers. Finally, no complete taxonomy of nontechnical skills for bridge officers exists as of now for facilitating standardised training and assessment.

Challenges such as those mentioned above may contribute to the regulatory barriers maritime industry faces and thereby impact the rate of adoption of autonomous vessels and may also restrict their operations in national waters of selected states in immediate future. Therefore, the perceived benefits in relation to the more sustainable modes of transportation with such ships could initially require support in terms of international policy, guidelines and frameworks for maritime education and training.

4 The Role of Digital Technologies

MET has not remained insular to the wider changes occurring with respect to the usage of digital technologies for education and training of industrial workforce. From the use of simulators onshore for training the seafarers in various functional roles for their jobs, to the use of distance learning solutions utilising ubiquitous mobile devices for supplementing the competence development onboard, maritime industry is adopting various approaches for keeping up with changing skillset demands. In relation to this, there is ongoing debate around the use of Virtual Reality (VR) and Augmented Reality (AR) for their potential application in MET.

The utility of immersive technologies such as VR and AR, can provide a wide range of new possibilities and applications for MET practices. Some of the pedagogical approaches VR and AR can support are: constructivist learning, situated learning, game-based learning, enquiry-based learning, for example. These technologies bring novel and innovative opportunities for enhancing the way we learn. They immerse users completely within a computer-generated environment providing experiences not found in other simulation mediums. A study on the training usage of immersive technologies (Nazir et al. 2014) suggests better task efficiency and increased performance in VR, while under stress compared to other conventional methods (i.e. power point presentation and class-room-based training). Another experimental study by Mallam et al. (2018) revealed that participants have better task efficiency in virtual environment compared to the traditional desktop environments, which is the main focus for maritime training as well.

On the other hand, head-mounted virtual reality (HMD VR) provides promising means of training in terms of better accessibility, mobility and participants' motivation (Mallam et al. 2018). With recent challenges concerning distance learning during the COVID-19 outbreak (Oranburg 2020), the need to deploy effective remote training solutions has been amplified. Moreover, differing technological solutions (i.e. augmented reality, mixed reality, etc.) within the framework of the reality-virtuality continuum are emerging amidst the necessity for diversification in the maritime training and assessment paradigm. Mallam et al. (2019) provided the context for their practical implementation (e.g. cost and fidelity), complying with the taxonomy for these technologies being theorised by Milgram and Kishino (1994) (Fig. 11.3).

In relation to the above continuum, Augmented Reality (AR) can be defined as a *"situation in which a real world context is dynamically overlaid with coherent location or context sensitive virtual information"* (Klopfer and Squire 2008). There has been some evidence regarding application of AR in various educational settings for increasing student engagement, motivation and helping them to achieve the intended learning outcomes (Bower et al. 2014). AR systems can also help in visualising abstract concepts and unobservable phenomenon (Wu et al. 2013). Further, AR can provide resources to the educational context which may otherwise be costly or impractical to acquire (for example: lab equipment) (Fjeld and Voegtli 2002).

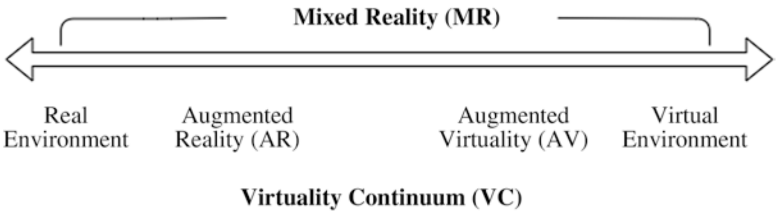

Fig. 11.3 A representation of a "virtuality continuum" (Milgram and Kishino 1994)

AR training solutions, just like VR, can therefore make ubiquitous learning for maritime students a possibility in near future and contribute in the skills development. There have been studies related to practical application of AR for maritime operations as well. Von Lukas et al. (2014) illustrated how AR technology might be used for maritime engineering, production, operation and harbour surveillance functions. Further, projects like Maritime Augmented Reality (M-AR) by the Royal Norwegian Navy, investigate the use of AR to support the navigation and enhance the Situational Awareness (SA) of the navigator by providing augmented information (Hareide and Porathe 2019).

Continuous research and development converging towards the refined output of VR and AR training solutions has shown potential for increased training transfer, better immersion and reduced cost (Buttussi and Chittaro 2017; Jensen and Konradsen 2018; Renganayagalu et al. 2019). Various other disciplines including the process (Nazir et al. 2012), health (Riva 2002; Gregg and Tarrier 2007), and aviation (Marion et al. 2007; O'Neil et al. 2000) have also been investigating the benefits of VR/AR training.

5 Implication for Maritime Education and Training

Implementation of maritime autonomous shipping solutions would have profound implications to skillsets required to handle the new technology, and consequently there will be a race between the technology and domain of MET in order to keep pace with the ever-growing change in the types of competence demanded. The returns in terms of value creation for MET are potentially high, however, it should be acknowledged that the quality of schooling differs across the globe for the seafarers. Automation may further increase the gap between the developed and developing countries in MET practices as MASS is widely being researched, tested and developed in industrialised and advanced countries, such as Norway, Japan, South Korea, etc. This implies that future technological disruption will potentially have a bigger impact for the MET market in developing countries.

Based on these predictions, we believe that there are several policy priorities that MET industry should be considered, in order to prepare for the future:

Firstly, automation implies new skills but also deskilling: some skills that are needed today might be eliminated by the introduction of more advanced technologies (Sharma et al. 2019). The business model should be updated, and more focus should be placed on early development of new competences, in order to keep pace with the technological advancements and market demands.

Secondly, it is important to provide good balance between the current competence development programme and the new ones, in order to ensure the seafarers are capable of operating in difference mode of MASS and remain immune to automation.

Thirdly, the use of digital technologies such as VR and AR should be further explored for training in skills required for maritime operations, as they can support the transfer of training, enhance task effectiveness, and provide ubiquitous learning solutions, while potentially reducing associated costs.

Finally, it is important to note that the goal of introducing automation is to increase the productivity and safety by freeing personnel from working in the perceived risky, remote and repetitive jobs, which in turn has the potential to contribute to greater welfare in society. Nevertheless, how well the automation technology will be implemented and operated is heavily dependent on the quality and relevance of education and training in preparing future ship operators. Accordingly, re-establishing the future of MET needs to be a collective effort between all stakeholders in the maritime industry. More industrial-MET alliances and collaboration will be crucial for technological progress and goal achievement.

6 Conclusion

Maritime industry is going through a wave of digitalization and automation. To keep pace with technological advancements and market demands, the global standard for maritime training and certification practices will also require revision and adaption. In the midst of this major change, it is important that the MET institutes in each jurisdiction are proactive in building competence structures for seafarers to embrace this new era of ship operations and to stay ahead of competition. The discussions and arguments in this chapter, hopefully, could encourage more contributions and research into future seafarers' competence requirements and the novel outlook towards training methods and practices.

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Chapter 12
Synergies Between the Obligations and Measures to Reduce Vessel-Source Underwater Noise and Greenhouse Gas Emissions

Anita Rayegani

Abstract Despite awareness of the impacts of underwater noise on marine life and the interpretation of noise as pollution under international law, regulatory action continues to stall. In addressing this disconnect, the chapter narrows in on the International Maritime Organization's proposition—that interactions and contributions of tools initially developed to attain other objectives, including increasing energy efficiency, should be considered when striving to reduce underwater noise. As the pressure to reduce greenhouse gas emissions from international shipping expedites progress in improving energy efficiency, States have options to circumvent law of the sea restrictions by adopting rules and standards with dual benefits to mitigate underwater noise impacts. The distinct central regulatory frameworks for the two challenges and the possible mitigation measures intertwine. Therefore, in many scenarios, efficiency optimization can be a vehicle for reducing both greenhouse gas emissions and underwater noise.

Keywords Underwater noise · Greenhouse gas emissions · Maritime transport

1 Introduction: Another Way Is Possible

Concerns about the impacts of anthropogenic underwater noise on marine mammals began in the 1970s (e.g., Payne and Webb 1971; Myrberg 1978) and drastically increased since the early 1990s (Williams et al. 2015). The consideration of underwater noise as a potential source of pollution by the United Nations Environment Programme (UNEP) dates back to 1985 (UNEP 1985). First associated with seismic

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activities and the oil and gas industry, underwater noise started to gain public attention as a threat to marine life after a series of cetacean stranding incidents linked to sonar experiments (Scott 2004; Southall et al. 2008). In the aftermath of the incidents, the scientific community was encouraged to fill gaps in knowledge required to implement policy guidelines and regulations (UNGA 2006; McKenna et al. 2008; Markus and Silva Sánchez 2018). Legal discussions followed, supporting the interpretation of underwater noise as a form of (transboundary) pollution under international law subject to the regulatory framework for pollution control (Dotinga and Elferink 2000; McCarthy 2001; Scott 2004).

Since then, various sources and impacts of underwater noise have been identified, lengthening the list of potentially harmful activities and adversely affected species. Among the recognized causes of underwater noise are seaborne transportation (McKenna et al. 2012; Erbe et al. 2019), sonar (Parsons 2017), offshore renewable energy (Gill 2005), underwater construction, explosions, airguns, echolocation, and acoustic deterrents (Richardson et al. 1995; National Research Council 2003; CBD 2012). Since the sources yield varying consequences and demand specific mitigation and reduction approaches, this chapter narrows in on only one: noise emitted by commercial vessels.

As vessels raise the volume, the voices of marine species are increasingly interrupted. Underwater noise obstructs ways of life and threatens survival. It also adds to the multiple other stressors damaging marine ecosystems worldwide. Today, many of the leading concerns, such as warming waters and increased acidification, are interlinked with climate change (IPCC 2019). However, actions often remain slow and segmented, separated by the multitude of comprehensive regulatory frameworks. Including frameworks for carrying out ocean activities (see the law of the sea) and frameworks for regulating climate change (see the climate change regime). Meanwhile, the overarching framework comprised of goals, targets, and action items (Sustainable Development Goals) depends on our abilities to approach problems with the intent of implementing solutions not only for isolated issues but for parallel challenges.

We do not have time to wait (IPCC 2018), and pressures to decarbonize international shipping continue to mount. It is now technologically possible to increase the energy efficiency of ships to reduce greenhouse gas (GHG) emissions and underwater noise. We also have functional operational measures, including routing systems and slow steaming, to avoid impacts to noise-sensitive areas and reduce GHG emissions.

In some ways, we remain limited in the actions we can take to safeguard the environment by the legal frameworks we have created. However, there is a will to circumvent restrictions and pressure on coastal States to adopt measures to reduce the risks of underwater noise introduced by foreign-flagged vessels. A way to do so is by implementing measures available to reduce GHG emissions. This chapter aims to shine a light on the proposition that consolidating tools initially developed for other purposes can be used to strengthen approaches to mitigate the risks of underwater noise.

After outlining the relevant Sustainable Development Goals (SDGs) and how they interact, the chapter proceeds in Sect. 2 by defining underwater noise in context. Next, Sect. 3 provides an overview of GHG emissions from international shipping and the regulatory framework set out in the climate change regime and supporting tools developed by the International Maritime Organization (IMO). Section 4 explains the applicable legal framework within the United Nations Convention on the Law of the Sea (UNCLOS, 1982), the limitations on coastal States to impose regulations on foreign-flagged vessels, and the IMO voluntary guidelines to reduce underwater noise. Section 5 considers static and operational measures designed to increase energy efficiency and reduce GHG emissions and the projected consequences of the measures on underwater noise generation. Lastly, the conclusion identifies synergies and suggests harnessing measures initiated to reduce GHG emissions as a way to enhance and expedite action to reduce underwater noise and mitigate associated risks.

1.1 Sustainable Development Goals

The 17 sustainable development goals within the 2030 Agenda for Sustainable Development are *integrated and indivisible* (SDGs 2015, para. 55). Together they are meant to incite action on three fronts: economy, society, and environment. Regarding the planet, the goals and affiliated targets encompass the need to urgently address climate change and prevent environmental degradation (SDGs 2015, Preamble).

Goal 13 entails urgent action to address climate change and acknowledges the United Nations Framework Convention on Climate Change (UNFCCC 1992) as the primary international, intergovernmental forum to negotiate the global response (SDGs 2015, Goal 13). Subsequently, Goal 14 presents the aim to *"[c]onserve and sustainably use the oceans, seas and marine resources for sustainable development"* (SDGs 2015, Goal 14). Among the actionable targets are the prevention and severe reduction of marine pollution of all kinds and tackling ocean acidification (SDGs 2015, Goals 14.1, 14.3).

There are many links between the challenges underlying Goals 13 and 14. Ocean acidification is a consequence of climate change (SDGs 2015, para. 14; IPCC 2014). It results from rising carbon dioxide (CO_2) concentrations in the atmosphere and their absorption by the ocean (Herr et al. 2014; IPCC 2014). Furthermore, ocean-based ecosystems mitigate climate change by storing carbon and generating oxygen (Laffoley et al. 2014). As the marine environment degenerates, the ability to mitigate climate change through these processes weakens, and accordingly, CO_2 concentrations in the atmosphere will increase (Laffoley et al. 2014). Ocean acidification, ocean warming, and oxygen loss are among the primary, closely related stressors on the marine environment associated with climate change (IUCN 2017a).

The ocean's role in the carbon cycle underlies the links between Goals 13 and 14. Yet, human activities have a range of other impacts on the marine environment that aggravate risks and threaten biodiversity. Underwater noise is among these impacts. Due to the associated risks to marine life, underwater noise falls within the scope of Goal 14 and requires prevention and reduction for effective ocean conservation (UNGA 2017; Lüber et al. 2017; IUCN 2017b).

2 Underwater Noise as a Risk to Marine Life

In the current context, *noise* refers to all sound which can be harmful, dangerous, or disruptive (OSPAR undated). To monitor underwater sound, sources are categorized as either ambient or impulsive. The majority of underwater sound resulting from the operation of vessels is ambient, which means that it contributes to overall underwater background noise, adding to naturally occurring sources including earthquakes, submarine volcanic activities, strong winds, waves, and heavy rain against the water's surface (Richardson et al. 1995). Over the past decades, ambient noise in parts of the ocean has doubled every 10 years (PAME 2019).

Vessels generate noise primarily through propeller cavitation. This occurs when a fast-rotating propeller pushes water, and a low-pressure zone forms at the backside of the blade, as the water boils it forms collapsing bubbles—which emit sounds when bursting (Jalkanen et al. 2018). Vessels also generate noise through rotating machinery, including engines and water flow related to the hull (ICES 1995). When vessels create high levels of sound, ambient noise levels increase and may, consequently, conceal vital communication and echolocation signals of marine species, reduce hearing sensitivity, and increase general stress responses (Southall et al. 2017; Rolland et al. 2012). Over time, impacts may result in changes in behavior and influence marine animals' relationships with their habitats, potentially leading to habitat abandonment (National Research Council 2003). Furthermore, the interdependence of marine species suggests that impacts of noise may be felt beyond individual populations, raising concerns over rippling effects on entire ecosystems (CBD 2012).

Concerns regarding the impacts of vessel-source underwater noise on marine life have risen in correlation with the expansion of maritime transport (McKenna et al. 2012) Recently, attention has also been directed toward (previously) ice-covered areas, where maritime traffic routes are becoming more viable, thus expanding areas of potential risk (PAME 2019).

2.1 Tackling Vessel-Source Underwater Noise

Presently, the IMO is widely supported as the competent international organization to regulate international shipping (Treves 1998; Chircop 2019). In 2014 the IMO's Marine Environment Protection Committee (MEPC) adopted the *Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life* (IMO 2014), hereafter: IMO Underwater Noise Guidelines.

The IMO Underwater Noise Guidelines encourage the reduction of underwater noise from commercial shipping. The second paragraph of the preamble to the guidelines proposes a path to success in developing a strategy to reduce underwater noise. It suggests that interactions and contributions from measures created to attain other objectives, namely onboard noise reduction or improved energy efficiency, should be considered when striving to reduce underwater noise.

In this way, the IMO implies that combining the guidelines with the side effects of measures created for other purposes may be an effective way to reduce the impacts of vessel-source underwater noise on marine life. The core of this proposition is reminiscent of the preamble to UNCLOS, which asserts that *"the problems of ocean space are closely interrelated and need to be considered as a whole"* (UNCLOS 1982, Preamble). Considering the technological advancements propelled forward to increase the energy efficiency of ships, investigating this proposition involves observing the influence that the climate change regime has on shipping, and the benefits of measures developed.

3 GHG Emissions from Ships

On average, international shipping contributes about 2.7% to total global anthropogenic GHG emissions (Third IMO GHG Study 2015; Olmer et al. 2017). The majority of these emissions consist of CO_2 emissions, and depending on economic growth and development in energy, may grow between 50–250% by 2050 (Third IMO GHG Study 2015). In comparison with other modes of transportation, shipping is a low-carbon method for moving freight (Second IMO GHG Study 2009; Bows-Larkin 2015). However, it also has significant untapped potential to reduce emissions by applying technological and operational measures (Bows-Larkin 2015). The following overview summarizes key instruments of the climate change regime and their relationship to the regulation of emissions from international shipping. It highlights regulatory challenges, the pressure for meaningful progress, and supplementary instruments developed by the IMO.

3.1 International Shipping and the Climate Change Regime Framework

The regulatory framework of the global climate change regime centers on the UNFCCC, adopted in Rio de Janeiro in 1992 and entered into force in 1994. The UNFCCC forms the core upon which subsequent agreements and tools have been developed to combat climate change. Guided by the principle of "common but differentiated responsibility and respective capabilities" (CBDR-RC), it maintains the ultimate objective of stabilizing GHG concentrations in the atmosphere *"at a level that would prevent dangerous anthropogenic interference with the climate system"* (UNFCCC 1992, Art. 2).

The objective is to be achieved within a timeframe that allows for the natural adaptation of ecosystems to climate change (UNFCCC 1992, Art. 2). Within its list of commitments, the UNFCCC includes the control, reduction, and prevention of GHGs outside the scope of the Montreal Protocol within all relevant sectors of the economy, including transportation (UNFCCC 1992, Art. 4.1(c)). Yet, reducing emissions from international maritime transport (together with aviation referred to as "international bunker fuels") involves particular regulatory challenges.

The UNFCCC has considered the allocation and control of emissions from international bunker fuels since the first meeting of the Conference of the Parties (COP) in 1995 (Berlin Mandate 1995). In Berlin, the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) was assigned the task to consider options for allocating and controlling international bunker fuel emissions (Berlin Mandate 1995, Decision 4/CP.1, para. 1(f)). However, despite weighing eight options, an agreement could not be reached to allocate the emissions (Ringbom 2020). Consequently, when the Kyoto Protocol was adopted in 1997, emissions from international shipping were excluded from the targets (Martinez 2016). Instead of being calculated into national totals, international bunker fuel emissions are reported separately (FCCC/CP/1997/7/Add.1, 1998, 2/CP.3, para. 4).

3.2 The Kyoto Protocol

The Kyoto Protocol to the UNFCCC (Kyoto Protocol 1997) is a legally binding treaty. It is guided by the principles of the UNFCCC and pursues the same objective (Kyoto Protocol 1997, Preamble) with the aim to strengthen and operationalize commitments (Berlin Mandate 1995, Decision 1/CP.1, para. 2(a)). For this purpose, it adopts binding GHG emissions reduction targets for Annex I (industrialized) Parties and sets a timeline for their achievement through commitment periods (Kyoto Protocol 1997, Art. 3). Since international bunker fuels are excluded from national totals, international shipping emissions are not subject to the reduction and limitation targets. Despite the exclusion, the necessity to address international shipping emissions is recognized, and Annex 1 Parties are to work through the IMO to pursue reduction measures (Kyoto Protocol 1997, Art. 2.2).

The IMO considered vessel-source atmospheric pollution issues since the 1980s, yet a renewed focus on developing a CO_2 reduction strategy arose after the Kyoto Protocol was adopted (Chircop et al. 2018). In its approach to tackling GHG emissions, the IMO and its MEPC have developed technical, operational, and market--based measures. Yet, despite the IMO's work, the COP kept the regulation of international shipping emissions on its agenda until the final days of negotiations of the Paris Agreement (Paris Agreement 2015). In the end, international bunker fuels were excluded from the text (see an overview by Martinez 2016).

3.3 The Paris Agreement

The Paris Agreement was adopted in 2015 and entered into force in 2016 as another additional instrument of the climate change regime to enhance the implementation of the UNFCCC (Paris Agreement 2015, Art. 2(1)). It specifies the aim of strengthening the response to climate change threats and links the challenge to the broader context of sustainable development (Paris Agreement 2015, Art. 2). Additionally, the Paris Agreement sets a temperature goal to limit the increase of the average global temperature to well below 2 °C and ideally to 1.5 °C above preindustrial levels (Paris Agreement 2015, Art. 2(1)(a)).

The Paris Agreement is also based on the principle of CBDR-RC but has a broadened scope of applicability. Instead of applying the Kyoto Protocol approach of binding only Annex 1 Parties to targets, the Paris Agreement uses pledges—referred to as Nationally Determined Contributions (NDCs)—to meet its goals. Notably, the NDCs are to be submitted by all Parties (Paris Agreement 2015, Art. 4(2)). Since a significant proportion of vessels are flagged under non-Annex 1 States (Olmer et al. 2017; Lloyd's List 2019), broadening the scope of applicability allows for more comprehensive coverage of the global fleet.

The Paris Agreement encompasses all emissions. Despite no mention of international maritime transport *explicitly*, the sector remains included through the UNFCCC, Article 4(1)(c) reference (Ringbom 2020). Nothing in the Paris Agreement precludes Parties from including domestic or international shipping emissions in their NDCs (Martinez 2016; Doelle and Chircop 2019). However, despite the possibility of including international emissions in NDCs, the mobile nature of shipping, difficulties in allocating responsibility for emissions from international voyages, and the ease of changing a ship's flag State remain challenges in doing so (Doelle and Chircop 2019). Due to the hurdles of regulating GHG emissions from international shipping through the climate regime framework, the IMO continues to develop alternative approaches.

3.4 Reducing GHG Emissions by Increasing Energy Efficiency

Recently, the IMO adopted an Initial Strategy to cut GHG emissions from international shipping, in accordance with SDG 13 (Initial Strategy 2018). In its current preliminary state, the instrument is a milestone, part of a roadmap for developing a comprehensive strategy to be finalized and adopted in 2023 (Initial Strategy 2018, para. 1.4).

Within the Initial Strategy, the IMO presents a vision to phase out GHG emissions from international shipping "*as soon as possible in this century*" (Initial Strategy 2018, para. 2). Furthermore, it establishes a goal to reduce "*total annual GHG emissions by at least 50% by 2050 compared to 2008*" (Initial Strategy 2018, para. 3.1.3). Action items to achieve this mission include a list of short-, mid-, and long-term measures (Initial Strategy 2018, para. 4). Among the listed short-term measures is improving the existing IMO framework for energy efficiency, namely, the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP). The EEDI and SEEMP were adopted by the MEPC in 2011 as a new chapter 4 through amendments to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).

The EEDI relates to the design efficiency for new vessels. It is a performance-based tool that establishes and periodically strengthens the minimum standards of efficiency for different types and segments of ships. The standards set by the EEDI are to be met using technologies chosen by the industry, thereby motivating innovation and continued development and refinement of technologies. Although the EEDI does not apply to all ships, it does cover the most energy-intensive vessels (Chircop 2019).

The SEEMP complements the EEDI by addressing the energy efficiency of ships through operational measures and makes it mandatory that all newly built and existing ships have an energy management plan onboard. The SEEMP also does not specify the precise type of measures that are to be incorporated (MARPOL 73/78 annex VI, chap 4, reg. 22). Both, the EEDI and the SEEMP should continue to be developed and increasingly implemented as the objective of reducing GHG emissions by improving the energy efficiency of ships remains.

The drafting processes and texts of the UNFCCC, the Kyoto Protocol, and the Paris Agreement show continued efforts to tackle international shipping emissions through the climate change regime. However, ongoing challenges in allocating responsibility for emissions, and the ease with which a ship can change flag States reaffirm the importance of regulatory options outside the core framework of the climate change regime. The IMO's approach to reducing atmospheric emissions raises the question of whether existing technological and operational measures can be applied to mitigate underwater noise risks.

4 Managing Underwater Noise from Ships

Underwater noise radiated from vessels can introduce varying levels of risk to marine life. Categorizing the risks for regulation has involved the interpretation of noise as a pollutant under UNCLOS. Meanwhile, the mobile nature of marine transportation and sound's ability to travel great distances has raised it as a form of *transboundary* pollution. These interpretations invoke rights and obligations relating to the prevention, reduction, and control of pollution within and beyond UNCLOS. Furthermore, the recognition that environmental protection requires more than pollution control further reinforces the duty of States to mitigate underwater noise-related risks to protect and preserve the marine environment.

4.1 Underwater Noise and the Law of the Sea

The UNCLOS provisions were crafted to be able to address ocean-related challenges discovered after the finalization of the text (Stephens 2016). Accordingly, it has been reasoned that the definition for marine environmental pollution contained in UNCLOS Article 1(4) should be interpreted with consideration for developments in the understanding of new and old sources of pollution (Dotinga and Elferink 2000; Scott 2004). The definition begins as follows,

> *"[p]ollution of the marine environment" means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life* (UNCLOS 1982, Art. 1(4)).

It is justified that the inclusion of energy in the definition encompasses all forms of energy, including sound (Dotinga and Elferink 2000; Scott 2004). The position is supported by reference to the 1969 Vienna Convention on the Law of Treaties (VCLT 1969), which maintains that a treaty shall be interpreted per its ordinary meaning, and in light of its object and purpose (VCLT 1969, Art. 31(1)). Since the purpose of UNCLOS includes the protection and preservation of the marine environment (UNCLOS 1982, Preamble and Part XII), there is a risk that it may be undermined by applying a narrow interpretation of the definition limited to sources of pollution known at the time of drafting (Scott 2004).

Likewise, the cross-border impacts of underwater noise may result in transboundary pollution. Ecological impacts are not restrained by human boundaries (McCarthy 2001). Therefore, since sound can travel great distances and international shipping entails crossing maritime borders, the obligation to prevent pollution-related transboundary damage may also be applicable (Dotinga and Elferink 2000; McCarthy 2001).

Given the momentum that the understanding of noise as pollution has generated, it is undoubtedly an important basis for regulatory action. Regulatory action is further supported by renewed clarity within international law on the protection and preservation of the marine environment under UNCLOS Part XII and the general provisions on prevention, reduction, and control of pollution under Article 194 (see analysis in Czybulka 2017).

In the *Chagos Case* (Mauritius *v.* UK 2015), the tribunal held that Part XII extends beyond pollution control and cites Article 194(5), which concerns both pollution control *and* biodiversity protection to support this holding (Mauritius *v.* UK 2015, para. 320, 538). Article 194(5) expresses that measures necessary to protect rare or fragile ecosystems and habitats of marine life fall within the scope of Part XII. Thereby indicating that necessary measures aimed at protecting biodiversity are permissible (Czybulka 2017). The tribunal held that Article 194 is *"not limited to measures aimed strictly at controlling pollution and extends to measures focussed primarily on conservation and the preservation of ecosystems"* (Mauritius v. UK 2015, para. 538).

The statement is reaffirmed in the *South China Sea Arbitration* (Philippines v. China 2016) and articulated with emphasis on necessary measures to protect rare or fragile ecosystems and *"depleted, threatened or endangered species"* (Philippines v. China 2016, para. 945). The interpretations expressed by the tribunals in the 2015 *Chagos Case* and 2016 *South China Sea Arbitration* bring attention to the meaning of environmental protection (Czybulka 2017). A meaning which has evolved with an increased understanding of environmental risks. The tribunals convey reasoning which supports the obligation to address underwater noise since, in many circumstances, the control of underwater noise is necessary to protect and preserve biodiversity.

4.2 Generally Accepted International Rules and Standards

Since UNCLOS functions as a framework, it does not include the specific rules and standards that are to be applied. Instead, concerning the regulation of vessels, it expresses the obligations and capabilities of States acting in their varying capacities as flag, coastal, and port States by reference to "generally accepted international rules and standards" (GAIRS) (UNCLOS 1982, Arts. 211(2), 211(5), 211(6)(c)).

The GAIRS are to be established by States through the competent international organization or general diplomatic conference (UNCLOS 1982, Art. 211(1)). Once the GAIRS are established, they function as both a point of reference and a form of criteria (Treves 1998). They determine the minimum threshold for the rules that a flag State *shall* adopt for its ships regardless of the geographic location and the maximum threshold for rules a State *may* adopt and enforce in accordance with jurisdictional limits within the distinct maritime zones.

Due in part to fundamental freedoms of navigation, coastal States face numerous restrictions in adopting unilateral measures. Therefore, when rules and standards are developed but have not attained status as GAIRS, their adoption as mandatory measures are limited (Ringbom 2020), save for a few exceptions (e.g., UNCLOS 1982, Art. 234 for ice-covered areas). Within the territorial sea, where coastal States maintain sovereignty, they remain limited by vessels' rights to innocent passage (Treves 2015). Therefore, despite the relatively extensive types of regulations that they may adopt (UNCLOS 1982, Art. 21), coastal States are explicitly restricted when adopting regulations on the construction, design, manning, or equipment (CDME) of foreign-flagged vessels. Concerning CDME regulations, coastal States are restricted to adopting measures that have attained status as GAIRS (UNCLOS 1982, Art. 21(2)).

Likewise, additional rules and regulations on CDME that coastal States may adopt in the exclusive economic zone to prevent, reduce, and control vessel-source pollution are also restricted to GAIRS (UNCLOS 1982, Art. 211(6)(c)). The result is that coastal States seeking to make the use of CDME technologies mandatory to mitigate underwater noise are limited to adopting GAIRS. The restriction raises the question of whether GAIRS exist to control underwater vessel-source noise or if voluntary measures can be effective.

4.3 International Instruments to Reduce Underwater Noise and Mitigate Risks

The IMO Underwater Noise Guidelines consist of voluntary measures intended as advice for ship designers, builders, and operators on reducing vessel-source underwater noise (IMO 2014). Although there is no intention to develop the guidelines into a mandatory instrument, they can attain status as GAIRS. Considering the conclusion of the Marine Pollution Committee of the International Law Association (ILA), GAIRS are not equal with customary law or treaty law. Instead, they are primarily based on the practice of States (ILA 2000; Ringbom 2008). It is the attainment of general acceptance of a particular rule or standard which defines GAIRS, and not the instrument in which it is included (ILA 2000). Accordingly, States may implement rules and standards for vessels flying under their flag, which adhere to the IMO Underwater Noise Guidelines. With time, the measures can become widespread enough to gain general acceptance and status as GAIRS.

The IMO Underwater Noise Guidelines focus mainly on primary sources of underwater noise relating to the vessel, addressing propeller and hull design and onboard machinery (IMO 2014, paras. 7–8.5). The design measures predominantly aim to reduce cavitation, a primary cause of underwater noise (IMO 2014, paras. 7–8.5). Furthermore, it contains a list of maintenance routines and operational measures applicable to both new builds and existing ships. These relate to propeller cleaning, hull surface maintenance, speed modification, and routing measures to avoid sensitive marine areas (IMO 2014, paras. 10–10.5). The guidelines are not specific, leaving both maximum noise thresholds and the technologies to be used to be determined. They are also open, allowing the liberty of other measures to be implemented and consider *"interactions and contributions from measures provided to achieve other objectives"* (IMO 2014, para. 1.2).

Although GAIRS give coastal States legislative power and flag States a base threshold to meet when adopting regulations, unilateral action by flag States remains a possibility (Owen 2003). So too does limited action by coastal States within the territorial sea and exclusive economic zone. In this regard, there exist a range of best practices around the world to control underwater noise from various sources. Most of which are part of instruments with broader marine protection agendas (see Erbe 2013; Markus and Silva Sánchez 2018). Many focus on measures to achieve other objectives and reduce noise as a side effect. The following sections provide an overview of a selection of such measures linked to reducing atmospheric emissions and highlight interactions with underwater noise.

5 Interlinkages Between the Reduction of GHG Emissions and Underwater Noise

The overview of measures indicates that rules which apply to ships generally either target a specific static feature of the vessel or the way it is operated. Addressing static features entails addressing the vessel's component that generates noise or emissions by altering the design, construction, or equipment. Changes to static features are implemented before the ship leaves port and remain throughout the voyage, regardless of the maritime zone (Molenaar 2007). However, this does not work for all existing vessels as altering static features can only be done either at the design phase or through retrofitting.

Meanwhile, operational measures aim to mitigate risks of the noise emitted, essentially compensating for design, construction, and equipment. Operational measures address the impacts of noise or emissions within a designated area. They are flexible and applicable to both new and existing vessels, allowing for timely action. The following section provides an overview of a selection of measures and how they relate to energy efficiency, atmospheric emissions, and underwater noise.

5.1 Design, Construction, and Equipment

Table 12.1 lists a selection of technologies alongside the projected influence the technologies have on vessel-source emissions and energy efficiency, and the considered level of success for underwater noise reduction. The data and structure used for the development of the table originate from a report and technology matrix developed by Vard Marine Inc. (a Fincantieri Company). The company was commissioned by the Government of Canada to conduct necessary research to improve the understanding of, and possible response measures to vessel-source underwater noise (Kendrick and Terweij 2019). Canada has submitted the outcomes of the report and matrix to the IMO (IMO 2019). The author invites readers to refer to the original document for technical details relating to the measures and data collection process.

Table 12.1 illustrates technologies from the original document presented with either a positive (Advantage) or negative (Disadvantage) relationship on efficiency and emissions. This information is extracted and shown in line with the projected effect on noise reduction, categorized as: low, medium, or high. When influence on noise is reported to vary, the range is represented by an "X" under more than one heading. The table's purpose is to illustrate the relationship between energy efficiency measures, emissions, and underwater noise. The list of technologies incorporates the categories included in the IMO Underwater Noise Guidelines (shaded cells).

Table 12.1 illustrates that not all efficiency-optimizing measures influence emissions. Wake flow modifications show increased efficiency and emissions reduction while showing low or medium noise reduction. Hull treatments show varying benefits for noise reduction. Alternative fuels show benefits for all variables, while the use of wind demonstrates a range from medium to high, due to weather dependence.

Batteries are inherently silent yet depend on either stored energy from shore power or an integrated electric power plant onboard the ship (Kendrick and Terweij 2019). The use of batteries in ships is both attractive and on the rise, since benefits include reduced fuel consumption, costs, maintenance, and air emissions, thereby supporting a strong business case for their implementation (DNV 2018). Battery power can reduce both onboard machinery vibration noise and propulsion noise due to *"the absence of a mechanical transmission path from the engine to the propeller"* (Geertsma et al. 2017). On the other hand, cavitation noise increases under certain operational conditions, especially when using fixed pitch propellers and speed control (Geertsma et al. 2017). Battery power is currently championed for short

Table 12.1 Relationship between energy efficiency optimization measures, emissions and underwater noise reduction

Quieting technology	Emissions		Efficiency		Noise reduction		
	Advantage	Disadvantage	Advantage	Disadvantage	Low	Medium	High
Propeller/propulsion							
Contracted loaded tip propellers			X			X	
High skew propellers			X	X		X	
Contra-rotating propellers			X		X	X	
Kappel propellers			X		X		
Podded propulsors				X	X	X	
Water jets			X (high speed)	X (low speed)			X
Pump jets				X			X
Wake flow modification							
Pre-swirl Stator	X		X		X		
Schneekluth duct	X		X		X		
Propeller Boss Cap Fin	X		X			X	
Propeller cap turbines	X		X			X	
Grothues spoilers	X		X		X		
Mewis duct	X		X		X		
Promas	X		X		X	X	
Costa propulsion bulb			X		X		
Twisted rudder			X		X		
Asymmetric body for single screw vessels			X		X		
CPP combinator optimization			X			X	
Supplementary treatments							
Air bubbler system				X		X	
Propeller blade maintenance			X		X		
Machinery selection							
Gas/steam turbine	X (cf. diesel)			X			X
Stirling engine	X		X			X	

(continued)

Table 12.1 (continued)

Quieting technology	Emissions		Efficiency		Noise reduction		
	Advantage	Disadvantage	Advantage	Disadvantage	Low	Medium	High
Machinery treatment							
Spur/helical gear noise reduction			X			X	X
Structural (Hull/girdle/floor thickening)				X		X	
Alternative fuel selection							
Fuel cell	X		X				X
Battery	X		X				X
Hull treatments							
Underwater Hull surface maintenance	X		X		X		
Air bubbler system (masker)			X				X
Hull air lubrication			X				X
Stern flap/wedge	X		X		X		
Other mitigation technologies							
Kite sails	X		X			X	X
Flettner/Magnus rotors			X			X	X
Conventional sails			X			X	X

Source: adapted from Kendrick and Terweij (2019) Ship Underwater Radiated Noise—Report 368–000-01 Rev. 4. Vard Marine Inc. 12 February 2019

voyages or portions of longer trips (Kendrick and Terweij 2019), thereby offering a viable option when transiting near particularly noise-sensitive areas.

As for ships equipped with sails or using the Magnus effect, there is a dependence on the wind. Despite the significantly high potential for noise reduction, there is an "X" under both the "Medium" and "High" columns due to variations in the proportion of power coming from the sails/rotors. The thrust generated by capturing the wind's force can lessen the need for louder propulsion sources, thereby reducing underwater noise. Yet, when higher speeds need to be maintained and not enough wind power can be captured, other louder machinery and propeller propulsion are used.

5.2 *Operational Measures*

The current average age of a ship is just under 30 years (Statista 2020), and not all vessels can undergo retrofitting to reduce GHG emissions and underwater noise. Therefore, operational measures and maintenance routines can be implemented to reduce noise impacts by new *and* existing vessels. The IMO Underwater Noise Guidelines list operational measures to reduce underwater noise, many of which are directly related to increasing energy efficiency.

5.2.1 Slow Steaming

Deliberately operating vessels at a slower speed (slow steaming) recently reemerged around 2007 as a response by carriers to the global economic recession and increased oil prices (Mander 2017). Slow steaming involves reducing the speed of a vessel to varying extents depending on the type. For container ships, slow steaming entails reducing speed to 21 knots, while extra-slow and super-slow steaming require 18 knots and 15 knots, respectively (Maloni et al. 2013).

The practice intends to cut operation costs by lowering fuel consumption through increased efficiency and is considered an immediate measure to reduce GHG emissions. Maloni et al. (2013) present results from a simulation of container flows at varying speeds, suggesting that slow steaming yields an average decrease in CO_2 emissions by 26.1% from full speed, while extra-slow steaming yields a 43.3% decrease and super-slow steaming a reduction of 46.7%. It has been suggested that this reduction may even be greater (Third IMO GHG Study 2015; IMO 2008). Incorporating the outcomes, the IMO's Initial Strategy includes the optimization and reduction of speed in its list of short-term measures (Initial Strategy 2018, para. 4.7.4).

In addition to reducing GHG emissions through increased efficiency, slow steaming is an operational measure to reduce underwater noise. It is included in the IMO Underwater Noise Guidelines, particularly for vessels with fixed-pitched propellers (IMO 2014, para. 10.4.1). The most significant noise reduction occurs when vessels operate below the cavitation inception speed, defined as *"the lowest ship speed at which cavitation occurs"* (IMO 2014, para. 4.1). However, for many vessels, this requires speeds below 10 knots (Leaper and Renilson 2012). Since this option is unviable for most purposes, ships may still operate at speeds that cause cavitation, thereby generating some noise, though less than at higher speeds (Leaper and Renilson 2012).

Other drawbacks are longer transit times, accurately estimating just-in-time shipments (Maloni et al. 2013), and the consequence of requiring more vessels on the water at once to compensate for slower speeds (Leaper 2019). However, deploying more ships to carry the same cargo would still reduce the overall acoustic footprint with slow steaming (Leaper and Renilson 2012). Therefore, slow steaming provides a primary operational measure that can be widely applied to reduce underwater noise while also reducing CO_2 emissions.

5.2.2 Routeing Measures

Routeing measures can either increase the separation between sensitive species and the ship or alter the way sound propagates. Since received noise levels reduce with distance, routeing decisions that take into account the location of at-risk species could mitigate the intensity and severity of underwater noise impacts. Furthermore, sound from ships may enter sound channels in some areas, wherein sound can travel uniquely long distances. Small routeing changes can prevent sound from entering these channels. The flexibility of routeing measures allows for responsive implementation with consideration for geographic location, seasonal behaviors of species, and weather.

Among the list of best practices for the fuel-efficient operation of ships, the SEEMP includes improved voyage planning and weather routeing (MEPC 70/18/Add.1 2016, paras. 5.2.1 and 5.2.3). Meanwhile, the IMO Underwater Noise Guidelines acknowledge that routeing decisions responding to sensitive marine areas, including habitats and migration pathways *"will help to reduce adverse impacts on marine life"* (IMO 2014, para. 10.5). Routeing measures to avoid sensitive areas may differ from those required to reduce GHG emissions. However, the SEEMP and the IMO Underwater Noise Guidelines highlight the importance, applicability, and variability in the use of routeing measures for both purposes.

UNCLOS acknowledges the rights of coastal States to designate sea lanes and prescribe traffic separation schemes within the territorial sea (UNCLOS 1982, Art. 22(1)). It also imposes an obligation on States to implement routeing systems wherever appropriate to reduce threats of accidents, which may pollute the marine environment (UNCLOS 1982, Art. 211(1)). IMO amendments, including the 1995 amendments to Chapter V of the International Convention for the Safety of Life at Sea (SOLAS 1974), expand the objective of ship routeing measures to include environmental protection (Roberts 2005).

The measures may be implemented together with particularly sensitive sea areas (PSSAs) upon approval by the MEPC (Revised PSSA Guidelines 2005, paras. 6.1.2 and 2.2) or as a separate regulatory technique under SOLAS Chapter V.

For mitigating vessel-source underwater noise risks, two routeing systems may be particularly useful: areas to be avoided and precautionary areas. Essentially, areas to be avoided are recommendatory or mandatory no-go-zones, while precautionary areas allow navigation within the defined zone but require particular caution. Both can be used in association with PSSAs or other forms of protected areas. Doing so creates a buffer by expanding the distance between the source of sound and at-risk species or ecosystems.

5.3 Applying the Synergies Between Measures to Reduce GHG Emissions and Underwater Noise

With the adoption of the Paris Agreement, the climate change regime has commenced a renewed approach for addressing climate change. The requirement of all Parties to submit NDCs and the inclusion of all sectors of the economy reinforces the pursuit of global solutions. Furthermore, pressure from the climate change regime has ignited and motivated meaningful IMO action. Although the IMO is not the only body with the authority to lead the decarbonization of shipping, it has secured a position as a competent international organization to do so and presented a series of tools at varying stages of implementation. Most recently, the IMO Initial Strategy shows a step to strengthen existing tools for increasing the energy efficiency of ships. It is demonstratively using energy efficiency as a vehicle to cut GHG emissions.

Notable similarities arise when comparing energy efficiency measures developed to reduce GHG emissions with the IMO Underwater Noise Guidelines. The similarities suggest potential in using tools designed for addressing climate change risks to reduce underwater noise. The overview of static measures highlights options that address multiple challenges simultaneously. Therefore, increasing the options for States to adopt measures within areas under their jurisdiction. States can adopt measures for the reduction of GHG emissions, which have the side effect of reducing underwater noise.

The approach taken by the Vancouver Fraser Port Authority is an example of addressing vessel-source GHG emissions and underwater noise together. The Vancouver Fraser Port Authority has implemented programs using voluntary speed limits, combined with incentives and a reward system, which encourages the reduction of GHG emissions and underwater noise. The series of initiatives under its Enhancing Cetacean Habitat and Observation Program include voluntary ship slow down trials, which began in 2014 and are accompanied by annual summary reports (Vancouver Fraser Port Authority 2019a). The 2018 program report demonstrates an 87% participation rate for ships in transit, with 50% meeting the target speed, and 77% within one knot of the target (details in Vancouver Fraser Port Authority 2019b). The high rate of participation suggests that many shipping lines are willing to adopt slowdown measures. To further entice compliance, the Vancouver Fraser Port Authority added a monetary incentive, which rewards quieter ships with harbor due rate discounts.

The incentive was added by amending an existing EcoAction Program, which launched in 2007 and rewards ships with discounts for reducing multiple environmental impacts, including atmospheric emissions (Vancouver Fraser Port Authority, EcoAction 2020). The criteria include measures aimed to increase energy efficiency to reduce GHG emissions. Furthermore, there are three award levels for comporting 15, 20, and 25% better than required by the EEDI (Vancouver Fraser Port Authority, EcoAction 2020). The new criterion includes a list of underwater noise-reducing technologies (Vancouver Fraser Port Authority, EcoAction 2020). The Vancouver Fraser Port Authority initiatives demonstrate a local approach to conserving at-risk species and reducing environmental risks by incentivizing lower emissions and controlling underwater noise risks.

6 Conclusion

The oceans have become increasingly loud. With the rise of ambient underwater noise, anthropogenic activities wash out essential communication signals of marine life and introduce risks of various severities. Despite ongoing scientific research since the 1970s, the dangers of underwater noise lack widespread understanding and mitigation. In contrast, the climate change regime has pushed through, raising awareness and adopting numerous tools and treaties to mitigate the impacts of climate change and stabilize GHG concentrations in the atmosphere. Although the UNFCCC, the Kyoto Protocol, and the Paris Agreement fall short of addressing emissions from international shipping, supporting tools developed beyond the core framework of the climate change regime, are being progressively implemented.

Many of the technologies developed to target static features within ships to increase energy efficiency or cut GHG emissions also function to reduce underwater noise. Similarly, operational measures including routeing and slow steaming can reduce both GHG emissions and underwater noise. Although not all measures have mutual benefits, the multiple overlaps support the proposed approach that, interactions and contributions of measures created to attain other objectives can be implemented to address underwater noise. Consolidating tools provides States with increased grounds for adopting measures to mitigate the risks of underwater noise within their areas of jurisdiction. Coastal States have options to circumvent UNCLOS restrictions, which limit efforts to the adoption of GAIRS. Since addressing GHG emissions has a more substantial mandatory basis, utilizing synergies in the works of various institutions and measures with multiple benefits allows for precautionary action to be taken to tackle parallel, urgent environmental issues.

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Chapter 13
Sustainable Maritime Labour Governance: The Role of Transformative Partnership in Seafarers' Welfare

Desai Shan and Pengfei Zhang

Abstract In the 2030 agenda for sustainable development, decent work and economic growth are the eighth sustainable development goal (SDG). Maritime transportation supports over 80% of the international trade, and more than 1.6 million seafarers work at sea to ensure marine transportation is safe, efficient and environmentally friendly. Seafarers make a critical contribution to sustainable maritime transportation. To ensure decent work conditions at sea and protect seafarers' rights is an important sustainable development goal. Drawing upon the case of port-based welfare facilities, this chapter aims to examine the current partnership of maritime labour governance, different roles of governmental and non-governmental organisations and how they work together to ensure and promote well-being and welfare of seafarers. This chapter also discusses the current challenges faced by the public–private partnership in sustaining and developing seafarer welfare. We argue that a transformative partnership, involving both public and private actors, is required in the maritime labour governance and that sovereign states should recognise seafarers' key workers' status and assign more resources to international seafarers' welfare facilities.

Keywords Maritime labour governance · Sustainable development · Decent work · Port-based seafarers' welfare

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1 Introduction

Maritime transportation supports 80% of the international trade, connecting businesses worldwide (UNCTAD 2019). It is estimated that more than 1.6 million seafarers work at sea, who are responsible for ensuring maritime transportation operates safely, efficiently and environmentally friendly (ICS 2020). Promoting decent work and economic growth were set as the eighth sustainable development goal (SDG) in the 2030 agenda for sustainable development by the United Nations (UN) (United Nations n.d.). As highlighted by the International Maritime Organization (IMO), *"[w]orld trade and maritime transport are, therefore, fundamental to sustaining economic growth and spreading prosperity throughout the world, thereby fulfilling a critical social as well as an economic function"* (International Maritime Organization (IMO) 2020a). Seafarers are key workers who operate global maritime transport (IMO 2020b). In the IMO's statement *IMO and the Sustainable Development Goals*, to achieve SDG 8, decent work and economic growth, IMO continues its work to promote seafarers' welfare. Seafarers are contributors to achieve SDG 8 and will also benefit from the achievement of decent working conditions (IMO 2020c).

Seafarers' welfare can be defined as the health, happiness and fortunes of seafarers and institutional protection or social efforts designed to promote physical health, material and mental well-being (Exarchopoulos et al. 2018). The preamble of the Maritime Labour Convention, 2006,[1] declares that *"given the global nature of the shipping industry, seafarers need special protection"*. However, seafarers' welfare is still compromised in many aspects nowadays and, in particular, during the COVID-19 pandemic. Seafarers have been stranded at sea, with limited chances to take shore leave. Regular crew change cannot be conducted, and many seafarer service periods onboard exceed the maximum period of 12 months (Shan 2020a). The crew exchange crisis reveals the weakness of the current seafarers' welfare governance system: seafarers' welfare still receives limited attention and resources from sovereign states.

Due to the highly mobile nature of the seafaring occupation, seafarers are distanced from families and communities and have restricted access to shore-based infrastructures, for a prolonged period (Shan and Neis 2020). The seafaring occupation remains one of the most dangerous forms of work, and the mortality rate at work is significantly higher than in the general labour force (Roberts et al. 2014). A study in Denmark showed that the accidental mortality level to be more than 11 times higher among Danish seafarers than in the male, working-age population of Denmark generally (Hansen 1996). Seafarers not only face risks of maritime casualties due to poor weather and rough sea but also face occupational hazards on board, including chemical exposure and physical hazards, such as slip, trip and falls.

[1] For more information about the Maritime Labour Convention, 2006, see https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:91:0::NO::P91_ILO_CODE:C186

In the hazardous and challenging working environment, mental health problems are also widely reported among seafarers (Mellbye and Carter 2017).

To achieve the SDG8 target in the maritime sector, which is to ensure decent working conditions at sea, requires a comprehensive international partnership between the industry, civil society, sovereign states and international organisations. Nowadays, a Filipino seafarer may work onboard a ship registered in Panama and owned or operated by a Greek shipping company that navigates between Asian and American ports. In this scenario, to ensure seafarers' efficient protection, the protective effects of current maritime labour governance are far from enough. The seafarer welfare crisis during the COVID-19 pandemic proves this once again. Even though significant efforts have been made by the UN, IMO, International Labour Organization (ILO), International Chamber of Shipping (ICS), International Transport Workers' Federation (ITF) and some sovereign states, the crew exchange crisis has been developed into a welfare as well as a humanitarian crisis for global seafarers.[2]

The sources of seafarer protection can be found at both the international and national levels. For example, ILO, a UN agency, has a long history in establishing uniform standards to protect seafarers (Zhang et al. 2019). However, before introducing the MLC 2006, the ILO's instruments were criticised as "lack of teeth". At the national level, seafarer protection mainly relies on the supervision of flag states, port states and seafarer supply states. However, there are various challenges to the effective implementation of seafarer protection standards at the national level. These challenges include lack of political will, lack of financial motivation and lack of competent expertise (Zhang 2016).

In this chapter, we argue that a transformative partnership involving both public and private actors is required in the maritime labour governance, and sovereign states should recognise seafarers' key workers' status and assign more resources to international seafarers' welfare facilities. Drawing upon the port-based welfare facilities as an example, this chapter critically evaluates the strength and weaknesses of the current maritime labour governance partnership. The chapter is divided into four parts. Firstly, it introduces the significance of port-based welfare facilities for seafarers' welfare. Secondly, the legal frameworks of maritime labour governance regarding the port-based seafarers' welfare are examined. Thirdly, the leading players of the maritime labour governance partnership are identified. Fourthly, the strengths and weaknesses of the partnership are discussed, and recommendations are made.

[2] For more information, please see https://news.un.org/en/story/2020/06/1066262

2 Seafarers and Port-Based Welfare Facilities

As a group of highly mobile workers, seafarers face considerable challenges, including mental and physical problems. A transnational study (Jensen et al. 2004) shows that 8.5% of seafarers suffered an injury during their most recent tour of duty, while a Danish study (Hansen et al. 2002) finds that the fatal accident rate in merchant shipping is ten times that in shore-based industries. Pauksztat (2017) considers that job demands for seafarers have direct and indirect effects on fatigue and the working climate on board. In addition to the physical health risks, mental health problems cannot be ignored among the seafaring population. Anxiety, depression, stress, fatigue and burn out are reported to be seafarers' mental health problems in the current literature (Jepsen et al. 2015; Zhang and Zhao 2017; Yuen et al. 2020; Shan 2020b). The working environment at sea, to a large extent, is isolated from the land-based societies. Medical care and mental health support onboard are highly limited.

In many cases, seafarers have to overcome mental health challenges by themselves, with limited support on board. Access to the internet and telephone on board is limited, making communication opportunities with families and friends very precious for seafarers. Even a short period of rest on the land is of great importance for seafarers' health and well-being (Oldenburg and Jensen 2019) and, hence, has significant implications for the safety of life and property at sea.

Port stay is argued to account for 43.6% of the entire voyage duration (Oldenburg and Jensen 2019), which provides seafarers opportunities to access port-based infrastructures, such as grocery stores and cafés, high-speed internet and affordable telephone lines. Nearly 450 port-based welfare centres around the world are serving seafarers during their port stay. Some of the welfare centres operate independently. However, most of them belong to regional or international non-governmental organisations, such as the Apostleship of the Sea, Sailors' Society, the Mission to Seafarers and international associations like the International Seafarers' Welfare and Assistance Network (ISWAN), the International Christian Maritime Association (ICMA) or the North American Maritime Ministry Association (NAMMA).

Port-based welfare organisations provide transportation to shopping facilities, a quick ride to the seafarers' centre, equipment to call home to speak with friends and loved ones and a welcoming environment to relax ashore. More importantly, the staff and volunteers committed to seafarers' welfare make sure that mariners feel acknowledged, valued, cared for and genuinely welcome in the ports they call (Zuidema et al. 2018). In the COVID-19 pandemic period, ship visitors play crucial roles in assisting seafarers in accessing groceries and mobile phone SIM cards.

However, with sole support from charity organisations, it may not be enough to support the port-based welfare facilities. To ensure the sustainable development of such facilities, a comprehensive public–private partnership is required, and sovereign states should assign sufficient resources to port-based welfare facilities. Ratified by 97 states representing 91% of the world gross tonnages, the MLC 2006 confirms and promotes such a public–private partnership.

The MLC 2006 is, first and foremost, a consolidation of the previously existing corpus of ILO law relating to seafarers' labour standards. The regulatory scope of the Convention covers the full range of subject areas on the living and working conditions of seafarers and deals with numerous aspects of a seafarer's "rights to decent employment", including recruitment, conditions of employment, accommodation, food and catering, medical care, recreational facilities, hours of work and rest, health protection, welfare and social security and so on. It is expected to mainstream the human, labour and social rights for seafarers within the wider maritime regime (Zhang 2016). However, despite the great strength, the MLC 2006 has the same weaknesses attached to other ILO standards, including political, financial and expertise challenges. For example, Bauer (2007) argues that MLC 2006 fails to provide an adequate guarantee for seafarers' entitlements. On the contrary, it is likely to discourage any further developments in seafarers' protection for the foreseeable future.

According to Regulation 4.4 of the MLC 2006, members state shall provide shore-based welfare facilities accessible to international seafarers. They are further obliged to promote the development of welfare facilities, including cultural, recreational and information facilities. At the national legislation level, sovereign states are the most vital player to ensure the availability and accessibility of the welfare facility.

3 The Legal Frameworks of the Port-Based Welfare Facilities

The importance of establishing port-based welfare has been recognised at the international level for more than half-century. In 1952, at the Joint Maritime Commission of the International Labour Organization, the necessity to promote port welfare for seafarers was recognised, and reciprocal international cooperation was regarded as a foundation to develop such work (PAA 1952). In addition to a humanitarian perspective, Hohman (1955) justified the economic necessity to provide welfare facilities for seafarers in port through three aspects: to attract skilled workers to join the shipping industry, to retain personnel in the industry longer and to increase the work efficient on board. Hohman's argument is still relevant to the current maritime industry, which is facing a significant shortage of seafarers.

In 2001, seafaring unions and shipowners in the ILO's Joint Maritime Commission proposed a consolidated maritime labour convention, bringing together in a single instrument many existing maritime labour conventions, updating them and applying an enforcement mechanism (ILO 2002). The new instrument, passed after years of sometimes difficult negotiations in the February 2006 Maritime Session of the International Labour Conference, borrows elements from the existing ILO global labour rights regime and the global maritime safety regime, centred on the IMO (Zhang and Zhao 2015).

As required by the MLC 2006, port states shall ensure that shore-based welfare facilities, where they exist, are easily accessible for seafarers onboard a ship. Also, port states shall promote the development of welfare facilities and services to secure seafarers' health and well-being. Seafarers' welfare services including welfare, cultural, recreational and information facilities and services. As a primary responsible party, port sates are required to ensure that port-based welfare facilities are accessible to seafarers with no discrimination.

3.1 Mandatory Standards: Regulation 4.4. and Standard A4.4

In terms of seafarers' access to shore-based welfare facilities, the five provisions of Regulation 4.4 and Standard A4.4 provide general requirements. Firstly, the member state shall ensure that existing shore-based welfare facilities are accessible, and that in the development process of welfare facilities, a partnership between states, shipowners and seafarers is required through consultation, to promote the development of welfare facilities. Secondly, the member state shall ensure that welfare, cultural, recreational and information facilities and services are provided according to the Convention. Thirdly, the existing welfare facilities should be available for all seafarers, regardless of their nationalities, race, colour, sex, religion, political, opinion or social origin. Fourthly, the member states shall promote the development of welfare facilities in appropriate ports after consultation with shipowners' and seafarers' organisations. Fifthly, the Convention shall encourage the formal establishment of a collaboration between states, shipowners' organisations and seafarers' organisations, in the form of welfare boards, which will review welfare facilities regularly to ensure the facilities can be improved to adapt to the technical, operational and other developments in the shipping industry. Supervision of welfare facilities and services should include participation by representatives of the shipowners' and seafarers' organisations concerned.

The above requirements are stipulated in Regulation 4.4 and Standard 4.4 as minimum standards for seafarers' welfare services. As per these standards, the maritime labour partnership governance model between port states and organisations of shipowners and seafarers is the core governing body of seafarers' welfare facilities. The partnership governance is crucial to ensure seafarers' access to welfare facilities in port, and the welfare facilities are up to date to provide appropriate services for seafarers.

However, there is a major weakness in these standards. These mandatory standards do not require the compulsory establishment of port-based welfare facilities in member states. For those states, which currently have no port-based welfare facilities, they may not have incentives to develop such welfare facilities. During the COVID-19 pandemic, many states imposed restrictions on crew exchanges and shore leave. Port-based welfare workers provide even more important services to support seafarers. For example, the affordable SIM cards brought by welfare workers help seafarers sustain their communication with families and friends. Without the compulsory establishment of port-based welfare facilities in a state, it is very unlikely that seafarers could have welfare workers' visits on board. The formal partnership between governments, shipowners and seafarers, in the form of welfare boards, is "encouraged" rather than "required". The current mandatory standards of the MLC 2006 are not enough to promote the development of new port-based welfare facilities.

3.2 Guideline B4.4: Non-mandatory Recommendations

In the Guideline B4.4, the Convention provides detailed provisions of the partnership governance of seafarers' welfare service. Although these provisions are not mandatory, they have provided valuable instructions for member states to establish an effective partnership with shipowners and seafarers' organisations.

MLC 2006 recommends member states to cooperate in promoting the welfare of seafarers at sea and in port. Cooperation should include activities including (a) consultations among competent authorities aimed at the provision and improvement of seafarers' welfare facilities and services, both in port and onboard ships; (b) agreements on the pooling of resources and the joint provision of welfare facilities in major ports to avoid unnecessary duplication; (c) organisation of international sports competitions and encouragement of the participation of seafarers in sports activities and (d) organisation of international seminars on the subject of the welfare of seafarers at sea and in port.

In the Guideline B4.4.2, the providers of seafarers' welfare facilities are not limited to public authorities, shipowners' and seafarers' organisations and voluntary organisations, which are all recognised as welfare service providers. In the Guideline, port authorities are also required to develop welfare facilities for seafarers, including meeting and recreation rooms, sports and outdoor facilities, educational facilities and facilities for religious observances and personal counselling.

The Guideline emphasises the partnership between crew supply states, port states and flag states to consult each other to make the best use of the resources to provide hotels, clubs and sports facilities in a particular port for a large number of seafarers of different nationalities. In addition, provision should be made for accommodating seafarers' families if necessary.

In addition to voluntary workers, port state authorities also need to take measures to ensure competent persons are employed full time in the operation of welfare services. The financing of welfare facilities includes grants from public funds, levies from shipping sources, voluntary contributions from shipowners, seafarers, their organisations and others. Welfare taxes, levies and special dues can be imposed and should be used only to improve seafarers' welfare in port.

For seafarers in foreign ports, the Guideline B4.4.6 requires measures to facility seafarers' access to consuls of their state of nationality or state of residence. Effective partnerships between consuls and local authorities are required to support seafarers detained in foreign countries. Efforts should also be made by the port states to ensure seafarers can take shore leave as soon as possible after a ship arrives in port, and the port states should ensure the safety of seafarers from aggression and other unlawful acts.

Guideline B4.4. provides comprehensive instructions for member states and stakeholders to develop effective maritime labour governance partnerships to promote the development of port-based welfare facilities. However, these provisions are not mandatory, which restricts member states' incentives to implement such standards. As mentioned in the previous context, member states and stakeholders may not have the political will, financial motivation and human expertise to promote the development of port-based welfare facilities. For example, China used to have "seamens' clubs" in most of its main ports. In recent years, most of the clubs, with the loss of government financial support, have had to close or survive in the emerging market economy by diversifying their income sources. In some cases, the port welfare facilities were changed into luxurious hotels that no seafarer could afford (Zhao et al. 2018). The positive meaning of the Guidelines B4.4 enables non-governmental organisations, such as maritime charities, and seafarers and shipowners' organisations to lobby policymakers to develop such public–private partnership in maritime labour governance and leverage public grants to promote the development of port-based welfare facilities.

For those seaports where satisfactory port-welfare facilities do exist, seafarers may not have the opportunities to visit them. In the last 20–30 years, however, most seaports have been increasingly built in more remote areas, typically far away from urban centres (Zhang 2016). In these areas, it is difficult for seafarers to gain access to taxis or public transport. In the meantime, advanced technological development in the industry has brought more efficient cargo-handling, faster turnarounds and shorter port-stays for ships. The primary concern of port authorities and shipowners is to increase cargo operation efficiency. The possibility for seafarers to have shore leave has been drastically reduced as a result of the structural change of the industry (Sampson et al. 2016).

4 Public–Private Partnership in the Maritime Labour Welfare Governance

Through examining the legal framework, it can be found that the public–private partnership plays a key role in regulating and operating port-based welfare facilities. In this governance partnership, the states, particularly port states and shipowners' and seafarers' organisations, are vital players in developing and maintaining port-based welfare facilities. Port states and shipowners and seafarers' organisations within one state construct a tri-partite foundation of this maritime labour governance.

In some countries, such as China, the port state government is the leading player to establish and operate port-based welfare facilities. The international seafarers' clubs, the main form of the port-based seafarers' welfare facilities in China, are administered by the All-China Federation of Trade Unions. Before the 1980s, all of the funding and personnel of the international seafarers' clubs came from the Chinese government. After the 1980s, Chinese government funding was gradually withdrawn from the seafarers' welfare sector after the economic reform. With loss of government funding, most of the international seafarers' clubs have had to survive in the emerging market economy. There were more than 30 international seafarers' clubs in China. However, now only 15 deliver regular seafarer welfare services in China (Zhao et al. 2018) and are now classified as charities. Among the international seafarers' clubs that survived in the market economy, such as Shantou International Seafarers' Club, most funding is still from the government, and the remaining funding is raised from other sources. In the case of international seafarers' clubs in China, government and the All-China Federation of Trade Unions have been critical players in maritime labour welfare services. This partnership provided stable seafarers' welfare services over three decades (1950–1980). However, government policy reform has created a tremendous impact on seafarers' welfare services. Once the government funding is fully or partially withdrawn, many port-based seafarer welfare facilities cannot survive.

Voluntary organisations, such as in North America, also play a role as the fourth party in maritime labour governance. For example, in the USA and Canada, seafarers' welfare is provided voluntarily in most ports (Zuidema and Skaggs 2017). In this scenario, the importance of partnerships cannot be overestimated. A port levy has become an essential financial support to seafarer centres operated by voluntary organisations. According to a survey conducted by the North American Maritime Ministry Association, 45% of the seafarers' welfare centres reported a port levy invoicing system or contribution (Zuidema and Skaggs 2017). In this type of partnership, voluntary organisations and port authorities are the leading players. Shipowners, though the port levy system and donation, will also be essential contributors in the partnership.

Without substantial legislative financial support, the success of port welfare relies on the partnerships coordinated by voluntary organisations. The risk of this type of collaboration is that if the government or port authority fails to make a substantial contribution, voluntary organisations are left to self-fund port-based welfare facilities. In this situation, port-based seafarers' welfare may not be sustainable. For example, according to a study conducted by Human Rights at Sea, in 2017, it costs New Zealand seafarers' welfare charities over $700,000 to finance port-based welfare facilities. Maritime New Zealand and port authority and the local council contributed $20,000 to the port-based welfare charities (Shepherd and Hammond 2020).

At the national level of maritime labour welfare governance, it can be found that state, seafarers' organisations, shipowners' organisations and voluntary organisations are key players. The sustainable development of port-based seafarers' welfare depends on sound financial support from the local partnership. The state government is a crucial player in sustaining the finance of port-based welfare facilities. Through China and New Zealand cases, it can be found that government fundings are necessary to maintain seafarers' welfare services. In North America, the operation of seafarers' welfare services has relied on voluntary organisations. However, the partnership with port-based welfare services to obtain seafarers' welfare levy is crucial for the port-based welfare services.

At the international level, the partnership between the ILO and IMO is notable in the maritime labour welfare governance. Recognising the challenge to protect seafarers under the laws of a country other than their own, the ILO has approached the difficulty by adopting comprehensive maritime standards and cooperation with the IMO. IMO/ILO ad hoc working groups have been established to address various aspects of maritime labour governance (ILO n.d.).

Within the tripartite governance model of the MLC, 2006, the government of member states, representatives of shipowners and seafarers are three key players in the tripartite governance model. According to Article XIII of the MLC, 2006, the Special Tripartite Committee was established in June 2013 to conduct a regular review of maritime labour standards (ILO n.d.). Every 3 years, the Special Tripartite Committee appointed three representatives (government member, shipowner member and seafarer member) as vice-chairpersons. There were 220 government representatives, 44 shipowners and 76 seafarers' participants. In addition, non-governmental organisations including ISWAN, IMHA and ICMA are all international maritime labour governance participants. In this international maritime labour governance institution, the Special Tripartite Committee, the Shipowners' and Seafarers' group each have half the voting power of the government group. Although the non-governmental organisations do not have voting power, their professional knowledge can inform decisions made by representatives of governments, shipowners and seafarers.

In addition to the public–private partnership in the Special Tripartite Committee of the MLC, 2006 at the international level, between the non-governmental organisation, the private partnership also leads to essential roles in promoting seafarers' welfare. For example, the ISWAN receives financial support from Seafarers' Trust of the International Transport Workers Federation and the TK Foundation. The former is a seafarers' organisation. The latter is a shipowner's trust, which was established to fulfil the legacy of J. Torben Karlshoej, who funded the Teekay Shipping Company, now Teekay Corporation (ISWAN 2020).

5 Concluding Discussion

Considering the hazardous working environment at sea and limited supports onboard ships, port-based welfare facilities are crucial for seafarers to access high-speed internet, mental support and counselling services. In addition, ship visitors from the shore-based welfare centres also play a significant role in supporting seafarers in the isolated working environment. Access to port-based welfare facilities is crucial for seafarers' health and well-being, which is stipulated as a compulsory requirement in the MLC, 2006, Regulation 4.4. Access to the internet, affordable transportation service and SIM cards are reported to be the three most important port-based welfare services for international seafarers (Mellbye and Norman 2016).

Although these services seem to be simple, sustaining these services relies on a comprehensive maritime labour governance partnership between states, organisations of shipowners and seafarers, and voluntary organisations. In the maritime labour governance partnership, the government of port states plays a crucial role in maintaining the financial sustainability of port-based welfare facilities. In the case of China, once the government funding was withdrawn, many port-based welfare facilities were no longer to provide services for international seafarers. In the ports where voluntary organisations operate the welfare facilities, port authority support is still key to the seafarers' welfare facilities' financial success. The case of New Zealand illustrates how difficult it would be for seafarers' welfare centres if the government and port authorities fail to commit to the maritime labour governance partnership.

In the public–private partnership for port-based welfare governance, voluntary organisations play critical roles in leading seafarers' welfare services, both historically and contemporarily. Mobile Chaplains visited ships at anchor to inspire seafarers and give them the support of a church community. Shore-based centres and hostels offered many services, including food, shelter and recreation. The sector has returned to ship visitors bringing SIM cards and mobile hotspots, with the shore-based centres offering services. The outbreak of COVID-19 created significant challenges for seafarers. Not only are shore leave requests denied in most ports globally, but crew changes cannot be conducted as usual (IMO 2020d). Many seafarers are trapped at sea. Port-based seafarers' welfare workers should be termed as essential workers to keep providing service to seafarers who are stuck on board. Their services are even more crucial for seafarers in this challenging period (Human rights at sea 2020).

Many of the port-based seafarer welfare services have a social focus that makes it hard for them to make a profit. Seafarers' need for non-profit driven seafarers' centres or clubs is imperative. A robust public–private partnership involves frontline voluntary organisations, governments, shipowners and seafarers' organisations and is the only approach to ensure the social and financial success of the seafarer welfare facilities. The COVID-19 pandemic has revealed the necessity that seafarers should be recognised as essential workers, and their access to welfare facilities must be ensured. The development of port-based welfare facilities should be compulsory for port state governments rather than being "encouraged".

The success of port-based welfare facilities is vital to ensure decent working conditions for seafarers and the maritime sector to achieve SDG 8 of the United Nations 2030 Agenda of the Sustainable Development. Seafarers are working in a confined space at sea. Port-based welfare facilities are essential for seafarers to maintain their social life and maintain a healthy social connection with society, which helps seafarers to keep a work-life balance.

The public–private partnership is confirmed in Regulation 4.4 of the Maritime Labour Convention, 2006. However, there are two types of provisions related to the seafarer welfare governance: the Regulations and Part A provisions are compulsory, while the Part B provisions are recommended. Detailed provisions, including responsibilities of members, welfare facilities and services in ports and financing of welfare facilities, are stipulated in the Part B guidelines, which are recommended practices rather than compulsory. In this legislative context, inevitably, in some regions, the Part B recommended guidelines may not be fully implemented, and an effective public–private maritime labour governance partnership may not be well established at local levels.

Maritime labour governance is an essential component of global labour governance, which has gained resonance in debates about globalisation and labour standards (Meardi and Marginson 2014). A conceptual shift from "government" to "governance" and from "hard law" to "soft regulation" is visible at both international and regional levels. Governance refers to the system of steering mechanisms, in which the top-down government steering is only one among many governance options. Correspondingly, the responsibility for dealing with sustainability was attributed not only to the government but also to the non-governmental organisation, including market parties and civil society organisations. In this chapter, drawing upon the case of port-based seafarers' welfare facilities, we have illustrated a transformative public–private partnership in the maritime labour governance and why this partnership is vital to achieving the SDG8, decent work and economic growth.

The international ocean governance builds on a widely shared understanding that the ocean governance framework needs to be strengthened, that pressures on the oceans need to be reduced and that the world's oceans must be used sustainably (European Commission 2019). Maritime labour governance is a key component of ocean governance, because seafarers are the essential workers to ensure maritime transport operates in a timely, safe and environmental friendly manner. However, their rights to access decent welfare facilities are frequently compromised, or even sacrificed, in particular during the COVID-19 pandemic. The infringement of seafarers' rights threatens the sustainable development of maritime human resources, which plays a key role in maintaining global trade and ensuring safety of human life, property and marine environment. An effective maritime labour governance can ensure decent working conditions for seafarers and retain skilled seafarers to make continuous contribution to the sustainable ocean development.

In the maritime industry, as a frontline of globalisation, the shift from "government" to "governance" through the public–private partnership is still facing many challenges. The lack of commitment of the government is the main issue. On the other hand, the detailed provisions of public–private partnerships are provided as recommended practices rather than compulsory requirements in the Maritime Labour Convention, 2006, which is not sufficient to ensure the active participation of the government in some port states.

Efforts should be made to enhance shipping awareness, recognise seafarers' status as keyworkers, and to require the government of states to strengthen their collaboration with non-governmental organisations, including organisations of shipowners, seafarers as well as voluntary organisations. The government is responsible for ensuring funding is available for port-based welfare facilities through either direct government funding or special port levies.

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Chapter 14
Underwater Noise from Shipping: A Special Case for the Arctic

Check for updates

Melanie L. Lancaster, Peter Winsor, and Andrew Dumbrille

Abstract Until recently, the Arctic Ocean has supported limited shipping, and it remains one of the only oceans on the planet to be relatively unpolluted by anthropogenic underwater noise. Climate change is transforming the Arctic Ocean and opening it to unprecedented levels of industrial development, including shipping expansion. Concurrently, Arctic marine biodiversity—relied upon by many coastal Indigenous communities—is under pressure to adapt to rapid environmental changes. In this chapter, we discuss why the Arctic is a special case for underwater noise from shipping and how management tools could be applied to safeguard its unique biodiversity and ecosystems. The Arctic Ocean's underwater acoustic properties differ from non-polar waters, being primarily affected by sea ice, which is a source, shield and diffuser of underwater sound. Cold water and changing salinity gradients also affect sound propagation underwater. Long-range sound propagation occurs at shallow depths within the swimming and diving ranges of many marine animals, which are likely to be highly sensitive to noise. Finally, Arctic shipping itself has distinctive characteristics, including icebreaking, and has a high propensity for spatial overlap with biodiversity hotspots due to ice cover. With trans-Arctic shipping routes predicted to become navigable by mid to late century, we suggest a proactive approach by Arctic coastal states that addresses key knowledge gaps about noise-sensitive species, systematically monitors underwater soundscapes and holds noise at safe levels for biodiversity. Climate change-induced effects on underwater soundscapes, ecosystem processes and the distribution of biodiversity in time and space must also be accounted for.

Keywords Acoustic · Arctic · Arctic Council · IMO · Marine mammal · Shipping · Soundscape · Underwater noise

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1 The Arctic Ocean: A System Under Rapid Change

The Arctic Ocean consists of largely unfragmented marine seascapes home to unique ecosystems and species. As a result of human-induced climate change, it is a region under transformative change. Over the last decades, global warming has led to pervasive shrinking of Earth's cryosphere, with dramatic reductions in sea ice extent and thickness (IPCC 2019).

Climate change has, and is projected to continue to have, significant implications for Arctic marine ecosystems. Loss of sea ice, ocean warming, acidification and changes in currents and stratification will result in a profoundly different Arctic Ocean than exists today. These changes have altered, and will continue to alter, the distribution and composition of species, functioning of ecosystems and the well-being of Indigenous and local communities. Impacts are projected to worsen even under the lowest global warming scenarios as warming of the Arctic is predicted to continue at about twice the global rate for the remainder of this century, resulting in transformed landscapes and seascapes across much of the region (IPCC 2019).

The Arctic Ocean, previously largely inaccessible to shipping, is becoming increasingly ice-free, and with this comes the opportunity and ambition for industrial development at a scale unprecedented for the region. Financial experts estimate that future development in the Arctic will attract approximately a trillion dollars of new spending in the next 25 years (Guggenheim Partners 2016). Realisation of new development and infrastructure plans, stimulated by global demand for resources, is now possible because of climate change effects on the Arctic's terrestrial and marine environments.

2 Shipping in the Arctic

The Arctic is home to approximately four million people, of whom 10% are Indigenous. The region is reliant on marine transportation for the supply of food, fuel and other goods needed by its residents and communities. In recognition of the transformative changes taking place in the Arctic, in 2009 the Arctic Council undertook an Arctic Marine Shipping Assessment through its Protection of the Arctic Marine Environment (PAME) working group. Arctic shipping was assessed as having a number of potential impacts on the Arctic marine environment: discharges of oil, ship strikes, introduction of alien species, disruption of migratory patterns of marine mammals and underwater noise pollution from shipping (Arctic Council 2009).

While most shipping in the Arctic takes place in waters that are seasonally or permanently ice free, special purpose vessels designed to navigate ice-covered waters (icebreakers) are necessary for salvage, pollution response and search and rescue. They are also used for surveying and research and as escorts for other vessels in ice, including to support natural resource development.

2.1 Recent Trends in Arctic Shipping

Even with the capabilities of icebreakers, commercial shipping in Arctic waters is limited by sea ice cover (see Fig. 14.1). In 2004, Arctic shipping represented less than 2% of the world's registered fleet of oceangoing vessels over 100 gross tonnage (not including fishing vessels) (Arctic Council 2009). Approximately 3000 individual vessels operated in the Arctic, half of which were fishing vessels and about one-fifth bulk carriers. Icebreakers represented a relatively small portion of vessel traffic in the Arctic and were operational in the spring, summer and autumn (Arctic Council 2009).

In the past two decades, shipping activity during the Arctic summer has increased, concurrent with reductions in Arctic sea ice extent and a shift to predominantly

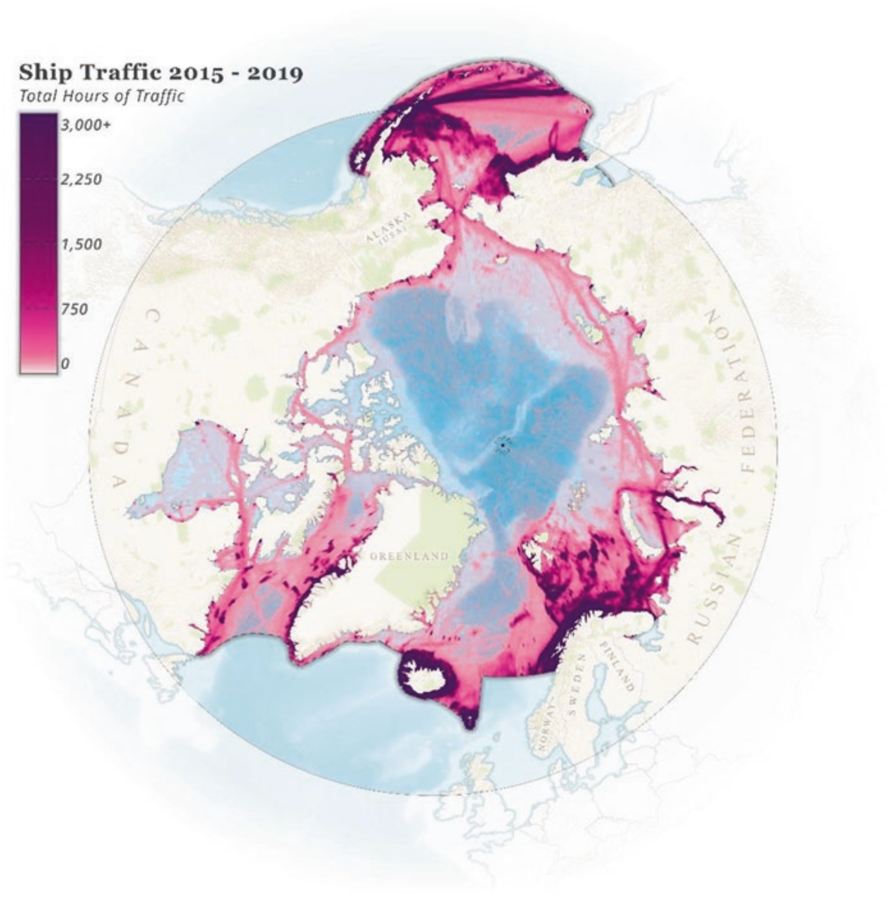

Fig. 14.1 Distribution of annual ship traffic in the Arctic, 2015–2019, represented as total hours and based on Automatic System (AIS) data from the PAME Arctic Ship Traffic Database and within the CAFF Arctic boundary

seasonal ice cover. A recent assessment of shipping trends in the Arctic by the Arctic Council's PAME working group illustrated that the number of ships entering Arctic waters (defined by IMO Polar Code boundaries) (IMO 2015) grew by 25% between 2013 and 2019 (PAME—Arctic Shipping Status Report #1, 2020). As well, the total distance sailed by ships during that time grew by 75%, from 6.51 million nautical miles in 2013 to 9.5 million nautical miles in 2019 (PAME—Arctic Shipping Status Report #1, 2020). The PAME report also found that the distance sailed by bulk carriers in the Arctic Polar Code area has risen to 160%.

2.2 Arctic Shipping in the Future

Continued sea ice loss in the Arctic has the potential to extend the open-water shipping season, reduce transit times and open previously inaccessible trans-Arctic routes. Equally influential on vessel transits is the demand for resources to support a growing global economy. Regardless of sea ice loss, the push for resources and economic growth will be a significant factor for shipping traffic volumes in the future. Predictions of when and where in the Arctic new access will emerge have been carried out regionally (e.g. as illustrated in Box 14.1), but most forecasting is focused largely on trans-Arctic routes that could replace traditional trade routes. These are the Northwest Passage (NWP), the Northeast Passage (NEP) (which includes the Northern Sea Route (NSR)), the Transpolar Sea Route, and the Arctic Bridge.

All the four trans-Arctic routes offer significant benefits of shorter distances compared to the two current global routes connecting the Atlantic with the Pacific Ocean (via the Panama Canal) and the Indian Ocean (via the Suez Canal) (IPCC 2019). Forecasting using sea ice models under various greenhouse gas emissions scenarios indicates that by mid-century there could be expanded navigability in September for open-water ships crossing the Northern Sea Route, new routes for moderately ice-strengthened ships over the North Pole and new routes through the Northwest Passage for both vessel classes (Smith and Stephenson 2013). By the late twenty-first century, under a high emissions scenario (RCP8.5), simulations suggest guaranteed September open-water transits across a practically ice-free Arctic, with trans-Arctic shipping potentially commonplace across a season extended to 4–8 months (Melia et al. 2016). For a low emissions scenario (RCP2.6), the frequency of open water vessel transits still has the potential to double by mid-century with a season ranging from 2 to 4 months (Melia et al. 2016).

While sea ice thickness and concentration represent the greatest physical obstacles to the expansion of trans-Arctic shipping, greater accessibility will be limited by many additional factors. These include economic and insurance considerations, infrastructure, emergency response capacity, poor charts, climate change-induced environmental hazards (e.g. fog, waves and icing), climate considerations (e.g. emissions targets), and the needs and concerns of local communities whose food security and livelihoods could be affected by disturbance caused by shipping.

Box 14.1: Shipping Scenarios in the Alaskan Arctic

In 2018 the U.S. Coast Guard (USCG) convened experts to develop growth scenarios for shipping in the Alaskan Arctic up to 2030. Depending on the scenario, the USCG found that there could be an increase in shipping anywhere from 136% to 346% from 2008 levels by 2030 (Fig. 14.2 and Table 14.1).

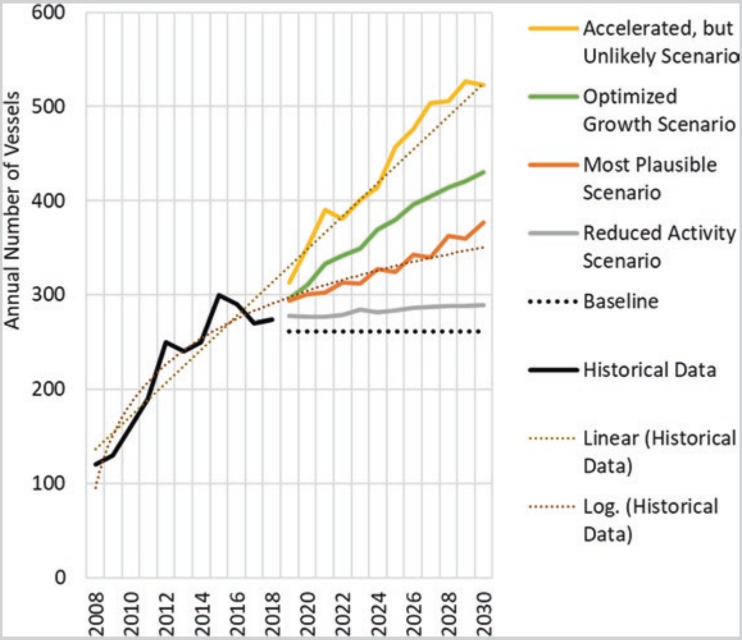

Fig. 14.2 Historical and projected annual vessel counts by scenario, 2008–2030. Source: U.S. Committee on the Marine Transportation System (2019)

Table 14.1 Summary of the scenario projection results

Scenario	Additional vessels in 2030	Total vessels in 2030	Projected average annual growth rate (%)	Change from 2008 baseline level (%)	Change from current (2015–2017) baseline (%)
Reduced activity scenario	29	284	0.30	136	11
Most plausible scenario	124	379	2.58	215	48
Optimised growth scenario	171	425	3.31	255	67
Accelerated, but unlikely scenario	281	535	4.93	346	110

Source: U.S. Committee on the Marine Transportation System (2019)

3 The Arctic Underwater Soundscape

Excluding anthropogenic contributions, the world's oceans are ensonified (filled with sound) through a combination of abiotic (e.g. wind, rain) and biotic factors (Medwin and Clay 1998 and references therein). These factors change in space and time, making underwater soundscapes dynamic. The Arctic Ocean has physical and chemical properties that make it a special case for underwater sound. In this section, we discuss these abiotic properties, how they are influenced by climate change and subsequent effects on underwater sound in the future.

3.1 Ambient Sound in the Arctic Ocean

In the Arctic Ocean, the seasonal or multi-year presence of sea ice makes the ambient soundscape more complex than in non-polar waters. Ice itself is a major source of underwater sound (Kutschale 1969). It is in continual motion, is affected by surface winds and water currents and generates significant sound through movement of ice floes and cracking, shearing and ridging of ice. Sea ice also interacts with other abiotic factors to affect the overall soundscape. In areas of shore-fast pack ice, the ambient soundscape is quiet because the ice isolates the water column from the effects of wind, thus reducing ambient noise levels. However, in areas where ocean waves interact with the marginal ice zone, sound levels are higher (e.g. Johannessen et al. 2003). Across the Arctic, ambient sound levels are generally low compared to non-Arctic regions (PAME 2019). Where underwater sound has been measured, the ambient soundscape is dominated by a combination of biological, environmental and, in some places, anthropogenic sound, with large seasonal variation (e.g. Ahonen et al. 2017; Stafford et al. 2018; PAME 2019).

3.2 Sound Propagation in the Arctic

The way sound propagates underwater is distinctive in the Arctic. In oceans around the world, a naturally occurring layer within the water column where low-frequency sound waves are channelled over long ranges is found at a depth of around 1000 m (Au and Hastings 2008). This layer is called a sound fixing and ranging (SOFAR) channel. In the Arctic, the polar extension of this deep sound channel, referred to as the surface sound channel, is found at shallower water depths—50–300 m (Kutschale 1969). Although sound does not travel as far within the Arctic's surface sound channel as it does within the SOFAR channels of more temperate oceans, the surface sound channel enables relatively long-range sound propagation at shallower depths in the Arctic Ocean. The surface sound channel is well within the swimming and diving depths of many Arctic marine mammals, which have likely evolved to take advantage of it for long distance communication (e.g. Payne and Webb 1971).

The presence of sea ice also affects sound propagation in the water column (see Au and Hastings 2008). High-frequency sound waves that hit the underside of sea ice tend to attenuate due to scattering caused by repeated reflection. Sound waves travelling close to the surface of ice-covered waters will therefore not propagate as far as those travelling deeper in the water column, or as far as sound waves travelling near the surface in ice-free waters. The age of sea ice also affects sound attenuation, with older, deformed (e.g. by ridging) sea ice having complex and rugged underside topography leading to higher attenuation of sound. In contrast, younger sea ice, such as first-year ice, tends to have a smoother, level underside and thus results in less attenuation of sound waves.

3.3 A Changing Underwater Soundscape

Future rapid warming and associated feedback loops are expected to cause increased loss of sea ice, affecting sea ice thickness, extent and age (e.g. Zhang and Walsh 2006). In addition, greater input of freshwater to the Arctic Ocean, delivered to the upper ocean primarily from rivers, will result in more upper-ocean stratification (lowered upper-ocean salinities compared to lower-lying layers). Upper-ocean stratification in concert with warming ocean temperatures and less sea ice (both a longer ice-free season and less multi-year ice with rugged underside topography) will likely lead to a significant increase in near-surface sound propagation underwater. Other effects have also been predicted to make sound propagation more efficient in the future, including lowered pH (e.g. Duda 2017). Finally, greater exposure of the ocean's surface to the effects of wind will result in higher ambient noise levels in some parts of Arctic.

These changing ocean properties mean that the Arctic underwater soundscape will be different in the future. In addition, greater accessibility to shipping and other noise-producing activities will introduce more anthropogenic noise or new types of noise in months that were previously quiet, thus heightening the potential for disturbance of Arctic marine species.

4 Arctic Marine Wildlife and Sound

In the ocean, sound travels further than light (Urick 1983). Many marine species have taken advantage of the ocean's physics by developing the ability to use underwater sound. Most mammals, fish and even some invertebrates rely on sound for sensing their environment (Payne and Webb 1971; Richardson et al. 2013), with marine mammals being the most well-studied of these taxa in terms of their use of sound and responses to underwater noise. Marine mammals rely on sound to find

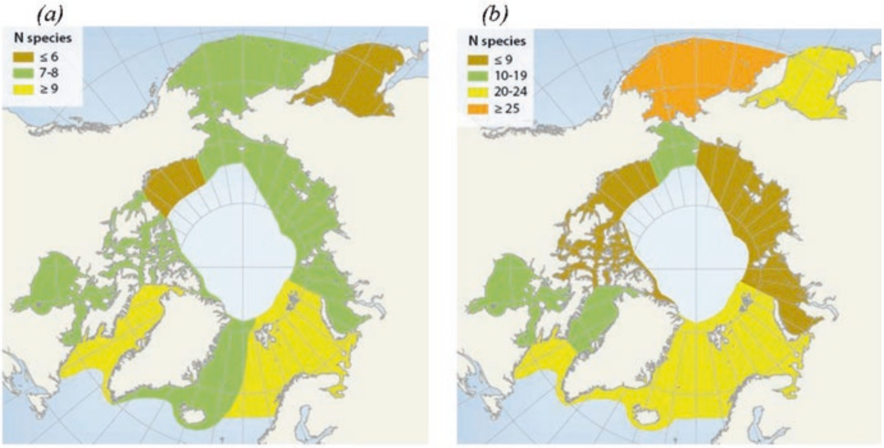

Fig. 14.3 Species richness of (**a**) endemic and ice-dependent marine mammals and (**b**) seasonally occurring marine mammals in high and low Arctic waters. Source: CAFF (2013)

prey, avoid predators, communicate with other members of their species, and find mates (Tyack 1998). Toothed whales use echolocation to direct their migrations, whereas baleen whales can listen to returning echoes from their own vocalisations to navigate (Zapetis and Szesciorka 2018).

The Arctic is home to 35 species of marine mammal for at least part of the year (see Fig. 14.3). Seven of these are endemic and dependent on, or strongly associated with, sea ice for all aspects of their lives. They include three cetacean species (beluga whales, narwhals, bowhead whales), three pinniped species (walruses, ringed seals, bearded seals) and polar bears. An additional four species of seal are dependent on sea ice in the low Arctic for pupping each spring (ribbon, harp, spotted and hooded seals). The remaining 24 species move into Arctic waters each year to take advantage of abundant prey during the Arctic's productive summer season (CAFF 2013).

Arctic marine mammals produce sound across a broad spectrum (see Fig. 14.4). Baleen whales (mysticetes), such as bowhead and grey whales, produce sound mostly in the low-frequency range. Toothed whales (odontocetes), including narwhals and beluga whales, produce sound in the mid-frequency and high-frequency range. Pinnipeds (seals, sea lions and walruses) can be segregated into two functional underwater hearing groups: sea lions and fur seals (otariids), which use a wide range of mid-frequencies, and "true" seals (phocids) and walruses, which hear across a wide range of low- to mid-frequencies. Specific frequency ranges used by marine mammals are discussed by Richardson and colleagues (2013) and Bradley and Stern (2008) and in a recent state of knowledge report produced by the Arctic Council's PAME working group (PAME 2019). There is little information on how Arctic fishes and marine invertebrates use sound underwater. Although it is not known why Arctic cod use sound, they produce it in the form of "grunts" at frequencies ranging between 59 and 234 Hz (Riera et al. 2018).

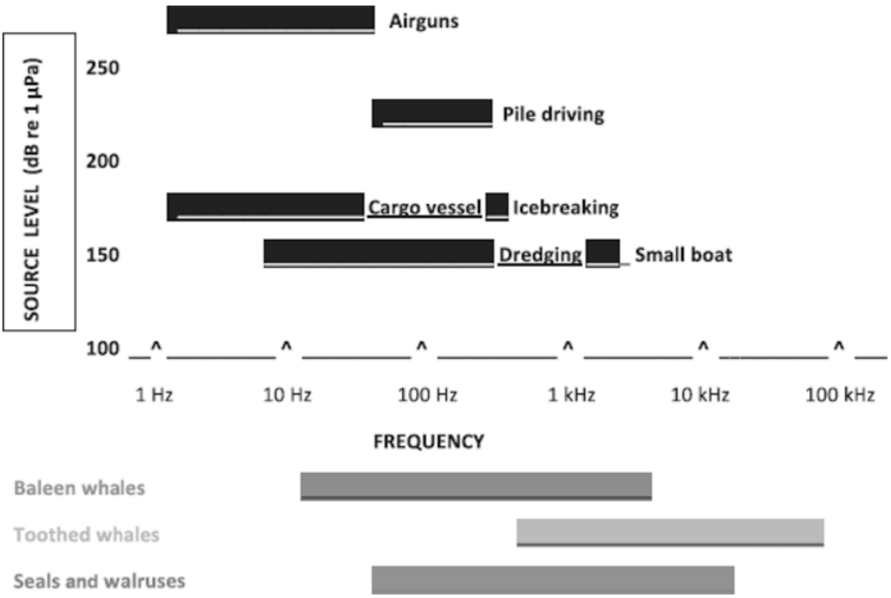

Fig. 14.4 Approximate frequency bands and source levels for common offshore activities in the Arctic (Greene 1995; Hildebrand 2009) relative to frequencies used by Arctic baleen and toothed whales, seals and walruses. Abbreviations: dB, decibels; Hz, hertz; kHz, kilohertz; µPa, micropascals. Source: Moore et al. (2012)

Narwhals and beluga whales use echolocation to find food and navigate. Belugas also have a wide variety of additional vocalisations used in social contexts (Wood and Evans 1980). Bowhead whales produce low-frequency sounds thought to be for courtship, socialising, navigating in ice, and maintaining group cohesion during migration (e.g., Stafford et al. 2008; Blackwell et al. 2015). Walruses vocalise in many social contexts above and underwater including mother–calf interactions, courtship displays (underwater) and predator or danger alerts (Miller 1985; Stirling et al. 1987). Male bearded seals trill underwater to advertise their breeding status and defend territories during the mating season (Burns 1981; Van Parijs et al. 2003).

5 Impacts of Underwater Noise on Arctic Marine Life

Anthropogenic underwater noise has potential to cause detrimental effects on marine animals that use sound. Around the world, scientific evidence of these effects is mounting, together with recognition that underwater noise from shipping is a significant, pervasive pollutant with the potential to impact marine ecosystems and the services they provide on a global scale (Williams et al. 2015a and references therein).

Impacts from various sources of anthropogenic underwater noise on Arctic marine mammals, fishes and marine invertebrates have been summarised by the Arctic Council (PAME 2019). Here we focus only on effects of underwater noise from shipping. Although Arctic cetaceans, seals and walruses use sound at frequencies that overlap with underwater noise from ships operating in the Arctic (Moore et al. 2012, Fig. 14.4), few studies have documented the impacts of ship noise on marine mammals, and none have described direct responses of fishes or marine invertebrates to ship noise.

Several studies describe responses of Arctic animals to the presence and activity of ships. While not explicitly addressed, underwater noise is inferred to be at least one causal mechanism for observed responses. Two Arctic fish species, Arctic cod and Shorthorn sculpin (*Myoxocephalus scorpius*), responded to ship presence in the Canadian high Arctic by altering their behaviour and home ranges (Ivanova et al. 2018, 2020). Pacific walruses in the Chukchi Sea responded to vessel traffic while in the water by diving and changing their course and speed when vessels were within 500 m (McFarland et al. 2015).

The three endemic Arctic cetacean species have been found to react to shipping activity and associated underwater noise. In the Canadian high Arctic, beluga whales and narwhals are highly susceptible to icebreaking ships operating in the spring, although the two species respond very differently. In a 3-year study by Finley et al. (1990), beluga whales were aware of an icebreaker approaching at 80 km away and at 35–50 km had a strong “flee” response: alarm calling, herd formation, rapid swimming up to 80 km away and subsequent avoidance of the area. Narwhals responded by “freezing”: becoming motionless, huddling in groups, sinking below the water’s surface and temporarily ceasing vocalisations. These behaviour combinations are recognised by Inuit in Canada as fear of killer whales, a natural predator of belugas and narwhals (Finley et al. 1990). Underwater noise received up to 20 km from the ship during icebreaking operations, including approaching, backing and ramming, was higher than the underwater ambient soundscape, despite the latter being recorded at the ice edge, which typically has a relatively loud underwater soundscape. In the Beaufort Sea, bowhead whales also show strong behavioural responses to approaching vessels as far away as 4 km or more (Richardson et al. 2013). Observed behaviour includes trying to outswim the vessel by increasing swimming speed and short surfacing, but within a few 100 m, fleeing in a perpendicular line from the vessel, up to a few kilometres away. Although bowhead whales appear to be more tolerant to slow moving ships or those not approaching directly, in all three cetacean species (bowhead and beluga whales and narwhals), the recorded underwater noise levels that elicited strong behavioural responses were relatively low (Finley et al. 1990; Richardson et al. 2013).

There are no published studies on impacts of vessel traffic or underwater noise from shipping on Arctic marine invertebrates, even though ship noise has been found to cause multiple stress responses in marine invertebrate species elsewhere. For example, responses of blue mussels to ship noise include potential effects on growth, reproduction, filter feeding and therefore the ecological services reefs provide (Wale et al. 2019).

Given the Arctic Ocean's relative inaccessibility, challenging field research conditions and a lack of baselines on "normal" behaviour ranges of marine animals, the dearth of empirical studies describing impacts of underwater noise from shipping in this part of the world is not surprising. Several recent studies have circumvented these challenges by modelling underwater noise from ships and inferring potential impacts on marine species. Using noise source levels of ships and known or inferred auditory thresholds of focal species, noise propagation has been modelled in the Canadian Arctic under present levels of ship traffic (Erbe and Farmer 2000; Halliday et al. 2017) and under future scenarios (Aulanier et al. 2017). The effects of modelled underwater noise on bowhead and beluga whales and ringed and bearded seals have also been discussed (Erbe and Farmer 2000; Halliday et al. 2017). These studies provide initial results that can be verified in the field and are a valuable starting point for policy discussions on underwater noise regulation.

As we learn more about impacts of underwater noise, it is becoming clear that sub-lethal responses by animals are complex and highly context dependent. Behavioural responses of marine species can depend on hearing sensitivity, behavioural state, habituation or desensitisation, age, sex, presence of offspring and location of exposure. In marine mammals, for example, responses may range from subtle changes in surfacing and breathing patterns to cessation of vocalisation, and active avoidance or escape from the region of highest sound levels. While it is difficult to translate observed responses into biologically significant population-level impacts, this should not preclude mitigation and management.

6 Addressing Underwater Noise: From Monitoring to Management

Effective measures to regulate underwater noise in the Arctic should include monitoring, mitigation and management. Monitoring underwater noise, implementing mitigation measures, and establishing legal tools to guide management regimes, can be costly, and countries may need to be incentivised or obliged to invest in proper frameworks and programmes. Currently there is no such requirement for Arctic states to do this.

Recognition of underwater noise as a pollutant is one way to enforce its regulation. The European Union (EU), for instance, has expressly defined underwater noise as a form of pollution in its 2008 Marine Strategy Framework Directive (MSFD), where it outlines the need for the introduction of energy, including underwater noise, to be at levels that do not adversely affect the marine environment in order to achieve Good Environmental Status (Directive 2008/56/EC of 2008) (European Parliament and Council 2008). European Member States are required to develop strategies for their marine waters to achieve such status. This has encouraged new research in the field, stimulated the market of underwater sound equipment, engineering and advice and instigated technical working groups to define indicators, targets and guidelines for measuring and monitoring underwater noise from impulsive and continuous sources.

6.1 Monitoring the Arctic Ocean Soundscape and Underwater Noise

Regional underwater noise baselines are necessary because they define the receiving environment for marine species and enable changes in noise to be measured over time. Although there is no purpose-built acoustic observing system in place across the Arctic, ambient soundscapes of the Arctic Ocean have been explored since the 1960s across various regions (PAME 2019). While these studies could provide valuable baselines to compare how anthropogenic noise has changed over time, there are still large geographic areas without available information on ambient sound levels. Most of these gaps exist in regions where shipping is increasing, including in the Russian Arctic (East Siberian Sea, Kara Sea and Laptev Sea) and much of the Canadian Arctic Archipelago (PAME 2019). In Russia, this increase is due to the use of the Northern Sea Route, mostly for the export of Liquified Natural Gas (LNG), and in Canada, it is due to the export of iron ore by bulk carriers from one of the Arctic's largest mines.

Strategic, systematic acoustic monitoring of the Arctic Ocean is needed for effective management of underwater noise. Coverage should encompass locations within and beyond the Exclusive Economic Zones (EEZ) of Arctic coastal states. A comprehensive acoustic network would include locations where other sources of anthropogenic underwater noise are occurring or likely to increase, as well as areas that are currently quiet. Implementing such a system could be staged, since it would require significant financial and logistical investments due to the sheer size of the region and because the use of underwater acoustic equipment can be seriously challenged by ice conditions. Priority could be given to areas ranked as having high combined biological, ecological and cultural importance (regardless of their current overlap with underwater noise-producing activities), and to locations where shipping is increasing or predicted to increase, including along future trans-Arctic shipping routes. Arctic coastal states may also choose to prioritise habitats used by commercially valuable species that are sensitive to noise.

In combination with collecting actual measurements, modelling to create noise maps would be of benefit and is a focus of a current Arctic Council PAME project. In the EU, the combined use of measurements and models is considered the best way for Member States to ascertain levels of and trends in ambient noise (Dekeling et al. 2014). If sufficiently ground-truthed with acoustic data to calibrate noise propagation, models can provide an overview of noise levels and their distribution across time and space and, further, can help to inform positions for acoustic monitoring (Dekeling et al. 2014). Accurate data on source levels of noise from ships operating in Arctic waters would be needed, so efforts to understand the levels of underwater radiated noise emitted by different vessel classes, propulsion systems and vessel components during operation, including transiting through ice, could inform not only noise models but also adaptive approaches to mitigating noise through redesign or retrofit.

If Arctic coastal states were to commit to a goal to ensure that underwater noise is managed at levels safe for Arctic marine biodiversity, it would be essential that they obtain high-quality information not just about underwater noise, but also biodiversity. There are still many gaps in our knowledge about noise-sensitive species in the Arctic, including their important habitats, their use of sound and thresholds for behavioural and hearing effects of underwater noise. Filling these gaps could be a priority for the Arctic Council through supporting scientific research and Indigenous knowledge studies. Further, climate change effects on the Arctic marine environment mean that important areas for biodiversity are unlikely to be static over time. Loss of sea ice and shifts in distributions of predators and their prey mean that high-quality habitats and important processes (e.g. spawning, migration) are likely to continue to change spatially and temporally in the future. Monitoring and predicting these shifts, where possible, will be necessary for proactive management of underwater noise.

6.2 Mitigating Impacts of Underwater Noise from Shipping

Unlike other forms of pollution, underwater noise does not linger in the environment. Changing the amount of noise emitted will therefore have a virtually immediate effect. There are numerous tools and solutions to mitigate effects of underwater noise from shipping that can be categorised broadly into technology and operations. We will discuss them briefly here in relation to their applicability for the Arctic.

Technological solutions focus on redesigning, retrofitting, or maintaining ships to reduce noise at the source. Retrofits and modifications to propellers have significant potential to reduce underwater noise generated by ships. This has been demonstrated by Maersk's Radical Retrofit programme in 2015 and 2016, where 11 Class G container ships were retrofitted to improve fuel economy. Modification of the bulbous bow to reduce drag, a new propeller with four fins, and propeller boss cap fins to reduce cavitation resulted in a six decibel reduction of underwater noise in the 8–100 Hz frequency band and an 8 decibel noise reduction in the 100–1000 Hz frequency band, together with a 10% improvement in fuel economy (Gassmann et al. 2017). Modifying the design of new vessels to be quieter is another option to reduce underwater noise. Ship classification societies have a quiet notation for ships and new builds that incorporates quiet ship design and technology to ensure certain standards of noise emissions are met. This latter option–to modify the design of new ships–is certainly an opportunity Arctic coastal states could take. Recent media articles have stated that Canada has commissioned six ships to be constructed for

Arctic operations in 2020[1] and Russia has plans to build a new fleet of 14 icebreakers.[2]

Operational solutions most commonly comprise reducing vessel speed or implementing routeing measures. Source levels of underwater noise increase with ship speed and size (McKenna et al. 2013). Slow steaming has resulted in an estimated reduction in underwater noise by as much as 50% in the eastern Mediterranean Sea (Leaper et al. 2014) and by 29% in Haro Strait, Canada (MacGillivray et al. 2019). Routeing measures entail physically separating ships from important areas for marine wildlife such as breeding, feeding, spawning, nursery and mating areas and migration pathways by changing the location of shipping routes or creating dedicated shipping corridors. The creation of marine protected areas (MPA) or other special management areas with restrictions on shipping traffic is an additional spatial measure to reduce impacts of underwater noise.

In the Arctic, all the above-mentioned operational solutions are feasible, but once again the characteristics of the Arctic marine environment affect which measures can be used where. In the presence of sea ice cover, ships are likely to take routes through open water for safer and faster passage. Leads and cracks are used by Arctic marine mammals in ice-covered waters, and polynyas—highly productive features of the Arctic Ocean because they are ice-free in winter—are hotspots for marine mammals, seabirds and their prey (fish and invertebrates). Similarly, the Bering Strait is a "choke point" for the Northern Sea Route and all future trans-Arctic shipping routes and is also a seasonal migratory corridor and permanent hotspot for millions of animals. Here, physical separation of ships from wildlife may not be possible, but slow steaming could be. In other parts of the Arctic, physical separation is possible. Area-based protection of important habitats and rerouteing of ships far enough to ensure that underwater noise does not permeate into these habitats could be a viable option. With only 4.7% of Arctic waters currently under protection at the most recent inventory (CAFF and PAME 2017), there is plenty of scope to expand marine protection to include quiet MPAs (concept suggested by Williams et al. 2015b).

6.3 *Policy to Guide Management of Underwater Noise*

Stronger regulation of underwater noise from shipping at the global scale would benefit the Arctic. The International Maritime Organization (IMO), the global standard-setting authority for the safety, security and environmental performance of international shipping, established voluntary guidelines in 2014 for the reduction of underwater noise from commercial shipping to address adverse impacts on marine

[1] https://www.ctvnews.ca/canada/delivery-of-the-navy-s-first-arctic-and-offshore-patrol-ship-delayed-until-2020-1.4682002

[2] https://thebarentsobserver.com/ru/node/164

life (MEPC.1/Circ.833). Recent analysis suggests that the guidelines have not been effective in reducing underwater noise or compelling the marine sector to invest in quiet ships (MEPC 75/14). A mandatory instrument, either through existing measures like the EEDI (Energy Efficiency Design Index) or regulated targets for ship design, retrofits and performance, could prompt stronger action.

Because the existing IMO guidelines are not specific to polar environments, in themselves they may be insufficient for protecting Arctic marine biodiversity (Czarski 2017). An additional policy instrument specific to the Arctic and Antarctic is the IMO International Code for Ships Operating in Polar Waters (Polar Code), which came into force in 2017. While the Polar Code does not include underwater noise in its definition of vessel pollution, it calls upon mariners to take into account, when considering a route through polar waters, known areas with densities of marine mammals, including seasonal migration areas (Paragraphs 11.3.6, 11.3.7). While not sufficient to avoid impacts on other groups of noise-sensitive marine species, this provision could be a starting point by which to mandate stronger measures for underwater noise impact mitigation.

Additional voluntary or mandatory measures at the international or regional scale that could contribute significantly to managing impacts of underwater noise are underwater noise management plans (UNMP) and habitat-based noise budgets. UNMP generally include public and transparent commitments to reduce underwater noise and operational and maintenance guidance to achieve those reductions. For example, British Columbia Ferries on Canada's west coast has made a commitment in its UNMP to reduce underwater noise levels by 50% and developed a plan to achieve those targets. Having habitat-based noise budgets in place can also help define the operating environment for shipping, encourage innovation, and be specific enough to include unique features and account for sensitive and threatened species.

7 Conclusion

The Arctic is a region under rapid transformation as a result of climate change. The Arctic Ocean is home to many wildlife species that use sound to survive and, until recently, have been naïve to anthropogenic activities. This situation is changing as sea ice retreats and new industrial development opportunities become a reality. Healthy populations of marine mammals, fish and invertebrates are critical for ecosystem function, the livelihoods and cultures of Indigenous coastal communities and, in some cases, commerce. Already experiencing stress brought on by climate change effects, marine species are highly threatened by the adverse effects of anthropogenic underwater noise introduced to their envronment by multiple sources. The increase in Arctic shipping in the past decade and the predicted extension of the shipping season and expansion to new areas requires commitment by Arctic states to understand and manage underwater noise pollution. Their leadership to strengthen policy in the shipping sector through the IMO Polar Code and other instruments, together with protection of high-quality habitats for noise-sensitive wildlife within their waters are measures that can be taken immediately. The Arctic Ocean is one of the last on the planet to remain relatively unpolluted by underwater noise. While the rest of the world adopts noise reduction targets, and shoulders the hefty economic costs of mitigation and rehabilitation, in the Arctic, there is an opportunity for a proactive, more cost-effective approach to management of underwater noise pollution that will safeguard Arctic species, ecosystems and the people who depend on them.

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Chapter 15
Canadian Ports Sustainability: A Strategic Response to Disruptive Paradigms Such as COVID-19

Yoss Leclerc, Debbie Murray, and Michael Ircha

Abstract Canadian ports, like others around the globe, faced significant challenges during the COVID-19 pandemic. This chapter reflects on these challenges with regard to the United Nation's sustainable development goals. Canadian ports evolved as a federal government responsibility, providing a national perspective to their pandemic response. The chapter considers the steps taken by ports to ensure resilience during the pandemic, how they responded to the UN's sustainability agenda and what potentially lies ahead in the post-COVID era. The pandemic crisis led some ports to suffer cargo throughput losses, while others gained. Overall, Canadian ports maintained their operations ensuring a continued supply of essential goods. Looking ahead, the government has embarked on an ambitious international trade agenda by entering many free trade agreements (FTAs) with nations around the world. These FTAs will significantly increase port throughputs leading to a need for improved and expanded cargo-handling infrastructure—a financial challenge. At the same time, ports are mandated to "provide a high level of safety and environmental protection". Canadian ports are actively engaged in environmental protection from ballast water management to air and water quality to protecting fish habitats. Further, ports contribute in many ways to improving the quality of life of their surrounding communities. Canadian ports demonstrated their nimbleness in

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adapting to the COVID-19 pandemic. They remain among the world's most efficient ports as they support Canada's expanding international trade agenda.

Keywords Responsiveness · Environment · Community · Operations · Infrastructure · UN 2030 agenda · Climate change · Emissions

1 Introduction

During its seventieth anniversary in September 2015, the United Nations (UN) developed its global vision, *Transforming Our World: the 2030 Agenda for Sustainable Development* (UN 2015). This ambitious vision encompassed 17 Sustainable Development Goals (SDG) including 169 associated blended targets that aim to foster sustainable growth while considering the status of each country (i.e. economic, environmental and social). The UN's International Maritime Organization (IMO) has identified its support for the 17 SDGs along with a plan for focused on five selected goals (IMO 2019a). The Canadian government actively supports the IMO. Canada Port Authorities (CPAs), with their established efforts on sustainability, work with the government in realising the UN SDG domestically.

This chapter reflects on the UN SDG as they relate to Canada's ports. It provides an overview of Canadian ports including their evolution as a federal government responsibility, the steps taken by ports to ensure sustainability, particularly in the COVID-19 pandemic, how ports are responding to the UN 2030 sustainability agenda, and what lies beyond.

With its relatively sparse population and immense distances between major urban centres, Canada depends on an efficient transportation system to support national supply chains moving goods and people across the country and beyond. The country's overseas trade depends on productive ports serving as key gateways supporting Canada's international trade strategy.

Canada is a major trading nation. In 2019, Canada ranked 12th among the world's leading exporters (Statista 2020). Although the US remains Canada's leading trading partner accounting for 65% of the country's exports and imports, dependence on US trade has declined over the past decade as Canada seeks to diversify its trade in offshore markets. The federal government has undertaken free trade agreements with 51 countries in its quest to increase Canada's overseas exports by 50% by 2025 (Canada 2020a). Increased overseas trade is placing significant pressure on Canada's ports to develop facilities to handle growing cargo volumes.

Canada has the world's longest coastline stretching along three oceans (Pacific, Arctic and Atlantic) as well as the world's longest inland marine corridor; the Great Lakes and St. Lawrence River serving the continent's industrial heartland. There are many deep-water, natural harbours along the Pacific and Atlantic coasts as well as ports serving international shipping along the St. Lawrence River and on the Great Lakes.

2 Ports in Canada

As the country's major ports, Canada Port Authorities (CPAs) handle over 347 million tonnes of cargo with trading partners in more than 170 countries. This tonnage represents more than 60% of Canada's total waterborne cargo. Smaller public ports and private facilities handle the remaining tonnage of primarily bulk minerals and petroleum.

CPAs are federally incorporated, autonomous, non-share commercial corporations operating at arm's length from government. They fulfil important public policy objectives (support for economic development) and regulatory requirements (safety, security and environmental protection). Their corporate structure seeks to balance commercial autonomy with public sector requirements by aligning the ports' business orientation and freedom to operate with broader government policy objectives. CPAs are commercialised federal agents administering public port lands as landlords managing long-term leases with private terminal operators. Port authorities are financially independent. They do not receive federal funding to cover their operating costs or deficits. Although CPAs finance capital projects from their own revenues, they can partner with the private sector, borrow from a commercial lender and/or apply for federal grants related to infrastructure, environment or security.

Today, Canadian ports rank among the world's most efficient facilities. To reach this point, Canada's ports evolved through a series of distinct stages from former British Colonies to today's National Ports System (Brooks 2017).

The 1867 Confederation of three British colonies established the Dominion of Canada as a federal system with legislative responsibilities divided between federal and provincial governments. The *British North America Act* of 1867 (now *Constitution Act* of 1982) placed navigation and shipping solely within federal jurisdiction. The Department of Marine and Fisheries had responsibility for ports, harbours and commissions (Appleton 1989). However, Canada's extensive geography meant the Department was unable to effectively manage the country's many ports and harbours. Over time, weak central control led to various forms of ports and harbour commissions; some integrated into local governments and others more independent. By the early twentieth century, Canada's ports were hampered by extensive political patronage and weak accounting practices, leading to uncontrolled and escalating federal port expenditures (Manning 1968).

2.1 First Stage: National Harbours Board, 1931–1983

In 1931, the federal government retained Sir Alexander Gibb, a noted British port specialist, to evaluate its problematic ports system. Gibb's *National Port Survey—1931/1932* led to major restructuring. His basic principle was that "the National ports have to serve more than local interests, and in the interest of the whole country, must be directed on national lines and in accordance with a definite coordinated policy" (Appleton 1989).

Adopting Gibb's recommendations led to the 1936 creation of the National Harbours Board (NHB), initially comprised of seven major ports: Montréal, Québec, Halifax, Vancouver, Saint John, Trois-Rivières and Saguenay. Later, seven other ports were added. Local Harbour Commissions continued to operate independent of the NHB. Over time, the NHB model came to be known for its rigid centralised financial control, isolation from provincial and municipal input and having no interaction with commission ports (Dosman 1978).

Harbour Commissions operated under their initial acts of incorporation. In 1964, the *Harbour Commissions Act* rationalised the system with commissions remaining financially self-sufficient entities representing local interests. Transport Canada's Harbours and Ports Directorate administered a third group of 346 smaller ports.

The first stage of port evolution presents a picture of confusion and conflicting federal port objectives ranging from the NHB's rigid control of major ports to semi-autonomous commission ports to smaller, publicly subsidised Transport Canada harbours and ports (Ircha 1999). By the 1960s, continental transportation issues had become more complex, leading industry and government to seek a more comprehensive ports system.

2.2 Second Stage: Canada Ports Corporation, 1983–1993

The *Canada Ports Corporation Act* of 1983 replaced the National Harbours Board with the Canada Ports Corporation (CPC) as a central Crown corporation and subsidiary Local Ports (Crown) Corporation (LPC). This second stage sought to balance CPC's national coordination with the LPCs' local and regional commercial responsiveness. Significant national and regional ports were designated LPCs with semi-autonomous Boards of Directors (appointed by the Minister of Transport). Seven major ports were granted LPC status: St. John's, Halifax, Saint John, Québec, Montréal, Vancouver, and Prince Rupert, with CPC administering seven smaller commercial ports.

The Act defined a national port policy but was silent on the role of the other federal ports (harbour commissions, Transport Canada harbours and ports, and private ports). At the time, McCalla (1988) pointed out that, "*While the national ports policy exists on paper there is no strategy for its implementation.… There seems to be no person or body charged with the responsibility of overseeing the development of all ports in Canada*".

Despite the commercialisation intentions of the Act, over time federal bureaucratic rules and regulations prevented LPCs from operating as true commercial entities. Creating the CPC and LPCs may have addressed the challenges of the 1960s and 1970s, but the Act did not create the unfettered, commercialised and market-responsive ports needed to meet growing continental and global competition.

2.3 Third Stage: Canada Port Authorities, 1993–2020

In 1993, a newly elected federal government undertook an in-depth programme review of all departments seeking improved efficiencies, cost reductions and ways of doing things. Transport Canada's marine sector review was initiated with a senior-level seminar on port privatisation (Ircha 1993). In parallel with the department's internal review, the House of Common's Standing Committee on Transport (SCOT) undertook marine hearings across the country. The review and hearings led to a government white paper, *National Marine Policy* (Canada 1995) and the *Canada Marine Act* of 1998 (Canada 1998).

In 1995, the Deputy-Minister of Transport presented the Government's proposed ports policy to ports' community (Mulder 1995). The policy sought to limit the government's involvement to ports of national significance as Canada Port Authorities and a limited number of smaller ports serving remote communities. Harbour Commissions and Transport Canada ports were to be divested to other governments, non-profit public organisations, and the private sector.

The *Canada Marine Act* (CMA) established 17 Canada Port Authorities (CPAs) as federal agents managed by autonomous boards of directors as a clear step towards increased commercialisation. User groups nominate CPA directors for appointment by the Minister of Transport. The 17 CPAs included former LPCs and selected harbour commissions. These are shown in Fig. 15.1.

Despite the *Canada Marine Act*'s positive steps towards commercialisation and corporatisation, CPAs continue to struggle with constraints created by conflicting federal legislation and bureaucratic regulations as well as the increasing complexities of today's global economy. As the ports' economic environment continues to evolve, the question is whether or not Canada's major ports are facing a fourth stage of evolution?

3 Challenges Faced by Canadian Ports

Canadian ports face many challenges as they compete on a global scale. Some of these challenges include infrastructure development, protecting the marine environment, consulting First Nations, community engagement and a need for increased financial flexibility and autonomy.

3.1 Port Infrastructure

The federal government's quest to increase international trade by 50% by 2025 implies a need for significant port infrastructure development to accommodate growing cargo throughput. The government recognises this need and has supported

Fig. 15.1 Canada Port Authorities. Source: Association of Canadian Port Authorities (2020)

relevant infrastructure projects for ports and their intermodal partners through the National Trade Corridors Fund (NTCF). However, additional port infrastructure is required to meet the government's ambitious 2025 target.

3.2 Protecting the Marine Environment

The *Canada Marine Act* requires Canada Port Authorities to "*provide a high level of safety and environmental protection*" (Canada 1998). Ports understand their cargo-handling, and other operations may create externalities that could harm nearby communities. As a result, each CPA goes to considerable lengths to eliminate or mitigate environmental irritants. Canadian ports are committed to a wide range of environmental protection practices that include reducing shore-side and underwater noise, monitoring and mitigating dust, decreasing light emissions, protecting fish habitats and undertaking shoreline rehabilitation.

3.3 Duty to Consult

As federal agents, CPAs have a unique duty to consult meaningfully with the First Nations affected by port projects. Within the ports' proximity, there are more than a hundred First Nations communities living and practicing their constitutionally protected rights. These communities are diverse, and their interaction with ports vary significantly. CPAs have embraced relationship building with First Nations with arrangements varying from informal engagement to more formal and detailed Protocol and Partnership Agreements.

3.4 Supporting Port Communities

Historically, ports have always been the heart of their communities driving local and regional economic development as well as helping to shape the community quality of life. The contiguous nature of ports and communities creates the need for continuous mutual interaction, involvement and understanding (Ircha 2012). CPAs understand the importance of their role within local communities. They strive to safeguard and invest in the communities' social, cultural and environmental fabric. CPAs dedicate a portion of their revenues to support a myriad of community projects and initiatives. Many ports have established formal processes for seeking and vetting requests for the ports' community contributions.

3.5 Financial Flexibility and Autonomy

Over the years, CPAs have made many recommendations to government seeking improved efficiency through enhanced financial flexibility and increased autonomy from constricting government rules and regulations, particularly in the area of port land transactions (ACPA 2018).

Increasing the efficiency and effectiveness of Canada's ports requires a further shift along the commercialisation spectrum to corporatisation—operating in a true arms-length, business-like manner. The need for change was earlier outlined by the Canadian Transportation Act Review Committee (CTARC 2016): "*Canada's post-commercialization policy framework for the marine sector works for the current environment. However, as the model ages, the limits of the marine system governance will become more apparent; it may well be too inflexible to meet the needs of the economy of the future*".

3.6 Fourth Stage: Ports Modernisation?

In 2018, the Minister of Transport initiated a Port Modernization Review. The Minister's initial consultation was a roundtable discussion with CPAs. This was followed with a series of stakeholder workshops across the country. On behalf of CPAs, the Association of Canadian Port Authorities (ACPA) submitted recommendations on the changes needed to ensure ports remain efficient and effective as they strive to support the government's ambitious export trade agenda (ACPA 2018).

At the time of writing (mid-2020), port authorities and others await the "what we have heard" report from Transport Canada. The report will be followed with consultations with ports and stakeholders in the fall of 2020, with the government likely implementing the recommendations in 2021.

Will the Port Modernization Review's recommendations be the fourth stage of port evolution? Will port authorities shift further towards full corporatisation? Will the recommendations reflect CTARC's conclusion that beyond financial flexibility, the CPA governance structure needs to become more business-like, "… *government service providers must emulate successful private enterprises in evolving their business models and asset structures. More flexibility and responsive governance is required*" (CTARC 2016).

Canada Port Authorities stand on the cusp of change. The scope of the Minister's Port Modernization Review recommendations and their impact on Canadian ports are not known. However, the expectation is they will ensure Canadian ports remain efficient and effective in support of the government's expanding trade agenda.

4 Canadian Ports and Sustainability Planning

Canada has been an active member of the UN's International Maritime Organization (IMO) since 1959. As such, the country has ensured alignment with the IMO's Strategic Directions (UN 2017). These included the incorporation of IMO codes and guidelines into Canada's marine regulatory regime, which also involves CPAs.

Canada has emerged as a leader in marine safety, security and environmental issues. In 2016, the country's leadership role was reinforced with the adoption of a Canadian $1.5 billion[1] Oceans Protection Plan (OPP) aimed at protecting Canada's coasts and waterways (Transport Canada 2016). Under the OPP, Canada strengthened its international engagement by establishing a permanent Canadian mission at the IMO. Further, the OPP supports port sustainability initiatives through improved ship navigation systems and enhanced oil spill prevention and recovery measures.

As federal agents CPAs are under the authority of the Minister of Transport. As such, they are required to keep the Minister regularly informed on their activities, their financial health, and their sustainable operations (environmental, social and

[1] Please note that all dollar values in this chapter are in Canadian dollars.

economic). Port authorities provide reports to Transport Canada and other governmental agencies, including annual sustainability reports published on each port's website.

CPAs abide with the *Port Authorities Management Regulations* (Canada 2020b) and *Port Authorities Operations Regulations* (Canada 2020c). These regulations ensure safe, secure and sustainable port management and operations. Through various departments and agencies, such as Transport Canada, Environment and Climate Change Canada and Department of Fisheries and Oceans, port authorities are monitored with respect to relevant Acts and Regulations.

4.1 Sustainability of Canadian Port Authorities

The *Canadian Marine Act* (CMA) requires port authorities to consider the operational, social and environmental impacts of their activities and project development. As such, CPA initiatives are aligned with the IMO's Strategic Plan (UN 2017) including climate change, enhancement of international trade's global facilitation and security, and organisational effectiveness.

Canada Port Authorities support economic prosperity through trade while maintaining a healthy environment and community growth. Along with ensuring safety, security and environmental protection, CPA activities generate well-paid jobs across the country.

In many communities, ports are major employment and income generators. Canada Port Authorities create over 200,000 direct and indirect jobs generating $14 billion in wages and $2.1 billion in taxes, paid to the federal government ($1.4 billion), provincial governments ($684 million) and municipalities ($22 million) (InterVISTAS 2017). Ports work closely with their neighbouring communities and have programmes in place to address issues and concerns.

Port authorities have embraced or introduced marine environmental programmes. For example, all CPAs are members of the Green Marine Alliance, a Canada-based environmental organisation seeking to reduce the marine sector's environmental footprint by sharing best practices tackling air, land and water pollution along with certifying ships, ports and terminals. As part of their Corporate Social Responsibility (CSR) programmes, CPAs participate in national and international collaborative organisations dealing with global environmental challenges, such as climate change and greenhouse gas emissions.

All CPAs are required to be financially self-sufficient with revenues derived from their operations, lease payments and fees. Ports fund almost all of their own environmental protection programmes and measures. The *Canada Marine Act* permits federal contributions to environmental projects, such as Onshore Power Supply (OPS), but there is no formal funding allocation or regularity to these contributions. Port environmental initiatives and programmes require considerable funding and resources. Depending on their financial capacities, CPAs dedicate between 1% and

15% of their total annual budget on environmental and sustainability programmes.[2] This creates significant challenges in the alignment of port sustainability initiatives with Canada's climate commitments, land and animal (fish and marine mammals) conservation initiatives, as well as protecting local air quality and human health.

4.2 International Environmental Collaboration

Canada Port Authorities are involved with many different international organisations, including:

- International Maritime Organization (IMO), the UN's special agency responsible for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships;
- International Harbour Masters Association (IHMA), a professional body for port staff who are responsible for the safe, secure, efficient and environmentally sound conduct of marine operations in port waters;
- International Association of Ports and Harbors (IAPH), supporting ports worldwide through collaboration and information-sharing on common issues to enhance port services and advance sustainable practices; and
- Association of American Port Authorities (AAPA) and Association of Canadian Port Authorities (ACPA), promoting best practices in North American ports relating to environmental, operational, technological and security concerns.

These collaborative organisations provide Canadian ports with best practices to develop programmes that go beyond regulations to address environmental and operational issues. For instance, the Vancouver Fraser Port Authority (VFPA) implemented a ballast water management programme long before it became national regulation. Further, some ports developed LNG bunkering operations based on information, procedures and protocols provided by European ports.

The VFPA is a member of the World Ports Climate Action programme. This is a new initiative that brings ports from around the world together to work on projects tackling global warming. In 2018, VFPA received the Excellence in Governance Award for its best practices in sustainability and environmental, social and governance factors by the Governance Professionals of Canada (GPC 2018). The port also received the Lloyd's List Environmental Award for its ECHO programme supporting the recovery of its nearby population of endangered southern resident killer whales (Lloyd's 2018). In the following year, VFPA's ECHO programme received an Award for Conservation Leadership in Support of Corporate Responsibility (VFPA 2019b).

To support their overall sustainability, port authorities have Emergency Preparedness and Business Continuity Programs to ensure efficient and reliable

[2] Source: interviews with CPA representatives in 2019.

response to any emergency, including the management of gastrointestinal illnesses on cruise ships. Hence, from a port perspective, CPA are able to address a broad range of situations within their jurisdictions, including the COVID-19 pandemic. This latter extraordinary situation was handled efficiently and seamlessly as CPA response plans were encompassing and flexible enough to ensure business continuity and services delivery.

5 Canadian Port Traffic Prior to COVID-19

Canadian ports, comprised of CPAs and other facilities, handle a wide range of import and export commodities including containers, liquid and dry bulk, cruise ships, ferries and general cargo. In 2019, Canadian ports handled more than $245 billion worth of cargo, including US marine shipments (primarily petroleum products, LNG and fuels). The major international commodities handled in ports, by value, include agricultural and food (20%); machinery and electrical equipment (12%); chemical products, plastics and rubber (11%) automobiles, parts and transportation equipment (11%); and other manufactured goods (11%) (Transport Canada 2019a, Table M19).

As shown in Table 15.1, over the past decade, CPA have handled increasing commodity throughputs from 262 million tonnes in 2010 to over 347 million tonnes in 2019, with a compound annual growth rate (CAGR) of 2.2%.

Table 15.1 Cargo handled by Canada Port Authorities (millions of tonnes)

Port	2010	2015	2019	CAGR (%)
Vancouver-Fraser	118.5	138.2	142.6	2.3
Montreal	25.9	32.0	40.6	6.3
Prince Rupert	16.4	19.7	29.9	9.1
Sept-Iles	25.1	22.7	29.3	1.9
Quebec	24.6	21.4	29.0	2.0
Saint John	30.5	26.4	25.4	−1.8
Hamilton-Oshawa	11.7	9.6	10.6	−0.9
Thunder Bay	6.9	8.9	9.3	3.9
Halifax	9.5	7.6	8.6	−1.0
Windsor	5.3	5.6	4.8	−1.1
Nanaimo	2.4	4.9	4.7	10.8
Trois-Rivieres	3.0	3.1	4.2	4.7
Belledune	2.1	1.8	2.6	2.3
Toronto	1.5	1.7	2.3	5.5
St. John’s	1.5	1.8	1.7	1.8
Port Alberni	1.0	1.6	1.0	−0.3
Saguenay	0.4	0.3	0.6	7.3
Total	*286.2*	*307.3*	*347.2*	*2.4*

Sources: Transport Canada (2019a, Table M17) and Binkley (2020)

Table 15.2 Containers handled by Canada Port Authorities (millions of TEUs)

Port	2010	2015	2019
Vancouver-Fraser	2.514	3.055	3.398
Montreal	1.331	1.445	1.745
Prince Rupert	0.343	0.776	1.211
Halifax	0.434	0.418	0.547
Saint John	0.046	0.097	0.069
Total	*4.67*	*5.792*	*6.971*

Source: Transport Canada (2019a, Table M18)

The significant growth of container throughputs in Canada's major ports is shown in Table 15.2. In 2010 Canada's five container ports handled 4.7 million TEU (20-foot equivalent units), by 2019, this had increased by 50% to almost seven million TEU (Transport Canada 2019a, Table M18).

With over 53,000 commercial vessel transits in Canadian ports reported by Transport Canada, most of CPAs had a good year in 2019 with record cargo volumes as outlined below (Ryan and Frederick 2020).

5.1 West Coast

On the west coast, international trade was very strong in 2019 with the Canadian flagship port of Vancouver handling a record 3.4 million TEUs. The port of Prince Rupert has also had a good year with an increase of 12% in its overall throughput.

5.2 Great Lakes

Ports witnessed an increase in tonnage of cargo handled in 2019 compared to 2018. For instance, total throughput for the port of Hamilton-Oshawa was over 10.5 million tonnes in 2019. The increase of grain shipments reinforced the positive annual throughput. For example, the port of Thunder Bay shipped an additional 500,000 tonnes of grain reaching 9.3 million tonnes in 2019.

5.3 East Coast

In 2019, CPAs in Eastern Canada handled more cargo volume. The port of Montreal had an increase in TEUs handled in 2019, while the ports of Saguenay, Sept-îles and Trois-Rivières all had an increase in overall cargo volume. The ports of Halifax and Saint John experienced modest declines in cargo throughput in 2019.

The COVID-19 pandemic and its extraordinary health challenges put enormous pressure on Canada's ports as they adapted and responded quickly applying relevant protocols and processes to safeguard port operations and maintain the flow of goods moving through the country's supply chains.

6 Impact of COVID-19 on Canadian Ports

In early March 2020, Canada was affected by the global COVID-19 pandemic. By the end of the month, the country had gone into lockdown, with the exception of essential services including ports and logistics supply chains. The lockdown came as the country was recovering from national blockades by First Nations, at the beginning of 2020, which had closed rail lines and constricted the flow of goods domestically. As a result, as the country recovered from the blockades and burgeoning shortages and other related disruptions, the pandemic struck.

The COVID-19 pandemic impacted ports around the world. The IAPH, in partnership with World Port Sustainability Program (WPSP), established a global Port Economic Impact Barometer measuring the pandemic's effect on ports. In their final IAPH-WPSP report, Notteboom and Pallis (2020) found that overall, between April 6 and July 15, there was a general decline in vessel calls in ports around the world. This included a 44% decline in container ship visits, 41% for other cargo vessels and 74% for passenger ships. However, in June and July, vessel calls improved.

Canada Port Authorities participated in IAPH-WPSP survey. The Canadian ports cohort results were comparable to global findings, with similar impacts on passenger and cruise traffic, and steady capacity utilisation. Indeed, the Canadian results demonstrated a resilient port and intermodal system that continued to operate with little disruption and at almost full capacity.

Also challenging, since 2018 the port sector had been going through significant introspection with the Minister of Transport leading a strategic consultation on ports modernisation. The government had also revised the federal environmental Impact Assessment Framework for major projects, which was affecting project review timelines. At the same time, federal financial support from the National Trade Corridor Fund was starting to flow to support many port and related multi-modal projects across the country.

In this context, the pandemic impacts on Canadian ports can be categorised as short term and long term, operational and strategic, respectively.

Canadian ports demonstrated resilience and were able to quickly pivot themselves to meet the COVID-19 challenge by applying protocols to protect supply chain integrity and ensure operational continuity to support Canada's way of life (Zatylny 2020). ACPA, on behalf of its member CPAs, worked closely with Transport Canada, Canada Border Services Agency, Public Safety and the Public Health Agency on protocols to ensure the safety of workers and the movement of goods. In a short period of time, and with significant teamwork and effort by government and marine stakeholders, including ports, the marine sector mobilised to put in place the safety frameworks needed to keep the supply chain moving.

As ACPA noted to decision makers and to the public, "*Canada has weathered the COVID-19 crisis with commitment and innovation…Throughout this time, Canada Port Authorities (CPAs) have been doing their part to continue operations, move cargo, employ people, and support communities in a sustainable, safe and innovative manner, all with remarkably little disruption*" (ACPA 2020a). The fact that consumers could readily access coffee beans and bananas throughout the pandemic provided a clear demonstration of the strength of Canada's international and domestic ports and logistics system.

The COVID-19 pandemic altered maritime trade patterns, and these changes were felt at Canadian ports. Global decreases in container trade during the pandemic were also manifested at Canadian ports. As consumer demand and trade in durable goods dropped, so too did volumes of steel, electronics and automobiles, all of which go through Canada's ports. Some Canadian ports suffered single- or double-digit cargo losses in the first half of 2020, while others held steady or even had moderate growth.

As shown on their websites, Canada's major container ports had reductions in TEU throughput in the first half of 2020: Vancouver was down by 8%; Montreal, −4%; Prince Rupert, −16%; and Halifax, −23%. Although these major ports lost container traffic, on a total cargo tonnage basis, they did not suffer overall significant declines. For example, Vancouver's cargo throughput declined 0.4% by the end of May. By the end of June, Montreal witnessed an overall reduction of 9%, with most of the loss being inbound cargo. In the same period, Halifax declined almost 3%. On the other hand, Prince Rupert witnessed a 4% increase in overall throughput. Other smaller Canadian ports also suffered cargo reductions due to the pandemic, including Trois-Rivières, Windsor and Nanaimo (Ryan and Frederick 2020).

Notably, some Canadian ports had no adverse traffic reductions from the pandemic, such as Sept-îles and Toronto, while others gained traffic. For example, grain movements through the port of Thunder Bay were up 35% over its 5-year average (Alex 2020). As pointed out by Tim Heney, Thunder Bay's CEO and President, "*The global COVID-19 pandemic has created voids in grain supply as some countries restrict exports and consumers stock up on staple foods…. The railways, stevedores, grain elevators, inspectors and mariners, to a name a few, are handling increased trade... they are keeping commodities flowing to parts of the world that could otherwise see a food shortage*" (Ryan and Frederick 2020, p. 45).

Overall, by mid-year on the St. Lawrence Seaway cargo tonnage was down by 8%. The COVID-19 pandemic affected commodities differently. Iron ore shipments were down 13%, reflecting a decline in steel production. Coal shipments were similar reduced by 16%. Bulk traffic declined by 12% for dry cargoes and 20% for liquid commodities. These cargo declines were offset to a degree by a stronger uptake in grain movements (up 6.7%) and general cargo, primarily wind turbines, up 3.6% (SLSMC 2020).

Despite continued operations, there were other COVID-19 impacts. Ports lost revenue from decreased rents from terminals and other port tenants that ceased operations. A significant negative impact was Canada's suspension of the cruise industry. This was a growing sector in Canada and directly affected over ten Canadian ports and the many communities that drew revenues from it. As part of Canada's early pandemic response, the Minister of Transport prohibited all cruise ships with accommodation for 100 persons (passengers and crew) from sailing in Canadian waters until October 31, 2020. This blanket restriction essentially cancelled the 2020 cruise season. In the words of a cruise industry association representative, "*Disaster is not too harsh a word for what has happened*" (Ryan 2020). Canada has extended the cruise ship ban until February 2022.

Several Canadian ports serve as cruise ship "homeports" where passengers disembark and embark, and ships are resupplied. For example, Vancouver estimated that the 288 cruise ships visiting the port in 2019 stimulated $3 billion in the local economy (VFPA 2019a). Montreal and Québec serving as homeports were similarly impacted by the loss of cruise traffic in 2020. Some smaller Canadian ports depend on cruise visits for a major portion of their revenue. Ports such as Sydney, Charlottetown and Victoria were particularly hard hit.

While Canada's ports were affected in the short term, there are long-term impacts and policy responses that will ultimately shape the pandemic's impacts on Canadian ports. Most Canadian ports are proud of the fact that they had no employee layoffs in the face of declining cargo throughput—despite the lack of federal government support from its COVID-19 Wage Support Program. This is a significant consideration for COVID-19 economic recovery. CPAs used their financial reserves set aside for capital projects and maintenance to cover operational costs. This use of liquidity for short-term operations and maintaining employment may affect the ports' abilities to leverage funds to build trade-enabling projects in support of the pandemic recovery.

On a positive note, the resilience of Canadian ports was demonstrated through their quick response to the COVID-19 pandemic crisis. When possible, port authority staff worked online from their home. Annual Port Days were cancelled, and the port authorities held virtual annual general meetings. During the crisis, port authorities reached out in support of their neighbouring communities. Many ports supported local food banks, provided port facilities for food storage and distribution, and repurposed staff to assist in community support projects.

The following examples outline some of the ports' community support (ACPA 2020b). The port of Québec realigned its cruise-oriented staff to assist in delivering meals to low-income families. When the Greater Saint John Emergency Food Program began to run out of space, the port provided a cruise terminal as a food distribution centre. The port of Sept-Îles purchased a commercial freezer to help store food for the local meals on wheels organisation. Windsor acquired locally produced facemasks for port workers to aid the local economy. Vancouver set up a programme to provide pre-packaged meals to truck drivers coming to the port as a demonstration of the port's appreciation of their continuing service (VFPA 2020). Along with some of its supply chain partners, Halifax developed a "Fastlane" initiative to identify and fast track the delivery of critical COVID-19 cargo. Other Canadian ports undertook similar pandemic-related critical delivery initiatives.

As the initial pandemic wave passed, ports positioned themselves to support Canada's economic recovery. In a recent submission to government, ACPA suggested that COVID recovery "*is a unique and critical opportunity to transition or even catapult Canada into a position of global leader in green, inclusive, digital and resilient port supply chains*" (ACPA 2020a). The federal government has signalled that a key to economic recovery is strategic infrastructure investment. Canadian ports agree and have numerous relevant projects ready to go. For example, the port of Vancouver is in the final stages of initiating development of its major Roberts Bank Terminal 2 project, which will increase its container capacity by 50%. Similar major container terminal projects are being planned and readied for development in Montreal (Contrecoeur, 40 km downriver) and Québec (Laurentia—a joint venture with CN and Hutchinson Port Holdings). Other port projects include: Sept-Îles' $20 million intermodal project; Trois-Rivières' industrial port zone; Saint John's $205 million West Side Modernization project; and Halifax' South End Container Terminal expansion.

Canada's ports are among the world's cleanest and most efficient. They demonstrated their resilience through their critical supply chain role during the COVID-19 pandemic. Some ports had cargo throughput reductions while others did not. However, all ports continued operations with virtually no disruptions. In the post-COVID-19 era, Canadian ports stand ready to do their share in supporting the country's economic recovery by developing port infrastructure that will be essential for Canada's growing maritime trade.

7 Looking Ahead to What Comes After the UN 2030 Agenda for Ports

The world's population is projected to reach 8.5 billion by 2030, 9.7 billion by 2050 and exceed 11 billion in 2100, with India expected to surpass China as the world's most populous country (UN 2019). To cope with this continued growth, the UN is encouraging industries and businesses to make sustainability a critical priority. As key elements of national economies, ports will have to adjust to an emerging new radical landscape; one that will see political and business constituencies shifting from considering climate change as a resource and environmental problem to viewing climate change as an economic concern related to mitigating environmental impacts, as well as developing opportunities and sharing costs.

7.1 Canada Transportation 2030: Waterways, Coasts and the North

Canada's vision is to develop a green, safe, secure, innovative and integrated transportation system that will ensure sustainable growth over the next decades (Transport Canada 2019b). Infrastructure alone will not be enough to support growth and position Canada as an international economic player. Increasing the competitiveness, productivity and efficiency of national gateway ports is key to supporting economic recovery. Waterway governance is challenging and requires a systems approach to safety, environmental protection and competitiveness. Competing jurisdictions between ports, pilotage authorities, regulators and agencies is often complex. There is a need for clear and coherent management of Canadian waterways.

As prominent supporters of Canada's international trade goal, the country's ports have developed initiatives and programmes to ensure that their operations and future infrastructure development are sustainable. As mandated by SDG13: "Taking urgent action to combat climate change and its impact", CPAs are actively improving and reinforcing environmental and operational sustainability with the end goal of developing and maintaining low-carbon, zero-waste ports.

7.2 Climate Change

A critical port-related sustainability concern is climate change, rising sea levels and extreme weather events. Changing sea levels require port infrastructure investments to protect port facilities from future flooding and storm surges, as they are particularly vulnerable, as illustrated by the detrimental impacts of hurricanes Sandy, Harvey and Maria.

In *Climate Change and Adaptation Planning for Ports*, Ng et al. (2015) argue that "*Despite some strong evidence suggesting that institutional systems will influence climate change adaptation … most attention focuses on physical layouts and technical details of capital-intensive engineering projects, e.g., elevation, levee, dykes, etc. Adaptation is clearly under-researched especially in terms of the reduction of uncertainties in decision-making, the development of effective public policies and institutional practice*".

Given their strategic role in the global trading system, CPAs and shipping need to be seen as a clear priority in ensuring climate change resiliency. Canadian ports have included climate change in their "risks portfolio". They are adapting to climate change through resilience planning to ensure continued operation in the event of a climatic incident or environmental disruption. For instance, new technologies, materials and techniques are being developed ranging from climate resilient concrete mixes to innovative pier design.

In order to make a difference in addressing climate change, ecosystem protection and air quality improvement, CPAs have integrated environmental sustainability as part of their organisational vision and mission. Their environmental policies are based on four pillars, environmental protection, environmental conformity, continuous improvement and communication.

7.3 Reduction of CO_2 Emissions

In 2018, IMO adopted a strategy to reduce CO_2 emissions from ships by 50% by 2050 (Cushman 2018). Following the coming into force of IMO's initial emission controls in 2010, Canada was one of the first countries to establish an offshore Emission Control Area (ECA) for ship discharges of sulphur oxides and other particulate matter. Further, some port authorities offer incentives for vessels using low sulphur fuel or for "green" ships operating with high environmental standards. Canadian ports have also promoted CO_2 reduction from transportation and operations such as incentives/requirements for tier 1 and 2 engines for port equipment (trucks, locomotives, cargo-handling equipment and so forth).

7.4 Energy Transition

Resources are not unlimited and need to be managed to ensure a sustainable world for future generations. Canadian port authorities have been and will be continuously engaged in initiatives and programmes to promote better and innovative use and type of energy and mandated by SDG 7: "Ensuring access to affordable, reliable, sustainable and modern energy for all".

Canada has enabled port energy transition projects by developing infrastructure for alternative fuels, such as LNG bunkering systems, and financially supporting the provision of Onshore Power Systems (cold ironing). Several CPA have installed shore power, particularly for cruise and container terminals.

7.5 Energy Clusters

CPAs support the creation of energy industry clusters to develop and deliver green initiatives supporting the transition to future sustainable energy. The greening of ports requires the collaboration of industry partners and large investments for providing clean energy, infrastructure connectivity and green grids (both pipelines and cables). The aim of greening ports is to move them from being energy takers to producers and providers of clean energy solutions, such as the port of Rotterdam where solar energy and other clean sources are being used for its activities (such as cooling warehouses, offices) (Rotterdam 2020).

7.6 Circular Economy

The presence of industry and proximity to large urban agglomerations make many ports ideal places to turn waste into viable products. The potential development of this form of circular economy offers a significant avenue for Canadian ports to explore.

Canada Port Authorities understand the criticality of sustainability in everything they plan and do. All CPAs have sustainability policies and programmes encompassing the social, environmental and financial aspects of their activities as mandated by SDG 9: "*Building resilient infrastructure, promoting inclusive and sustainable industrialization and foster innovation*".

7.7 Logistics and Supply Chains

Port authorities are embracing new technologies to become smarter and greener, thus reducing inefficiencies and their environmental footprint while introducing balanced use of renewable resources. Indeed, the introduction and implementation of digitalisation enable the transparency and efficiency of the supply chain while reducing their environmental footprint.

Short Sea Shipping (SSS) is an important modal shift in inland freight transport that minimises environmental impacts (noise, traffic, emissions per tonne-km and so forth). Canadian ports have promoted and implemented SSS whenever feasible as part of their sustainability programme. For instance, Canada's inland marine corridor, the Great Lakes-St. Lawrence hosts several Canadian shipping lines such as CSL, Algoma and Transport Desgagnés, that provide SSS between Canadian and US ports situated thousands of kilometres apart.

7.8 Digitalisation of the Marine World

Led by the IMO and signatory countries, including Canada, marine sector digitalisation is becoming a reality. In 2019, IMO Secretary-General Kitack Lim announced: "*The new FAL Convention [Facilitation of International Maritime Traffic] requirement for all Public Authorities to establish systems for the electronic exchange of information related to maritime transport marks a significant move in the maritime industry and ports toward a digital maritime world, reducing the administrative burden and increasing the efficiency of the maritime trade and transport*" (IMO 2019b).

For example, there are several international initiatives underway to develop electronic exchange standards (data, equipment and systems) that will shape the future of the marine world. These initiatives include Mona Lisa 2.0 working towards bringing maritime transport into the digital era and Maersk's blockchain trade digital platform. The Maersk initiative was developed in partnership with IBM to give port authorities and businesses along the supply chain a single source of shipping data, with a single non-modifiable record of transactions. Port Community Systems (PCS) and other electronic exchange platforms have confirmed their critical role in ensuring business continuity.

Certainly, today's digital infrastructure facilitated remote operations required by the COVID-19 pandemic (confinement and distancing) by enabling continuous data/information exchanges (i.e. trade facilitation and cross border logistical, administrative and regulatory processes) that are paramount for supply chain performance.

The use of electronic exchange platforms has proven to be so effective that ports and other organisations have embraced them. For example, the Abu Dhabi Port Authority has seen an increase of 30% more transactions through their platform and with no reported interruption of operations during the COVID-19 crisis (Al Dhaheri 2020).

The COVID-19 pandemic had a catalysing impact on the introduction of digitalisation in many organisations, including ports, as they adapt to the "new normal" way of operating and doing business. Moreover, organisations are prioritising their digitalisation projects as they experience the benefits, including the productivity of employees working remotely, reliability of video conferencing and potential savings from not having to maintain offices and other facilities (parking, desks, cleaning, renting and so forth). CPA have embraced this new era of remote office work and are actively developing their technical capabilities to expand its use. For instance, in the port of Halifax, several processes, approvals and authorisations that used to be provided directly to vessels are now handled in an online virtual mode.

7.9 Nearshoring

The COVID-19 pandemic led to an emerging trend of "nearshoring", shifting manufacturing production closer to end users to limit supply risks. This potential transition from economic globalisation will challenge ports as new processes, procedures and connectivity will be needed to reflect new supply chain systems. As nearshoring becomes a reality, Canadian ports will have to build new business and operational processes and trade structures to respond to this emerging paradigm shift.

In the midst of adapting to the future, CPAs will need the support and collaboration of all levels of government and stakeholders to achieve Canada's international and national trade goals. The country's transportation framework needs a clear roadmap, including incentives along with adequate and accessible funding, to support a sustainable transition.

8 Conclusion

The 2020 COVID-19 pandemic health crisis impacted the whole world by deeply disrupting the "normal" ways of living, trading and operating, forcing everyone to change their modes of operating to encompass the new reality. Ports, like other organisations, faced strategic challenges in responding to the COVID crisis. They had to continue operations to ensure the supply of essential commodities in support of Canada's economy and society.

Despite the public health restrictions imposed by the COVID-19 crisis, Canada's ports and their operations continued to embrace broad-ranging sustainability goals. As the world eventually emerges from the pandemic, ports, along with other transportation partners, will play a crucial role in supporting Canada's economic recovery. This role will be tempered with their goal of ensuring continued sustainability.

The Canadian government's vision of having a green, safe, secure, innovative and integrated transportation system in 2030 is reflected in the vision and mission of the country's ports. This vision was maintained throughout the paradigm change created by the COVID-19 pandemic. The collaborative and supportive response of the country's transportation sectors bodes well for Canada's future sustainable economy.

Ports are taking critical steps in their resilience planning to address climate change challenges including rising sea levels and extreme weather events. As active participants in the environmental measures established by the IMO and other organisations, ports are taking active steps to address operational issues, such as ballast water management, water pollution, protecting fish habitat and addressing air quality.

Canada Port Authorities are involved in global initiatives to transition to the use of sustainable energy. Major ports are supplying shore power systems to allow ships to shut off their generators when at berth. Cargo-handling equipment is being electrified, and alternative fuel bunkering systems, such as LNG, are being developed. Further, Canada's ports are taking positive steps to developing energy clusters promoting the use of solar and other clean energy sources.

The COVID-19 pandemic led to a quantum leap in the use of digital electronic communication systems, accelerating its adoption by ports and the marine world. Several major digital integration initiatives are underway aimed at devising common electronic exchange standards that will help to reshape the marine world to the post-COVID paradigm.

Tomorrow's international trading world will also be different due to the pandemic. Supply challenges that occurred during the COVID crisis are reshaping globalisation. Nearshoring will potentially increase as manufacturers and suppliers seek to avoid potential supply chain disruptions by shifting from global sourcing to a more regional approach. This shift will impact ports and the shipping world as new businesses, operational processes and trade structures emerge.

Canada's ports demonstrated their resilience as they quickly and successfully adapted their operations during the pandemic crisis. At the same time, they kept their infrastructure development projects in the forefront to improve their efficiency and competitiveness to be ready to support the country's economic recovery. Port authorities have demonstrated incredible nimbleness, responsiveness and readiness to adapt to changing environments such as the COVID-19 pandemic as they remain efficient and effective in support of the government's expanding trade agenda.

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Chapter 16
Lessons Learned from Robotics and AI in a Liability Context: A Sustainability Perspective

Anil Ozturk

Abstract An important area of application of robotics technologies is unmanned water surface and underwater vehicles, such as in remote exploration work, maritime transportation, repairs of oil rigs and so on. This study evaluates the consequences of these technologies, particularly in a liability context. Taking into account the characteristics of vehicles mentioned above, especially autonomy, it is expected that development of these vehicles, and their increased use in the civil sector, is likely to require a new approach other than the well-established fault-based liability regime. Still, these autonomous vessels are not expected to require amendments to the basic tenets of maritime law as illustrated in, for instance, the 1972 IMO COLREGs Convention. In the light of contemporary applications, it is submitted that most unmanned water surface and underwater vehicles are becoming more and more autonomous, and they are closer to reasonable safety when compared to the ultra-hazardous activity of unmanned aerial vehicles. Safety being the keyword, this chapter argues that the liability regime that applies to unmanned marine vessels should not only conform to the technical characteristics of these vehicles but also balance the social interest in technological progress with the interest of general security and the freedom of commercial enterprise. Indeed, the liability regime to be applied to marine vessels should respond to similar needs with the regime to be applied to robots. A balanced and consistent liability regime is essential for the economic viability of maritime sectors, especially maritime transport, and the economic viability is a prerequisite for sustainability. Moreover, long-term sustainability concerns make it unreasonable to altogether refuse technological innovation, which has many advantages in terms of environmental protection and resource management. To that end, the present study focuses its analysis on the EU law.

Keywords Robotics · Unmanned underwater vehicles · Unmanned surface vehicles · Liability · Sustainability

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1 Introduction

Oceans cover more than two thirds of the earth and are a vital element of life on our planet. Not only are they a primary source of food, they are also central to the carbon cycle; they regulate the climate and produce most of the oxygen in the air we breathe.
Scholaert (2019)

In addition to their vital roles for the preservation and sustenance of human life, the oceans are of exceptional socio-economic importance. To begin with, with more than 90% of worldwide trade being sea-borne, the oceans are indispensable highways for global commerce and human transportation (International Chamber of Shipping—ICS 2020). Beyond serving as trade routes, the oceans also provide the resources and environment necessary for other traditional maritime sectors, such as offshore oil and gas extraction operations, commercial fishery, and coastal and cruise tourism (OECD 2016). The Organization for Economic Cooperation and Development (OECD) estimates that more than three billion people depend on these traditional industries to earn their livelihoods, that in turn rely on the oceans' natural resources (OECD 2020). Furthermore, there are new, fast-growing ocean-based sectors such as offshore wind farms, ocean energy facilities and blue biotechnology that also demonstrate high potentials for further economic growth, job creation and industrial renewal (Dalton et al. 2019).

However, "the over-exploitation of resources, pollution and the effects of climate change" (Scholaert 2019) are endangering the ecosystem of the planet (and ultimately the well-being of human societies), as well as threatening the long-term capacity to sustain most ocean-dependent economic activities. In order to eliminate these risks and guarantee the environmental and social sustainability of ocean-based industries, it is posited that these activities should be undertaken with fresh approaches that focus on balancing the preservation of healthy oceans and ever-increasing economic activities. Moreover, although the maritime trade volumes are expected to increase in the future, and accordingly, the number of freight ships needed will grow, there is a lack of seafaring personnel worldwide even today (Caesar 2016). The reasons behind the failure to attract seagoing professionals include the assessment of seafaring as a high-risk occupation and unfavourable working circumstances (Caesar et al. 2015).

The pressures on the sustainability of both maritime trade and other ocean-based economic activities have sparked interest in exploring the marine applications of robotics and artificial intelligence (AI). Just as for their other uses, the marine applications of robotics and AI promise to improve safety, increase efficiency and undertake the tasks that are "dull, dangerous, and dirty tasks" for humans (Marr 2019). Furthermore, given that the marine applications of robotics and AI would eliminate the need for operating personnel-support systems such as sewage treatment or waste management and make it possible for vessels to slow steam for extended periods, it is assessed that such applications would at least result in lower costs and therefore bring economic benefits (Koumentakos 2019). Moreover, it is suggested that the marine application of robotics and AI is likely to go hand in hand with the use of renewable energy sources, thereby decreasing their residue and consequently the danger of causing pollution (Koumentakos 2019).

The most conspicuous marine applications of robotics and AI are the development of autonomous water surface and underwater vessels. Such unmanned vessels have been the subject of intense technological research in recent years, and the purposes for which they can be used are continuously expanding (Van Hooydonk 2020). However, regulatory issues prevent exploitation of the full potential of autonomous vessels. Notably, the absence of specific safety standards and risk allocation rules makes it unattainable to assign liability and therefore to define compensation and insurance schemes (Ferreira et al. 2018). Currently, the most important work that aims to address the shortcomings of the existing regulatory framework is the ongoing regulatory scoping exercise on Maritime Autonomous Surface Ships (MASS), which the International Maritime Organization (IMO) started in 2018. With this exercise, IMO looks at "how to implement existing IMO instruments to see how they might apply to ships with varying degrees of automation" (IMO 2018). Nonetheless, this scoping exercise is marked as a starting point, and it solely endeavours to investigate what needs to be done in the future, rather than introducing of a new regulatory framework or modifying the existing one (Ferreira et al. 2018). Thus, the ambiguity revolving around liability for autonomous marine vessels is yet to be clarified.

The present study proposes that European Union (EU) models developed to identify the liability for other autonomous artificial agents can be used to define the liability regime of autonomous marine vessels at the global level. To that end, the present chapter first briefly surveys the current state of the art in autonomous marine vessels, and then explains why the existing legal framework lags behind the technological progress, concentrating on examining the current regulatory instruments for collision liability. The remainder of the chapter discusses what lessons can be learned from other applications of robotics and AI with regard to sustainability—a concept that is deeply rooted in the United Nations 2030 Agenda for Sustainable Development.

2 Setting the Scene: Definitions of "Robotics" and "Artificial Intelligence"

> *A robot can be a lot of things these days—and this is just the beginning of their proliferation. With so many different kinds of robots, how do you define what one is? […] This isn't a trivial semantic conundrum: Thinking about what a robot really is has implications for how humanity deals with the unfolding robo-revolution.*
>
> Simon (2017)

Perhaps because of the determination of the boundaries of "the conceptual playing field" by science fiction before the engineers or maybe due to the continual evolution of existing definitions with the technological developments and the changes in social contexts over time (Jordan 2016), there is no universally accepted definition for “robot”, instead there are myriad definitions which contradict each other (Nourbakhsh 2013; Wilson 2015). There is no consensus even among computer scientists on what is a robot (Gunkel 2018), such that Joseph Engelberger—a pioneer of industrial robotics—was led to say “I can’t define a robot, but I know one when I see one” (Joseph Frederick Engelberger 1989). Whatever the reason might be, the diversity of definitions and the subsequent indeterminacy requires this chapter to examine the characterisation of robotsm in order to be able to attain its aims (Gunkel 2018).

2.1 Conceptualising “Robotics” and “Artificial Intelligence”

In the simplest terms, it can be suggested that robots are devices that are designed for specific purposes. They differ from other devices not in terms of the purposes they are designed for, but in the ways that they fulfil their purposes. Therefore, it is suggested that “autonomy” is the sole characteristic that differentiates robots from other devices. Autonomy is defined as *“the extent to which* [an artefact] *can carry out its processes without external intervention”* (Angelo 2007). The characteristic of autonomy is the result of the sense-think-act paradigm that models how robots—or autonomous artefacts—work, and therefore an artefact is autonomous to the extent that it adapts to this paradigm. Peter Singer explains the components needed to satisfy the said paradigm as follows:

> That is, they [robots] are *[artefacts]* with three key components: “sensors” that monitor the environment and detect changes in it, “processors“or “AI” that decides how to respond, and “effectors” that act upon the environment in a manner that reflects the decisions, creating some sort of change in the world around a robot. (Singer 2009; p. 67)

Thus, an artefact can be classified as autonomous and therefore defined as a robot to the extent that it can self-manage in order to perform its designated tasks. Hence, within the framework of the said paradigm, autonomous artefacts must have three capabilities—sensing, thinking and acting.

- “Sensing” is the capacity to detect what is going around: Autonomous artefacts not only use the data uploaded by their programmers, but they are also be able to perceive their environments with their own sensors and discern any changes therein (Gunkel 2018).
- “Thinking” denotes the artefacts’ ability to reach conclusions through their own evaluative processes. Here, “evaluative processes” refer to the mental competences (i.e. intelligence) that enable autonomous artefacts to make their own decisions (Thielscher 2005; Turner 2018). “Thinking” expresses artefacts as all algorithmic processes except for “sensing” and “acting”; includes reasoning, self-learning, problem-solving, and planning mechanisms (Santasuosso and Bottolico 2017). As such, the capability of “thinking” constitutes AI (Chopra and White 2011).

- "Acting" is the artefacts' capability to operate on their environments without any external instructions. To be characterised as autonomous, artefacts that perceive their environments, and make a decision by processing these perceptions, must also be to manipulate their surroundings (Russell and Norvig 1995; Chopra and White 2011). Consequently, mechanisms that repeat some pre-programmed motions without ever perceiving their environments cannot be regarded as acting and therefore cannot be identified as autonomous.

At this point, it should be emphasised that artificial intelligence is evaluated as a characteristic of robots—their "thinking" capability—and therefore not considered as a separate concept for the purposes of the present study.

2.2 Robotics and Artificial Intelligence and Sustainability

In the literature, there are some authors who believe that robots are not very effective when it comes of sustainability. On the contrary, these authors suggest that robots are very demanding in terms of energy consumption and assert that "they accelerate the unsustainable, insupportable damage we are doing to Earth" (Read 2016). In addition, it is suggested as microchips that enable robots to perform more difficult tasks, become increasingly smaller and complicated, recycling them would become nearly impossible, potentially causing the robotic industries to consume vast amounts of natural materials, therefore contributing to environmental collapse (Read 2016). Moreover, it is often been noted that as the proliferation of robots can lead to mass unemployment due to the increasing number of tasks that they can perform (Wong 2016). The present study, however, finds most of these concerns unfounded and anachronistic. In this section, these concerns are debunked. Unmanned marine vessels are evaluated briefly in terms of economic and sustainability in the next section where the current state of art of autonomous marine vessels are addressed.

First and foremost, by definition, robots operate more accurately and make fewer mistakes than humans. This means that fewer products produced in a factory where robots are employed would be defective and discarded. Besides, unlike humans, robots can work in the dark and unheated environments, translating into serious savings when it comes to energy consumption (Rosen and Kishawy 2012). In the literature, it is recorded that the preliminary investment for an industrial robot is recovered in 2 years, and after that, the cost of an industrial robot is essentially limited to the energy it consumes to operate, "leading to an annual cost about 50 time smaller than that of a manual labourer in developed countries" (Bugmann et al. 2011).

Furthermore, in fact, robots are highly useful during the recycling process as they separate the reusable components of discarded goods without damaging the said component and risking the injury of a human worker. The robotic systems used by Apple to recycle discarded iPhones can be cited to illustrate this point:

> Apple's Liam robot is tasked with picking out the reusable components from discarded iPhones. Liam separates SIM card trays, screws, cameras and batteries to make them easier to recycle, and precious metals, such as bits of silver in motherboards, are reused for other products. These tasks normally would be performed by shredders, which do a poor job of separating the components, or human hands, which are prone to injury when handling sharp materials and chemicals. (Flex 2017)

This example reveals how effective robots are in recycling thanks to their ability to operate in line with the sense–think–act paradigm. Accordingly, robots can help prevent the waste of reusable materials and minimise economic and environmental costs.

Robots will inevitably cause people in specific sectors to be unemployed. This predicament, however, should not be considered as a sustainability puzzle prompted by the emergence of robots. On the contrary, it would make more sense to consider this situation as being able to do some work more effectively by using machines instead of relying on human physical power on its own, thanks to technological progress. In the past, when the printing press was invented, the vast majority of those who copied books by hand became unemployed, but the education of masses and the age of enlightenment became possible, as thousands of pages could be copied in 1 day, instead of just a single page. More recently, when the train became widespread, the majority of those who rode horse-drawn carriages became unemployed, but long-distance travel and communication became accessible and cheaper, making room for the development of commerce trade and international relations developed. Thus, it is absurd to say that the technological progress that makes these humans unemployed creates a sustainability problem. History proves that human society survives more easily thanks to technological innovations, even though these innovations may cause unemployment. In other words, sustainability is an individual problem of workers who cannot adapt themselves in the face of developing technology. The present study, of course, does not disparage the problems of those who are to become unemployed, and acknowledges that training should be provided to reintegrate these humans into working life. That said, it is suggested that unemployment caused by technological developments cannot be approached as a social sustainability problem.

3 Survey of Unmanned Marine Vessels

As stated previously, the most significant marine applications of robotics and AI are autonomous marine vessels. That statement was intended to indicate that autonomous marine vessels are types of robots. First, to determine the sameness between robots and autonomous marine vessels, it is essential to examine how autonomy can exist in marine vessels before surveying the current state of the art.

3.1 Degrees of Autonomy

Autonomy is not a binary concept and better illustrated as a spectrum. In the maritime context, remotely controlled vessels that hold a minimum level of autonomy in that they function independently of their operators would lie at one end of this spectrum. At the other end, there would be fully autonomous vessels that are equipped with sensors, work without any intervention and can adaptively modify themselves in response to user and environmental inputs.[1]

In furtherance with the foregoing, IMO has identified four degrees of autonomy for the purposes of its scoping exercise on MASS (Ringbom 2019). Unfortunately, these degrees are only useful when examining MASS and do not reflect the broad range of purposes, risks and possible damages of autonomous marine vessels. Instead, the present study adopts the categorisation developed European Defence Agency's Safety and Regulations for European Unmanned Maritime Systems (SARUMS) group and incorporated into the voluntary code of Maritime UK (2019):

Degree 1, *Manned*: Vessel is controlled by operators aboard.

Degree 2, *Operated*: All cognitive functionality is within the human operator. The operator has direct contact with the unmanned vessel over through remote control and/or cable. The operator makes all decisions, directs and controls all vessel and mission functions.

Degree 3, *Directed*: Some degree of reasoning and ability to respond is implemented into the vessel. It may sense the environment, report its state and suggest one or several actions. It may also suggest possible actions to the operator, such as prompting the operator for information or decisions. However, the authority to make decisions is with the operator. The vessel will act only if commanded and/or permitted to do so.

Degree 4, *Delegated*: The vessel is authorised to execute some functions. It may sense environment, report its state and define actions and report its intention. The operator has the option to object to intentions declared by the vessel during a certain time, after which the vessel will act. The initiative emanates from the vessel and decision-making is shared between the operator and the vessel.

Degree 5, *Monitored*: The vessel will sense environment and report its state. The vessel defines actions, decides, acts and reports its action. The operator may monitor the events.

Degree 6, *Autonomous*: The vessel will sense environment, define possible actions, decide and act. The vessel is afforded maximum degree of independence and self-determination within the context of system capabilities and limitations. Autonomous functions are invoked by the on-board systems at occasions decided by the same, without notifying any external units or operators.

[1] This spectrum was formulated by the author, inspired by the example in p.11 of Chopra and White's (2011) work.

It must be noted that, in practice, levels of autonomy may often be different for different functions aboard the same vessel, for example, a vessel navigating “monitored” may deploy a payload “directed”. Further, the degree of control over the vessel can also change during a voyage. As such, when assigning liability, it is critical to determine the level of control under which the function that caused the damage was executed.

3.2 Current State of the Art

In the widest sense, there are two categories of autonomous marine vessels: autonomous water surface vessels (ASVs) and autonomous underwater vessels (AUVs). Despite the potential economic and environmental benefits, and even though the sea surface is regarded as one of the most easily navigable environments for autonomous vessels, ASVs are perhaps the least developed member of the family of autonomous vessels (Gogarty and Hagger 2008). Until recently, their uses were limited to the purposes of scientific research and military applications, and their autonomy levels did not exceed “operated” or “directed”. Only in the last decade has the ill fate of ASVs started to reverse, thanks to the implementation of more effective and affordable navigation equipment, “including global positioning systems and inertial measurement units as well as more powerful and reliable wireless communication systems” (Liu et al. 2016). These developments made it possible for ASVs to perform longer missions than crewed vessels, with lower maintenance costs and greater personnel safety, paving the way for a broader range of applications, including environmental missions and ocean research explorations (ibid). Nonetheless, unmanned maritime carriage of goods or persons is not yet beyond the experimental stage, even though there are indications that a breakthrough in that regard is imminent or at least on the horizon, considering that technological research to that end has been extensive in recent years.

For instance, the European Union co-sponsored project, “Maritime Unmanned Navigation through Intelligence in Networks” (MUNIN), completed in 2015, demonstrated the technical feasibility of crewless bulk carriers (MUNIN 2016a, b). One other project, sponsored by the Finnish Funding Agency for Technology and Innovation and led by Rolls-Royce, “Advanced Autonomous Waterborne Applications Initiative” (AAWA), completed in 2017, “produced the specification and preliminary designs for the next generation of advanced ship solutions” (AAWA Position Paper 2016). More recently, the first autonomous container vessel, *Yara Birkeland*, has been successfully tested, and it is expected to be deployed by the end of 2020, though it is only going to operate in the territorial waters of Norway (Yara International ASA 2020).

AUVs, on the other hand, appeared long before other autonomous vessels, and their use has consistently increased since their introduction in late 1960s.[2] The best-known use of AUVs are perhaps in oceanic exploration, for purposes such as current and temperature measurement, ocean floor mapping, collecting seafloor samples or images; as put by Gogarty and Hagger,

> *[T]he golden age of [AUVs] occurred more than a decade before the UAV [unmanned aerial vehicles] revolution when the public was provided footage of undersea wrecks like the Titanic through the tethered cameras of robotic submersibles.* (Gogarty and Hagger 2008)

Nevertheless, it is assessed that the driving force behind the advancement of this technology is its commercial and industrial applications, such as in deep-sea mining, offshore oilrig inspections and repairs, or sub-sea pipeline and cable laying and maintenance (Liu et al. 2016). Since these functions require working under dangerous conditions, it is contended that considerable interest must have been shown to the development of technologies that can supplant humans in performing operations in the high-risk and alien deep sea environment. In the present state of the art, the AUVs have already proved to be very reliable and amply cost-effective that there is now little reason to employ crewed submersibles for the requirements of most of these operations. Though most AUVs employed at the present day are "operated", AUVs that can execute their functions without requiring any input from an operator are employed in ever-increasing numbers with each passing day, for both scientific and commercial purposes. Being able to navigate the deep sea on their own and to map a broad range of organic and inorganic features of the ocean, AUVs help researchers collect data that were previously impossible to obtain and therefore have become a unique tool of oceanic exploration. Similarly, they are often used by the oil and gas industry to make high-resolution maps of the ocean floor and identify its characteristics before any subsea infrastructure is installed, thereby optimising the building costs and minimising disruptions to the environment. When it comes to commercial applications, it is worth mentioning that there are AUVs that are entrusted with "preventing damage, alerting controllers, and repairing oil rigs in the Caribbean Sea" (Pagallo 2013), and it is claimed that more independent AUVs are gradually replacing their operated predecessors that have been used for decades to undertake repairs to hulls, pipelines or oil rigs in the underwater environment, on a global scale.

[2] The first device that can be classified as AUV was developed in 1957 in the USA and named SPURV (Special Purpose Underwater Research Vehicle), designed to research in the Arctic waters (see Gafurov and Klochkov 2015).

4 Existing Legal Framework

The voyages across the oceans are governed by a broad range of domestic and international regulations. It is not within the scope of the present study to explore much of these laws. Notwithstanding, it is worth mentioning that, a significant part of the regulations that ASVs and AUVs will have to comply with, including the admiralty law, is based on the presumption that seafaring vessels are always human-operated, or "manned" (Gogarty and Hagger 2008). Still, acknowledging that navigational casualties represent more than half of marine casualty events and that a substantial proportion of navigational casualties are due to collision of two vessels or a vessel colliding with a stationary object according to the European Maritime Safety Agency's (EMSA) Annual Overview of Marine Casualties and Incidents 2019. Thus, it is found to be necessary and sufficient to examine the current regulatory regime for collision liability in the context of ASVs and AUVs to assess the shortcomings of the existing legal framework.

Determination of liability in cases of collisions is actually within the remit of domestic legislation, and naturally, there may be differences between national regulations. However, since the 1910 Brussels Collision Convention (International Convention for the unification of certain rules of law with respect to collisions between vessels, signed at Brussels on 23rd September 1910) has achieved widespread adoption by maritime nations, it can be regarded as the primary instrument for assigning liability for collision damages.

The 1910 Convention provides for a fault-based liability regime in Article 3: "[i]f the collision is caused by the fault of one of the vessels, liability to make good the damages attaches to the one which has committed the fault". The Convention further lays down that if the fault cannot be proven, no liability shall arise in Article 2: "[i]f the collision was accidental, caused by *force majeure*, or if the cause of the collision is left in doubt, the damages are borne by those who have suffered them". It is not always necessary, however, to establish fault by positive evidence; there is a presumption of fault when a moving vessel collides with a stationary object or with another vessel that is properly moored or anchored, and the burden of proving freedom from fault will lie with the moving vessel.

Moreover, the 1910 Convention introduces the principle of liability in proportion to fault or the concept of contributory negligence in Article 4: "[i]f two or more vessels are in fault, the liability of each vessel is in proportion to the degree of the faults respectively committed". It is further stated that if in such cases "it is not possible to establish the degree of respective faults, the liability is apportioned equally".

Even though the 1910 Convention establishes a fault-based liability regime, it does not define what "fault" is. Nevertheless, there is a consensus in the literature that a breach of the rules set out in the 1972 Convention on the International Regulations for Preventing Collisions at Sea (COLREGs) would constitute "fault" under the 1910 Convention.

COLREGs set out the navigation rules, or "rules of the road", to be followed by the watercraft, in order to avoid collisions. Even though the main purpose of

COLREGs is to prevent collisions, they are also used to detect with whom the fault lies with. COLREGs consist of 41 rules that are divided to six parts that cover application, responsibility and general definitions; steering and sailing rules to keep vessels apart when they are approaching each other or are in restricted visibility; lights and shapes to be carried by vessels at night or by day by which they can be recognised; and sound and light signals. There are also four annexes covering the positioning and technical details of lights and shapes; additional signals for fishing vessels fishing nearby; technical details of sound signal appliances; and distress signals.

According to its Rule 1(a), COLREGs apply to "all vessels upon the high seas and in all waters connected therewith navigable by seagoing vessels" and Rule (3) describes "vessel" in the context of COLREGs as "every description of watercraft, including non-displacement craft, […] used or capable of being used as a means of transportation on water". It is clear that this description makes the applicability of COLREGs contingent on the crafts' transportation capability is problematic for most autonomous vessels. While some ASVs are expected to be used for transportation of goods and humans, many other ASVs and almost all AUVs—except for a small number of "cargo-carrying/cable-laying AUVs" (Ferguson 2003)—are closed units such as exploration, research or mapping crafts with no transportation capabilities whatsoever (Gogarty and Hagger 2008). As such, the vast majority of autonomous vessels seem to be excluded "from the reach of the COLREGs". That said, Gogarty and Hagger suggest that the term "transportation" can be interpreted more broadly, and the above-mentioned closed units may fall under the ambit of COLREGs as "they transport scientific and sensor equipment" (Gogarty and Hagger 2008).

Moreover, some scholars believe that compliance with COLREGs is the essential means by which autonomous marine vessels' operators "may discharge the broader duty of good seamanship, i.e. the duty of care owed as between users of the seas" (Veal et al. 2019: 38). They remark that the duty of good seamanship is reiterated in Rule 2, that reads as follows:

(a) Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.
(b) In construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances, including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger.

Rule 2 imposes a general duty of good seamanship that takes precedence over other rules, since it provides that actions contrary to the explicit directions of other rules may be required by this duty, should circumstances so demand. In other words, other rules in COLREGs can be regarded as mere standards that help observe this broader duty, and their unjustified breach determines "fault" when assigning collision liability (Gosch 2019). It should be conceded that this general duty of good seamanship applies to ASVs and AUVs, as well as all sea-going vessels (Veal et al. 2019).

While the duty of good seamanship stemming from Rule 2 applies in the operation of surface vessels (including ASVs) and AUVs alike, the rest of COLREGs cannot be reasonably applied to AUVs. To be exact, in no part of COLREGs it is explicitly stated that they are exclusively for sea-surface navigation; however, still, nearly all rules about the conduct of vessels are patently set up to be complied by water-surface crafts. COLREGs require light and sound signals that might work well at the surface but are not as useful underwater. Accordingly, it is concluded that COLREGs only apply to ships operating at the surface of the water, not to vehicles operating completely underwater (Showalter 2004). There are no similar navigation standards to prevent underwater collisions and even though the use of AUVs has not currently at a level where such accidents are a common occurrence; as the uses of AUVs increase, it is anticipated that such underwater collisions would happen more frequently. Consequently, in the future, rules for underwater navigation will likely need to be established.

By the same token, whether the AUVs are under the remit of COLREGs when they are at the surface is still controversial. Despite some views claiming that the rules can be applied to any vessel on the sea surface (Henderson 2006; Veal et al. 2019); it is maintained that they are not compatible with the applications and technical structures of AUVs and therefore should not be applied to AUVs, regardless of whether they are afloat or submerged. That is to say that compliance with these navigation rules, even only when they are on the surface, is problematic for AUVs. The aerodynamic characteristics of AUVs have a significant impact on their performances and affixing lights to AUVs may disturb these characteristics (Pan and Guo 2013: 3), most certainly resulting in dramatic decreases in their efficiency. Furthermore, in terms of the sound and light signals, when on the surface, required by COLREGs would still affect the quality and quantity of the data collected by AUVs used in deep sea research. For example, if a AUV observing *lantern sharks* (a bioluminescent shark species) in their natural habitat comes to the surface to relay data and generates the signals prescribed in COLREGs, in all likelihood, it will not be able to resume observing after resubmerging, as *lantern sharks* are sensitive to sound and light and, like most animals, avoid “anything unnatural and different” (Wheeler 2014; Chapuis et al. 2019).

In contrast to AUVs, ASVs are accepted to fall under the remit of COLREGs, and it is assessed that they can comply with the rules therein. However, it should be emphasised that there are concerns in the literature. First and foremost, it is thought that deciding when the duty of good seamanship standard necessitates a deviation from the COLREGs is a very advanced cognitive process surpassing even the most sophisticated modern ASVs. Because of this, it is suggested that ASVs can adhere to the good seamanship duty only to the extent that they are permanently monitored by operators who can assume control of the ASVs. Additionally, it is argued that Rule 5 of the COLREGs, which reads as follows, be problematic in terms of ASVs (Cain and Turner 2018; Veal et al. 2019):

Every vessel shall at all times maintain a proper look-out by sight as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

Here, "look-out" is understood as the task of collecting and processing information about the vessel's environment, and it is questioned whether the rule provides sufficient flexibility to allow sensors to execute the "look-out" task. It is concluded that considering that cameras and sensors can record and process their environments faster and more accurately than humans, as well as provide warnings to those in risk of collisions; the ASV look-out would be compliant with Rule 5 (Cain and Turner 2018).

5 Lessons Learned from AI and Robotics: European Union Context

It is contended that the analyses made for the resolution of the legal challenges posed by AI and robotics can be used as guides when deciding the liability regime the damages caused by autonomous vessels, particularly since they are types of robots.

5.1 Fault-Based Liability

To begin with, it should be emphasised that both AI robots and these vehicles, at varying degrees, can carry out their own processes and operate independently, without external intervention. That capability, which is referred to as "autonomy" above, makes it challenging to apply fault-based liability principles to the damages caused by these artefacts. The challenge here primarily stems from the difficulty of exposing who had a "duty of care" and failed to fulfil that duty when the vessel is "monitored" or "fully autonomous", or in other words, navigating without any real-time human intervention as fault-based liability arises when there is a breach of a duty of care owed to the claimant that has caused damages.

It is submitted that those who manufacture the hardware and program the software of such vessels, as well as the vessels' operators, have duties of care. Manufacturers and programmers of autonomous vessels, as with all other technologically advanced artefacts, have the duties to make their customers aware of any risks and to practice reasonable care to prevent any damages that may occur due to the errors in manufacturing and programming processes (Asaro 2007). Whether the manufacturers and programmers have fulfilled their duties is determined according to the standards of the industry (Asaro 2007) For example, in robotics, the faults of manufacturers and programmers may include their failures to detect apparent bugs in the software or attaching incorrect and inadequate data sets to the software.

Additionally, operators and owners of autonomous artefacts are evaluated be responsible for keeping the artefacts' software up-to-date (Gerstner 1993). It should be noted that if manufacturers, programmers, operators and owners have taken reasonable precautions under the circumstances, there will be no breach of their duties of care, even if the vessel caused damages, as there would be no fault and no possibility to apply fault-based liability principles.

Another question in applying the fault-based liability principles to the damages caused by autonomous artefacts is whether or not there was a "sufficiently close causal connection" between the breach of duty and said damages. Here, "sufficiently close causal connection" not only refers to the cause-and-effect relationship—factual link—between the breach of duty and damages but also "inquires into whether this factual link was proximate rather than remote" (Owen 2007). The concept of foreseeability is the cornerstone of "proximate" cause. Accordingly, the liability of anyone for the damages caused by his wrongful conduct is limited by the principles of reasonable foreseeability. The characteristic of autonomy, by definition, indicates the artefacts' capabilities of devising their own means to attain their tasks, and these means are not always foreseeable by their owners, operators or programmers (Karnow 2016). Considering the growing autonomy and expanding range of applications of such artefacts, their operations are likely to become increasingly unforeseeable "except perhaps at a very high level of abstraction and generality", making it increasingly tricky to establish "sufficiently close causal connection" and apply fault-based liability principles to the damages caused by them.

5.2 Strict Liability

Instead of fault-based responsibility principles, in the literature devoted to legal challenges of AI and robotics, it is also discussed whether strict liability principles may find application for the damages caused by autonomous artefacts. Strict liability refers to the imposition of liability on a party regardless of the finding of a fault. The law imputes strict liability to "those activities it considers useful and necessary, but that create abnormally dangerous risks to society" (Barfield 2018). In terms of the liability for autonomous artefacts, two strict liability theories are considered to be relevant: "strict product liability" and "liability for ultra-hazardous activities".

"Strict product liability"focuses on the defective condition of the product itself, and away from an examination of the defendant's conduct in making the product, since "the innocent victim of a dangerous product should be compensated, even if the defendants were not negligent in making it" (Karnow 2016). This study examines "strict product liability" for robots based on the Product Liability Directive[3] of the European Union, which provides for one of the most developed "strict product

[3] Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products [1985] OJ L210/29.

liability" regimes in the world (Turner 2018). The Directive holds the "producer" liable for the damages caused by a defective product. Under Article 6, a product is defective when,

> *it does not provide the safety which a person is entitled to expect, taking all circumstances into account, including (a) the presentation of the product; (b) the use to which it could reasonably be expected that the product would be put; (c) the time when the product was put into circulation.*

For the purposes of the Directive, under Article 9, "damage" means damage caused by death or by personal injuries; damage to an item of property intended for private use or consumption other than the defective product itself, with a lower threshold of €500. Under Article 4, The injured person must prove the actual damage, the defect in the product and the causal relationship between damage and defect. Fault on the part of the producer does not need to be proven. The producer is, however, freed from liability if he proves that, according to Article 7, *"he did not put the product into circulation, the defect was due to the compliance of the product with mandatory regulations issued by public authorities, the state of scientific or technical knowledge at the time the product was put into circulation could not detect the defect"*.

It is worth mentioning that it is controversial whether autonomous artefacts fall under the scope of this Directive as "products". For the Directive, "product" means all movables, except for primary agricultural products and game, even though incorporated into another movable or an immovable. According to Article 2, "product" includes electricity. Yet, the Directive does not explicitly mention software, which brings into existence and maintains all the characteristics of autonomous artefacts; robots, ASVs and AUVs alike. It is, however, determined that most commentators agree that "the software and its medium constitute a tangible product" even though "the information contained within the software medium is intangible and cannot always be regarded as a product" (Alheit 2001). According to that understanding, autonomous artefacts including ASVs and AUVs are "products" in the context of the Directive, and it can be argued that programmers must also be regarded as "producers" for the Directive.

Even if it is accepted that the Directive applies to autonomous artefacts, it nonetheless operates on the assumption that products are static once they are put into circulation. Autonomous artefacts do not follow this paradigm by their very nature; they continue to change in unpredictable ways after they have left the production lines. As such, the "strict product liability" regime established by the Directive is subject to a number of defences that may be regarded as overly permissive when applied to producers of autonomous artefacts, according to its Article 7:

> […] *having regard to the circumstances, it is probable that the defect which caused the damage did not exist at the time when the product was put into circulation by him or that this defect came into being afterwards; or* […] *that the state of scientific and technical knowledge at the time when he put the product into circulation was not such as to enable the existence of the defect to be discovered* […]

Consequently, it is likely that producers of autonomous artefacts will increasingly be able to take advantage of these defences and thereby weaken the protections afforded to their consumers.

"Liability for ultra-hazardous activities" focuses on the activities that are considered so inherently dangerous "that the law makes those who are engaging in them in effect insurers to others who are hurt without requiring proof of negligence and other types of fault" (Karnow 2016). In most legal systems, as a matter of principle, an activity may be regarded ultra-hazardous if it is uncommon, poses a high risk of harm, and creates very heavy injuries when injuries do occur. Examples of ultra-hazardous activities include blasting and demolitions, disposing of nuclear and chemical wastes, and transporting radioactive materials (Christensen 1951).

It is submitted that "ultra-hazardous liability" is not suited for the imposition of liability for the damages caused by autonomous artefacts, especially ASVs and AUVs. In fact, with human error behind 75% of marine liability losses, there are expectations that autonomous vessels can improve maritime safety (Allianz 2017). Moreover, the risks inherent to the crewed operation of vessels such as injury or loss of life should be significantly reduced and perhaps eliminated with the increasing use of ASVs and AUVs.

5.3 Vicarious Liability

Vicarious liability refers to the liability of the superiors for the acts of their subordinates, or, in a broader sense, to the liability of any person that has sufficient control over the actions of another. Vicarious liability is understood as liability imposed upon a person simply because of their relationship to another who have committed the wrong, even though they have committed no wrong themselves (Nolan and Davies 2013). For example,

> *The law may hold the employer liable for the wrongs of an employee, the principal liable for the wrongs of an agent, or the firm liable for the wrongs of its partner, in spite of the fact that the employer, the principal, or the firm may not have been at fault in any way. When the law imposes liability in these circumstances we speak of the employer, principal, or firm being "vicariously liable".* (Binchy and McMahon 2013)

It is assessed that vicarious liability may be utilised in determining the liability for autonomous artefacts, but to do so when it comes to ASVs and AUVs requires modifications in the law. This is not because the vicarious liability provides a perfect, just and fair solution, but because in the case of the application of vicarious liability, both the independent agency of autonomous artefacts will be acknowledged, and legally recognised persons will be liable for the damages caused by them. Considering that autonomous artefacts are often characterized as objects under fault-based and other forms of strict liability, the application of vicarious liability also appears to be less restrictive and therefore better suited to their characteristics.

5.4 Liability Through the Prism of Sustainability

The technical characteristics of ASVs and AUVs, as explained above, reveal that they are sustainable not only in terms of the management of human resources and the use of natural resources but also regarding their impact on natural impact. Then, the likely proliferation of ASVs and AUVs would directly help achieve some of the UN Sustainable Development Goals, namely Goal 3 (Good Health and Well-being), Goal 6 (Clean Work and Education), Goal 8 (Decent Work and Economic Growth), Goal 12 (Responsible Consumption and Production), and Goal 14 (Life Below Water). However, the fact that the existing liability regimes do not comply with the characteristics of ASVs and AUVs may result in putting either manufacturers or users under heavy burdens may have an impact of limiting their use. If the use of these vehicles starts to be considered to come with the risk of heavy legal burdens, this will slow technological innovation and somewhat hamper the achievement of sustainable development goals.

To begin with, the fault-based liability system cannot be implemented in most cases where the manufacturer and users take the necessary precautions since it is already difficult to establish whether there is any fault and if so, with whom it lies. Moreover, as these vessels evolve, their autonomy increases, and their capabilities become even more complicated, it is going to become nearly impossible to establish the causal link between damages and fault. Thus, the implementation of the fault-based legal system cannot be considered applicable, as it stands, in terms of ASVs and AUVs.

Further, the implementation of the institution of strict liability in the form of liability for ultra-hazardous activities, leading to the no-fault liability of the manufacturers or users of ASVs and AUVs, would make the production and use of ASVs and AUVs a financially perilous undertaking financial terms and therefore will restrict their proliferation. Restriction of the proliferation of these vessels, in turn, would hamper the achievement of sustainable development goals in terms of ocean governance. "Strict product liability", as it exists within the EU acquis, is currently not capable of responding to the requirements of the level of technological developments.

Even if robots and artificial intelligence (including ASVs and AUVs) are to be considered products, the EU Product Liability Directive is not designed to apply to the vessels that can continuously improve themselves. The defence afforded to the manufacturers that absolves them from any liability if "the state of scientific and technical knowledge at the time when he put the product into circulation was not such as to enable the existence of the defect to be discovered" is indeed a broad opportunity for manufacturers to protect themselves from any claims for damages. Then, the implementation of the Directive for the liability for ASVs and AUVs would put the burden of damages on the injured party, and that is likely to disrupt the balance between the competing interest of manufacturers in freedom of economic enterprise and the general interest in security. Considering that the primary purpose of the law of liability is to strike a balance between these two interests, it can be posited that applying the Directive to ASVs and AUVs would not produce socially sustainable results.

Vicarious liability, as explained above, appears to be the most appropriate instrument for establishing liability for ASVs and AUVs. This liability regime provides room for the recognition of the agency of autonomous vessels for causing the damages. However, since these vessels cannot hold property and pay compensation, it stipulates that whoever benefits from the activity that caused the damages should be liable. Adoption of the vicarious liability principles for the determination of liability for ASVs and AUVs not only would satisfy the injured parties' interest in safety and security but also would not cause a sense of unfairness for the manufacturers and users of such autonomous vessels. However, as of the present day, the vicarious liability regime has never been applied for damages caused by any vessel, and there are no plans yet to do so. Nonetheless, the present study holds the view that vicarious liability principles should be considered to achieve the UN Sustainable Development Goals in terms of ocean governance.

6 Conclusions

This chapter has examined the liability regime applied to damages caused by autonomous maritime vehicles, which it considers as marine applications of AI and robotics. At the end of this examination, the following conclusions have been reached:

1. The future proliferation of ASVs and AUVs presents a unique opportunity for the achievement of the UN Sustainable Development Goals since they promise to make maritime activities more environmentally friendly, less costly and more efficient. Then, steps should be taken not to remove any restrictions that hinder the widespread use of these vessels. In its current form, the law of liability impedes the broader adoption of autonomous vessels.
2. Marine navigation rules (COLREGs) should apply to ASVs—because these traffic rules to reduce the risk of collisions collections are also necessary for ASVs. In terms of ASVs, it is also assessed that no significant modification is required in these rules. However, it is noted that it may not be possible to apply COLREGs to AUVs, and new rules may be required for underwater navigation in the future.
3. The characteristic of autonomy is what primarily distinguishes the robots, including autonomous marine vessels from other artefacts. Autonomy should be understood as the artefacts' capability to make decisions and implement them as a result of their evaluative processes (AI), without the need for any external influence, and it should be treated as a spectrum rather than a binary concept. The first three degrees of the autonomy scale include "operated", "directed" and "delegated" levels of control. It is determined that at these levels of control, final decisions are made by human operators, who are expected to make decisions themselves or supervise decision-making at all times. Accordingly, any damage that may occur due to navigation decisions can be traced back to the human

operators, and the current fault-based liability regime can be applied to these vehicles.

4. However, in "monitored" and "autonomous" vessels, and "monitored" and "autonomous" vehicles, decisions are not always made by human operators and nor are they always controlled before being carried out. In such cases, the existing fault-based liability system based on the fault of human operators or shipowners cannot be applied. When it is assessed whether strict liability mechanisms can be applied instead, it is concluded that "liability for ultra-hazardous activities" would put an unreasonable financial burden on the manufacturers and users of these vehicles, and the application of EU Product Liability Directive would absolve the manufacturers and users from any liability to the extent of leaving the injured parties without any compensation, thereby creating socially unsustainable results.
5. It is concluded that the vicarious responsibility principles may find application here. This liability regime makes it possible to acknowledge the agency of ASVs and AUVs themselves vessels for causing the damages and stipulates that in the absence of any causal connection, whoever benefits from the activity that caused the damages should be liable. However, this liability mechanism has never been applied for establishing the liability for any vessel before and therefore needs to be studied further.

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Chapter 17
The Role of Slow Steaming in Shipping and Methods of CO_2 Reduction

Aspasia Pastra, Panos Zachariadis, and Artemios Alifragkis

Abstract Environmental organisations require the shipping sector to act promptly on new practices to cut down greenhouse emissions. Over the last few years, a lot of discussions have taken place about the 'slow-steaming' philosophy, the practice of operating cargo ships at significantly less than their maximum speed, and thus optimising a vessel's speed to match the arrival time to a berth slot opening at the port. Slow steaming has been considered as sustainable means of reducing CO_2 emissions. However, there are concerns that although slow steaming could lower emissions in the short term, it could actually lead to increased CO_2 emissions in the long term. The purpose of this chapter is to shed some light on the debate and provide a holistic overview of the slow steaming concept. The chapter examines all the current trends relating to speed limits, speed optimisation and speed reduction. In the meantime, the challenges of slow steaming are addressed, giving special emphasis on the port and market stakeholders.

Keywords Slow steaming · Greenhouse emissions · Speed reduction · Speed optimisation · Speed limits

1 Introduction

Greenhouse gas (GHG) emissions from marine shipping include various gases, such as carbon oxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), which contribute significantly to global human-induced air pollution. The Third Greenhouse Gas study of the International Maritime Organization (IMO 2015) estimated that 3.1% of annual global CO_2 and 2.8% of annual GHGs on a CO_2 basis were emitted from

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shipping, whereas the percentage of CO_2 could increase even more between 50 and 250% by 2050. Therefore, significant technical and operational measures are being taken by the maritime community to reduce its CO_2 emissions. Another important contributor to shipping emissions, although it is not categorised as a strict GHG, is black carbon which is emitted as a solid particulate matter. Most of the international and regional policy measures for shipping emissions are relevant to the reduction of CO_2, as policy options for black carbon are still in their infancy.

International efforts to reduce GHG emissions include the Paris Agreement adopted in 2015, which falls under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC). The long-term goal of the agreement is the reduction of GHG emissions until 2050 by at least 50% below 1990 levels. Besides, the United Nations 2030 Agenda for Sustainable Development includes 17 sustainable goals, one of which is Goal 13: "Take urgent action to combat climate change and its impacts", focusing on transforming the goals of the Paris Agreement into national actionable strategies.

The International Maritime Organization (IMO) has, since the Kyoto Protocol in 1997, started acting on the issue via a series of intersessional meetings and resolutions on GHG emission reduction from ships. IMO has introduced policies to tackle the emission of air pollution from ships and has implemented obligatory energy-efficiency acts to decrease greenhouse gas emissions from international shipping under Annex VI of IMO's pollution prevention treaty MARPOL (IMO 1978). IMO has discussed shipping pollution in the MARPOL Convention and has necessitated a gradual reduction of nitrogen oxides (NOx), sulphur oxides (SOx) and particulate matter (PM) from marine engines.

In 2011, the resolution MEPC.203(62) on "Inclusion of regulations on energy efficiency for ships in MARPOL Annex VI" introduced mandatory technical and operational Ship Energy Efficiency Management Plan (SEEMP) measures for the energy efficiency of ships. The long-term technical measures are relevant to the Energy Efficiency Design Index (EEDI), a performance-based mechanism that enables ship innovation and sets a minimum energy efficiency level for the work undertaken for new ships of 400 GT and above. For the operational measures, a SEEMP permits operators to monitor and improve the performance of existing ships of 400 GT and above engaged in international trade. At the time of this writing (2020), IMO is considering strengthening the operational measures with mandatory reduction of the operational horsepower of all ships in the water, as well as further mandatory SEEMP measures.

In 2018, in line with the Paris Agreement, the Member States of IMO adopted Resolution MEPC.304(72) on the "Initial IMO Strategy on ship GHG emissions reduction". The Initial Strategy sets a series of short-, mid- and long-term measures for both the existing fleet and new ships with immediate reductions achieved by 2023. The Strategy aims to minimise: (a) CO_2 emissions by at least 40% by 2030; and (b) the total annual GHG emissions by at least 50% by 2050 compared to the levels of 2008. One of the potential short-term measures proposed for the reduction of GHG is the use of speed optimisation and speed reduction approaches. In conjunction with the IMO strategy on GHG emissions reduction from ships, IMO's

Marine Environment Protection Committee adopted on 17 May 2019 the MEPC.323(74) Resolution inviting *'Member States to encourage voluntary cooperation between port and shipping sectors to contribute to reducing GHG emissions from ships'*. Onshore Power Supply, bunkering of alternative low-carbon fuels and optimisation of port calls' process are some of the measures that port authorities could enforce to facilitate the reduction of GHG emissions from ships.

While not linked to the reduction of GHG, but rather as a health issue, a crucial global measure taken as of 1 January 2020 is the global sulphur cap that reduces the maximum sulphur oxide content (SOx) of marine fuels from 3.5 to 0.5%. In fragile ecosystems, such as the Baltic Sea, drastic measures have been taken since 2015 when these areas were designated as *'Sulphur Oxides Emissions Control Areas'* (SECAs) with a maximum SOx of marine fuels of 0.10%.

At the regional level, aligned with the IMO context, the European Commission in 2013 developed the strategy "*Integrating maritime transport emissions in the EU's greenhouse gas reduction*" for the reduction of GHG emissions from the shipping industry via a three-step approach:

- Monitor and report of CO_2 emissions from companies of large ships visiting EU ports through a robust Monitoring, Reporting and Verification (MRV) system (in conformity with Regulation 2015/757, as amended by Delegated Regulation 2016/2071) that will provide comparable emission data on GHG emissions.
- Reduction emission objectives for the maritime sector.
- Medium- and long-term market-based measures (i.e. an Emissions Trading System (ETS)).

At the international, regional and national levels, there are strong arguments about the untapped potential to reduce air pollutants through slow steaming of vessels. The slow steaming proposals vary. On the one hand, there are proposals for vessels operating with the lowest speed that the market can afford, whereas, on the other hand, the arguments involve the regulatory enforcement of a maximum speed limit for ships, varying according to the type and size of the ship. Regarding the second option, there are serious concerns about the enforcement and monitoring of the speed of each vessel and the need for potential supply of new vessels to meet demand. The slow steaming approach has revived the discussions about "speed optimisation", "speed reduction" and speed limits, and all these concepts will be examined in the following sections.

2 The Slow Steaming Approach

Slow steaming has been conceptualised as the reconfiguring of the engine so that a lower power output is achieved, and a slower speed can be reached (Psaraftis 2019). Speed reduction reduces the engine power, resulting in a significant reduction in fuel consumption and air pollutants (i.e. Kontovas and Psaraftis 2011a, b; Sherbaz and Duan 2012; Psaraftis and Kontovas 2013; Woo and Moon 2014).

According to Faber and Nelissen (2012), there is a non-linear correlation between speed and fuel consumption and as a rule of thumb by lowering the average speed of the vessel by 10%, a 27% reduction in shaft power requirements and fuel consumption could be achieved. Historically, the slow steaming approach has been proved a sound approach for shipowners when three market conditions coincide: falling freight rates, rising fuel prices and oversupply of vessels (Finnsgård et al. 2020).

However, the slow steaming approach has been criticised for possible adverse economic, operational and environmental outcomes such as increased lead time (Maloni et al. 2013). From the shipper's perspective, the findings of Finnsgård et al. (2020) from six large Swedish multinationals reveal that none of the participants recognised slow steaming as an explicit measure for increased environmental performance. Despite the GHG emission resulting from slow steaming, the participants support that in the future may shift transport modes, especially for short-sea trades, if slow steaming would come at the cost of transit lead time of their products. There are cases where higher speed of vessels encompasses an economic added value for the delivery of products and a boosting of trade throughput per unit time (Psaraftis 2019).

3 Speed Reduction

There is a lot of confusion in the industry on the definition of speed reduction. Some confuse it with speed optimisation which is discussed below; others with mandatory speed limits proposed to reduce GHG emissions. To the authors, speed reduction is an operational decision made as a result of scheduling or other constraints and is not necessarily connected to speed optimisation.

For example, bad weather, or transiting narrow straights, necessitates operational speed reduction. Transiting the Pacific or Atlantic Oceans during winter will force the ship to reduce speed due to safety considerations. The amount of speed reduction in rough seas is proportional to the scale of bad weather. In another example, if the ship has received notification that, on its normal speed arrival date, the berth will not be free and the ship will have to wait at anchor for days, the ship may reduce speed to further save on fuel and to arrive closer to the berth-free date. Of course, that has to be arranged in coordination with the receivers, so that the ship does not lose its turn at the berth to another possible ship that may not slow down and thus may arrive ahead.

Lastly, reduced speed may be the result of regulatory limits as in areas of migrating whales, high traffic volumes or even the proposed universal speed limits which are examined below.

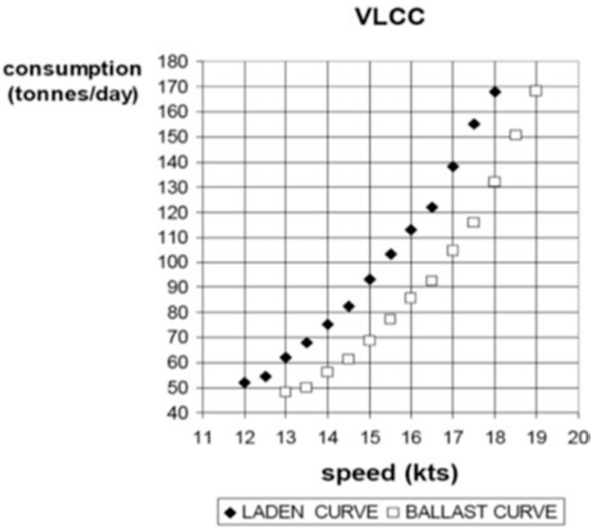

Fig. 17.1 Typical fuel consumption functions for a VLCC. Source: Gkonis and Psaraftis (2012)

3.1 Fuel Consumption Reduction Due to Speed Reduction

Fuel consumption reduction by slowing down can be substantial. Conventionally, ship fuel consumption is considered to vary according to the third power of speed (see Fig. 17.1).

However, actual sea trial data would indicate the relationship to be higher than cubic, such as proportional to the power of 4 or 4.5 for most slow speed ships (e.g. tankers and bulk carriers) and even higher for higher speed ships (such as containerships). Furthermore, the effect of waves intensifies the horsepower (hence fuel) requirement to keep the same speed. Therefore, speed reduction in a normal sea operating environment results in even higher fuel consumption reductions. Even assuming the conventional cubic law, a 6% reduction in speed would offer an 18% reduction in fuel consumption for typical slow speed ships. It is therefore apparent that speed reduction has both an economic and environmental aspect. Reducing speed saves on fuel consumption which reduces costs; and reducing fuel consumption reduces CO_2 emissions to the atmosphere. These aspects are discussed below.

4 Speed Optimisation

Optimisation of a ship's speed can have both economic and environmental impacts. An overview of each impact is outlined below.

4.1 The Economic View

When a ship operator or ship charterer undertakes a voyage, the intention is, of course, profit maximisation. Within several constraints, such as scheduling requirements, profit maximisation is achieved also through speed optimisation. This involves finding the most suitable speed for the voyage which reduces fuel consumption (hence fuel costs) but does not unduly extend the trip duration. Clearly slower speeds extend trip time, and the amount of acceptable additional days at sea depends on many factors such as:

- Cargo inventory costs (high value cargoes carry higher inventory costs).
- Perishable cargoes.
- Shipper and receiver requirements (required deadlines to receive the cargo, etc.)
- Free berth availability dates.
- Whether the extra daily costs (daily hire paid by a charterer to the ship-owner, or daily ship costs—wages, overheads, etc. if the ship is operated for the owner's direct interests) are counterbalanced or exceeded by the fuel savings due to the slower speed.

Obviously, the last point is often the crucial consideration in determining the most suitable trip speed or optimum speed, within the constraints and considerations of the above-mentioned bullet points.

Therefore, both in the case of charterer who is paying daily hire to a shipowner and the fuel for the trip and in the case of a shipowner who has received a fixed hire amount ($ per tonne of cargo) for the trip, finding the optimum speed is mainly a cost minimisation exercise within several constraints and considerations. Similarly is the case of ballast voyages, where no cargo is carried. Figure 17.2 shows a simplified speed optimisation example.

In general, during times of favourable economic environments (e.g. high world GDP expansion), demand for trade is increased, and society is willing to pay higher costs for goods transportation, as well as even higher costs for faster transportation. Thus, ships can command high daily hires or high freight rates which, in turn, lead to higher speeds (in order to deliver the current cargo fast and rush to load the next high-paying cargo as soon as possible). This may occur even if oil prices and thus fuel costs are relatively high. In contrast, poor economic periods lead to slower speeds since a ship's income is constrained and the need to reduce operational costs becomes crucial. Among all cost elements, fuel cost represents the highest operating cost. Thus, the ship operator reverts to lower trip speeds to benefit from the reduced fuel consumption. So, in general, high freight rates induce high speeds and high fuel costs induce slow speeds.

It is noteworthy that, as always, supply and demand play an important role. In this case the supply of available ships for hire and the demand for them. At times of expanding economies, demand for ship transportation is high and thus shipowners command good freight rates and profits. During such times, every shipowner wishes he had more ships. Invariably, during "good times", new ship-building orders to the

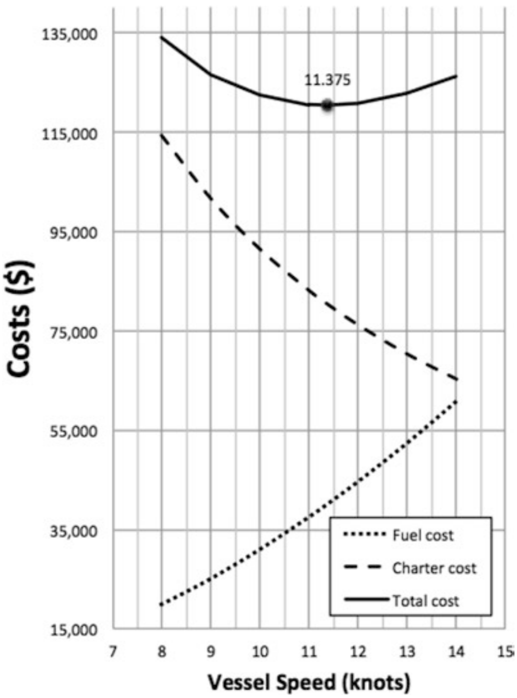

Fig. 17.2 Fuel, charter and total costs as functions of vessel speed. Source: Psaraftis and Kontovas (2014)

shipbuilders are soon coming in, with the ordered ships being delivered 1–2 years after the order. If too many orders are placed (which is always the case), or if in the meantime the economy slows down, the delivered ships join the existing fleet to create an oversupply of ships, which, of course, substantially lowers the commanded freight rates. A low profit, slower speed, cycle starts which purges the older, less efficient and more costly ships by forcing them to the scrap yard. Thus, supply re-balances until the next economic cycle.

4.2 The Environmental View

As discussed above, the "economic" operational optimum speed varies according to the economic environment. During good economic times, the optimum speed can be high, even as high as the ship's maximum speed. During tough economic times, the optimum operational speed is low, as low as the ship's engine may allow. It is unfortunate that the "economic" optimal speed seldom coincides with the "environmental" optimum speed, the latter being the speed of minimum fuel consumption (and thus minimum CO_2 emissions) for the trip.

It should be noted, however, that the optimum environmental speed is not the minimum speed that the engine will allow. Operating at very low speeds extends the trip time by many days, and thus the total CO_2 emissions will be higher. Furthermore, a ship's engine optimum operational range (range of minimum specific fuel oil consumption) is at 65–70% of its maximum horsepower. When operating at a rate below this optimum range, say below 50% of maximum horsepower, the specific fuel consumption of the engine (grams of fuel per horsepower, per hour) increases exponentially, as it does when operating at a rate above the optimum range, e.g. at 90% of its maximum horsepower.

Thus, from an environmental point of view, the optimum speed would be that of the lowest fuel consumption for the trip, irrespective of economic considerations. Such speed is, of course, different for each ship, and it would further depend on the trip peculiarities (e.g. amount of cargo carried, weather, etc.). Therefore, other than inserting some recommendations in the SEEMP for the ship operators to abide by the "environmental" optimum, speed cannot be strictly regulated. This is perhaps why many advocate for the concept of "speed limits", discussed below.

5 Speed Limits

Guided by the concept of "reduced speeds result in reduced CO_2 emissions" several NGO's such as Clean Shipping Collision, World Wide Fund for Nature (WWF) and Pacific Environment (see: MEPC 61/5/10 by CSC, 23 July 2010-MEPC 72/7/10 by WWF, Pacific Environment and CSC, 16 February 2018-MEPC 74/7/8 by CSC, 15 March 2019) have advocated in the last few years that IMO should enact "speed limit" regulations. Lately, as IMO was looking to implement serious operational measures to achieve the GHG reductions stipulated in its initial strategy, the idea gathered traction even among shipowners. Several proposals were submitted to IMO by NGOs and member states (France among others) proposing strict speed limits to be set according to each vessel type. For example, the average speeds of bulk carriers of the last few years could be looked at and a speed limit at, or further below, such average speed could be set. The idea was seen by its proponents as simple and a "low hanging fruit" towards reducing fuel usage and thus CO_2 emissions. An earlier study by CE Delft,[1] paid for by NGO's, was used as the primary argument for the effectiveness of the measure.

It turns out, however, that both the idea and the study on which this study was based, had serious problems. The study found that a 10% speed reduction would reduce CO_2 emissions of the most common ship types (tankers, bulkers and containerships) by 75 million tonnes per year; a 20% speed reduction would save 140 million tonnes and a 30% reduction 190 million tonnes per year. The speed reductions of the study are, of course, reductions from the typical ships' design speeds. However, due to the slow economic climate, ships have already been proceeding at

[1] Study on *Regulating speed: a short-term measure to reduce Maritime GHG emissions, by Jasper Faber* et al.*, CE Delft, of 18 October 2017.*

slow speeds in the years since the crisis of 2008. Whereas the typical design speed of bulk carriers and tankers is 14.5–15.5 knots, the average actual speeds of the last few years are around 11–11.5 knots, i.e. already 25% slower than design. Any further slowdown from today's speeds will actually increase CO_2 emissions (see Sect. 4.2). In addition, the calculated GHG reductions of the study are theoretical, the actual ones being less than half of those stated, since the effect of waves on the ship (sea margin) is not constant, as typically assumed, but seriously decreases at slower speeds (thus less horsepower is needed meaning less fuel is required). The CO_2 reductions could be finally half or less than those stated in the study.

Nevertheless, a speed limit regulation would be fraught with more problems, all counterproductive to the environment. If the limit is set below market needs, more ships would be needed to satisfy world trade demand. According to the same CE Delft study, 10% speed reduction means 10% more ships will be needed, 20% speed reduction requires 22% more ships, and 30% reduction requires 37% more ships (and 47%! more tankers). One may use the method of Gratsos et al. (2010) to calculate the CO_2 to be emitted to make the steel and build these—otherwise unneeded—ships. It results in excess of 1 billion tonnes of CO_2 which will wipe out all claimed reductions and even more. Of course, until the time that these extra ships hit the water, freight rates will skyrocket for 1–2 years, which may be the reason for some shipowners to be in favour of the measure. Yet the impact of so many new ships flooding the market will be catastrophic for the shipping industry. It should be noted that speed reduction is one of the short-term measures examined by IMO (Resolution MEPC.304(72), Adopted on 13 April 2018) and will therefore be a temporary measure until 2030. After that date, all ships may speed up again, creating an unprecedented oversupply of tonnage.

Clearly, speed limits favour the old, inefficient ships, in a way that protects them and extends their useful lives. This is because their fuel consumption difference at design speed is much larger than the new "eco" ships. However, at reduced speeds, the fuel consumption differences are small. Thus, the old ships can remain competitive. It does not seem appropriate for the efficient ships, which consume half the amount of fuel, to have the same speed limit as the inefficient ships. Additionally, there is no incentive to retrofit new energy saving technology (new hull paints, energy saving devices), nor any incentive for better operational practices (e.g. keeping the hull and propeller clean). All ships will comply with the speed limit regulation, but a dirty-hulled one will emit 30% more CO_2, and this will be perfectly legal.

The above issues eventually became evident to the majority of IMO members and thus—rightly—support for "speed limits" evaporated. Instead, current discussions focus around Japan's Energy Efficiency Existing Ship Index (EEXI) (Ref. MEPC 74/7/2 by Japan, 7 February 2019) for "power limits", whereby each existing ship will have to satisfy the EEDI phase 2 requirement (the requirement applicable to new building ships for the years 2020–2025). To achieve this, ships will have to cut their maximum operational horsepower to the level that will reduce their EEDI (or EEXI as EEDI is called for existing ships) to phase 2. Obviously, the older, less efficient ships will have to cut their power more than the newer ships (thus the new ships will be able to speed up more). Moreover, retrofitting energy-saving devices, such as wake equalising ducts before the propeller, wind assistance, etc., may diminish the required reduction in horsepower. Reduced power is, of course, a safety concern especially in bad weather. Thus, the Japanese proposal includes an "emergency bypass" whereby, if necessary, the full original engine power can be available.

It is therefore quite safe to say that "speed limits" are being abandoned by IMO in favour of "power limits" which will result in reduced operational speeds but in a fairer way towards the already efficient ships, while promoting best operating practices, such as keeping the hull and propeller clean, in order to utilise, as much as possible, the available power for speed.

6 The Commercial Point of View of Slow Steaming

> *… One complexity is ever-present in every management problem, every decision, every actions—not, properly speaking a fourth task of management, and yet an additional dimension: time. Management always has to consider both the present and the future; both the short run and the long…* (Peter Drucker, "Management: Tasks, Responsibilities, Practices" 1977).

In every aspect of commercial activity, time is an indefinable element; a catalyst by itself. Its observation varies based on shipper's, port's or market's point of view. Although the observation varies, the concept remains the same; bridging the parties involved within a transaction, connecting points of reference, enabling the smooth operation of activities at the end.

A "Market" is a system (mechanism) where the core elements composing it, those of demand and supply, are confronted, creating break-even points, and eventually establishing trade. From a business point of view, this should be examined if the market is willing to pay an additional amount of money for earlier delivery of products. In a case where the market is willing to do so, a higher price of the products may be charged. In the maritime industry, the diversity of products being transported within the pattern of time (seasonality issues) is the basic ingredient for industry's viability and upgrade of the services provided, both on a short- and long-term basis.

In the event that the transportation industry is not willing to provide faster delivery of products to the markets, then a different approach should be taken. The "slow steaming" philosophy is about the gradual increase of the overall responding time of the transport, creating many consequences in demand and supply, and an imbalance of their in-between equilibrium (or break-even) point. This change to their break-even point will create economical disorders since the parties involved are directly exposed to new market risks, with no clear option if those risks are to be absorbed fully, partially (i.e. transferred to other less vulnerable units) or rejected in total.

Slow steaming is an exogenous parameter, creating insecurities to the parties involved. If we take for granted the option that the demand will remain (at least) stable in the case of slow steaming, then the availability of the products will be decreased as well, creating a negative impact in the balanced ratio of supply to the market.

7 The Supply Chain Management Point of View

From robust to resilient and vice versa.

It is crucial to understand that we are ahead of a turbulent market environment, with many shifted parameters. There is a so-called evolution of the standards since nowadays there are more players in the industry and a loss of market share. The supply chain management systems have been evolved drastically as information technology (IT) has a substantial impact on the overall business performance.

Nowadays, innovative techniques enable the supply chain sector to identify changing patterns and suitable existing techniques per case. Innovation provides detailed information to the shippers and other relevant stakeholders about shipments, delivery time, delays, associated expenses and downsizing of operational costs.

The parties involved in the supply chain process should consider the slow steaming as a parameter of a crucial impact on trade. The best-case scenario is to establish an approach more resilient to its clientele, meaning more "flexible" and easily adjustable on a case-by-case basis, continuing at the same time to provide the same level of quality of service to its providers. This requires a more open-minded appreciation of the benefits involved by following an approach that will ultimately establish a mechanism. It is therefore clearly a point of view as to how the market is to react and how the elements are to deliver their services and at what level.

According to Packowski (2014), there are ten pain points that every supply chain manager faces in the business environment and, among them, lack of supply chain visibility, demand volatility and supply chain complexity are ranked in the first three positions. Lack of supply chain visibility in the supply chain is mostly considered as a high-risk element, engaging so many unforeseen factors that their combination can disorder the smooth planning and execution of a project. Visibility within a supply chain consists of many elements that are synonymous to the transparency a logistics channel should have in all of its operational stages and connecting points. Furthermore, highly variable demand for services and products, as well as complexity in planning processes and systems, creates various challenges for organisational leaders.

7.1 The Port Perspective

The ports, apart from their scope of connecting the shipment and trans-shipment of cargoes between the parties involved, also serve as parts of the logistics scheme within a supply chain. There are many elements that ought to be taken into account in the conceptualisation of ports, since their definition varies from a logistic, geopolitical, financial, economic and societal point of view.

Talley (2009) states that '… *A port is an "engine" for regional economic development by increasing employment, labour incomes, business earnings, and taxes in the region...*'. On the other hand, Stopford (2005) describes its importance as the third component in the transport system, which is just as important as the merchant fleet, specifically stating that '…*A port is a geographical area where ships are brought alongside land to load and discharge cargo—usually a sheltered deep water area such as a bay or river mouth…'*. Along with the several important functions that ports have, their main purpose is to provide a secure location where ships can berth. For the conceptualisation of the ports, we should also consider the micro and the macro approaches, covering quite different patterns, but at the same time also interrelated. In the micro approach, the seaport has an interface with other forms of transport and, in so doing, provides connecting services, whereas in the macro approach emphasis is given to its overall contribution to the improvement of the national or regional quality of life.

There are a plethora of elements composing the way of thinking for those selecting a set of services a port can provide and some of them are:

- The fast execution of the operational activity (i.e. loading, discharging, bunkering, supplying stores/provisions, crew changes, medical assistance, etc.)
- Minimum delays (within reasonable time windows).
- Safety of cargoes being transported and kept (within warehousing facilities, silos, etc.)
- Logistics solutions.
- Low (as much as possible) percentage of cargo claims.
- Expertise in cargo handling operational activities.
- Expertise in port personnel and port management.
- 24/7 (all day and all night long) response
- Reduced expenses (as much as possible).
- Port authorities' flexibility (good co-operation with shippers, operators, all parties engaged).

Slow steaming may have an impact on the operational performance of ports, as they will be faced with a gradual upheaval of their storage facilities due to the forthcoming ship cargoes. Port operational performance consists of many elements, from cargo handling equipment to the use of sophisticated transport systems, in order to satisfy the needs of their clientele for improvement. In a slow steaming scenario, the port should redefine itself to meet its core target; providing qualitative services to its clientele, competitive pricing, warehousing, forwarding and logistics services, agency services, along with specialised services for highly sensitive cargoes, like hazardous materials, chemical, etc. (niche market). The main elements dealing with disorder in the demand and supply of products are:

(a) The existing port cargo handling equipment (CHE).
(b) The warehousing facilities.
(c) The logistics scheme being created by using efficient and effective elements of port handling equipment, management and warehousing facilities.

7.2 *The Bottleneck Effect*

Taking for granted the option of slow steaming, the average waiting time for ships in ports could be increased. The port congestion concept may become a stable parameter in the operational procedures between port and ship. Following this principle, the ports will eventually enforce a downsizing operational scheme as a provisional solution for the congestion. At the current time, there is a tense competition between ports in terms of the services they provide to shippers, without declining their operational reputation, meaning they have to do what they promise, in all cases. In the shipping industry, reputation is a bridging point whereby the shipper is willing to pay—even in some cases a higher amount of money, so as to be able to receive a set of services without compromising quality. Response time, although an intangible element, can be transformed into an asset (best case scenario) if all the parties act properly and deliver the service they agreed to do, in the way and mode they were ordered to. We can say for sure that response time is highly considered as a qualitative element, with the potential to increase the overall value of the service they provide to the shippers and to their charters.

In the opposite case, failure to comply in a timely manner will create a disadvantage to all parties involved and finally result in a disappointed service receiver (i.e. the shipper) with direct negative impacts, not only from a financial point of view, but also from trustworthiness perspective. The latter is riskier for the port, since it is a rejection, in other words, from the shipper to the port.

Port congestion could lead to disappointed clients with few or no alternatives at all. With an increase in the gross weight of seaborne freight handled in all ports, the bottleneck effect due to slow steaming is exposed as a risk, with unforeseen reactions from the shipping industry. The smooth planning of operational procedures will no longer be available, but the need for freight handling will continue to exist, requiring ports to provide alternative (temporary) solutions with no guarantees.

However, we should also take into consideration the "in-between" time period, during which the port must serve simultaneously ships arriving with the conditional speed (i.e. not under slow steaming concept) and those arriving under slow steaming. In this timespan, the port will actually operate under two-speed functionality. This "temporary" mode of operation will eventually create an imbalance on the distribution of its existing warehousing facilities, cargo-handling equipment/gear, as well as to port personnel allocation and management. Prioritisation issues are likely to be generated, requiring the port management to deal with them, following a case-by-case basis, on its equilibrium equation.

In the same mode, this dysfunctionality will be gradually stabilised, and the port will eventually meet its normal operational rhythms, as soon as the parameter of ships' arrival can be streamlined, following a commonly accepted guideline, i.e. the slow steaming approach.

Communication and cooperation between the parties involved (i.e. port, shippers and operators) are the main elements that will define the smooth co-ordination of the process. The shipping environment is characterised by economic booms, fluctuations in the shipping market's supply and demand, and market volatility (Stopford 1997). These characteristics themselves are acting as the catalysts in moderating the system and consequently, the operational balance between the parties involved.

8 Conclusions and the Way Forward

The emission of air pollutants from ships is a thorny issue, and a series of international, regional and national initiatives have been implemented to reduce GHG emissions and carbon intensity of international shipping. At the same time, discussions are centred around terms such as slow steaming, speed optimisation and reduced speed limits. The 'slow steaming' approach, which is related to the voluntary approach of sailing slower than a vessel's design speed, could squeeze operational costs, achieve fuel cost savings and lower GHG emissions, as well as lower emissions of black carbon, sulphur oxides and nitrogen oxides. However, it should be stated that the slow steaming approach may lead to gradual increase of the overall responding time of the supply chain system, creating imbalances between the demand and supply of services and products.

Furthermore, it is unfortunate that, through speed optimisation, the 'economic' optimal speed does not usually coincide with the 'environmental' optimum speed. As a 'maximum allowed' speed by regulation (speed limit) is fraught with problems, regulators should consider a shift instead to mandatory operational power limits. 'Power limits' seem the best alternative scenario for reduced operational speeds and CO_2 reduction targets but in a fairer way towards the already efficient ships.

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Part IV
Good Ocean Governance

Chapter 18
Maritime Governance and Small Island Developing States of the Wider Caribbean Region in the Era of Climate Change Adaptation

Jonatan Echebarria Fernández

Abstract The chapter analyses the readiness and preparedness of Small Island Developing States (SIDS) located in the Wider Caribbean Region (WCR), in terms of climate adaptation to fight against global warming and climate change that affects maritime ecosystems and the indigenous communities' livelihood. The increased threats posed by marine pollution due to anthropogenic sources not only affects marine ecosystems and marine biodiversity, but it also intensifies adverse weather phenomena including sea-level rise. At the outset, the aforementioned issues are considered to be interrelated and have raised concerns of the international community and can only be solved through specific policy measures and multilateral governance. International efforts to comply with the UN 2030 Agenda for Sustainable Development Goals (SDGs), and the implementation of global and regional instruments, serve as the guiding thread throughout the chapter, considering the impact of the rise of the sea level, the economic and social implications for coastal communities, as well as the coordinated mechanisms to assist the Caribbean SIDS in fighting climate change. Knowledge exchange, capacity building through training and deploying the necessary means in such endeavour serve the purpose of ensuring the Caribbean SIDS' population's well-being and preserving the natural resources for generations to come.

Keywords Climate change adaptation · UNFCCC · Paris agreement · Blue economy, Maritime governance and fight against pollution · IMO instruments · Greenhouse gas emissions

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1 Introduction

Seas and oceans are vital for sustainable development and the fight against climate change. These, along with rivers, waterways and estuaries, cover two thirds of the Earth's surface. In addition to being the primary mode of the global trade sector, the ocean is a valuable source for food, minerals, and energy (Rayner et al. 2019). Moreover, the oceans also '*generate oxygen; absorb greenhouse gas (GHG) and regulate climate change; determine weather patterns and temperatures; and serve as highways for sea-borne international trade*' (Onguglo and Eugui 2014a, b). Oceans and their seabed constitute a shared resource largely located beyond national jurisdiction, and largely used by mankind that requires it to be managed and preserved for the use and enjoyment of future generations (Pace 2018). They are described as the '*new economic frontier*' and are projected to generate over US$3 trillion between 2010 and 2030, according to the Organization for Economic Cooperation and Development (OECD 2016). The OECD report also highlights the threats facing the ocean, such as pollution, excessive exploitation, climate change and declining biodiversity (OECD 2016; Rayner et al. 2019). Several aspects of the ocean economy were incorporated into the final document of the United Nations (UN) Open Working Group on the Sustainable Development Goals (SDG) of 19 July 2014 (EU Report, 2017), with SDG 14, Life Below Water, relating to the ocean economy and marine ecosystem protection (UN General Assembly on SDG 2014; Onguglo and Eugui 2014a, b).

Onguglo and Eugui (2014a, b) indicate that, according to World Bank figures, the oceans generate around 350 million jobs in fishing, maritime and coastal tourism, aquaculture and research. They further note that fish are the main source of protein for one billion people. However, seas and oceans are currently facing major environmental and economic risks that '*arise from climate change, rise in the sea level, acidification of sea water, over-exploitation and poor management of marine resources, and deposit of pollutants and fertilisers in the seas, damaging the seabed and oil, gas and mineral extraction*'. Onguglo and Eugui (2014a, b) further identify that there is a growing need to increase transfer of maritime technology and regulation and for the elimination of negative incentives and subsidies that affect the marine environment. Over the last decade, globalisation has also accelerated and intensified, causing poor legislative decision-making. The resulting impact allows corporations to maximise profits by imposing or removing borders—a characteristic known as territorial porosity (Roe 2013).

In 2017, the UN General Assembly convened an intergovernmental conference to adopt Resolution 72/249, an international legally binding instrument under the United Nations Convention on the Law of the Sea (UNCLOS) on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ Treaty; IUCN (International Union for Conservation of Nature) 2020a, b). The BBNJ Treaty is the first step in addressing threats like overfishing, deep-sea mining, toxic spills and climate change, which are compromising oceanic resources and services needed for human survival. Under UNCLOS, the BBNJ Treaty would equalise marine resources sharing, provide standards for the assessment of environmental impacts, create requirements for capacity building and technology transfer and create Marine Protected Areas (MPAs) (IUCN 2020a, b). The final negotiation session for the BBNJ has been postponed due to the Covid-19 pandemic (IUCN 2020a).

Thus, in the outcome document of the Rio + 20 Summit (Rio Earth Summit) of 20–22 June 2012 of the UN Conference on Sustainable Development (UNCSD) 'The Future We Want', UN Member States agreed '*to protect, and restore, the health, productivity and resilience of oceans and marine ecosystems, to maintain their biodiversity, enabling their conservation and sustainable use for present and future generations*' (Onguglo and Eugui 2014a, b). The Draft Abu Dhabi Declaration resulting from the Blue Economy Summit in Abu Dhabi on 19–20 January 2014 '*stressed the contribution that an oceans economy can make towards the alleviation of hunger, poverty eradication, creation of sustainable livelihoods, and mitigation of climate change*' (Onguglo and Eugui 2014a, b). There has been an increase in the number and extension of MPAs during the last decades (for instance in Kiribati and the Cook Islands) (Vierros and De Fontaubert 2017). UN Member States are '*committed to halting and reversing the decline in the health and productivity of our oceans and its ecosystems and reversing the decline in the health and productivity of our ocean and its ecosystems and to protecting and restoring its resilience and ecological integrity*' (UN General Assembly Resolution 71/312 2017). This proposed Call for Action focuses on different topics such as marine pollution (including plastic pollution), fishery management and subsidies, adaptation to climate change impacts, scientific research and public education (Chan 2018). Many good initiatives are currently underway.

The Wider Caribbean Region (WCR) is the relevant area of focus for this chapter since its rich marine ecosystem is under threat due to different sources of pollution, and several measures have been put in place to protect it from an international and regional governance perspective. MPAs have been constituted and cooperation has been enhanced to reverse the noxious effects of climate change in the region. Adaptation to such change is addressed in the context of the WCR. The Caribbean ocean economy is expected to double its contribution to both the 2030 Agenda and Sustainable Development (Patil et al. 2016).

Against this backdrop, the focus of this chapter is a concentration on the interconnectedness between marine pollution and other adversities related to climate change, which have a negative effect on the livelihood of the citizens of Small Island Developing States' (SIDS). Climate adaptation, maritime governance and the International Maritime Organization (IMO) instruments are paramount to these countries' understanding of how to effectively address the challenges posed by such a threat to the environment and its inhabitants. The focus is guided by the question: what are the challenges regarding climate adaptation and marine governance that the SIDS in general, and the Wider Caribbean Region (WCR) in particular, are facing to avoid the adverse effects of climate change? To this end, the WCR is the key case study, the analysis of which will exemplify the forms of cooperation in combatting climate change. Many climate change-related threats are pending the WCR including shoreline recession, which would lower the availability of land for agriculture and recreation, as well as residential and commercial areas.

2 The Special Case of SIDS and the WCR

The SIDS can be defined as '*a distinct group of developing countries facing specific social, economic and environmental vulnerabilities*', according to the UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States. Those countries have common characteristics that make them highly dependent on international trade and limited resources due to their limited availability of soil. Some of the challenges facing SIDS are climate change-related rising temperatures, sea levels and extreme weather patterns, as well as high cost of transportation, low connectivity, and limited human, financial and technical resources (Onguglo and Eugui 2014a, b; Rhiney and Baptiste 2019; Scobie 2016).

SIDS heavily rely on maritime transport, with up to 95% of their transport being seaborne and only 5% of their goods are carried by air (Sciberras and Silva 2018). The SIDS, who are reliant on fuel imports, have more than 30% of foreign reserves allocated to fossil fuel costs, but desire to create their own sustainable energy to lessen their dependence on fossil fuel imports. This is troublesome for some fossil fuel-dependent SIDS because debt burdens have hindered the possibility of acting on an investment for renewable and sustainable energy (OECD 2018). Although many SIDS and coastal States are parties to the *Convention on Biological Diversity* (CBD), and some to the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization to the Convention on Biological Diversity* (UN 2010a), there is little or no development of national Access and Benefit Sharing (ABS) laws and regulations leading to a '*potential economic development in marine bio prospecting with mutual benefits*' (Onguglo and Eugui 2014a, b). The CBD, which entered into force 29 December 1993, aims at the conservation and sustainability of biodiversity as well as the fair and equitable sharing its resources (CBD 2020).

The WCR, according to the 1983 *Convention for the Protection and Development of the Marine Environment of the WCR* (the Cartagena Convention) and its Protocols (1983 *Protocol on Cooperation in Combating Oil Spills in the WCR,* 1990 *SPAW Protocol on Protected Areas and Wildlife, and the* 1999 *LBS Protocol on Pollution from Land-Based Sources and Activities*),[1] spans the area from the northeast coast of Brazil to Cape Hatteras, including all coastal States in between. A map of the WCR including its marine ecosystems is illustrated in Fig. 18.1.

[1] For more information on the Cartagena Convention, see: https://www.unenvironment.org/cep/who-we-are/cartagena-convention

Fig. 18.1 The WCR's states including their three large marine ecosystems. Source: Fanning et al. (2011), 14; Parris (2016)

The WCR is characterised as one of the '*most geopolitically complex regions in the world*' formed by 28 continental States and SIDS including independent States and overseas territories of metropolitan States. These '*range from among the largest to the smallest, the richest to the poorest, and the most developed to the least developed*'. This complexity is coupled with a European colonial past, five official languages (Spanish, English, French, Dutch and Portuguese) and indigenous cultural elements (Fanning et al. 2009; Trouilliot 1992; Mahon and Fanning 2016). However, the region faces some ecological challenges that affect the livelihood of their local communities, in general, and particularly their coastal communities.

Poverty, economic inequality and population growth vary amongst the WCR, which contributes to further developmental instability (Parris 2016). The economies of the WCR are particularly vulnerable and primarily depend on the exploitation of its natural resources (Parris 2016; Knight and Palmer 1989). This exploitation includes agricultural fishing, connecting passages and straits and, most significantly, tourism (Parris 2016; Pinnock and Ajaguana 2012).

The WCR population relies particularly on tourism income more than any other region of the world. As of 2019, tourism contributed 13.9% to the regional gross domestic product (GDP) and 15.2% of the region's population was employed in the tourism sector (World Travel & Tourism Council 2020). Marine recreation, such as sport fishing, snorkelling, scuba diving and exploration, as well as seafood harvesting are crucial to the tourism sector and relies on healthy and sustainable marine ecosystems (Martin and Hines 2017). Climate change, overfishing, pollution and population growth have threatened the sustainability of the marine ecosystem of the

Caribbean, specifically the local coral reefs (Torres and Jackson 2017). Of these threats, the most impactful is climate change.

The impact of the sea level rise on SIDS will achieve its highest peak by 2100. The Bahamas will be one of the most affected globally (Mycoo and Donovan 2017). The regulation of its coastal zone established in the Planning and Development Act 2010 has been stalled since 2016 due to a lack of enforcement (Benjamin and Thomas 2019). Moreover, the WCR accumulates the highest ratio of natural disasters per square kilometre, having a considerable impact on the vulnerable small economies of the SIDS in terms of public expenditure and climate action-oriented resources investment (Benjamin and Haynes 2018; Benjamin and Thomas 2019).

Around 322,745 tonnes of plastic per year are not collected and 22% of that amount ends up in waterways or land affecting the Caribbean Sea, despite 14 Caribbean SIDS having banned single-use plastic bags or Styrofoam (Diez et al. 2019). Coral reef degradation is identified as the cause of an estimated annual revenue loss of between US$350 million and US$870 million. The Caribbean coral reefs have an economic value of US$3.1 billion and US$4.6 billion generated by shoreline protection, dive tourism, and fisheries (Diez et al. 2019). Pollution, overfishing and coastal development being the three largest threat to these coral reefs, with land-based pollution having a 20% impact (Diez et al. 2019).

It is predicted that the continued pollution will have a further value reduction of 11 and 19% and an estimated revenue loss of US$172 million by 2050 (Burke et al. 2011; Diez et al. 2019). Reef degradation from pollution and overfishing is identified as the cause of an estimated annual revenue loss of between US$350 million and US$870 million with an impact on tourism and fishing industries (Diez et al. 2019), and it may decrease reefs' value between 11 and 19% by 2050 (Burke et al. 2004, 2011). Land-based pollution accounts up to 20% of that impact on coral reefs and represents an estimated loss of US$172 million in the WCR. Climate change has a dramatic effect increasing '*bleaching, disease, acidification, and damage by stronger storms and hurricanes*' (Diez et al. 2019).

3 Climate Change Adaptation, Climate Treaties and '*Blue Economy*' for SIDS and the WCR

In order to provide an analysis of the main challenges that SIDS, and the ones located in the WCR in particular face regarding climate change adaptation a definition and its implications for the region are put into context. The main developments that the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement bring on climate change adaptation for Least Developed Countries (LDCs) and SIDS in general are introduced, with some remarks on the WCR. Finally, the last subsection brings the main implications of the '*Blue Economy*' concept for SIDS in the WCR.

3.1 Climate Change Adaptation in the WCR

Climate adaptation spotlights the socio-ecological system model and environmental justice. Research dedicated to the science and policy interface of the socio-ecological model is scarce (Choquet et al. 2018), especially on climate change adaptation governance (Vink et al. 2013) and the role and mechanisms of power (Olsson et al. 2014). Governance is defined as a regulating authority of a region, nation or location (Long 2014). It is '*ever-evolving and involves a variety of public and private actors*' (Rhodes 1997). Although, Burgt et al. (2017) and Bailet (2002) have distinguished that the management and enforcement of a governance is inclusive—unlike an established government. Ocean governance, as defined by Pace (2018), is an ocean management '*framework*' with the same responsibilities of a conventional government (Bailet 2002).

Adaptation, in short, is the ability to adjust to climate change and minimise its effects (European Commission 2020). Adaptation may allow a reduction in the vulnerabilities of undesirable consequences for the population, enhancing the exploitation of any benefits in human systems and facilitating the '*adjustment to expected climate and its effects*' in natural systems (IPCC 2014). While climate change is a global threat, it is experienced locally. Climate change adaptation policy is more common amongst cities and municipalities in the absence of national or international climate policies (NASA 2020b). Therefore, adaptation action '*should follow a country-driven, gender-responsive, participatory and fully transparent approach*' (Phillips and Koutouki 2019) and be rooted on the relevant science and, as appropriate, conventional and general knowledge, including the indigenous peoples and local systems (Article 7[5] of the Paris Agreement). While it is necessary to normalise climate change adaptation, these responses need more long-term solutions (O'Brien and Selboe 2015). The sooner adaptation policy is implemented, the easier it will be to adapt to the effects of climate change (O'Brien and Selboe 2015; NASA 2020b). Adaptation amongst SIDS means improved irrigation policy, coastal area protection, water infrastructure, protected marine areas, health infrastructure and climate resilient society (Scobie 2015).

Socio-ecological resilience is the '*capability of a system to maintain important feature by self-organising and adapting to unexpected disturbances and change*' (Wenta et al. 2019), based on the pre-emptive measures tackling the prospect of change, rather than impact reactions (Folke 2006; Holling 1973). Resilience in the concept of climate change is a society's ability to resist, prevent, withstand or recover from hazards, timely and efficiently (IPCC 2014). Adaptation anticipates extreme events that threaten vulnerable areas and develop strategies to build resilience (Nicholls 2018). For example, areas that are vulnerable to flooding adopt proactive adaptation strategies such as flood drainage and defence, flood-proof building standards and regulations and elevated infrastructure designs (Nicholls 2018).

Climate adaptation is addressed at international, regional, national and local levels. The role of sovereign States in drafting climate adaptation laws considers four principles that climate adaptation laws. Some states boost their adaptation to preserve their system (Flatt 2012) would rather transform it (Chaffin et al. 2016). Adaptation laws should prioritise '*the meaningful adaptation of all individuals and communities*' (Maantay 2002; Kennedy et al. 2017; and Wenta et al. 2019) assisted by '*adequate resources, technical support, and greater tolerance of alternative understandings of environmental change*' (Gauna 1998; Kaswan 1997; O'Brien 2011). For instance, there has been a trend towards further participatory rights by recognising '*the benefits for both problem solving and the perceived legitimacy of regimes*' (Kirk 2011). Wenta et al. (2019) present four principles that require the fulfilment of climate adaptation laws by integrating key elements of resilience thinking and environmental justice. Climate adaptation laws should facilitate resilience and justice, addressing the distributive effects of climate change and adaptation, to promote a fair and inclusive public participation, by considering sectors, geographic scales and timescales. Legislators should consider these aforementioned principles when drafting climate adaptation laws. Furthermore, when drafting climate adaptation laws, legislators should be driven by scientific to achieve the necessary long-term results (O'Brien and Selboe 2015).

National climate adaptation laws may avoid the conflicts mentioned in Sect. 2.1 with improved communication (Flatt 2012; Camacho 2009) and supporting '*multidimensional learning across sectors and scales*' (Wenta et al. 2019). As of 2019, 170 countries have addressed adaptation in executive policies, and at least one legislation addressing adaptation has been passed in 91 countries (Nachmany et al. 2019). National governments are critical in mandating, addressing, and overseeing adaptation policies that occur at local levels (Nachmany et al. 2019). These government entities are able to incorporate specific hazards and highlight necessary measures to be taken to combat these hazards, as well as provide guidance for lower entities for adaptation prioritisation (Nachmany et al. 2019).

Regional adaptation legislation can have the same effects as national adaptation laws but can be between countries or a region within a country. The Treaty of Chaguaramas (replaced by the Revised Treaty of Chaguaramas of 2001) established the Caribbean Community (CARICOM) is the highest regional intergovernmental administrative body that consists of a vast majority of the Caribbean countries. It promotes and furthers foreign policy and cooperation amongst its Member States (Scobie 2016). In 1994, the UN focused on regional action for climate change adaptation and created the Caribbean Programme for Adaptation to Climate Change (CPACC) (Joseph 2017) with CARICOM (CCCCC 2020). The CPACC eventually evolved into the Caribbean Community Climate Change Centre (CCCCC) in 2005, and it provides advice and guidelines for policies related to climate change to CARICOM Member States of the WCR (Rhiney, 2019; CCCCC 2020). The regional aim of the CCCCC is to organise and regulate regional mitigation and adaptation efforts as a part of CARICOM's adaptation planning projects (Scobi 2017; CCCCC 2020). Since the Caribbean region has been recognised as having a particular vulnerability to the effects of climate change, the region has banded together to push for climate change adaptation, regionally and globally.

Climate adaptation policies build resilience at the local level. The multi-tier approach of climate adaptation policy provides information and guidelines at the national and regional level for the implementation of climate adaptation policy at the local level. National and regional adaptation policy spotlights the current climate change challenges experienced at local levels, thereby guiding local governments to implement their own climate adaptation policies to align with the goals of the national or regional government. Adapting to climate change builds resilience to the adverse effects of climate change.

3.2 *Climate Change Adaptation Under Climate Treaties*

Adapting to climate change builds resilience to the adverse effects of climate change. The UNFCCC and the Paris Agreement represent the milestones that have greatly contributed to climate change adaptation.

3.2.1 UNFCCC

The UNFCCC is the UN entity that supports the global response to climate change and climate adaptation, marine ecosystem conservation and the fight against marine pollution. Approved in New York in 1992 and implemented in 1994, the UNFCCC is the parent treaty of the 1997 Kyoto Protocol and the 2015 Paris Agreement with a membership of 197 countries. The UNFCCC provides experts and assistance with analysis and review of climate change information and also maintains the Nationally Determined Contributions registry as well as organises biannual or quarterly negotiation sessions. The UNFCCC focuses on the cross-sectoral and cross-geographical scales that should be adhered by national adaptation laws. These activities can alter the atmospheric composition or be attributable to natural causes (IPCC 2014).

Article 1 of the UNFCCC defines climate change as '*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and, which is, in addition to natural climate variability, overserved over comparable time periods*'. Scientists have acknowledged that human activity as the cause of climate change due to the burning of fossil fuels, industry pollution and increased agriculture creating more carbon dioxide (CO_2) in the atmosphere (NASA 2020a). An increase of CO_2 in the atmosphere causes the earth's temperature to rise, creating a warmer planet and biosphere (NASA 2020a, b). In addition to rising sea levels, climate change is the cause of strength and frequency of severe storms, floods, draughts and wildfires, as well as threatened the extinction of one million plant and animal species (NASA 2020b; Greenpeace 2020). Human health, food and quality of life is therefore threatened as well (Greenpeace 2020).

As it has been stressed in the previous section, there should be multiple responses provided at the national level and these legislated responses should minimise any conflicting responses (Wenta et al. 2019). This can be best achieved by sharing and distributing plans and executions via the UNFCCC's Secretariat (Wenta et al. 2019). The UNFCCC's Adaptation Committee's function is to share '*relevant information,*

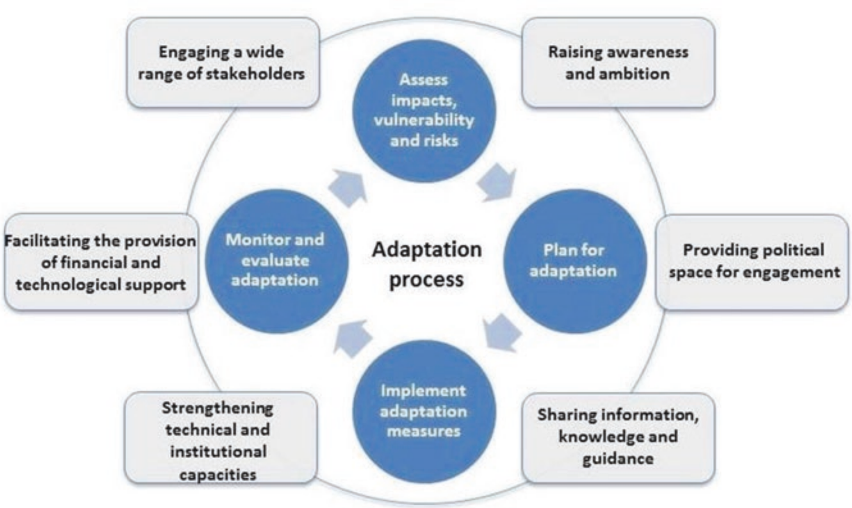

Fig. 18.2 How the parties address adaptation. Source: UNFCCC (2020c)

knowledge, experience and good practices, at the local, national, regional and international levels' (UNFCCC Secretariat, Decision 1/CP.16, 2011, para 20). The global challenge of adaptation on all governmental levels is recognised by the UNFCCC and the Paris Agreement and the goal is to create long-term global responses to climate change (UNFCCC 2020c). In order to achieve these goals, the UNFCCC has acknowledged that adaptation action should be guided by science, transparent, participatory and country-driven and consider vulnerable groups, ecosystems, communities and societies. The UN created adaptation workstream, using specialised groups, committees and work programmes to help members execute their climate adaptation activities (UNFCCC 2020c). The main adaptation workstreams carried out under the UNFCCC framework are composed of the National Adaptation Programmes of Action (NAPAs), National Adaptation Plans, an Adaptation Committee, the LDCs Expert Group, Technical Examination Process on Adaptation, as well as the Nairobi work programme on impacts, vulnerability and adaptation to climate change (to assist '*developing countries to make better informed decisions about possible policy responses*' Bodansky et al. 2017). These are shown in Fig. 18.2.

3.2.2 The Paris Agreement

In order to fulfil the climate change adaptation ambitions of the UNFCCC, it was necessary to develop a sense of international solidarity amongst all nations. The aim of the Paris Agreement (2015) was to unite all nations in the pursuit of combating and adapting to climate change as well as provide support to developing and impoverished countries (UNFCCC 2020a, b). It was adopted by 195 States on 12 December 2015 at the XXI United Nations Climate Change Conference (COP 21). The EU and 188 States ratified the agreement that entered into force on 4 November 2016 (Paris Agreement, 2016). Its preamble acknowledges the concern that climate change poses for mankind, while stressing the relevance of protecting biodiversity and ensuring the integrity of all ecosystems, including oceans (Phillips and Koutouki 2019). Moreover, the Agreement is aimed at fostering climate resilience and low GHG emissions development, as well as making finance flows consistent with direction towards low GHG emissions and climate resilience, according to its Articles 2.1.b and 2.1.c (Phillips and Koutouki 2019).

The global adaptation goal of the Paris Agreement is '*enhancing adaptation capacity, strengthening resilience, and reducing vulnerability to climate change*' (UNFCCC 2017). This infers that implementing proactive and effective adaptation policies will strengthen the resilience of vulnerabilities to climate change on a global scale. In order to achieve its overall goal, the Paris Agreement set a tangible goal of limiting the global temperature level to 1.5° Celsius (C) through the end of the century (Benjamin and Thomas 2016: UNFCCC 2020d). The Paris Agreement has brought considerable progress by acknowledging the disadvantages and detriments facing the LDCs and SIDS in respect of the moderately and fully industrialised countries.

Vulnerable groups, communities and ecosystems should maintain a priority when it comes to climate change adaptation. Advocating for SIDS and the 1.5 °C cap was the coastal developing state coalition, the Alliance of Small Island States (AOSIS). Their influence was prominent in shaping the aspirations of the Paris Agreement while ensuring the SIDS were continuously recognised. Since 2008, AOSIS advocated the '1.5 to stay alive' campaign created by the CCCCC (Sealey-Huggins 2017; Benjamin and Thomas 2016). The campaign was a call for the stabilisation of GHG emissions to prevent the global temperature from rising 1.5 °C over the current level (Sealey-Huggins 2017). In turn, this would create a manageable climate change temperature, thus allowing the LDCs and SIDS to adapt and build a resilience for future climate change events (Sealey-Huggins 2017).

The Paris Agreement's temperature goal will be determined by the efforts put forth by the parties' nationally determined contributions (NDCs) (Benjamin and Thomas 2016). According to Article 4.2 of the Paris Agreement, '*each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions*'. About 186 parties have submitted a NDC (and 3 of them a second one), which receive a review every 5 years according to Article 4.3 of the Agreement. The most effective method of achieving the temperature goal would be to implement low-carbon emission policies (Binsted et al. 2020). The NDCs are non-binding intentions, even though the parties are obliged to prepare, maintain and communicate their respective NDCs (Benjamin and Thomas 2016). Unlike the Kyoto Protocol that contained binding climate targets for parties, NDCs are merely intentions that lack accountability (Benjamin and Thomas 2016). Additionally, a party's NDC must meet the goals of the Paris

Agreement (Article 4.2 and 4.9 of the Agreement; NDC Registry 2020; Phillips and Koutouki 2019). However, some current NDCs are on track to a 2.7 °C temperature increase (Benjamin and Thomas 2016).

LDCs and SIDS, on the other hand, may '*prepare and communicate strategies, plans and actions for low GHG emissions development reflecting their special circumstances*' as stated in Article 4.6 of the Paris Agreement. Few Caribbean SIDS mention their integrated disaster risk policies and climate change adaptation in their NDCs, but the preservation of tourism is the main focus of the climate change adaption policies (Thomas and Benjamin 2018). Jamaica recently submitted a new climate change plan promising to 25.4% reduction of GHG emissions and a 28.5% with international support by 2030 as well as a 1.8 million-tonne GHG emissions reduction compared to its 1.1 million-tonne reduction in 2015 (Government of Jamaica 2020). Furthermore, Jamaica also implemented a COVID-19 Economy Recovery Task Force, in order to recover the economy faster and meet their climate adaptation goals (Government of Jamaica 2020).

Article 6 of the Paris Agreement promotes environmental integrity (Schneider and La Hoz Theuer 2018) by providing a voluntary mitigation and adaptation cooperation framework for the establishment of an international carbon market and mechanisms for sustainable development (Shuai et al. 2019). The carbon market would allow a trade of carbon emissions between countries (Kizzier et al. 2019). About half of the parties showed interest in using the carbon market frameworks to achieve their NDCs (Shuai et al. 2019), and there are different mechanisms for parties to choose (Kizzier et al. 2019). Article 6.2 provides a trade framework between two or more countries. For instance, if country A reduces their carbon emissions by half of what was pledged, but country B is exceeding their carbon emissions by 10% of what they pledged, country B can purchase emissions from country A (Kizzier et al. 2019). Trade credits outlined in a project-based framework in Article 6.4 (Kizzier et al. 2019). For example, if country A pays country B to build a renewable energy source, country A receives the credit for the carbon reductions in country B (Kizzier et al. 2019). A non-market based approach is provided in Article 6.8 which establishes work programmes with the aims of either promoting climate change education, technology transfer, and capacity-building measures (Phillips and Koutouki 2019). Developed countries can act on Article 6.8 by providing climate change aid, financial support (Article 9), technology transfer (Article 10) and capacity-building (Article 11) to LDCs and SIDS (Phillips and Koutouki 2019). Article 6.8 is an integrated and balanced approach that strengthens adaptation and enables more opportunities for coordination amongst parties and their various institutions (Article 6.8 of the Agreement; Phillips and Koutouki 2019).

SIDS and LDCs, vulnerable to the adverse effects of climate change and with significant capacity constraints are favoured to receive financial resources '*to achieve a balance between adaptation and mitigation, taking into account country-driven strategies, and the priorities and needs of developing country Parties*' as per Article 9.4. These countries are also provided with an '*efficient access to financial resources through simplified approval procedures and enhanced readiness support*' as underlined by Article 9.9. The parties agreed to the pursuit of equity and fairness acknowledging the '*common but differentiated responsibilities and respective capabilities*' while also acknowledging the various circumstances of different countries (Paris Agreement 2015).

Capacity-building under Article 11(1) is meant to enhance the ability, adaptation and mitigation for developing countries who are particularly vulnerable to the adverse effects of climate change. It should '*facilitate technology development, dissemination and deployment, access to climate finance, relevant aspects of education, training and public awareness, and the transparent, timely and accurate communication of information*'. The UNFCCC created the Paris Committee on Capacity-building (PCCB) to discuss current and developing inconsistencies in developing countries as well as the needs for implementing and further capacity-building (UNFCCC 2020b). Not all countries have the resources or support available to handle climate change challenges. Therefore, the Paris Agreement requested that developed countries provide and enhance the support for capacity-building for developing countries (UNFCCC 2020b).

Parties of the Paris Agreement are expected to be committed to minimising the adverse effects of climate change. Article 8 reiterates that global commitment and specifies the minimisation of loss and damage. SIDS and LDCs are particularly vulnerable to climate change events, such as floods, rising sea-level, and severe storms. Loss and damage arise from the negative effects resulting climate change events which have yet to adhere to adaptation and mitigation (Warner and van der Geest 2013) and Article 8.3 provides that these developing countries will receive cooperation, facilitation, action, and support in the event of loss and damage. The Warsaw International Mechanism for Loss and Damage is included in Article 8.2. Its inclusion was merely to be an immediate reference and guideline to recovering a loss and damage event (Mace and Verheyen 2016).

The transparency and support framework outlined in Article 13 provides enhanced clarity of the climate change actions implemented domestically and internationally which are contributing to goals of the relevant NDCs (Phillips and Koutouki 2019). Article 13.10 of the Agreement states that developing countries, like SIDS and LDCs, should provide information of the support needed and received in relation to the provisions of Articles 9–11. As Jones and Philips (2008) suggest risk assessments with localised and adequate data are necessary in order to '*determine the costs and benefits of adopting particular adaptation strategies along coastlines*'. The transparency provided by developing countries in relation to their NDC goals allows for developed countries to provide adequate support. A '*facilitative, non-intrusive, non-punitive manner, respectful of national sovereignty*' transparency framework is envisaged under Article 13.3 to '*avoid placing undue burden on Parties*'. Benjamin and Thomas (2019) point out that '*international financing to increase capacity within environmental and disaster-risk agencies*' but also finance departments or ministries is paramount.

The ability to adapt to climate change will build resilience and sustain civilisation. Local, national, regional and international legislation and regulation are working to implement adaptation and build more resilience. Vulnerable regions, like the Caribbean, cannot combat climate change alone, nor do they have the resources to put forth a valiant fight. The international unity of the Paris Agreement accentuates SIDS, LDCs, and their vulnerabilities by calling for an adherence to the 1.5 °C goal, and transparency of a Party's NDC. However, the voluntariness of NDCs and the market options for Article 6 permit countries to do the bare minimum for the fight against climate change. While the NDCs show a party's initiatives, they are non-binding and encounter no repercussions for failing to achieve their set goals. The non-market option of the carbon market makes it easy for parties to stay the course of education and emissions taxing, while the market options can permit a party to exceed its emission capacity by buying unused emissions credits from another. Although, the accountability of a party's agreement to the Paris Agreement has created a social and political pressure that urges governments to implement strict climate policies in addition to adaptation and capacity-building support for SIDS and LDCs.

3.3 The Blue Economy Strategy to Fight Against Marine Pollution in the Wider Caribbean Region

This section outlines the practical meaning of the Blue Economy concept and stresses its practical policy and legal implications. Economy means or what practical policy or legal implications for SIDS in the WCR. The World Bank's Marine Pollution in the Caribbean: Not a Minute to Waste Report (2019) suggests that investing in the transition to a '*Blue Economy*' and improving the use and management of marine resources in the Caribbean will provide more sustainable development and a thriving economic potentially having a positive impact on '*income growth, community development, environmental protection and poverty reduction*' for the WCR (Diez et al. 2019).

The term '*Blue Economy*' refers to a stable ocean economy and its greatest threat is pollution (Diez et al. 2019). The concept of the Blue Economy emerged at the United Nations Conference on Sustainable Development (UNCSD) Rio + 20 Summit in 2012, emphasising '*conservation and sustainable management, based on the premise that healthy ocean ecosystems are more productive and constitute a vital basis for sustainable ocean-based economies*' (UN DESA 2014) and working well with double focus of the Rio + 20 Summit (i.e. the green economy and the institutional frameworks: Information Committee (IOC) / United Nations Educational, Scientific and Cultural Organization (UNESCO), the IMO, the United Nations Organization for Agriculture (FAO) and the United Nations Development Program (UNDP)) (Silver et al. 2015). It is an evolutionary concept aimed at minimising waste as well as improving resource efficiency, human well-being and maritime security (Rahman 2017).

UNCLOS, which was developed on 10 December 1982 by the Cartagena Convention and its Protocols—the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES Convention). UNCLOS created obligations amongst its Parties to take action and prevent, control and reduce marine pollution (Diez et al. 2019). It is the most extensive global agreement on oceanic management that even extends to areas beyond the parties' jurisdiction (Diez et al. 2019). Parties are to enact legislation that is proportionate to the practice and procedures of UNCLOS (Diez et al. 2019). A partnership framework called SIDS Accelerated Modalities of Action (SAMOA) was established by the Third International Conference on SIDS between 1 and 4 September 2014 in Samoa with the aim of adopting '*measures to manage waste, and promote sustainable development of SIDS ocean-based economies for fisheries and aquaculture, coastal tourism, seabed resources, and renewable energy*' with a special focus on fighting marine pollution in its Article 58 (Diez et al. 2019).

The Blue Economy concept is deeply linked to the United Nations' Sustainable Development Goal (SDG) 14: Life Below Water (Attri and Bohler-Mulleris 2018). The SDGs are 17 UN guidelines, addressing challenges like climate change, poverty, peace, inequality, environmental degradation, and justice to create a sustainable future (SDGs 2020). The UN aims at achieving all 17 interconnected goals by 2030 (SDGs 2020). SDG 14 prioritises the ocean, marine biodiversity and their respective management, regulation, pollution and resources (UN DESA 2020). The Danish shipping industry has identified SDG 14, SDG 13 (Climate Action), SDG 8 (Decent Work and Economic Growth) and SDG 16 (Peace, Justice and Strong Institutions) as the top priorities for the shipping industry. International marine and coastal shipping trade have, perhaps, a deeper impact on the LDCs' ecosystems and marine resources due to pollution and spillages (Denmark, 2018).

The World Bank's report (2019) presents a 12-point action agenda focused on Caribbean SIDS aimed at contributing to the Blue Economy strategy for the wider region. The 2019 report introduces the measures to support the Blue Economy and contribute to a healthy, resilient and productive Caribbean Sea by assessing the costs of marine pollution through monitoring and economic evaluation. Educational campaigns are being carried out by NGOs and governments to raise public awareness on littering that ends up in waterways or along the coast of the Caribbean Region. The proposed 12-point plan provides the framework for finding solutions and preventative measures by means of policy reformation, analytics, public awareness and partnerships (Diez et al. 2019). Effective conflict resolution mechanisms should be made available in order to grant access to remedy for Caribbean coastal communities. A strong community-based management system and strong partnership with coastal communities following best practices and policies would clearly align with the 12 objectives set out by the World Bank. Preparedness and response mechanisms by local, regional and state authorities are equally important to effectively prevent marine pollution.

SIDS and LDCs have received ample acknowledgement and support in their fight against climate change. By means of national, regional and international regulations and policy implementation, the SIDS of the WCR are a top priority for creating a more sustainable world by 2030. Furthermore, the Blue Economy, SDGs as well as regional and international projects in the WCR are developing more climate change adaptation policies and strategies for Caribbean SIDS. The support received from developed countries are crucial to the SIDS' fight for sustainability, adaptation and their resilience to the adverse effects of climate change.

4 Governance Tools and Applicable Conventions in the Context of WCR and Its SIDS

This section introduces marine governance from an international and regional perspective. First, IMO's role on preserving the marine ecosystems of SIDS in the WCR as well as the Cartagena Convention and its Protocols is introduced. Second, regional institutions addressing governance in the WCR are analysed along with projects, plans and initiatives for a better climate change adaptation of SIDS within the region.

4.1 International Governance

An overview on international governance, stressing IMO's role in preserving marine ecosystems and fighting against climate change in SIDS of the WCR is introduced in this subsection along with the most important international instruments with a regional focus on the WCR.

4.1.1 IMO's Role on Preserving the Marine Ecosystems of SIDS in the WCR

As Cicin-Sain et al. (2016) proposed for UNFCCC COP 21, fisheries, tourism or infrastructures require an Integrated Coastal and Ocean Management (ICM) through institutional coordination, public engagement as well as science and policy interaction. Managing international and national MPAs would preserve marine biodiversity and improve marine ecosystems' resilience to climate change in line with the CBD's Aichi Biodiversity Strategic Goal C, Target 11 to conserve a minimum of 10% of the marine and coastal areas by 2020 (Cicin-Sain et al. 2016; UN 2010b). Under the Resolution MEPC.191 (60), the WCR is protected against waste ships by the Marine Environment Protection Committee (MEPC) of the IMO.

For many SIDS in the WCR, governance is ineffective, resulting in delays and inadequate policy implementation for climate change adaptation and mitigation (Scobie 2016). All Caribbean countries are IMO members, and the significant aspect of tourism in the WCR comes at a cost. In 2016, approximately 26.4 million tourists visited the Caribbean via cruise ships—amounting to a 30% increase from 2010 (Diez et al. 2019). A medium-sized cruise ship with a capacity of 3500 passengers produces 790,000 L of sewage, 500 L of hazardous waste, 95,000 L of oily water, 8 tonnes of rubbish and 3.8 million litres of grey water (Wan et al. 2016; Diez et al. 2019). Unfortunately, the WCR is ill-equipped and lacks adequate infrastructures to handle the sewage of incoming cruise ships (IMO 2016c; GEF-CReW 2020). Globally, ships add to ocean and sea pollution through waste from cargo accidents (UNEP 2016), the continued use of prohibited tributyltin (TBT) paints, and ballast waters disrupting marine species and their environments (Diez et al. 2019). As tourism in the WCR economy continuously grows and the climate change threat increases, the IMO has focused on marine safety and environmental protection for the WCR.

Shipping is the most regulated out of all marine activities (Diez et al. 2019), and compliance is expected from the industry for IMO port state controls relating to ship pollution (Mahon and Fanning 2016). The IMO is a global governance framework of the UN that is responsible for shipping and pollution from the shipping industry (Grip 2016). It is the objective of the IMO to protect the seas from pollution of industrial maritime activities (Grip 2016). The interviews carried out by Sciberras and Silva (2018) amongst the IMO's stakeholders at its headquarters suggest that the majority subscribed that the '*IMO is the de facto international regulatory authority for shipping*'. The study provides that the interviewees believe that the IMO can implement the 2030 Agenda in relation to maritime transport if resources are made available and Member States also take ownership (Sciberras and Silva 2018).

Regional implementation of IMO agreements is promoted by the UN Environment Programme (UNEP) Regional Seas Programme (Mahon and Fanning 2016; UNEP 1983). In 1973, the IMO adopted the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) in an effort to minimise ocean pollution. It encompassed pollution by oil spillage, dumping and air pollution and recognised the Caribbean as a special area (IMO 2010; UNEP/CEP 2011; Mahon and Fanning 2016). Another UNEP Regional Seas programme is the Caribbean Environment Programme (CEP), established along with an Action Plan in 1981, due to the need to protect the WCR's '*fragile and vulnerable coastal and marine ecosystems*' that includes '*endemic plants and animals*' (UNEP 2020b). An IMO Regional Maritime Adviser is located in Trinidad and Tobago (IMO 2020c). The Regional Maritime Adviser provides support for acts and regulations as well as executes the Integrated Technical Cooperation Programme (ITCP), which assists countries in their capacity-building and the implementation of IMO instruments for safe and secure shipping and maritime activities, international maritime traffic and environmental protection (IMO 2020b).

The IMO has received criticism regarding environmental impacts and shipping regulations (Parviainen et al. 2018), identifying its slowed or delayed ratifications (Lister et al. 2015) as well as its lack of enforcement of regulations ratified by Member States (Veritas 2014). Sciberras and Silva (2018) point out that the IMO should improve its '*regulatory framework to ensure a better global maritime transportation system*'. In response to this criticism, the IMO has committed its objectives to improving ship safety and reducing shipping's environmental impact (Parviainen et al. 2018).

4.1.2 The Cartagena Convention and Its Protocols

The 1983 Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention), ratified by 26 Contracting States, is a legal agreement for the protection of the Caribbean Sea (UNEP 2020d). Contracting States to the Cartagena Convention and Its Protocols have ratified UNCLOS and other international instruments, so they are bound by the obligations stemming from these previously ratified conventions. Contracting States will conclude regional or sub-regional, bilateral or multilateral agreements to protect the marine environment (Article 3(1)), within the reach of the 200 nautical miles of the Atlantic coasts of the signatory States. According to its Article 2(1), the Contracting Parties have to respect previous obligations assumed under agreements previously concluded as per Article 3(2), in accordance with international law. Present or future claims, as well as the legal views of Contracting Parties '*concerning the nature and extent of maritime jurisdiction*' are not precluded by the Cartagena Convention and its Protocols as stated in Article 3(3). Contracting State's obligations under Article 4 include assuming their obligations to '*prevent, reduce and control pollution from the Convention area and to ensure sound environmental management*', prevent pollution by implementing those measures, harmonising their policies, and cooperating with regional and sub-regional organisations to implement the Convention and its Protocols. In addition to preventing, reducing and controlling pollution from ships (Article 5), Contracting States should take the appropriate measures to prevent, reduce and control pollution from dumping (Article 6), from land-based sources (Article 7), from sea-bed activities (Article 8), air pollution (Article 9), and to protect and preserve specially protected areas (Article 10).

The Protocols providing technical support for the Convention related to Articles 5–10—Protocol Concerning Cooperation in Combating Oil Spills, Protocol Concerning Specially Protected Areas and Wildlife (SPAW), and Protocol Concerning Pollution from Land-Based Sources and Activities (UNEP 2020c). In addition to preventing multiple facets of pollution, Contracting Parties are required to also protect their own ecosystems and biodiversity as well as develop technical guidelines and plan for developed project assessments on environmental impact (UNEP 2020c).

Contracting Parties regularly meet once every 2 years and hold extraordinary meetings if necessary, to assess the implementation of the Cartagena Convention and its Protocols according to Article 16. Moreover, each party designates an appropriate authority that acts as a channel of communication with the Secretariat, according to Article 15. The Secretariat to the Cartagena Convention is hosted by the Caribbean Coordination Unit (UNEP-CAR/RCU). Coordination and implementation of activities related to the Cartagena Convention is carried out by the Regional Activity Centres (RACs) while the Regional Activity Networks (RANs) provide the Contracting States to the convention with scientific and technical support (Gonzalez and Hébert 2016).

The Cartagena Convention works in support of the IMO and its agreements for MARPOL 73/78, the International Convention on the Control and Management of Ship's Ballast Water and Sediment (BWM Convention) (2004), and the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972/1996) (UNEP 2020d). The BWM Convention has still not been ratified by all the States in the WCR, but many are now parties to that instrument: *Antigua & Barbuda, Bahamas, Barbados, France, Honduras, Jamaica, Mexico, Netherlands, Panama, Saint Kitts & Nevis, Saint Lucia*, or *Trinidad & Tobago* (Donohue 2017).

As Maruma Mrema (2016) points out, the Cartagena Convention Regional Coordination Unit (RCU) has four different RACs. The activities related to the Protocol on Cooperation in Combating Oil Spills. The Protocol aims to '*strengthen national and regional preparedness and response capacity of the nations and territories of the region*', as well as facilitating '*co-operation and mutual assistance in cases of emergency to prevent and control major oil spill incidents*' (UNEP 2020e). It is supported by the Assessment and Management of Environmental Pollution (AMEP) Sub-Programme that aims to reduce pollution, improve the assessment and measurement of pollution and share details of top management practices and technologies (UNEP 2020a). AMEP pertains to the Caribbean Environment Programme and is backed by the IMO-affiliated regional activity centre, the Regional Marine Pollution Emergency, Information and Training Centre—Caribe (RAC REMPEITC-Caribe), established in 1995 in Curaçao (Gonzalez and Hébert 2016). REMPEITC-Caribe assists the WCR states in implementing international conventions addressing oil pollution from ships and response by the development and assessment of national and multilateral contingency plans, training and workshops, scientific and technical assistance, consultancy, as well as information and public awareness (REMPEITC-Caribe 2020).

RAC REMPEITC-Caribe's activities are funded by the IMO, the UNEP and UNDP (REMPEITC-Caribe 2020) with the support of Curaçao, secondments from the US and France and temporary ones from the Netherlands and Venezuela (Gonzalez and Hébert 2016). However, there are many constraints to REMPEITC-Caribe's work, starting from the lack of contributions from Contracting States to the Cartagena Convention to accomplish the goals set by the convention to the absence of industry-sponsored secondments during the last years (Purnell 2018). The Caribbean Island Caribbean Island Oil Pollution Response and Cooperation Plan (OPRC) and the Central America OPRC Plan have been developed by REMPEITC-Caribe.

CIMAB/RAC, hosted by the Centre of Engineering and Environmental Management of Coasts and Bays located in Havana (Cuba), and the IMA/RAC, hosted by the Institute of Marine Affairs in Chaguaramas (Trinidad and Tobago) are both focused on the 1999 LBS Protocol on Pollution from Land-Based Sources and Activities by 15 Contracting States. SPAW/RAC, focused on the 1990 SPAW Protocol on Protected Areas and Wildlife that has been ratified by 17 Contracting

States, is hosted by the Ministry of Ecology in Guadeloupe (France). SPAW focuses on protecting marine areas, wildlife, as well as its ecosystem and species. Recently, the SPAW project on the Sargassum White Paper seeks to reduce Sargassum algae and seaweed from the WCR (UNEP 2020g). The algae discharges sulphur fumes which is harmful to human and animal health (UNEP 2020g; UNEA 2016). The Global Coral Reef Monitoring Network was created to support the International Coral Reef Initiative (ICRI) to improve scientific information and communication on the status of the coral reef ecosystems and harmonise monitoring efforts (UNEP 2016). The Global Coral Reef Monitoring Network (GCRMN) has regional networks in the Caribbean through the CEP (UNEP 2016).

A Regional Task Force on Control and Management of Ships' Ballast Water and Sediments in the WCR and El Salvador (RTF-WCR) was created in 2010, establishing a working group within the Regional Strategy to Minimise the Transfer of Harmful Aquatic Organisms and Pathogens in Ship's Ballast Water and Sediment. RTF-WCR is formed by *Antigua and Barbuda, The Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, France, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico* and the *Netherlands* (Donohue 2017). It was decided to review, amend and update the Action Plan for the CEP, and adopt the first State of Marine Pollution Report at the 18th Intergovernmental Meeting on the Action Plan for the CEP and 15th Meeting of the Cartagena Convention, which took place in Honduras, on 5 and 6 June 2019 (UNEP 2019c). However, a report on the Status of Plastics and Styrofoam Bans in the Caribbean was a topic of importance at the intergovernmental meeting (UNEP 2019b). It was also agreed at the intergovernmental meeting to increase the number of listed species to 256 and three new MPAs were added to the SPAW Protocol (Mount Scenery National Park and Saba Island in the Caribbean Netherlands, as well as the National Natural Reserve of Kaw-Roura and the National Natural Reserve of Amana in the French Guiana), accounting for up to 35 MPAs (UNEP 2019b).

The IMO has significantly helped to regulate ship pollution in the WCR by enhancing the implementation of the Cartagena Convention and recognising the WCR as a special area within MARPOL 73/78. In order to make governance more effective in the WCR, the IMO provided a regional advisor, both of which provide information, guidance, and support to UNEP and IMO Member States. The UNEP invoked four RACs to provide support, guidance and improvements to pollution in the WCR. Working in support of the IMO and its instruments, the Cartagena Convention created a legal agreement to protect the WCR amongst its Contracting States. Its institutions address marine biodiversity and wildlife protection and multiple pollution issues ranging from waste, oil and litter. The attention received by the WCR by the IMO will reduce the pollution in the WCR from the shipping industry. Each of these entities and their relative instruments and programmes have diminished the ineffectiveness of the WCR governance.

4.2 Regional Governance

The international framework with an specific focus on the WCR cannot be understood without a link to regional organisations that play a key role on the preservation of marine ecosystems in the region and the projects, plans and initiatives focused on fighting against the noxious effects of climate change.

4.2.1 Regional Governance in the WCR to Preserve Marine Ecosystems and Fight Against Climate Change

The transboundary living marine resources are the economic link of the WCR nations (Lausche 2008). Should the global temperature rise beyond the 1.5 °C threshold, the Caribbean will have to take immediate action to counteract the impending effects (Mycoo and Donovan 2017). By aiming to protect their ecosystem, its natural resources and the livelihood of its citizens, the WCR is an example of further cooperation between LDCs and SIDS for the benefit of their coastal communities.

In an effort to promote regional unity, cooperation and resolutions, Caribbean States created the Association of Caribbean States (ACS) at the 1994 Columbia Convention (ACS 2017; Singh 2008). In addition to establishing the Caribbean State consensus, the Caribbean States committed the ACS to the preservation of the ocean's environmental integrity (Singh 2008). Caribbean Sea Initiative UN General Assembly Resolution '*Towards the Sustainable Development of the Caribbean Sea for Present and Future Generations*' (Resolution 61/197, readopted as Resolution 65/155 on 20 December 2010) recognises that the Caribbean Sea has unique biodiversity and highly fragile ecosystems. Regional and international development partners are encouraged to cooperate in the '*development and implementation of regional initiatives to promote the sustainable conservation and management of coastal and marine resources*' (Article 1). Moreover, the document calls for efforts to preserve the Caribbean Sea for future generations, acknowledging that the Caribbean Sea is '*a special area in the context of sustainable development, including its designation as such without prejudice to relevant international law*' (Article 1). A call upon States to develop '*national, regional and international programmes to halt the loss of marine biodiversity in the Caribbean Sea*' is made, remarking the dangers that coral reefs and mangroves are exposed, by taking into consideration the CBD (Article 10).

Spanish-speaking countries founded the Central American Integration System (*Sistema de Integración Centroamericana* in Spanish, SICA)—adopted on 13 December 1991 with the signature of the Tegucigalpa Protocol, amending the Charter of the Organization of Central American States (*Organización de Estados Centroamericanos* in Spanish, ODECA) of 12 December 1962 that substituted the Charter of 14 October 1951 (SICA 2020). SICA is integrated by *Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama* and the *Dominican*

Republic. Its priorities are democratic security, prevention and mitigation of natural disasters and the effects of climate change; social integration, economic integration and strengthening institutions.

A Priority Agenda was set on 29 June 2017 in full alignment with UN's SDGs (SICA 2017). SICA's General Secretariat's Strategic Vision for 2017–2021 promotes '*an administration that promotes environmental sustainability and friendlier to the environment, through practices and regulations that promote environmental management systems*' (SICA 2018a). SICA's Action Plan for 2017–2021 (SICA 2018b) proposes to '*make the Region, through large integration projects, an attractive geographic space for foreign investment, motivating other countries to be partners in our development. This would produce direct benefits to the population, including the conservation of our environment together with the confrontation and mitigation of the effects of climate change*' (Specific Goal 2); to '*link the Central American Logistics Corridor project to the prevention of disasters caused by climate change and to the constitution of an "assistance and prevention fund" to assist vulnerable populations affected by these phenomena*' (Specific Goal 7) and to '*promote the sense of belonging of the SICA Region through education, guaranteeing the protection of the environment and the right to cultural diversity*' (Specific Goal 15).

The SIDS face challenges in terms of '*legislative and regulatory instruments that do not adequately address coordinated planning for Integrated Water Resources Management (IWRM), Sustainable Land Management (SLM) and biodiversity management*' (Granit et al. 2017).

The Caribbean Sea Commission (CSC), established in 1998 by the ACS, has adopted the Large Marine Ecosystem (LME) governance framework as its working model for regional ocean governance arrangements (Diez et al. 2019). It is the purpose of the CSC to mend disconnection between conservation and the legislative and executive governmental bodies (Fanning et al. 2013). LMEs are large coastal ocean areas which are in critical need of managing their ecosystem appropriate to sustain its vital marine life (Fanning et al. 2013). Countries who share transboundary LMEs have developed regional measurements to share marine resources (Fanning et al. 2013).

4.2.2 Projects, Plans and Initiatives to Address Climate Change in the WCR

The Global Environmental Facility (GEF) financially supports some of these regional initiatives by monitoring and assessing the productivity, pollution, fish and fisheries, socio-economy and governance of the LMEs (Fanning et al. 2013). Some of the regional or sub-regional projects, plans and initiatives for the WCR are included in Table 18.1.

In addition to the lack of environmental policy, SIDS in the WCR are impoverished, making it difficult to implement adaptation to climate change (Islam and Winkel 2017). In 2018, the poverty rate in the Caribbean was 29.6%, according to

Table 18.1 Projects, plans and initiatives in the WCR

Projects, plans and initiatives	Agency/partner	Specific information
The Caribbean LME Project (CLME+)	Implemented by UNDP and co-financed by GEF	The project runs between 2015 and 2020, and it focuses on the Caribbean and the North Brazil Shelf LMEs It aims to improve the knowledge and sustain the management of transboundary resources in the Caribbean, implement regional policy in the WCR and develop information procedures for future policy and decision-making in the WCR (GEF 2020a) Using an Ecosystem-Based Management (EBM), the CLME+ works to improve the management of WCR shared marine resources, like marine wildlife and their habitats, as well as pollution threats. It is the overall focus of the CLME+ to set up governance with a competency for transformation and adaptation, at both national and local levels (Fanning et al. 2013)
Caribbean Regional Oceanscape Project (CROP)	GEF funds the project through the World Bank	The project runs between 2017 and 2021 with an overall cost of around US$20.383 million (GEF 2020b) CROP is aimed at strengthening ocean governance capacity and marine geospatial planning while promoting sustainable economic development (OECS 2020; GEF 2020b) Its goal is the transition of the Caribbean towards a '*Blue Economy*' (OECS 2020)
Integrating Water, Land, and Ecosystems Management in Caribbean SIDS (IWEco)	Funded by the GEF and mainly implemented by UNEP in cooperation with UNDP The Secretariat to the Cartagena Convention, UNEP CAR/RCU and the Caribbean Public Health Agency (CARPHA) act as co-executing agencies	The project runs between 2016 and 2021 Antigua and Barbuda, Barbados, Cuba, Dominican Republic, Grenada, Jamaica, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines and Trinidad and Tobago participate in the project It is aimed at contributing to the preservation of Caribbean ecosystems for the sustainability of global livelihoods and improve the management of water and land resources (IWEco 2020)

(continued)

Table 18.1 (continued)

Projects, plans and initiatives	Agency/partner	Specific information
The Conservation Finance program (CFP)	The Caribbean Biodiversity Fund (CBF) with the financial support of Germany through the German Development Bank (KfW), The Nature Conservancy (TNC), as well as the GEF through the World Bank and the UNDP (CBF 2020b)	The Fund focuses on the conservation and effective management of biodiversity and natural resources The CBF Endowment Fund supports the CBF with approximately $US75 million It benefits partner national funds that disburse grant-making programs at sub-regional and national level. The latter can be supported by other partners (CBF 2020b)
The Regional Action Plan for Marine Litter (RAPMaLi) for the WCR	UNEP's Regional Seas Programme and UNEP Global Programme of Action. UNEP's Caribbean/Regional Coordinating Unit (UNEP-CAR/RCU) compiled and developed RAPMaLi in 2007 and commissioned the 2014 update (The Caribbean Regional Portal 2014)	Originally incepted in 2008 and updated in 2014 with 20 participating countries (RAPMaLi 2014) It focuses on marine litter and plastics pollution in SIDS with the aim of incorporating proper waste management across all sectors
The Global Partnership on Marine Litter Caribbean node (GPML-Caribe)	GPML is run by UNEP. GPML-Caribe is co-hosted by the Gulf and Caribbean Fisheries Institute (GCFI) and the Secretariat of the Cartagena Convention (UNEP 2020f)	The GPML, a multi-stakeholder partnership including actors involved in '*marine litter to share knowledge and experience to reduce the quantity and impact of marine litter*' in the WCR, was launched in Rio + 20 in 2012 The GPML-Caribe was established in 2016 to reduce '*the quantity and impact of marine litter in coastal zones in the WCR*' (UNEP 2020f) Governments in the WCR are committed to reduce plastic leading to a ban on single-use plastics in some countries, including plastic bags as well as Styrofoam Marine litter management is supported by RAPMaLI (UNEP 2020f)

Table 18.1 (continued)

Projects, plans and initiatives	Agency/partner	Specific information
The Implementing Sustainable Low and Non-Chemical Development in SIDS (ISLANDS) initiative	UNEP, UNDP, FAO and the Inter-American Development Bank	The initiative was launched in 2019. It involves 27 SIDS in an effort to tackle the management, disposal and elimination of toxic substances and pollutions in the Caribbean, the Pacific and the Indian Oceans The programme aimed at achieving these objectives by enabling environmental legislation and policy (UNEP 2019a)
Regional Clean Seas Campaign (#CaribbeanCleanSeas)	The Secretariat and the Gulf and Caribbean Fisheries Institute (GCFI) act as co-hosts of the Caribbean Node of the Global Partnership on Marine Litter (GPML-Caribe) in the WCR. The Caribbean Youth Environment Network (CYEN) also collaborates in the campaign (UNEP 2020d)	The campaign follows the Global #CleanSeas Campaign was launched by UNEP in 2017 to engage governments, society and companies in the fight against marine plastic litter focusing on the production and consumption of non-recoverable and single-use plastics. It was initially launched in Barbados, Grenada, St Kitts and Nevis, St Vincent and the Grenadines and Trinidad & Tobago The #CaribbeanCleanSeas Campaign is related to the International Coastal Cleanup (ICC) 2019 campaign (UNEP 2020d)
Caribbean Biodiversity Fund Ecosystem-based Adaptation (EbA)	Caribbean Biodiversity Fund (CBF), supported by Germany through the KfW and with the financial support of the International Climate Initiative (IKI) of the German Ministry of the Environment, Nature Conservation and Nuclear Safety (CBF 2020b)	The facility awards grants to organisations in beneficiary Caribbean countries to alleviate poverty and support climate change adaptation through biodiversity conservation and ecosystem management across the Caribbean (CBF 2020a) It manages around $50 US million and its sinking fund is aimed at awarding grants between 2018 and 2022 to support climate change adaptation and poverty alleviation through biodiversity conservation and ecosystems management in the Caribbean (CBF 2020a, b) Beneficiary countries eligible for Overseas Development Assistance (ODA) by the German Government are Antigua and Barbuda, Dominica, Dominican Republic, Cuba, Grenada, Jamaica, Haiti, Saint Lucia, and St Vincent and the Grenadines (CBF 2020a)

Source: Own elaboration based on data from the United Nations (2020) the Economic Commission for Latin America and the Caribbean (ECLAC). Poverty in the Caribbean has been linked to social, economic and environmental circumstances, which are all contradictory to sustainable development (Parris 2016).

Between 2010 and 2014, the EU contributed approximately US$190 million to Caribbean SIDS for climate change adaptation (Robinson 2018). The European Investment Bank (EIB), an International Financial Institution (IFI) owned by the EU Member States, has invested around €1.6 billion in the 15 Caribbean nations and 13 overseas countries and territories since 1978 (EIB 2016). It recognises that some of the Caribbean countries depend on tourism and lack economic diversification. An EIB report shows that the EIB has supported private sector development and basic infrastructure, but some of its priority action areas in the WCR include climate change mitigation and adaptation. Furthermore, the EIB agreed to increase the lending volumes in climate action from 25 to 35% in 2015 and is currently working with the United Nations' SDGs in mind, creating synergies for the benefit of the WCR (EIB 2016).

The WCR has aimed to protect their ecosystems by implementing a myriad of significant organisations with the objectives of implementing climate change adaptation policies or policy improvement for water and marine pollution. Each is committed to the protection of the SIDS in the WCR and preserving their marine biodiversity and ecosystems. These implementations have been a difficult challenge for the SIDS due to the poverty endured by the WCR. Poverty makes it more difficult to implement climate change adaptation policy. However, groups and regional governments like GEF and the EU have funded projects and adaptation policy implementations to help SIDS overcome climate change, strengthen their capacity, and build their resilience to future climate change events.

5 Reduction of Greenhouse Gas Emissions Related to Shipping on SIDS and the WCR

The aforementioned initiatives, adopted in the framework of international and regional governance within the WCR and its SIDS, have to be read in conjunction with other global initiatives adopted by the IMO to curve the levels of GHG emissions from shipping with a severe impact on marine ecosystems.

5.1 The Impact of GHG Emissions on SIDS and the WCR

GHG emissions are threatening the WCR. Burning fossil fuels, trees, waste and manufactured chemical reactions emits CO_2 into the atmosphere, which are the primary GHG emissions (EPA 2020). While CO_2 has a natural presence in the atmosphere, human activity is responsible for 81% of CO_2 emissions (EPA 2020). The more GHGs emitted into the air, the more solar radiation is trapped in the atmosphere which warms the earth (Metz 2012). This is known as the greenhouse gas effect (Metz 2012). Reducing the consumption of fossil fuels is the most effective way to reduce CO_2 emissions (EPA 2020). Sea warming causes sea levels to rise, reducing the land available for locals, agriculture and tourism. The WCR is particularly vulnerable because of the coastal land, settlements and geomorphology (Nicholls and Tol 2006; Vergara et al. 2013). Marine ecosystems in the WCR are very sensitive to environmental changes which can result in coral bleaching. Severe storms and their frequency in the Caribbean are also a consequence of climate change and creates great, flooding, property damage, land loss and marine ecosystem damage or loss (Vergara et al. 2013). Reducing the consumption of fossil fuels is the most effective way to reduce CO_2 emissions (EPA 2020).

5.2 IMO's Global Efforts with Regional Effects in the Caribbean to Reduce Emissions from Shipping

Market-Based Measures (MBM), a Roadmap, GloMEEP, the Global Maritime Network (GMN) and the sulphur cap are presented in this subsection followed by some conclusions to stress the importance of reducing GHG emissions with its potential benefits for LDCs and SIDS of the WCR in particular.

5.2.1 Market-Based Measures (MBM)

GHG emissions have a clear impact in the maritime ecosystem of the WCR and need to be addressed in a global scale, considering regional and national levels. In 2014, an IMO report discovered that the CO_2 emissions generated by the shipping industry was approximately 3.1% of global CO_2 emissions (Kontovas 2020). The IMO Assembly Resolution A.963(23), adopted in December 2003, which concerned '*IMO policies and practices related to the reduction of GHG emissions from ships*' has urged the MEPC to develop an action plan to limit or reduce international shipping GHG emissions, which would prioritise new technical, operational, and market-based solutions (Hughes et al. 2018). An MEPC working group was assembled to assess the impacts of international trade, LDCs, SIDS, environmental benefits and developing countries' maritime sectors for proposals from governments and organisations concerning Market-Based Measures (MBM) proposals (Hughes et al. 2018).

The proposed MBMs were to provide certainty for '*emission reductions or carbon price; revenues for mitigation, adaptation, and capacity-building activities in developing countries; incentives for technological and operational improvements in shipping; and offsetting opportunities*' by their proponents (Hughes et al. 2018). However, '*States with significant trading distances to market for their goods*' refrained from discussing MBMs and related issues until an evaluation of the impact at MEPC 65 (Hughes et al. 2018). At MEPC 62, the working group considered grouping the MBMs, their potential strengths and weaknesses, their impact as well as their relation to international Conventions (MEPC 62/5/1 Secretariat report of the third Intersessional Meeting of the working group on greenhouse gas emissions from ships), according to Hughes et al. (2018).

5.2.2 The Roadmap to Reduce GHG Emissions Related to Shipping

The IMO has made efforts to reduce the impact of emissions that cause the acidification of the seas, rising sea levels and worsening weather conditions. These will have an impact on the most vulnerable coastal communities of developing States and territories that are exposed to threats from climate change. These have to address the reduced competitiveness and the need to survive in a challenging globalised world. Although the Paris Agreement did not focus on shipping when addressing GHG emissions, the IMO has developed a Strategic Plan since its approval (IMO 2017). According to the '*Roadmap*' approved by IMO Member States in 2016, the initial strategy is due to be revised by 2023 (IMO 2020a). The Rules of Annex VI set up a global mandatory GHG emissions reduction regime (George 2019). The IMO approved the '*Roadmap for developing a comprehensive IMO strategy on reduction of GHG emissions from ships*' (IMO 2016d) in its MEPC 70. Amongst the steps taken to tackle GHG emissions, the IMO has promoted regulations of energy efficiency for ships in the MARPOL 73/78 Annex VI (Resolution MEPC.203(62)) as well as technical cooperation, technology transfer and assistance to all IMO Member States via the Integrated Technical Cooperation Programme (ITCP), the Global Maritime Energy Efficiency Partnerships Project (GloMEEP) or the Maritime Technology Cooperation Centres (MTCCs) (Resolution MEPC.229(65)) and fuel consumption data collection services for 5000+ tonnage ships (Resolution MEPC.278(70)).

The 2017 IMO Assembly adopted a strategic direction entitled '*Respond to Climate Change*'. The IMO also adopted on 13 April 2018 at the MEPC 72 an '*Initial IMO Strategy on reduction of GHG emissions from ships*' (IMO 2018). The Strategy envisages reducing carbon intensity of ships through the implementation of further phases of the Energy Efficiency Design Index (EEDI) for new ships, reducing CO_2 emissions by at least 40% in 2030 and 70% in 2050, as well as reducing annual GHG emissions by at least 50% in 2050 in comparison to 2008 and in line with the Paris Agreement temperature goals. The Amendments to MARPOL 73/78 Annex VI were the outcomes of MEPC 74 and will be proposed to be adopted in MEPC 75 (IMO 2019c). The IMO Resolution MEPC.323 set up new compulsory EEDI for certain types of ships such as containerships, gas carriers, general cargo ships and LNG carriers. The MEPC invited Member States through its '*Procedure for assessing impacts on States of candidate measures*', approved on 21 May 2019 (MEPC 74; MEPC.1/Circ.885), with the objective of reducing GHG emissions from ships as well as '*promote the consideration and adoption by ports within their* *jurisdiction, of regulatory, technical, operational, and economic actions to facilitate the reduction of GHG emissions from ships*' (IMO 2019b). Those could include but are not limited to the provision of: (a) Onshore Power Supply (preferably from renewable sources); (b) safe and efficient bunkering of alternative low-carbon and zero-carbon fuels; (c) incentives promoting sustainable low-carbon and zero-carbon shipping; and (d) support for the optimisation of port calls (IMO 2019a). The IMO 2019 Procedure for assessing impacts on States of candidate measures for reduction of GHG emissions from ship focuses on SIDS and LDCs by proposing a series of candidate short-, mid- and long-term measure (IMO 2019b). The MEPC 74 (IMO 2019c) pushed forward the establishment of a voluntary multi-donor trust fund for GHG. While MEPC 75 was postponed in March 2020 due to the COVID-19 pandemic (IMO Circular Letter No. 4220, 2020), its agenda includes plans for a further reduction in GHG emissions, capacity-building, pollution prevention and technical cooperation for marine environment protection (IMO 2019c).

5.2.3 GloMEEP and Global Maritime Network (GMN)

The IMO has approved two global partnership projects to support further technical cooperation, technology transfer and energy efficiency measures (George 2019; Hughes 2018). The need for technology transfer was restated in 'The Future We Want' document in order to implement UNCLOS and accomplish sustainable development (Salpin et al. 2016). The transition of the worldwide maritime transport industry towards a low-carbon future with improved energy efficiency is known as the Global Maritime Energy Efficiency Partnerships Project (GloMEEP). This supports '*the uptake and implementation of energy efficiency measures for shipping, thereby reducing greenhouse gas emissions from shipping*' (IMO/GloMEEP 2020), ocean acidification and local air quality. The initiative is backed by the GEF, UNDP and the IMO in '*building capacity to implement technical and operational measures in developing countries*'. It is executed by the IMO's Project Coordination Unit (PCU) established within its Marine Environment Division. GloMEEP provides for the implementation of legal, policy and institutional reforms, awareness raising and capacity-building activities and the establishment of public-private partnerships to support low carbon shipping. The Lead Pilot Countries (LPCs) for the GloMEEP project are Argentina, China, Georgia, India, Malaysia, Morocco, Philippines and South Africa. Furthermore, two countries located in the WCR are also part of the LPCs: Jamaica and Panama (GloMEEP 2020). GloMEEP is aimed at '*creating global, regional, and national partnerships [sic] and for countries to streamline this issue within their own development policies, programmes, and dialogues*' (Hughes 2018).

The GLoMEEP launched a Global Industry Alliance (GIA), a public–private partnership initiative under the auspices of the IMO with the aim of uniting maritime industry leaders to '*support an energy efficient and low carbon maritime transport system*'. The members of GIA are shipowners, operators, classification societies, engine and technology suppliers, big data providers, ports and oil companies. Such companies and corporations include ABB Engineering (Shanghai) Ltd., AP Møller–Mærsk A/S; Bureau Veritas, DNV GL SE; Grimaldi Group; Lloyd's Register EMEA, MarineTraffic; MSC Mediterranean Shipping Company SA, Panama Canal Authority, Port of Rotterdam, Ricardo UK Ltd., Royal Caribbean Cruises Ltd., Shell International Trading and Shipping Company Limited, Silverstream Technologies, Stena AB, Total Marine Fuels Pte Ltd. and Wärtsilä Corporation. GIA has identified some priority areas such as '*energy efficiency technologies and operational best practices, alternative fuels, and digitalisation*'. GIA is devoted to '*research and development; showcasing of advances in technology development and positive initiatives by the maritime sector; industry fora to encourage a global industry dialogue; and the implementation of capacity-building and information exchange activities*' (Global Industry Alliance 2020).

The Global Maritime Network (GMN), launched on 4 December 2017, is a 4-year project that gathers the Network of Maritime Technology Cooperation Centres (MTCCs) into a global network of centres of excellence in marine technology. The initiative is funded with €10 million by the EU and implemented by the IMO with the aim of reducing GHG emissions. These are focused on technical cooperation, capacity building and technology transfer (GMN 2019) to promote the apprehension of low-carbon technologies and maritime transport operations (Hughes 2018). It is formed by different networks—one of which being the MTCC-Caribbean. The GMN supports UN's SDG 13 (climate action), SDG 7 (affordable clean energy) and SDG 9 (industry, innovation and infrastructure) (IMO 2017). The selected five regions account for a large number of LDCs and SIDS.

5.2.4 The Sulphur Cap for the Reduction of GHG Emissions

GHG emissions created by ships also include sulphur oxide (SO_x). The 2014 IMO report also revealed that 13% of the global SO_x emission were generated from the shipping industry (Kontovas 2020). In addition to creating a GHG emission, the higher SO_x rate, the worse the air quality, which has devastating effects on human life (Larr and Neidell 2016). SO_x pollution can cause damage to the foliage of trees and plants, which stunts their growth and hinders their full potential for the production of oxygen and vegetative capabilities (EPA 2020). Short-term exposure to SO_2, for instance, can damage the respiratory system, which makes breathing difficult and cause lung disease (EPA 2020; IMO 2020d). In 2016, a Finnish study submitted to the MEPC estimated that continuing the current SO_x rate beyond 2020 would result in approximately 570,000 premature deaths globally between 2020 and 2025 (IMO 2020d). In 2008, the IMO recognised a study confirming that reducing sulphur levels in marine fuels could prevent 40,000 deaths per year. The same year, the MEPC introduced the Emission Control Areas (ECAs) to regulate the SO_x emissions (Kontovas 2020). The sulphur content of fuel depends on the sulphur content of the crude oil which makes the fuel.

It has been widely supported that a few ships using the maximum SO_x content emit as much damaging pollution as every car in the world using the cleanest fuel available (IMO 2020d). The EU Directive 2005/33/EC introduced a 1.5% maximum sulphur fuel content on passenger ships in EU waters. This was reduced to 0.1% when the directive was amended in 2012, but due to the lack of fuel available to comply with the requirement, it was postponed. A 2019 study conducted by Transport and Environment suggests that cruise ships emit 4–10 times more SO_x than all of the cars driven in Europe (Transport and Environment 2019). In 2020, the global standard of 0.5% will enter into force in EU waters—regardless of fuel availability (Mukherjee and Brownrigg 2013).

The study provided by Transport and Environment included an assessment of cruise companies docking in Europe, but majority of these companies are owned by Carnival and Royal Caribbean Cruises, which also travel to the WCR (Transport and Environment 2019; Carnival 2020; Royal Caribbean 2020). The crossover of this study provides an image of the SO_x emissions in the WCR. In order to control SO_x emissions, the IMO placed a global cap on SO_x emissions and proposed alternative fuels and exhaust cleaning systems (known as 'scrubbers') (Kontovas 2020). The IMO approved the first SO_x cap on fuel oils at 4.5% that entered into force with MARPOL 73/78 Annex VI in 1997. Furthermore, the limit was reduced to 3.5% in 2012. Recent developments have led us into a deeper understanding of the IMO's efforts to reduce GHG emissions. The MEPC decided to reduce the maximum sulphur fuel oil requirement from 3.5 to 0.5% on 1 January 2020 by modifying Regulation 14.1.3 of MARPOL 73/78 Annex VI during its 70th session between 24 and 28 October 2016 (IMO 2016a; Lloyd's Register 2018), thus reducing the global SO_x emissions cap to 0.10% (Kontovas 2020). However, there are SO_x ECAs in the Caribbean. These have provided for a sulphur cap of 0.10% since 1 January 2015 (StormGeo 2014; WestPandi 2013).

There are ways to refine oil for a 0.5% low-sulphur fuel; however, the availability of fuel is concerning, given the heavy funding needed and the delay it would cause (Mukherjee and Brownrigg 2013). However, the IMO has highlighted the benefits of introducing the new sulphur cap. It is envisaged that it will provide for cleaner air, reducing by 77% the SO_x emissions from ships; it has had a positive impact on human health, preventing premature deaths, cardiovascular, respiratory and pulmonary diseases; and it has improved fuel quality (IMO MEPC 2016b). It has been accompanied by guidance offered by the IMO to ship operators, shipowners and refineries (IMO 2018; IMO 2019). Flag and State control by each jurisdiction will allow the enforcement of the amended Annex VI to comply with the new requirements (IMO Sulphur 2020). BIMCO approved its '*BIMCO 2020 Marine Sulphur Content Clause for Time Charter Parties*' and '*BIMCO 2020 Fuel Transition Clause for Time Charter Parties'* to comply with the new limits set out by Annex VI (BIMCO 2020). Both clauses were published on 10 December 2018. Moreover, INTERTANKO (2019) equally made available the '*Bunker Compliance Clause for Time Charterparties*' in December 2018 (INTERTANKO 2018). Both would require bunker supplies to meet the imposed standards of the clause, therefore preventing the Charterer from a breach of MARPOL 73/78 Annex VI (INTERTANKO 2018).

5.2.5 Conclusions

The global effort to tackle GHG emissions is present in both the political and corporate realm. The IMO has heavily regulated the largest trade medium in an effort to reduce their GHG emissions, in addition to other pollution generated from the vessels. Member States were encouraged to implement similar regulation for incoming and outgoing ships. The creation of GloMEEP and GMN furthered technological transfers in addition to promoting low-carbon technologies and increased energy efficiency with corporate partnerships, thereby engaging in more proactive ways of reducing GHG emissions in order to combat climate change and preserve SIDS. The reduction of SO_x emissions reduces the dependency of fossil fuels and the impact on air quality, thus reducing the impact on plant life and human health (Larr and Neidell 2016). Since a large quantity of SO_x is emitted by shipping vessels, this is a challenge to the WCR, who is heavy reliance on tourism. The sulphur cap gives countries and industry a target for their air quality emissions, which urges industries to resort and progress to sustainable renewable energy. Alternative fuels may also provide a solution while the 0.5% sulphur fuel becomes more available. Where renewable energy is not present in the maritime sector, shipping vessels are required to meet bunker standards in order to prevent a breach of MARPOL 73/78 Annex VI for all parties involved in charterparty agreements. These reduction measures create accountability and have developed a sense of urgency in their implementation due to the detrimental effects of SO_x emissions on human life.

5.3 EU's Support to Reduce GHG Emissions

As previously stated, the EU supports and funds initiatives that combat the adverse effects of climate change in the WCR, which has a positive impact on SIDS and LDCs. The EU's role in international maritime affairs is reinforced by its support for fighting climate change, enhancing maritime policy and capacity building in SIDS and LDCs, '*marine biodiversity in areas beyond national jurisdiction*' and MPAs in the High Seas (European Commission 2007). The Commission will propose extending the EU Emissions Trading System (ETS) to the maritime sector and will end the free allowances allocated to airlines. The EU believes the Paris Agreement should be the fundamental multilateral framework to mitigate climate change and seeks establishing innovative forms of engagement. Around 80% of global GHG emissions come from the G20 Member States. For that reason: '*Stepping up the level of climate action taken by international partners requires tailor-made geographic strategies that reflect different contexts and local needs – for example for current and future big emitters, for the LDCs, and for SIDS*' (European Commission 2019).

The EU promotes cooperation on maritime affairs with the aim of bringing maritime affairs into the EU's agenda of cooperation with developing states, including SIDS (Power 2018). The EU is '*working with global partners to develop international* *carbon markets as a key tool to create economic incentives for climate action*' (European Commission 2019). In joint partnership with the IMO, the EU had initiated the Capacity Building for Climate Mitigation in the Maritime Shipping Industry which aspires to advance the energy efficiency of the maritime shipping industry as well as reduce GHG emissions (MTCC 2020). The EU intends to assist developing countries by capacity building initiatives and face other issues such as forced migrations and conflicts related to climate change by increasing climate and environmental resilience. The EU wants to share its successful expertise in environmental regulation by encouraging the adoption of a similar legal framework for facilitating trade, environmental protection and climate mitigation.

6 Final Remarks

Climate change and the effects of GHG emissions bring devastating threats and effects to SIDS in the WCR. Poverty, the increase of natural disasters, as well as air and water pollution have contributed to the degradation of the marine biodiversity in the Caribbean SIDS, which threatens a major contributor in their economy and GDP—tourism. Economically, SIDS have a heavier dependence on international trade, especially imports, thus making the economic structure of their countries more vulnerable to external factors. In order to ensure the survival of these SIDS, it is important that they adapt and build resilience to the adverse effects of climate change. This can be achieved by the implementation of climate adaptation laws in both developed and developing countries. Climate adaptation laws should be guided by science and foster the resilience of individuals, communities, nations and regions to readily respond and adapt to climate change. The ultimate goal is to build and sustain the ability to overcome the adverse effect of climate change.

Implementation strategies are key to successfully implementing appropriate climate adaptation policies, thereby building resilience to the adverse effects of climate change. Since climate change is experienced on a local level, regional and national adaptation guide implementations to be made at the local level. Policy recommendations from the UNFCCC propose an implementation of integrated coastal and ocean management institutions at every level, which effectively reduce the vulnerability of marine and coastal ecosystems and communities by building the management capacity, preparedness, resilience and adaptive capacity of coastal and island communities in close cooperation with disaster risk agencies and affected sectors and communities. The States and territories of the WCR have initiated regional instruments and organisations, such as IWCAM, CCCCC, and IWEco, with similar objective surrounding the most urgent issues that affect the coastal communities and marine ecosystems. The World Bank has rhapsodised the benefits of paving the way to more sustainable Blue Economy growth in the region with the aim of contributing to a healthy, resilient and productive Caribbean Sea. With the EIB and the GEF prioritising investments in areas such as the WCR, the adaptation of SIDS and the LDCs are being implemented and the threats of pollution and the continuous rise of sea levels are reducing.

The Blue Economy and the Paris Agreement have been a step forward in raising public awareness of the pollution and climate impact on the oceans, LDCs and SIDS. The evolutionary concept of the Blue Economy demonstrated the economic and global trade dependency on the ocean and the human life of the SIDS. Marine biodiversity protection and resilience of ecosystems to climate change are achieved by the creation of well managed networks of Marine Protected Areas in national and international waters. Due to the pressure of technical, financial and technological limitations, along with their geographical limitations, SIDS, LDCs and the WCR united with an advocation of the main concerns that affect the livelihood and well-being of their citizens at the UNFCCC COP 21. The Paris Agreement takes into consideration the limitations of SIDS and LDCs and broadens the scope in terms of capacity-building, technological and financial support, adaptation and mitigation actions designed to reduce GHG emissions and regulate the global temperature. Both the IMO and the UNFCCC have pushed forward an agenda to reduce the carbonisation of our atmosphere, our seas, and the trade industry. Land-, air-, and ocean-based pollution have a considerable impact on the LDCs that are most exposed to climate change and, more specifically, the SIDS. The carbon market introduced by the Paris Agreement allows for parties to trade carbon emissions or impose further restrictions and awareness in policy and decision-making bodies. The Emissions Trading System, representing the first and biggest carbon market worldwide, represents a landmark in reducing carbon emissions in the EU and drive the initiative to be followed by many non-European nations in order to reduce CO_2 emissions in the oceans. The non-binding NDC provisions in the Paris Agreement, however, cause scepticism about a more developed Party's commitment to the environmental sustainability outlined in the Agreement. Nonetheless, the carbon market of Article 6 and the developing countries support provisions of Articles 8–13 maintain a sense of accountability amongst the developed countries of the Paris Agreement.

With the ocean being recognised as the primary method of transportation for the trade sector, UNCLOS addresses the exploitation of available resources by coastal States including the obligation to control marine pollution from vessels by the contracting States which extends to areas beyond their natural jurisdiction. The Cartagena Convention provided a legal agreement to protect the Caribbean Sea and its marine ecosystems from pollution by its Contracting States and through its Protocols. The Cartagena Convention and its Protocols are supported and implemented by CEP regional programmes, while the IMO and its instruments are implemented by a regional advisor, who works with the Member States by providing data, information and support for new policies. The IMO, which is responsible for protecting the seas from shipping pollution, has made significant efforts in reducing GHG emissions from ships. MEPC 74 provided short- to long-term goals to further reduce GHG emissions while focusing on SIDS and LDCs. In addition to recognising the WCR as a special area, MARPOL 73/78, its Annex VI and other Conventions supplemented by MBMs, aimed at reducing GHG emissions from shipping at least by 50% in 2050, setting more stringent targets through the implementation of the EEDI for new ships. GloMEEP assists UNCLOS by creating global, regional and national partnerships coupled with the implementation of legal, policy and institutional reforms, raising awareness and capacity-building activities and the establishment of public–private partnerships. Moreover, GMN fosters technical cooperation, capacity-building and technology transfer to reduce GHG emissions through its networks. Furthermore, the sulphur cap has progressively reduced SO_x levels on fuel oils from 4.5% in 1997 to 0.5% in 2020. The WCR and its heavy reliance on tourism benefits greatly from SO_x reductions, which shows a positive effect for both the human health and the marine environment.

Finally, marine adaptation requires most developed countries, economic integration organisations, as well as national and local authorities to further assisting LDCs and SIDS in facing the most severe and adverse effects of climate change. It is scientifically proven that natural disasters and climate change are linked to GHG emissions, marine pollution and the overexploitation of natural resources. It requires that joining efforts to willingly draft new international, bilateral or multilateral instruments that can supersede the current legal framework in order to protect and support the SIDS and LDCs. UNFCCC and the IMO are of the most notorious institutions where these agreements can be reached. However, no international agreements are concrete. The US withdrawal from the Paris Agreement proves that the international community must remain vigilant about the future of the planet and further human impact. Funding and providing technology and technical transfer to LDCs and SIDS in the WCR will provide a better mitigation, adaptation and resilience strategies for these countries. GHG emissions and vessel sourced pollution require an ambitious agenda with tangible substantive agreements where their impact can be effectively reduced. The sulphur cap is one step further in that direction. GHG emissions should be subject to a dramatic reduction through both international CO_2 trading schemes and by adapting to carbon-free, Blue Economies, where alternative renewable green energies and technology can substitute fossil fuels. Our marine ecosystems and the planet yearn for a governance that takes effective actions to reach a stage where our communities, including the most vulnerable SIDS, can foresee and enjoy a better future—one in which the fight against global warming has been won.

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Chapter 19
Mind the Gap: Women in the Boardroom, on Board and in the Port

Aspasia Pastra and Mona Swoboda

Abstract Gender imbalance in the maritime sector is undeniable. The shipping and port sectors are one of the most male-dominated segments where stereotyping against women persists. Despite the initiatives that have been launched to promote career opportunities in maritime professions, women remain underrepresented both onboard ships and ashore. This chapter discusses the importance of female participation and gender diversity in the maritime and port industries. By highlighting the socio-economic and organisational benefits of increasing women's access, significantly to leadership positions and decision-making processes, this chapter offers an overview of recommendations to tackle the low representation of women and boost gender equality across the port and maritime sectors.

Keywords Gender diversity · Gender equality · Maritime sector · Women seafarers · Port sector

1 Introduction

Port and maritime industries are key facilitators in the global supply-chain, moving up to 90% of world trade (UNCTAD 2019). As trade facilitators, industrial actors and providers of substantial employment, they connect logistics, information and business and become drivers for socio-economic development. Maritime and port operations are fundamental to economic growth and social prosperity, and their scope of influence may significantly shape the societies in which they operate.

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While the need for gender diversity has long been recognised across sectors, women are still under-represented in political and economic leadership (UN 2020). However, their full participation in leadership and decision-making processes is key in boosting socio-economic prosperity. Per the United Nations Industrial Development Organization (UNIDO 2020), 'global gross domestic product could increase by more than 25% by 2025 if women played the same role in the labour market as men'. Promoting gender equality and diversity not only brings financial benefits, societies with greater levels of women's participation are more peaceful, prosperous and sustainable (UN 2020). Thus, empowering women to become central actors with economic, social, and organisational agency must be at the core of the twenty-first-century development strategies.

2 Women in the Boardroom

Although women have risen to key positions globally, including CEOs of the world's leading IT companies, the under-representation of women executives remains a hot subject of controversy, and extensive global discussions and political interventions are taking place to raise the number of women in leadership positions.

A 'board of directors' is the upper-level group of executives elected by shareholders for the strategy and the management of the company's operations. The need for better inclusion of women on the board of directors of listed companies has compelled many counties to take action, from soft initiatives to mandatory quota measures. In 2006, Norway implemented the most drastic measures, introducing a 40% female quota for boards of directors of publicly listed companies. Despite quota advocates claiming that gender equity must be fostered, this legislation received a lot of criticism, suggesting that it undermines the rights of employers. Moreover, Coate and Loury (1993) state that if highly qualified women cannot be established for an appointment, gender quotas may be adversely affected. This could result in lower selection standards, derogatory stereotypes, lack of merit and the recruiting of women who may not have the skills required for a particular position. Some other European countries, such as Iceland and Spain, have also adopted this type of quota regulation, while others have instituted voluntary measures, such as the United Kingdom. The female representation on boards varies across countries, as diverse institutional factors contribute to different national policies (Iannotta et al. 2016; Mensi-Klarbach et al. 2017), making it challenging to take a homogenous direction. Nevertheless, most European countries have established Corporate Governance Codes, including recommendations on the composition of the board, such as increasing the number of non-executive and independent directors and separating the roles of Chairperson and CEO.

Organisations have taken a variety of initiatives to address gender diversity, and some promising findings are starting to appear. For reference, the 2019 Board Monitor study by Heidrick and Struggles found 38% of board seats occupied by women relative to 37% for boards of European public companies in 2017. Deloitte

Global's sixth version of Women in the Boardroom (2019), covering 8648 organisations in 49 countries, showed that women occupied 16.9% covering board positions globally, a 1.9% rise from 2017. Nevertheless, the report found that women represent only 4.4% of CEOs worldwide. Moreover, studies, such as the Female FTSE Board Report 2019 from Cranfield University, suggest that efforts in the field of gender diversity need to increase. While the percentage of women on FTSE 100 boards rose from 29 to 32%, and on FTSE 250 boards from 23.7 to 27.3%, further significant results, that may indicate a trend, are anticipated in the coming years.

Efforts have also been made to raise awareness on gender issues in shipping and the growing presence of women seafarers, but still, the appointment of women to the boards of shipping companies is considerably low. The Hellenic Observatory of Corporate Governance (HOCG 2017) study evaluated the boards for Greek-owned listed firms in global stock exchanges from 2001 to 2017. The study found that 352 (95.1%) of the 370 directors were male, while there were only 19 female directors (4.86%). During the same period, only one woman became the Chairperson and CEO of four separate shipping firms, which favoured the duality structure for their governance. Between January and December 2017, there were just 15 female board positions available in the board of directors of the 25 public firms active in 2017, which were held by 12 women, one being the Chairperson and CEO of four different organisations. The research reveals that, despite the efforts initiated by certain countries, organisations and sectors, female representation of women in leadership positions remains far from a desirable level in the shipping industry.

Another study that confirms the low representation of women in leadership positions is that of Spinnaker Global (2019), finding that only 35% of 25,000 shore-based maritime positions are appointed by women, out of which 76% of them worked in administrative, junior or professional level roles. Only 0.17% of women have been appointed on the Executive Leadership Team.

2.1 Need for Gender Diversity in the Boardroom

There is a greater need for companies to increase the diversity of their boards and to integrate talent, expertise and insight from the labour market as a whole. Literature (Dalton et al. 1999; Hillman and Dalziel 2003) has illustrated the advantages of a diverse board in terms of the attributes and demographics of the organisation's performance. The valuable benefits of having women on boards are reflected in the value and financial performance of the firm (Apesteguia et al. 2012; Bonn et al. 2004; Campbell and Minguez-Vera 2008; Croson and Gneezy 2009; Carter et al. 2003; Erhardt et al. 2003; Gordini and Rancati 2017; Gul et al. 2013; Post and Byron 2015; Reguera-Alvarado et al. 2017; Torchia et al. 2011). Research, such as that by Gordini and Rancati (2017), reveals that gender diversity has a favourable impact on financial performance as measured by Tobin's *Q* ratio. In this context, the shipping community must take the large body of research, conducted over the last two decades, into account to understand the potential organisational benefits that stem from women's participation in upper echelons positions. Nonetheless, it can also be noted that a few studies do not observe any substantial correlation between performance and board representation (Carter et al. 2010; Miller and Triana 2009; Rose 2007) or any connection whatsoever (e.g., Adams et al. 2009; Darmadi 2013; Haslam et al. 2010).

Notwithstanding the potential benefits for the organisation's financial and operational performance, there is clear proof that gender diversity in the boardroom is of utmost significance as diverse stakeholders with specific expectations and skills are being represented (Harjoto et al. 2015). Women's risk aversion (Croson and Gneezy 2009; Post and Byron 2015; Vandegrift and Brown 2005; Wei 2007) enables them to devote more time to the monitoring role of the board and, through their expertise and abilities, can boost the efficiency of the board (Dunn 2012). Gender-diverse boards engage in less fraud and financial manipulation (Wahid 2019). Scholars have also documented that female leaders are stronger advocates than men of corporate social responsibility (CSR) in several parameters, such as broader community engagement, superior environmentally sustainable practices and enhanced corporate governance (Cook and Glass 2018). The diverse decision-making cognitive processes between men and women (Hillman 2015) can contribute to more robust strategic decision-making. In addition, the 2018 Deloitte research reveals that corporations with an inclusive environment are considerably more inclined to be innovative (Bourke and Dillon 2018), building an environment that promotes teamwork and utilising technology to break boundaries and generate innovation.

It is evident from the latter that women can break existing barriers and make significant contributions to the various areas of the shipping industry, where specialised expertise is required. Increased participation of women in shipping could lead to a considerable positive impact on the industry in the fields of economics, finance and maritime law, as well as on the dynamics of decision-making.

Placing just one woman on the boardroom will not lead to the desired benefits outlined. What is needed are at least three women to build a critical mass. The positive impact on the organisational outcomes and firm innovation is evident where there are three or more female representatives on a board (Campbell and Minguez-Vera 2008; Cook and Glass 2018; Konrad and Kramer 2006; Joecks et al. 2013; Torchia et al. 2011). Critical mass theory pursues to detect the representational thresholds needed to affect policy and organisational outcomes, and according to Dahlerup (1988, 2006), this number has been set at a minimum representation of 30% if women are going to achieve substantial impact on policies. Although three or more women on a board could create such a critical mass, the reality may be different. For instance, the study of Brieger et al. (2019) found that 91.3% of the 6390 sampled firms in 30 countries have none, one or two female directors in the board. These discouraging figures do not enable women to influence board processes, discussions and performance and suggest the pressing need for industries to re-evaluate the diversity of their boards.

3 Women Seafarers and the Way Forward

Seafaring has been a predominantly male industry, and the promotion of women's participation in the profession is low. The International Transport Workers' Federation (ITF) (2020) estimates the representation of women at around 2% of the global maritime workforce, and in Maritime Education and Training (MET) institutions, only a small percentage of women begin and complete the program (Barahona-Fuentes et al. 2020).

Key reasons behind the low representation of women on board the vessels are prejudice and discrimination in recruitment and employment of seafarers by the shipping companies, along with traditional societal values that exist in society (Zhao et al. 2017). Significantly, sexual harassment on board—which may range from physical and verbal to non-verbal forms—is another thorny issue as there is lack of access to confidential reporting mechanisms (Carballo Piñeiro and Kitada 2020).

A shift from the current working environment to a more inclusive and more desirable one for women requires multilevel efforts in policy and practice from many key stakeholders. For example, at the national level, maritime policymakers must include gender equality policies for the recruitment and employment of women in governmental programmes for education and training of seafarers. At the industry level, crew managers should be better trained to allocate women aboard in groups rather than as single woman crew member (Zhao et al. 2017), as well as establish discrimination and sexual harassment reporting instruments.

In the light of the challenges women face in the maritime industry, and aiming to provide a space for the exchange of information, resources and experiences, the World Maritime University (WMU) organised the WMU Empowering Women in the Maritime Community Conference in 2019. Female participants from more than 70 countries gathered to address the gender gap in the maritime, oceans, ports and fishing sectors. Among others, the Conference identified the following recommendations to promote gender diversity in the sector:

(a) *National level gender-responsive policies, frameworks and platforms to promote gender equality;*
(b) *Young women should be motivated to pursue a long-term career in the maritime sector;*
(c) *Creating awareness for girls in primary and secondary education of career opportunities in the industry;*
(d) *Role models to motivate women in the seafaring profession;*
(e) *Social media platforms should be utilized to promote the industry and seafaring profession;*
(f) *Promotion of the significant economic contribution of women in sea-related activities.*
(g) *Capacity building through education and training initiatives for women;*

(h) *Shipping companies must provide proper working and living conditions on board ships and create benefits that make life on-board compatible with family life; and.*
(i) *Equal employment opportunities and pay scales from shipping companies between men and women.*
(EWMC 2019)

4 Women in the Port Sector

While women represent only 2% of seafarers worldwide, the 2019 United Nations Conference on Trade and Development (UNCTAD) Review of Maritime Transport finds that their representation in the port industry is greater, with 16.8% globally. However, these numbers are still low, especially considering the broad and multifaceted working environment ports offer. While the global average of female representation in port management positions of 34% is somewhat promising, a more informed look at the 2019 UNCTAD data shows that women only represent 12.1% and 5.1% of operations and cargo-handling personnel, respectively. These findings suggest that they continue to face significant barriers that prevent them from fully participating as professionals in the sector.

Ports are integral to the global supply chain. Depending on the region, they can move up to 95% of exports (ECLAC 2019). However, port activities expand beyond the transportation of goods and passengers. As multi-stakeholder environments, they can integrate services, such as auxiliary services, including warehousing and custom clearance, (cruise) tourism, cargo, infrastructure and connectivity with the hinterland (Dwarakish and Salim 2015). Whether they are privately operated or government entities, ports play a significant role in formulating and implementing national, regional and international regulatory and legislative frameworks that range from security protocols and safety compliance to labour and environmental policies, among others. This complex multi-purpose characteristic makes ports a diverse, attractive and sometimes challenging working environment.

Improving the gender ratio of port employees in operational and managerial functions is both fundamental to promoting equality and women's empowerment and the competitiveness and efficiency of the industry. A 2016 Organization for Economic Co-operation and Development (OECD) publication highlights that greater levels of female leadership and decision-makers in business result in higher rates of industrialisation and social prosperity with significantly faster and more sustainably growing economies (OECD 2016). Even though there is a lack of industry-specific research to fully translate these findings into the port sector, the OECD publication strongly supports the assumption that ports and port-related businesses with more female personnel across all segments of the workforce will perform better than those with fewer women.

Data collection and gathering of relevant information on women's access to careers and promotions in the port sector are crucial to understanding the implications women's underrepresentation has for the industry's competitiveness. In order for port authorities and businesses to create a framework for the implementation of systemic strategic actions that increase female representation, they must first identify existing gaps and opportunities for improvement in their gender equality approach (IMO 2020). Through quantitative and qualitative assessments of female representation in their organisations, decision-makers can establish a baseline to help attract and harness female talent and provide better access to industry fields previously not (easily) accessible for women.

In its 2020 Report, the International Association of Ports and Harbors' (IAPH) World Ports Sustainability Program (WPSP) presents a focused actionable roadmap on how to effectively attract more women to pursue careers in the sector. Ranging from basic requirements, such as appropriate lavatories for all genders in port facilities, to more in-depth measures, including promotional campaigns, remuneration and hiring policies that consider gender components, significantly in operations and cargo-handling, WPSP names inclusive port governance and practice as integral to facilitating women's full potential as key actors in the port sector (WPSP 2020a, b).

One of the main challenges women in the port and maritime industries face is the acquisition of technical skills and capacities that enable them to attain high-level operational and decision-making positions within their organisations. Gender-specific education and training not only help build a more diverse pool of human capital but also lead to more empowered female port officials with robust technical and managerial skillsets. Accordingly, international associations, including IAPH, as well as regional port organisations, such as the Organization of American States' (OAS) Inter-American Committee on Ports (CIP), are paying special attention to providing gender-specific capacity building and training opportunities. The IAPH Women's Forum Ports Mentoring Program, launched as a pilot in 2019, offers an online mentor–mentee communications platform for women in the port industry to connect with both female and male senior-level mentors for educational knowledge-sharing purposes (IAPH 2020). Aiming at providing relevant educational resources, significantly in more male-dominated fields such as harbour master and pilotage, the programme also offers an important source for networking and relationship-building among participants (WPSP 2020a, b).

Bringing together the national port authorities of the 35 sovereign nations of the Western Hemisphere to facilitate competitive, sustainable, secure and inclusive port development in the Americas, the CIP became the first hemispheric port organisation to integrate gender as a cross-cutting mandate in its plans of action (CIP 2007). First establishing an Executive Subcommittee on the Participation of Women in Hemispheric Port Matters in 2005, the CIP later elevated gender-specific industry matters as one of the CIP's six priority areas under the Technical Advisory Group (TAG) on Social Responsibility, Gender Equality and Empowerment of Women. In addition to fostering port policy dialogue on gender equality, including changes in working practices, in biennial Hemispheric TAG Conferences, the CIP aims to tackle the sector's gender gap by strengthening technical capacities through gender-specific scholarships, such as in collaboration with the IMO, the port of Le Havre and the *Institut Portuaire d'Enseignement et de Recherche* (IPER). In 2019, the CIP sponsored over 100 female port officials from 22 countries to attend technical hemispheric conferences and seminars and awarded 17 scholarships for training courses, including port management, security, legislation and logistics, to women in the region's port sector.

Human and institutional capacity building is at the core of any industry. As the port and maritime sectors become more technology-reliant, through the establishment of integrated data-sharing and communication platforms, such as Port Community Systems, the development of new skillsets is fundamental (CIP 2019). Digitalisation and automation processes towards a *smart* port sector require stakeholders to redefine requirements, roles and responsibilities within the port workforce. According to the 2019 UNCTAD Review of Maritime Transport, this trend towards a more automated and less manual-labour-dependent industry, such as through automated cargo-handling, brings with it an opportunity to attract more women to pursue careers and may boost gender equality.

In order to maximise their modernisation efforts, port decision-makers and policymakers must provide equal opportunities to participate in modernisation processes through sound, inclusive strategies. When understanding female participation as vital to the sector's performance, the formulation of guidelines and policies to facilitate and amplify women's access becomes more effective. Taking advantage of all human capital without discrimination can enhance port and port-related business as it will expand their talent and resource pool, making the port sector a more competitive industry.

5 Conclusion

Despite the organisational benefits increased levels of women's participation bring, they are still under-represented on corporate boards (Terjesen et al. 2015; Labelle et al. 2015; Dezső et al. 2016). This chapter highlights that female board recruitment has been very slow and that women are not appointed easily to leadership positions, such as CEO or Chairperson. According to Gregorič et al. (2017), one of the main reasons is that, throughout the years, recruitment practices have become institutionalised, putting the control of upper-echelon positions into the hands of a small elite of demographically similar persons. A departure from the current practices would require a drastic transformation of the institutionalised patterns of selecting directors, an issue that implies a cultural change within organisations.

In seafaring, women are a minority group. In order to attract more women into the maritime workforce, policymakers and civil society actors should promote women's empowerment and motivate them to achieve greater professional opportunities. Policies that build capacity and enhance the educational background of women in the maritime sector can foster equality in both business and society.

Furthermore, appointments of women in leadership positions and the establishment of quotas should be encouraged.

As port and maritime industries continue to modernise their processes, operations and management, decision-makers are presented with an opportunity to facilitate women's integration in a more effective manner (UNCTAD 2019). The sound evidence of the organisational benefits of gender equality in businesses can serve as an important baseline for leadership in the design and implementation of more inclusive business plans. International and regional associations, such as IAPH and the CIP, have identified capacity building and the development of sophisticated technical skillsets as integral to any port- and maritime-related organisation in the context of modernisation, especially for the empowerment of women in the industry. Organisations, such as WISTA, promoting women at the management level in the maritime, trading and logistics sectors, as well as the IMO, in support of its Member States' efforts to achieve Goal 5—'Achieve gender equality and empower all women and girls'—of the UN 2030 Agenda for Sustainable Development, play a significant role as industry experts in developing direct strategic actions that can empower women in the sector. As digitalisation and automation trends will continue to shape the industries' future, stakeholders will have to redefine their workforce's responsibilities, skills and training needs. When this is done in an integrated and inclusive manner, port and maritime industries can become a more attractive, accessible and empowering working environment for women and with greater levels of efficiency (WPSP 2020a, b).

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Chapter 20
Maritime Governance and International Maritime Organization Instruments Focused on Sustainability in the Light of United Nations' Sustainable Development Goals

Anastasia Christodoulou and Jonatan Echebarria Fernández

Abstract Maritime transportation is the most international industrial sector with maritime governance at all dimensions—legislative, institutional and executional—exercised by the International Maritime Organization (IMO), a specialised United Nations (UN) agency, responsible for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. The IMO has adopted a number of instruments to enhance safe and secure maritime transportation and reduce the risk of environmental pollution since its existence. In the light of the UN Sustainable Development Goals (SDGs), the IMO has developed seven strategic directions (SDs) under its Strategic Plan for the period 2018–2023, in order to facilitate the achievement of its vision statement that includes the need for the maritime industry to meet the 2030 Agenda for Sustainable Development. At the regional level, the European Union (EU) is an example of maritime governance, environmental protection and fight against marine pollution that also works towards the achievement of the UN SDGs. This chapter is an attempt to highlight maritime governance instruments focused on sustainability in the light of the UN SDGs. IMO and EU instruments related to safety and security, environmental protection, the human element and technical cooperation are analysed in this chapter and linked to the UN SDGs.

Keywords International conventions · Marine safety and security · Marine environment · Human element (HE) · Technical cooperation · European Union

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1 Introduction

There are many distinct definitions on governance varying from 'building consensus to carry out a programme when there are many different interests at place' (de Alcántara 1998) to 'the sum of the many ways public and private institutions manage their common affairs' (Commission on Global Governance 1995). According to the Commission on Global Governance (1995), governance is the process of co-operating and accommodating conflicting interests and includes both formal institutions and informal agreements among the interested parties. The International Maritime Organization (IMO), a specialised United Nations (UN) agency, is a key figure in the ocean management and governance at the legislative, institutional and implementation mechanism dimensions since 1948. It is a relevant source of international maritime law with the objective of implementing methods to provide safe, secure and efficient shipping on clean oceans at various levels (Pace 2018). The IMO has received criticism of its lack of assertiveness, but it has been able to hold various maritime administrations accountable by imposing laws, directives, guidelines and recommendations (Mukherjee and Brownrigg 2013a).

The IMO has introduced the concept of sustainable maritime transportation since the Rio + 20 Summit, providing assistance to its Member States in the formulation of national maritime transport policies (NMTPs) since 2015 and imposing them a compulsory IMO Member State Audit Scheme (IMSAS) since 2016 (Pace 2018). The latter—also known as 'the Framework and Procedures for the Audit Scheme' or the III Code—consists of a rendition of Article 94 of the United Convention on the Law of the Sea (UNCLOS) of 1982 included with IMO convention requirements, with the purpose of protecting sea life and fighting marine pollution (Barchue 2018).

After the adoption of the 17 UN Sustainable Development Goals (SDGs) as part of the 2030 Sustainable Development Agenda in 2015, the IMO has started working towards the fulfilment of these goals (UN 2015; IMO 2017a; Sciberras and Silva 2018). IMO's commitment to the implementation of the 2030 Agenda for Sustainable Development is stated in the vision statement of its Strategic Plan for the period 2018–2023 (Resolution A.1110(30); IMO 2017c), where the IMO undertakes the leadership role to address the challenges of continuing technological developments and world trade and the need to meet the 2030 Agenda for Sustainable Development. In this direction, the IMO makes the commitment to provide support to Member States for the implementation of the 2030 Agenda for Sustainable Development, while reviewing and developing instruments that address emerging issues. There are seven strategic directions (SDs) under the Strategic Plan for the Organization for the period 2018–2023 (Resolution A.1110(30); IMO 2017c) to facilitate the achievement of its vision statement, illustrated in Fig. 20.1.

All SDGs are relevant to international shipping due to its indispensable role in global trade and sustainable economic growth (Wang et al. 2020; Lister 2015). According to Benamara et al. (2019), the sustainable development of the maritime industry is directly linked to the adoption of the UN SDGs, and at the same time, the

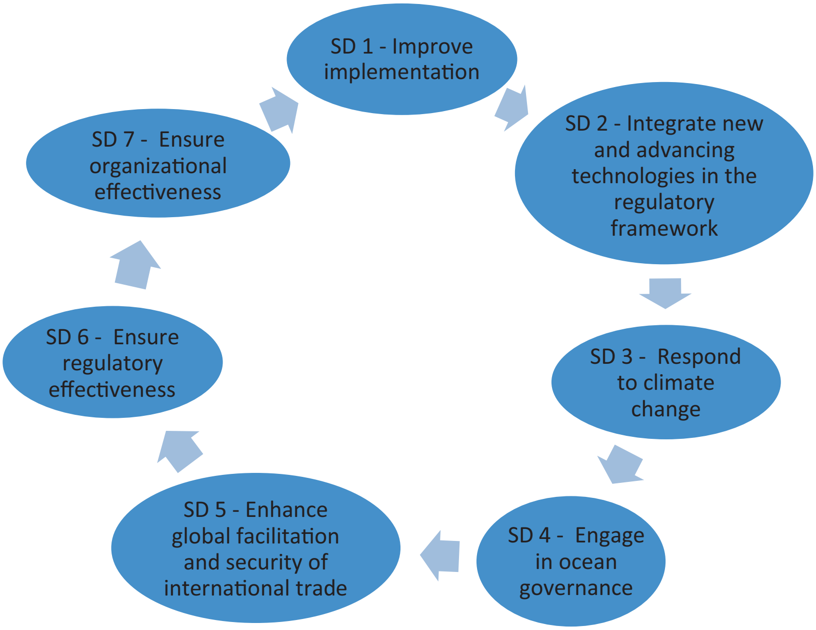

Fig. 20.1 Strategic directions under IMO's Strategic Plan for the period 2018–2023. Source: Resolution A.1110(30) (IMO 2017c)

SDGs provide the international framework that leads to sustainable maritime development. Although there is no explicit link of the IMO's work to the SDGs, except from the recent Initial IMO strategy on the reduction of greenhouse gas emissions from ships, many IMO international conventions and regulations adopted over the years can be related to the achievement of SDGs. As indicated by Wang et al. (2020), the contribution of shipping is not the same to all SDGs; instead, the focus lies on certain SDGs related to safety, security, environmental protection and technical cooperation in the maritime industry.

Apart from contributing to SDG 14 concerning the conservation and sustainable use of the oceans, seas and marine resources, IMO's work has been focusing on a number of SDGs. The adoption of regulations targeting the abatement of greenhouse gas emissions from shipping and promoting energy efficiency improvements are linked to SDG 7 (sustainable and modern energy for all), SDG 9 (building resilient infrastructure and fostering innovation) and SDG 13 (urgent action to combat climate change). Good health and well-being (SDG 3) are promoted through international regulations for the reduction of local air pollutants from shipping in the port and coastal areas as they are linked to health problems of the nearby populations. International safety and security regulations contribute to sustainable economic growth (SDG 8) and conservation of the oceans and marine resources (SDG 14) and concern pollution from crude oil and chemical substances in addition to dealing with piracy and armed robbery. Global partnership for sustainable development (SDG 17) is a core priority of the IMO that lies on technical cooperation for the effective implementation of the maritime governance instruments across the globe.

As Sciberras and Silva (2018) point out, the main challenge in terms of technical cooperation lies with the need for Member States to propose how the IMO through its programs and initiatives can fulfil 'the 2030 Agenda and the SDGs in a balanced and integrated manner' considering the economic, social and environmental dimensions of sustainable development. According to the IMO's overarching principles contained in its strategic plan for 2018–2023 (IMO 2017c), the organisation is committed in achieving a 'uniform implementation' by developing and executing 'projects to provide targeted capacity building and technical cooperation that fosters, promotes and supports implementation efforts' specially in LDCs and SIDS. The IMO strives for the effective management and use of IMO's financial resources, provided by Member States and other donors, while committing to 'establish new and further develop existing long-term strategic donor relationships and to optimise other sources of funding' in respect of its technical cooperation work (IMO 2017c).

Besides the IMO's work towards meeting the 2030 Agenda for Sustainable Development, the EU is a regional example of maritime governance developing relevant directives and regulations and providing support to its Member States for their effective implementation (Leeuwen 2015). Since 1986, the EU Member States have shown strong support of shipping policy principles by unilaterally adopting a common approach to maritime external affairs (Mukherjee and Brownrigg 2013a). Likewise the IMO instruments, EU Directives and regulations in the maritime domain are not explicitly linked to meeting the 2030 Agenda for Sustainable Development, but they can be related to the achievement of SDGs, especially those related to safety, security, environmental protection and technical cooperation in the maritime industry.

The EU maritime safety packages developed over the years enhance maritime safety across the EU ports and contribute to SDGs 3, 8 and 14 that call for promoting good health and well-being, sustainable economic growth and sustainable use of the oceans, seas and marine resources for sustainable development. EU environmental and climate directives targeting the protection of the marine environment and the reduction of air pollution and GHG emissions from shipping are related to a number of SDGs, namely SDG 8 (sustainable economic growth), SDG 7 (clean and affordable energy for all), SDG 9 (infrastructure investments and fostering innovation), SDG 11 (sustainable cities and communities), SDG 13 (climate action) and SDG 17 (strengthening regional partnerships to promote sustainable development).

This chapter is structured in the following way. A presentation of IMO instruments that relate to the fulfilment of the UN SDGs is included in Sect. 2 with a focus on safety, security and environmental protection issues, human element (HE) and technical cooperation. Regional maritime governance and, in particular, the EU's work on the UN SDGs is analysed in Sect. 3, and conclusions are drawn in Sect. 4.

2 IMO Instruments and SDGs

There are various international conventions that are paramount in maritime governance. The most important one regulating all issues relating to the law of the sea is the UNCLOS, which regulates ocean management (Pace 2018). The Convention regulates the exploitation of available resources by coastal States in their EEZs and territorial waters (Singh 2017).

Article 61(2) of UNCLOS protects biodiversity by ensuring 'through proper conservation and management measures that the maintenance of the living resources in the EEZ is not endangered by overexploitation'. In its Article 192, UNCLOS imposes on the States a general obligation to 'protect and preserve the marine environment', 'rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life'. The contracting States are compelled to 'establish international rules and standards to prevent, reduce and control pollution of the marine environment from vessels' (Article 211.1). These obligations relate to flag state implementation (Article 211.2), Port State Control (Article 211.3), territorial seas (Article 211.4) and EEZ (Article 211.5). Moreover, UNCLOS sets out an obligation on the contracting States to approve international instruments to prevent marine pollution in the EEZs (Article 211.6).

UNCLOS regulates other aspects (Pace 2018) such as:

- Maritime traffic (Article 22.3.a) in straits aimed at international navigation (Article 41.4 and 41.5) and archipelagic sea lanes (Article 53.9).
- Artificial islands, installations and structures in the Exclusive Economic Zone (Article 60.3 and 60.5)
- Enforcement by flag States (Article 217), port States (Article 218) and coastal States (Article 220)
- Measures with the purpose of facilitating proceedings on dispute resolution (Article 223)
- Special arbitration expert list (Annex VIII, Article 2.2).

The three globally relevant pillars complementing UNCLOS in the maritime transportation sector are: (1) the International Convention on the Safety of Life at Sea (SOLAS); (2) the International Convention for the Prevention of Pollution from Ships and the Protocol Relating to the International Convention for the Prevention of Pollution from Ships (MARPOL 73) and its Annexes (Protocol Relating to MARPOL 73 of 1978); and (3) the International Convention on the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) (Pace 2018; IMO 1978). A fourth pillar is embodied by the Maritime Labour Convention (Cartner et al. 2009; McConnell et al. 2011).

Before going into detail and analysing these IMO Conventions, it is worthwhile to provide some information on the world fleet composition and the main types of vessels involved in international trade, as the IMO Conventions are developed and adopted to enhance the safe and secure navigation of these vessels and support the

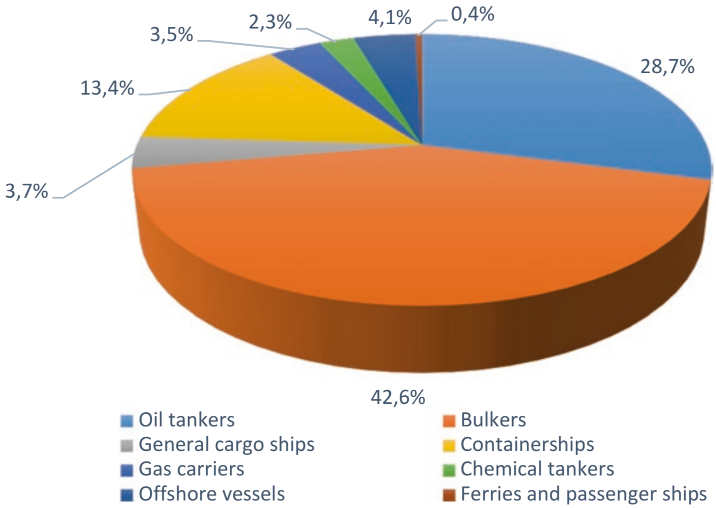

Fig. 20.2 Type of vessels involved in international trade (2019). Source: Own elaboration based on data from UNCTAD (2019)

HE engaged in their operations. An overview of the composition of the world fleet in 2019 can be seen in Fig. 20.2.

2.1 *Maritime Safety and Security*

Besides being the most international industrial sector, maritime transportation is one of the most dangerous industries due to a large variety of factors. Harsh weather conditions, noisy mechanical equipment, dangerous cargoes, exposure to rare diseases while visiting countries around the world, in addition to remoted medical assistance, are just some of the main factors that turn shipping into a truly dangerous industrial sector (Nielsen 1999). In this notion, enhancing maritime safety and security is a critical issue in IMO's work. This section analyses the IMO instruments pertaining to safe and secure navigation and relates them to UN SDGs.

2.1.1 Maritime Safety

The SOLAS Convention is the first International Convention ever adopted by IMO in 1959 and the most important Convention on maritime safety issues. The latest version of SOLAS was adopted in 1974 and has been amended various times since. Its primary mission is to set minimum safety standards for the construction, equipment and operation of ships (IMO 1974). To achieve its objective, SOLAS consists of 12 subdivisions dealing with issues such as construction and stability of vessels, fire protection and detection, life-saving appliances, radiocommunications, safety of navigation, carriage of cargoes, carriage of dangerous goods, nuclear ships, safe operation of ships, verification of compliance and safety measures for ships operating in polar waters.

A number of international regulations and codes on diverse safety issues have also been developed by the IMO that is assisted by its Maritime Safety Committee (MSC) in the safety domain. International Codes related to carriage of cargoes and dangerous goods that worth mentioning here are the International Maritime Solid Bulk Cargoes Code (IMSBC Code 2008c) and the International Maritime Dangerous Goods Code (IMDG Code 1965b), while the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code 2014c) deals with the construction and safe operation of this maritime segment (Laudal 2010; Ozcayir 2007; IMO 2003b, 2006a; Djadjev 2015). These International Codes are directly related to SDGs 3, 8 and 14 that call for promoting good health and well-being, sustainable economic growth and sustainable use of the oceans, seas and marine resources for sustainable development. Search and rescue issues that fall under the jurisdiction of the IMO Sub-Committee on Navigation, Communications and Search and Rescue (NCSR) also enhance the achievement of the above-mentioned SDGs.

2.1.2 Maritime Security

In the area of maritime security, SOLAS's chapter XI-2 deals with maritime security issues and includes the International Ship and Port Facility Security (ISPS) Code that aims to improve security for vessels and ports (Ng and Vaggelas 2012). The ISPS Code was adopted in 2002 and became mandatory for all IMO Member States 18 months after its adoption in June 2004. The ISPS Code includes both the security standards that maritime companies and port authorities have to meet (Part A) and guidance on the way these standards can be met (Part B). In order to assist its Member States in the effective implementation of the ISPS Code, the IMO is organising capacity building activities at national and regional levels through its technical cooperation programme; activities that correspond to SDG 17 on strengthening the means of implementation and revitalising the Global Partnership for Sustainable Development.

Apart from the ISPS Code, the Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation, known as SUA Convention, was adopted by the IMO Assembly in 1988 to enhance safe navigation and security of passengers and crews and was amended by the 1988 and 2005 Protocols (Beckman 2008). Unlawful acts covered by the SUA Convention and its protocols include violent behaviour against passengers and crew on board, forced seizure of ships and allocation of potentially damaging devices on board the ships. This Convention is directly related to SDGs 3 and 8 on promoting good health and well-being, and productive employment and decent work for all. Other IMO governance instrument relevant to the achievement of SDGs 3 and 8 and maritime security is the Convention on

Facilitation of International Maritime Traffic (FAL Convention; IMO 1965c), as amended, that aims to eliminate stowaways, the cases of people boarding ships without authorisation that can have an impact on their safe and secure navigation.

IMO Resolution A.872(20) on the Prevention and Suppression of the Smuggling of Drugs, Psychotropic Substances and Precursor Chemicals on Ships engaged in International Maritime Traffic (IMO 1997d) and revised in 2006 by Resolution MSC.228(82) and in 2007 by Resolution FAL.9(34) is directly relevant to SDG 8 that calls for action for sustained, inclusive and sustainable economic growth and SDG 3 on good health and well-being (Hesse 2003).

The IMO has provided technical assistance for the development of a number of Codes of Conduct to answer to piracy and armed robbery of ships in geographical areas where the threat of these actions is more severe. One of these areas is around the western Indian Ocean and the Gulf of Aden; IMO Member States in and around this area agreed in 2009 on the Djibouti Code of Conduct (DCoC) (2009) to improve cooperation and enhance countries' actions to address piracy and armed robbery of ships (Menzel 2018). Another Code of Conduct adopted by 25 countries located in West and Central Africa region in 2013 to address the piracy and armed robbery of ships in the Gulf of Guinea region of West Africa is the Yaoundé Code of Conduct (2013b) (Ifesinachi and Nwangwu 2015). The capacity building and technical assistance provided by the IMO to address these maritime security threats strengthens the implementation of these regional regulations and enhances partnerships for sustainable development that correspond to SDG 17.

2.1.3 Links Between IMO's Strategic Directions and the SDGs on Safety and Security

In addition to the identified links among IMO's instruments in relation to safety and security issues and the achievement of SDGs 3, 8, 14 and 17, there is a direct linkage between IMO's SDs and these SDGs (IMO 2017b). SOLAS Convention (1974), the International Codes related to carriage of cargoes and dangerous goods as well as the ISPS Code contribute to IMO's SDs 2, 3 and 5 on the integration of new and advancing technologies in the regulatory framework, the enhancement of global facilitation and security of global trade. SD1 (implementation improvement), SD4 (engagement in ocean governance) and SD6 (ensure regulatory effectiveness) are linked to SDG 17 and the assistance of the IMO to its Member States for the effective implementation of the ISPS Code through capacity building activities at national and regional levels that strengthen global partnerships for Sustainable Development.

Other IMO instruments that contribute to SDGs 3 (promoting good health and well-being) and 8 (productive employment and decent work for all) and correspond to IMO's SDs 4 (engage in ocean governance) and 5 (enhance global facilitation and security of international trade) are: the SUA Convention (1988/2005) that aims to enhance safe navigation and security of passengers and crews, the FAL Convention (1965c), as well as IMO Resolution A.872(20) on the Prevention and Suppression of the Smuggling of Drugs, Psychotropic Substances and Precursor Chemicals on

Ships engaged in International Maritime Traffic (1997d/2007). IMO's Codes of Conduct to answer to piracy and armed robbery of ships in geographical areas where the threat of these actions is more severe, like the Djibouti Code of Conduct (DCoC) and the Yaoundé Code of Conduct (2013b), relate to SDs 4, 5 and 6 and SDG 17 enhancing partnerships for sustainable development and addressing maritime security threats.

2.2 Marine Environment

MARPOL 73/78, along with the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972/1996), is the most important international Conventions contributing to the reduction of international marine pollution. The MARPOL Convention is the result of a merger of the Conference on Tanker Safety and Pollution Prevention (TSPP) and the International Convention for the Prevention of Pollution from Oil (OILPOL) (1954). It regulates ship pollution from operational discharge and prevents oil and pollutant spillage from tanker construction and design (IMO 2017f). The London Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter handles dumping wastes at sea—which is prohibited unless it meets strict requirements. Ships carrying wastes can be subject to the rules of the London Convention and MARPOL, although 'dumping' and 'discharge' are expressly distinguished in MARPOL (Mukherjee and Brownrigg 2013b).

Other international Conventions worth mentioning include the International Convention on the Control and Management of Ship's Ballast Water and Sediment (BWM) (2004); the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989); the Biofouling Guidelines (2011b); the Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life (IMO 2014b) and the Agreement for the Implementation of the Provisions of the UNCLOS relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN 1995). UN instruments that have an impact on ocean governance are the FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (1993), the Bonn Convention on the Conservation of Migratory Species of Wild Animals (1979), the Convention on Biological Diversity (CBD) (UN 1992), the Nagoya Protocol (UN 2010) and Chapter 17 (Protection of the Oceans) of the Agenda 21 (1992).

The importance of other types of agreements should be stressed. Certain specific sectoral instruments of the IMO and the International Whaling Commission (IWC) (Appendices 1 and 2 of the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES] and the Convention Relating to Wetlands of International Importance, especially as Waterfowl Habitat [RAMSAR] of 1971), and regional instruments (including Regional Seas Program of the UNEP, the Regional Fisheries Management Organizations [RFMOs] and the Regional Seas

Program of the UNEP) as well as codes and agreements (such as the FAO Responsible Fisheries Code of Conduct of 1995 or the FAO Guidelines for ecolabelling of fish and fishery products from marine capture fisheries of 2009) are aimed at protecting the marine environment and fighting marine pollution 'adopted under the auspices of the UNCLOS, FAO and UNEP' although 'the capacity to implement, monitor and enforce them still needs to be improved' (Valles 2014). Conventional laws must be given national effect to states which agree to it. This can be done by implementation, which gives effect upon the state's agreement or in express legislation in the agreed state's territory. Conventional laws can also receive national effect by enforcement, which uses administrative or judicial policing and enforcements to prevent violations (Mukherjee and Brownrigg 2013c).

2.2.1 Oil Pollution (MARPOL Annex I)

Annex I of the MARPOL Convention deals with the abatement of oil pollution and includes a number of regulations that have resulted in significant safety improvements in the construction and operation of oil tankers. The number of oil spills due to accidents has decreased constantly during the last three decades despite the significant increase in the amount of transferred crude oil and petroleum since the Regulations 19 and 20 of the MARPOL Annex I entered into force (Mattson 2006; Yip et al. 2011).

Regulation 19 was adopted in 1992 and required that all tankers above 5000 dwt ordered after 6 July 1993 should have double hulls to prevent oil pollution in the case of an accident (IMO 1992c). Three years later, regulation 19 of MARPOL Annex I was supplemented by regulation 20 that made the application of double hulls mandatory even for the existing ships and required the conversion of oil tankers after they were 30 years old to allow the necessary time for the shipping industry to adjust to this requirement given the long operational life of ships (IMO 1995a). The enhanced safety construction and operational standards coming from regulations 19 and 20 of MARPOL Annex I are directly related to SDG 9 on building resilient infrastructure to foster innovation and SDG 14 that calls for the sustainable use of the oceans, seas and marine resources for sustainable development.

Coming to the abatement of oil pollution from tankers' operations, Regulation 33 of MARPOL Annex I adopted in 1983 has made crude oil washing (COW) mandatory for all crude oil tankers of 20,000 tonnes dwt and above (IMO 1983). In addition, Resolution MEPC.107(49) includes Revised Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships (2003). Both these provisions of MARPOL Annex I target the reduction of operational oil pollution and contribute to SDGs 9 and 14 building safe infrastructure and promoting the conservation and sustainable use of oceans, seas and marine resources.

2.2.2 Chemical Pollution (MARPOL Annex II and III)

Regulations on the transfer of chemicals either in bulk or in packaged form are included both in SOLAS and in MARPOL Conventions. More specifically, SOLAS Chapter VII incorporates requirements for the transfer of chemicals in bulk, while Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk are introduced in MARPOL Annex II (Kasoulides 1989). The fundamental International Codes (included both in SOLAS and MARPOL Conventions) that sets the international standards for the sea transport of chemicals in bulk is the International Bulk Chemical Code (IBC Code, 2004) and the IGC Code (2014c) (IMO 2003b). Chapter 17 of the IBC Code sets the construction and operational requirements that chemical tankers carrying bulk chemicals, built after 1 July 1986, need to meet to ensure their safe navigation and protection of the marine environment.

Under MARPOL Annex II, chemicals and noxious liquid substances are divided into four categories (X, Y, Z and other) depending on the level of damage their disposal into the sea would cause to marine resources or human health. The prohibition or allowance for their discharge into the sea varies according to the category under which they fall with Category X chemicals being the most 'damaging' and not permitted to be discharged into the water and Category 'Other' being harmful and not subject to any restrictions.

The sea transport of chemicals carried in packaged form is regulated by both SOLAS Chapter VII and MARPOL Annex III. Regulations concerning the classification, packing, marking, labelling and placarding, documentation and stowage of dangerous goods are provided in SOLAS Chapter VII, while MARPOL Annex III goes one step further including details on the carriage of chemicals to improve the safety standards for their transportation and reduce the risk of environmental pollution (Ozcayir 2007). In the case of chemicals carried in packaged form, the IMDG Code is the fundamental regulatory instrument included in both SOLAS and MARPOL Conventions.

MARPOL Annexes II and III regulate the sea transport of chemicals, aim to enhance the safe navigation of chemical tankers and eliminate the associated risk of environmental pollution. In this sense, these regulations are directly related to the achievement of SDGs 3 and 8 concerning good health and decent work for all as well as SDG 14 on the conservation and sustainable use the oceans, seas and marine resources.

2.2.3 Sewage and Garbage (MARPOL Annex IV and V)

MARPOL Annex IV deals with the environmental pollution from sewage entering the sea and entered into force on 27 September 2003 (IMO 2003c). Since this date, all ships of 400 gross tonnage and above are required to have on board a sewage treatment plant or a sewage disinfecting system or a sewage holding tank to ensure the safe sewage discharge into the water and minimise the risk of marine pollution near the coast. Apart from the provision of this equipment on ships, MARPOL

Annex IV calls for sewage reception facilities at ports to promote the safe sewage disposal at port areas without interruptions of the ships' operations. Given the correlation of the proximity to coast of sewage disposal and marine pollution, MARPOL Annex IV mainly regulates the discharge of sewage near the coast. Resolution MEPC.157(55) requires that only ships equipped with a sewage treatment plant or a sewage disinfecting system or a sewage holding tank can proceed with the sewage disposal at three nautical miles and above from the nearest coast, while this distance reaches 12 nautical miles and above for untreated sewage in addition to limitations in vessel's speed and rate of sewage disposal into the sea (IMO 2006c). MARPOL Annex IV requiring the application of adequate equipment on board and port reception facilities corresponds to SDG 9 on resilient infrastructure that fosters innovation and SDG 11 on sustainable cities and communities.

The disposal of garbage from ships into the sea is considered in MARPOL Annex V that entered into force in December 1988 (IMO 1988a). According to MARPOL Annex V, the discharge of any kind of garbage into the sea is not allowed for any type of ship except from the cases of ship's safety or accidental loss (Regulation 7 of Annex V). Resolution MEPC.295(71) includes Guidelines for the implementation of MARPOL Annex V and aims to provide technical assistance to all relevant stakeholders to meet the requirements concerning garbage discharge into the sea (IMO 2017e).

Both MARPOL Annex IV and V are in the context of SDGs 14 and 17 as they build on the conservation and sustainable use of the oceans, seas and marine resources and, at the same time, provide assistance to countries, ports and ships for the effective implementation of these regulations.

2.2.4 Air Pollution and GHG Emissions (MARPOL Annex VI)

MARPOL Annex VI is the most recent Annex, first adopted in 1997, that regulates the abatement of air pollution and GHG emissions from ships (IMO 1997a). The initial MARPOL Annex VI included regulations targeting the reduction of local air pollutants from shipping, such as sulphur dioxide (SO_x), nitrogen oxides (NO_x), particulate matter (PM) and volatile organic compounds (VOC), while its revised version, adopted in 2008, proceeded with the designation of emission control areas (ECAs), areas where air emissions from shipping should be even lower than the global limits (IMO 1997a, 2008a, 2014a). The ECAs established under the revised MARPOL Annex VI are:

1. Baltic Sea area that includes SO_x only.
2. North Sea area that includes SO_x only.
3. North American area that includes SO_x, NO_x and PM.
4. United States Caribbean Sea area that includes SO_x, NO_x and PM.

Concerning the abatement of SO_x emissions from ships, the revised MARPOL Annex VI set a global limit in marine fuel sulphur content that has reduced constantly over the years to reach 0.50% since 1 January 2020 (Regulation 14 of

Table 20.1 Global and ECAs marine fuel sulphur limits

Global SO_x and PM emission limit	ECAs SO_x and PM emission limit
4.50% m/m prior to 1 January 2012	1.50% m/m prior to 1 July 2010
3.50% m/m on and after 1 January 2012	1.00% m/m on and after 1 July 2010
0.50% m/m on and after 1 January 2020	0.10% m/m on and after 1 January 2015

Source: Regulation 14 of MARPOL Annex VI (IMO 2008a)

MARPOL Annex VI). The relevant limits in marine fuel sulphur content within ECAs have been much stricter and came to 0.10% since 1 January 2015 (Table 20.1).

In relation to NO_x emissions, the NO_x Technical Code 2008 was included in the revised MARPOL Annex VI (Regulation 13). This Code sets limits (Tier I, II, III) on the NO_x emissions from the combustion of marine diesel engines of over 130 kW output power. All ships constructed on and after 1 January 2011 should install Tier II marine diesel engines, while this limit became stricter (Tier III) since 1 January 2016 for new buildings that operate within the North American Emission Control Area and the US Caribbean Control Area.

The regulation of GHG emissions from shipping came much later mainly due to the energy efficiency advantage of seaborne transport compared to other transport modes and its low contribution to global GHG emissions (Smith et al. 2014; Giziakis and Christodoulou 2009). This trend, though, is expected to change radically in the next decades given the energy efficiency improvements in other industrial sectors and the growth of global trade (UNCTAD 2016). In this direction, in 2011 Chapter 4 was added in MARPOL Annex VI including technical and operational measures for the improvement of the energy efficiency of ships. The Energy Efficiency Design Index (EEDI) sets specific energy efficiency standards for different ship types for new buildings that become stricter over time and the Ship Energy Efficiency Plan (SEEMP) provides guidelines for the adoption of operational energy efficiency improvements, such as use of alternative fuels, speed optimisation, weather routeing, just-in-time arrival in ports. The implementation of both measures became mandatory for all ships of 400 gross tonnage and above, irrespective of flag and ownership since January 2013. All these measures that target energy efficiency improvements (Chapter 4 of MARPOL) directly contribute to SDGs 7, 9 and 13 that call for urgent action to combat climate change, sustainable and modern energy for all and investments in resilient infrastructure that fosters innovation.

A more recent development for the reduction of GHG emissions from ships concerns the adoption of an initial IMO GHG reduction strategy in April 2018 that seeks to align the contribution of international shipping to the targets set by the Paris Agreement and calls for the reduction of maritime GHG emissions by at least 50% by 2050 compared to 2008 with the ultimate goal being to phase them out entirely (IMO 2018a). The Initial IMO Strategy on reduction of GHG emissions from ships underlines the importance of capacity building and technical cooperation for the achievement of this emissions reduction goal and contributes to several SDGs, namely SDGs 7, 8, 9, 13 and 17.

2.2.5 Links Between IMO's Strategic Directions and the SDGs on Marine Environment

IMO instruments on environmental protection are directly linked to the organisation's SDs and relevant SDGs. Regulations 19, 20 and 33 of MARPOL Annex I dealing with safety construction and operational standards for oil tankers contribute to SDGs 9 (building resilient infrastructure to foster innovation) and 14 (sustainable use of the oceans, seas and marine resources for sustainable development) and relate to IMO's SDs 2, 4 and 5 concerning the integration of new and advancing technologies in the regulatory framework, engagement in ocean governance and enhanced security of international trade. IMO's SDs 2, 4 and 5 are also promoted through MARPOL Annexes II and III that include regulations on the transfer of chemicals either in bulk or in packaged form. The IBC, the IGC and the IMDG Codes regulate the sea transport of chemicals and aim to enhance the safe navigation of chemical tankers and eliminate the associated risk of environmental pollution; through these regulations, SDGs 3 and 8 concerning good health and decent work for all as well as SDG 14 on the conservation and sustainable use the oceans, seas and marine resources are promoted and linked to IMO's SDs.

MARPOL Annex IV dealing with the environmental pollution from sewage entering the sea and requiring the application of adequate equipment on board and port reception facilities for the discharge of sewage near the coast contributes to SDG 9 on resilient infrastructure that fosters innovation and SDG 11 on sustainable cities and communities and promotes IMO's SDs 2 (integration of new and advancing technologies in the regulatory framework) and 4 (engagement in ocean governance). MARPOL Annex V that regulates the discharge of any kind of garbage into the sea for all ships is also related to SDs 2 and 4 and is in the context of SDGs 14 and 17 building on the conservation and sustainable use of the oceans, seas and marine resources and, at the same time, providing assistance to countries, ports and ships for the effective implementation of these regulations.

Chapter 4 of MARPOL Annex VI including technical and operational measures for the improvement of the energy efficiency of ships (the EEDI and the SEEMP) promotes IMO's SDs 2 and 3 on the integration of new and advancing technologies in the regulatory framework and the organisation's response to climate change and contributes directly to SDGs 7 (urgent action to combat climate change), 9 (investments in resilient infrastructure that fosters innovation) and 13 (sustainable and modern energy for all). The Initial IMO Strategy on the reduction of greenhouse gas emissions from ships (2018) is the first IMO instrument that explicitly links IMO's work with the SDGs and underlines the importance of capacity building and technical cooperation for the achievement of emissions reduction goal for shipping. This Strategy builds on IMO's SDs 1, 2, 3 and 6 and contributes to several SDGs, namely SDGs 7, 8, 9, 13 and 17. SDG 13 calling for urgent action to combat climate change lies in the centre of this strategy along with SDG 17 that aims to strengthen global partnerships for the promotion of Sustainable Development. Table 20.2 provides an illustration of the links between IMO's SDs and the SDGs on marine environment.

Table 20.2 Links between IMO's Strategic Directions and the SDGs on marine environment

MARPOL Convention	IMO Strategic Directions (SDs)	SDGs
Annex I (oil pollution)	SDs 2, 4, 5[a]	SDGs 9, 14
Annex II/III (chemical pollution)	SDs 2, 4, 5	SDGs 3, 8, 14
Annex IV (sewage)	SDs 2, 4	SDGs 9, 11
Annex V (garbage)	SDs 2, 4	SDGs 14, 17
Annex VI (air pollution)	SDs 1, 2, 3, 6	SDGs 7, 8, 9, 13, 17

Source: Own elaboration
[a]SDs are described in detail in Fig. 20.1

2.3 Human Element

There is no consensus on the definition of the HE at an international level, but the term refers to human behaviour and psychological factors in relation to 'any other human, or system or machine aboard ship' (Viorica 2015, 2019). This section considers the instruments pertaining to this concept and its relation to UN's SDGs.

2.3.1 The Human Element as a Cause of Marine Accidents

Maritime accidents encompass both marine incidents and casualties in this chapter. These relate to an event or sequence of events directly in connection with the operation of the ship. Marine casualties inflict severe damages to health, lives, vessels, marine infrastructures other than the ship or the environment while marine incidents 'endanger the safety of the ship, its occupants or any other person or the environment' (IMO 2008b).

The HE plays a role in recognising the socio-technical context of human factors, according to a study developed by Schröder-Hinrichs et al. (2013). Technological advancements are not always coupled by an equal evolution on safety. Certain aspects of 'technologies, environments, and organisations' may cause human errors, clashing with an 'optimal human performance' (Rothblum et al. 2002). Technology-related problems were considered the main cause of marine accidents (Wayne et al. 2005), but nowadays 'vessel design, technical infrastructure and global regulatory supervision' have improved to the extent that the HE has become a more relevant cause of these casualties (Dogarawa 2012; Oluseye and Ogunseye 2016). However, 'the interaction between technical, social, environmental and human elements' may lead to marine accidents (Cormier 1994; Oluseye and Ogunseye 2016).

As pointed out by Mindykowski (2017), seafarers have 260 times more chances to lose their lives in comparison to other sectors (Roberts 2002) and human errors cause 60% of the ship accidents according to a Turkish case study (Erol and Basar 2015). Furthermore, around 80% of groundings and collisions result from human errors according to the IMO's Sub-Committee on Flag State Implementation (Listewnik and Wiewióra 2007; Mindykowski 2017). Problems related to the ergonomics to design ships involve the human–system interface consisting of interactions between staff, 'hardware, software and the physical environment associated with the system' (Riahi et al. 2012). The HE also encompasses occupational health, ship design, adapting new systems or fixing bad ergonomics that may affect the performance of the vessel (Squire 2004) as well as crew-related issues such as fatigue (Chia Yong Hwa 2017).

2.3.2 IMO's Human Element Vision

The IMO's proactivity to deliver an 'adequate system of international treaties dealing with all the relevant aspects of marine safety' resulted in the introduction of a HE vision for its work (IMO 1997b and reviewed in 2003d) that would reduce the amount of time spent in treaty negotiations (Schröder-Hinrichs et al. 2013). The Resolution defines the HE as a 'complex multi-dimensional issue' that requires the cooperation of different stakeholders (crews, shore-based management, shipyards, legislators, recognised organisations, regulatory bodies, etc.) to address the whole range of human activities performed by them. The need for reviewing certain IMO instruments from an HE perspective, the promotion of safety and the need to set up a framework to develop non-regulatory solutions and their assessment was considered in that resolution (2003d; Schröder-Hinrichs et al. 2013). Not all the revised conventions were accident driven, e.g. the negotiations on the safety of large passenger ships (IMO 2000b, 2006a) and the review of the STCW Convention (IMO 1978, 2010). Tanker accidents such when the oil tanker *Erika* broke apart in the Bay of Biscay off the coast of France in 1999, spilling more than 10,000 tonnes of heavy fuel oil, or the oil tanker *Prestige* sinking off the coasts of Spain and France in 2002, had an impact in the review of the guidelines on places of refuge for ships in need of assistance (IMO 2003e).

2.3.3 The STCW and the STCW Code

The HE was addressed for the first time by the STCW Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) of 1978 that set the minimum standards of competence for seafarers. These standards were specified, and enforcement mechanisms were established, in regard to the STCW, in the 1995 amendment with the approval of the STCW Code (IMO 1995b, 2020a). Contracting Parties to the STCW Convention must provide information, including the validity of seafarers' certificates of competency to be checked by other Contracting Parties, 'on the measures adopted to implement the Convention nationally' to be assessed by the IMO (2020d). The IMO has equally established a suggested syllabi, timetables and learning objectives for courses that maritime training institutes around the world follow to meet the STCW standards (IMO 2020d). Moreover, the International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F; IMO 1995c) normally applies to seafarers onboard fishing vessels of more than 24 m long (IMO 2020d).

The STCW Convention and the STCW Code, amended in Manila (Philippines) in 2010, introduced 'enhanced standards of training for seafarers' (IMO 1978, 1995b, 2020a). The amendments to the STCW Code provide training in bridge and engine room resources management and require that deck and engineering officers should not only acquire leadership, managerial and team working skills but appropriate communication skills and motivation (Squire 2011; Chia Yong Hwa 2017). Section A-VIII/1 of the STCW Convention (IMO 2011a, b) requires a minimum of rest hours but it can be manifested 'through a variety of environmental and operational factors such as rolling, pitching, vibration, noise, workload and ship schedules' (Riahi et al. 2012; Squire 2007; Louie and Doolen 2007; Chia Yong Hwa 2017). Situation awareness is vital to form an overall picture by retaining and interpreting the acquired information and projecting these elements into the future (Hetherington et al. 2006; Chia Yong Hwa 2017). Organisational and management problems related to staff including crew onboard ships is equally relevant to avoid marine accidents; resource management and the 2010 amendments to the STCW Code (IMO 1995b) are paramount in this respect (Chia Yong Hwa 2017).

2.3.4 The ISM Code

Since the approval of the STCW Convention in 1978, the IMO started to address the HE in the 1980s. The HE has been present at IMO's Maritime Safety Committee (MSC) since 1991, following the *Herald of Free Enterprise* accident (Schröder-Hinrichs et al. 2013) when roll-on/roll-off ferry capsized when departing from the Port of Zeebrugge, Belgium, with the loss of 193 lives. The IMO adopted the Guidelines on management for the safe operation of ships and for pollution prevention before that accident in 1989, the precursor of the International Safety Management (ISM) Code (IMO 1993) 'that was made mandatory through the International Convention for the Safety of Life at Sea (SOLAS) of 1994' (IMO 2020a; Schröder-Hinrichs et al. 2013).

The ISM Code's aim is to upgrade ship's management and operations and to implement a Safety Management System (SMS) to provide further 'safety of international shipping and to reduce pollution from ships' (IMO 2020a). Self-regulation, based on each individual's decisions, is at the heart of the ISM Code to promote a culture of safety (IMO 2020a). Moreover, the HE is reinforced in the ISM Code by the introduction of a Marine Safety Performance Plan to improve 'crew communication and interpersonal relationship, teamwork and regular review meetings between crew members and other deck officers' (Oluseye and Ogunseye 2016). The Guidelines on implementation of the ISM Code by Administrations were adopted in 1995, subject to amendments in 2001 and 2010 (IMO 2020a).

Several outputs addressing the HE followed, including the establishment of guidelines for formal safety assessment (FSA) for use in the IMO rule-making process (IMO 2002) as well as the amendments to the Code for the investigation of marine casualties and incidents (IMO 1997c, 1999). A 'novelty' on the HE was introduced following this Code, as explained below.

2.3.5 Non-criminalisation of Seafarers in Case of Maritime Accidents

The Casualty Investigation Code

The Casualty Investigation Code (2008b) was introduced to facilitate the investigation of maritime accidents and was backed by the 'Guidelines on fair treatment of seafarers in the event of a maritime accident' (IMO 2005), jointly developed by the ILO and the IMO, to protect seafarers and avoid any discriminatory or unfair treatment to them, to respect their basic Human Rights and to allow their prompt repatriation or re-embarkation following these events. Seafarers could be detained for a longer period than strictly necessary after the accident or during its investigation. The fair treatment of seafarers is a collective responsibility of port or coastal States, flag States, the State of the nationality of the seafarer, shipowners and seafarers, and they should 'take steps to ensure that no discriminatory or retaliatory measures are taken against seafarers because of their participation during investigations' (IMO 2011b).

EU's Role over Vessel-Sourced Pollution in Conflict with the Human Element

The EU initiated a paradigm shift towards a zero-tolerance policy on ship-source pollution by introducing a Criminal Sanctions Directive 2005/35/EC and the Council Framework Decision that includes a classification of criminal offences and sanctions following the 1999 *Erika* and 2002 *Prestige* maritime accidents (Nengye and Maes 2009). The legislation is aimed at the harmonisation of sanctions for vessel-source pollution discharges in the EU (Anthony 2006; Nengye and Maes 2009). However, a parallel criminal liability system on top of the civil liability one provided by MARPOL falls within the principle of subsidiarity since this is not an exclusive competence of the EU but its Member States (Adshead 2018).

Articles 4–7 of MARPOL require flag States and coastal States to comply with the convention and forbids any violation of its requirements by enabling proceedings where 'sufficient evidence is available' (Gonsaeles 2011). However, the EU is only an observer at the IMO and is not a Contracting Party to MARPOL unlike its Member States that must comply with their treaty commitments. Nevertheless, the EU has adhered to UNCLOS and is abided by its article 230(3) under which 'in the conduct of proceedings in respect of [violations of national laws and regulations on applicable international rules and standards for the prevention, reduction and control of pollution and marine environment] committed by a foreign vessel which may result in the imposition of penalties, recognised rights of the accused shall be observed' (Luttenberg 2009).

The Criminal Sanctions Directive is applicable 'in accordance with international law' according to its article 3(1) and the non-discrimination principle against foreign ships and compliance with Sect. 7, Part XII of UNCLOS is provided in Article 9. Article 5 sets out some exceptions in respect of 'discharges into any of the areas referred to in Article 3(1)' if the requirements of MARPOL in Annex I (Regulations

15, 34, 4,1 or 4,3) or in Annex II (Regulations 13, 3.1.1 or 3.1.3) regarding discharge standards for 'oil or noxious liquid substances' (MARPOL 1973/1978; Gonsaeles 2011). The article also states that the owner, the master or the crew are exempted from criminal responsibility if they comply with the exemptions of Annex I (Regulation 4.2) or Annex II (Regulation 3.1.2) of MARPOL—a discharge of 'oil or oily mixture resulting from damage to a ship or its equipment' or 'noxious liquid substances or mixtures containing such substances' into the sea in 'straits used for international navigation subject to the regime of transit passage', 'the exclusive economic zone or equivalent zone of a Member State' and 'the high seas' is not considered a criminal offence (EU 2005a; MARPOL 1973/1978; Gonsaeles 2011).

Accusations of Criminalisation of Seafarers Against the EU

Accusations of criminalisation of seafarers and non-compliance with MARPOL were raised by the shipping industry. As a result, the Criminal Sanctions Directive was amended by Directive 2009/123/EC (Nengye and Maes 2010; Gonsaeles 2011). The 2009 amendment stipulates in its new article 5(a) that 'criminal offences to be committed with intent, recklessly or with serious negligence'. The Court of Justice of the EU annulled the Framework Decision in the *Commission v Council* case (CJEU, 2007), and there is currently no 'specific range and level of criminal actions on vessel-source pollution' (Nengye and Maes 2010). Although the polluter pays principle is seen as a 'key cornerstone of environmental law and policy' (Adshead 2018), it should never serve as an excuse to criminalise seafarers since it would not only contravene international law undermine their status and the whole HE concept.

A minimum level of harmonisation on criminal sanctions, among the disparities shown between EU Member States, may deter offenders but 'criminalising unintentional act is counter-productive' to seafarers and negatively affects any accident investigation (Luttenberg 2009).

2.3.6 IMO's Outputs in Relation to the SDGs

According to the IMO's overarching principles contained in its strategic plan for 2018–2023 (IMO 2017c), the organisation acknowledges technological advancements and the increased global fleet. For that reason, the HE is considered 'in the review, development and implementation of new and existing requirements, including skills, education and training, and human capabilities, limitations and needs' (IMO 2017c).

The MEPC and the MSC developed a checklist in 2006 compelling IMO bodies to consider the HE when 'developing and amending mandatory and non-mandatory IMO instruments related to safety, security and protection of the marine environment' and encouraging Member States to consider it before any proposal submission (IMO 2006b). Annex V of the Resolution on the application of the strategic plan for the organisation (IMO 2017d) also contains the aforementioned checklist.

Moreover, the HE is considered as a continuous output by the IMO for the 2020–2021 biennium (IMO 2019), with no target completion date, listed as 6.15 under IMO's SD 6 (Ensure regulatory effectiveness).

This output is delivered by the IMO, the MSC and the MEPC act as the parent organs, coordinated by the Sub-Committee on Human element, Training and Watchkeeping (HTW), while the Sub-Committee on Implementation of IMO Instruments (III), the Sub-Committee on Pollution Prevention and Response (PPR), the Sub-Committee on Carriage of Cargoes and Containers (CCC), the Sub-Committee on Ship Design and Construction (SDC), the Sub-Committee on Ship Systems and Equipment (SSE) and the Sub-Committee on Navigation, Communications and Search and Rescue (NCSR) act as associated organs.

2.3.7 Links Between IMO's Strategic Directions and the SDGs on the Human Element

The IMO's Technical Cooperation Committee (TCC), in its XXVII session, considered the linkage between IMO's work in relation to the UN's SDGs and the IMO's SDs (IMO 2017b). Although it is not explicitly stated in the IMO's Circular (IMO 2017b), SDs 1 (improve implementation) and 2 (integrate new and advancing technologies in the regulatory framework) are linked to SDG 4 (ensuring an inclusive and equitable quality education and promoting lifelong learning opportunities for all), SDG 5 (achieving gender equality and empowering all women and girls) and SDG 8 (promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all).

The following Technical Assistance Activities are linked to the aforementioned SDGs: promotion of the ratification and implementation of the STCW and STCW-F conventions, cooperation within the Joint IMO/ILO Ad Hoc Working groups on health and social protection of seafarers, promotion and implementation of women's role in the maritime sector, and the encouragement to award scholarships at the WMU, International Maritime Law Institute (IMLI) and other maritime institutions. The above-mentioned Technical Assistance Activities also seem to be aligned with SDG 3 (ensuring healthy lives and promoting well-being for all at all ages) that is directly related to the HE.

2.4 Technical Cooperation

The IMO aims to fulfil the 2030 Agenda and the SDGs and supports 'its Member States through, inter alia, policy advice, and technical cooperation' specially 'when implementing the SDGs within Member States' national setup through their respective national sustainable development strategies' (Sciberras and Silva 2018). This section considers IMO's work on technical cooperation in relation to the UN's SDGs.

2.4.1 Technical Cooperation Between the IMO and Its Member States

The IMO has acknowledged that Least Developed Countries (LDCs) and Small Island Developing States (SIDS) are in need of technical assistance in different resolutions, since the adoption of an 'Agreement on Relationship with the United Nations', by the Inter-Governmental Maritime Consultative Organization (IMCO, as the IMO was previously known) in 1959 (IMO 1959; Pace 2018). The IMO asserted its capacity to provide 'advice and guidance to those authorities on technical matters affecting shipping engaged in international trade' in 1961 (IMO 1961), while its membership of the UN's Technical Assistance Board was instructed in 1963 (Pace 2018). A technical assistance fund was set up in 1965 (IMO 1965a) and the IMO supported its participation in terms of technical assistance at the United Nations Development Programme (UNDP) in 1967 (IMO 1967; Pace 2018).

A Technical Assistance Committee was established in 1968 (IMO 1968) and a Working Group on Technical Cooperation among its Member States was set up in 1969 (IMO 1969b; Pace 2018). The establishment of a TCC in 1972 (IMO 1972a, b), institutionalised in 1984 (IMO 1984), represented a step further in providing assistance to LDCs to implement the technical requirements of the IMO Conventions (Pace 2018). The Integrated Technical Cooperation Programme (ITCP) assists LDCs and SIDS in the implementation of 'IMO instruments for safer and more secure shipping, enhanced environmental protection and facilitation of international maritime traffic' (IMO 2020b). ITCP advocates for global maritime rules and standards and prioritises institutional capacity-building and the HE via human resource development (IMO 2020b). Moreover, it focuses on improving the safety, security, environmental soundness and efficiency of maritime activities, enhancing marine environmental protection and promoting sustainable livelihoods and poverty eradication (IMO 2020b).

2.4.2 IMO Outputs and Performance Indicators in Relation to the SDGs

The IMO's strategic plan outlines the following Performance Indicators (PIs) against the Strategic Directions (SDs) in the field of technical cooperation to improve implementation (SD 1) of Member States requesting and receiving 'technical cooperation to implement corrective actions to address audit findings and observations' (PI 1.7 and 1.8) while measuring the amount of 'technical cooperation activities directed towards the implementation of IMO instruments with effective results for the receiving Member States' (PI 1.9). 'Capacity-building aspects of the IMO Audit Scheme reflected in and implemented through the ITCP' is a continuous output (1.1) led by the TCC in line with SD 1 for the 2020–2021 biennium (IMO 2019).

PI 3.3 is aligned with SD 3 (respond to climate change) in terms of the 'expenditure on funding of technical cooperation activities and major projects related to energy efficiency and reduced emissions'. Another continuous output (3.4) aligned with SD 3 is the 'promotion of technical cooperation and transfer of technology relating to the improvement of energy efficiency of ships' which has the MEPC as the parent organ and is due to completion in 2021 (IMO 2019).

SD 4 (engage in ocean governance) corresponds to PI 4.4, the 'expenditure on technical cooperation activities and capacity building related to Ocean Governance'. SD 5 (enhance global facilitation and security of international trade) relates to the 'expenditure on technical cooperation activities and capacity building allocated to facilitation' and 'security matters' (PIs 5.6 and 5.7, respectively). An annual output (5.5), 'analysis and consideration of reports on the linkages between the ITCP and the 2030 Agenda for Sustainable Development, including the SDGs' is led by the TCC (IMO 2019). SD 7 (ensure organisational effectiveness) is contrasted with the percentage 'of technical cooperation and capacity-building activities with effective results' and 'long-term impact for the receiving Member States' (PIs 7.3 and 7.4, respectively).

2.4.3 Links Between IMO's Strategic Directions (SDs) and the SDGs on Technical Cooperation

The linkage between the IMO's SDs and the SDGs identified by the TCC was already addressed in the previous Sect. 2.4.2 (IMO 2017b). The activities aligned with SDs 1 and 4, in connection with SDG 14 (conserve and sustainably use the oceans, seas and marine resources for sustainable development), are the following ones: 'promoting the ratification and enhancing effective implementation and enforcement of MARPOL, OPRC (International Convention on Oil Pollution Preparedness, Response and Co-operation 1990), SOLAS, OPRC-HNS (Protocol on Preparedness Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances; IMO 2000c) and BWM Conventions'; 'strengthening national capacity to respond to marine pollution incidents and enhancing regional cooperation'; 'assisting countries in developing and adopting relevant aspects of the UNCLOS', 'establishment of Special Areas under MARPOL and Particularly Sensitive Sea Areas (PSSAs)'; 'paying particular attention to the special needs of SIDS and LDCs' and 'supporting ratification and implementation of the Cape Town Agreement' (IMO 2017b).

Though still not in force, the Cape Town Agreement (IMO 2012a) on the Implementation of the Provisions of the Torremolinos Protocol of 1993 relating to the Torremolinos International Convention for the Safety of Fishing Vessels, 1977 (IMO 2012b) focuses on fishing vessel standards and safety of seafarers onboard these vessels (Hwang 2020). Moreover, the IMO aims to support the creation of externally funded projects in connection with the 'action plan to address marine plastic litter from ships' (IMO 2018b) that is significantly linked to fishing activities (Hwang 2020).

The following activities incardinated within SDs 1, 2, 3 and 4 are related to SDG 7 (ensure access to affordable, reliable, sustainable and modern energy for all) and SDG 13 (take urgent action to combat climate change and its impacts): 'promoting the ratification and enhancing effective implementation and enforcement of

MARPOL Annex VI'; 'training programmes on GHG emissions, EEDI (Energy Efficiency Design Index), SEEMP (Ship Energy Efficiency Management Plan)'; 'promoting the ratification and implementation of the London Convention and London Protocol'; 'implementation of the GloMEEP (Global Maritime Energy Efficiency Partnerships) project and the establishment of a global network of MTCCs' and 'paying particular attention to the special needs of SIDS and LDCs' (IMO 2017b). Regulation 23 of MARPOL Annex VI enhances 'technical cooperation and transfer of technology relation to the improvement of energy efficiency of ships', and thus, the IMO established an Ad Hoc Expert Working group on Facilitation of Transfer of Technology for Ships (TT-EG), technology transfer and assistance to IMO Member States through ITCP, GloMEEP and the Maritime Technology Cooperation Centres (MTCCs) in 2013 (IMO 2013a; Hughes 2018).

SDs 1 and 4 are linked to SDG 6 (ensure availability and sustainable management of water and sanitation for all) to promote the ratification and implementation of the London Convention, the London Protocol and MARPOL Annex V and the Hong Kong Ship Recycling Convention. SDs 1, 2 and 6 (ensure regulatory effectiveness) have been identified by the TCC in respect of the following activities related to SDG 9 (build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation) and SDG 17 (strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development): 'promote the use of Country Maritime Profiles by Member States and the implementation of National Maritime Transport Policies'; 'promoting the ratification and implementation of the Facilitation Convention (FAL)' and 'continue to develop and strengthen bilateral partnerships with Governments, international organisations, regional institutions and industry for delivering technical cooperation activities'.

3 Regional Maritime Governance: Best Practice Action from the EU

Besides IMO's work that has established and oversees a very broad range of international conventions, various regions have their own additional or maybe complimentary regulations, as is illustrated by the case of the EU. The EU is a regional example of maritime governance, environmental protection and the fight against marine pollution (Leeuwen 2015). It actively participates and coordinates its actions through Member States at the IMO; however, it is only an observer at the General Assembly (Mukherjee and Brownrigg 2013a). As previously mentioned, the EU supports and funds initiatives such as GMN, which have a positive impact on SIDS and LDC locations. On a regulatory level, the EU provides a regional framework to address marine environmental protection and aspires to set a higher threshold. Since the *Erika* tanker incident in French waters and the *Prestige* tanker sinking off the Spanish coast, the EU has developed all the necessary legal instruments to set protective standards comparable to the US Oil Pollution Act 1990 that followed the

Exxon Valdez tanker incident. '*The Erika I and II maritime safety packages were the pre-emptive answer focusing on the classification societies, strengthening the controls on vessels at the ports, the Member States requirement on having ports of refuge and installing black boxes on board ships*' (Echebarria Fernández 2018).

The maritime sector of the EU makes upto 40% of the GDP (European Commission 2007; Parris 2016). Coincidentally, 40% of the EU population inhabits the coastline of the region (Parris 2016). Recognising that the coastal and marine environment of the EU is a significant and integral part of its existence, the EU has invested in renewable energy and aquaculture (Parris 2016). The European Commission (2020) invests in the long-term 'Blue Economy' strategy 'to support sustainable growth in the marine and maritime sector' to achieve the goals set out by the Europe 2020 strategy for smart, sustainable and inclusive growth. Moreover, 5.4 million jobs depend on the 'Blue Economy' that generates an added value of around €500 billion per year (European Commission 2020a).

3.1 EU Legislation on Maritime Safety

The *Erika I maritime safety package* introduced a 'black list' preventing listed ships from entering EU ports. The list is updated every 6 months. Single-hull oil tankers have not been allowed to enter EU ports since 2010 (Luoma 2009). At the time, the 1967 *Torrey Canyon* oil tanker disaster shook a diplomatic conference in Brussels. The conference created two landmark conventions which cover ship-generated oil pollution on a public international law level as well as an international private law level (Mukherjee and Brownrigg 2013c). The International Convention on Civil Liability for Oil Pollution Damage of 1969 (CLC 69; IMO 1969a) and its Protocol ((CLC 92) (IMO 1992b) set out two different levels for compensation (IMO 2000a). These served as the foundation for setting up the International Oil Pollution Compensation Fund (IOPC Fund). The shipowner will be responsible for assuming the payment of a maximum amount in case of an oil spill, while that amount is topped up to 200 million euros by fulfilling the conditions set out in the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND) (IMO 1971) and its Protocol of 1992 (FUND 92) (IMO 1992a) that includes the States Parties to the Protocol of 1976.

The aim of the *Erika II* package was to upscale the inadequate compensation limits of FUND and FUND 92 (de La Fayette 2005). However, it was finally adopted by the IMO as a Protocol to these Conventions, known as the Supplementary Fund of 2003 (Protocol of 2003, IMO 2003a). The United Kingdom and most of the EU Member States have ratified it (Echebarria Fernández 2018). The *Erika II* package introduced an 'EU-wide vessel traffic, monitoring and information system' (Urrutia 2006) along with the establishment of the European Maritime Safety Agency (EMSA), which is a 'technical and operational arm of EU decision makers […] to reduce the risk of maritime accidents, marine pollution from ships and the loss of human life at sea' (Luoma 2009).

The *Erika III* maritime safety package followed the sinking of the tanker *Prestige* off Northwest Spain and consists of a battery of EU normative *instruments* (e.g. *vid* the Directives and Regulations in Annex III and the bibliography on flag State requirements, ship inspection, survey organisations, maritime administrations, the Community vessel traffic monitoring and information system, principles governing the investigation of accidents in the maritime transport sector, liability of carriers of passengers by sea in the event of accidents or insurance of shipowners for maritime claims) placing greater emphasis on a 'more stringent standard in regard to controls, liability and insurance' (Proelss 2013). One of the 'novelties' introduced by the package was the requirement for 'compulsory insurance to cover claims subject to limitation under the CLC 1969 and its Protocol of 1992' (Echebarria Fernández 2018).

In accordance with the linkages between IMO's instruments on maritime safety and the SDGs, the *Erika I, II* and *III* maritime safety packages build on the enhancement of maritime safety across the EU ports and contribute to SDGs 3, 8 and 14 that call for promoting good health and well-being, sustainable economic growth and sustainable use of the oceans, seas and marine resources for sustainable development.

3.2 EU Legislation on Marine Environment

The EU has 'one of the world's most comprehensive and advanced regulatory frameworks for ships' after the implementation of the *Erika III* package (Liu and Maes 2009; Echebarria Fernández 2018). Moreover, the EU is committed to assisting LDCs through international cooperation programmes, as shown in its Green Paper (Clarke 2006):

> *The Commission has made contributions (such as the 5th Framework Programme projects on the Treatment of Ballast Water …) to the efforts of the International Maritime Organisation in implementing the Global Ballast Water Management Programme, which helps developing countries understand the problem, monitor the situation and prepare to implement the BWM Convention. These efforts should be maintained.*

The Commission also expressed its commitment in assisting insular States in fisheries and marine environmental protection through its policy instruments:

> *EU development policy instruments will continue to be used as a vehicle to support the sustainable development of the maritime sectors in maritime and insular developing countries. Special attention is and will be given to activities to promote the sound management of fisheries and other marine resources, the protection of sensitive marine habitats and the management of coastal zones (e.g. in support of sustainable tourism).*

The EU develops shared responsibility over the seas it shares with its closest neighbours. In particular, it will make proposals for increased cooperation in managing the Mediterranean and the Black Seas (Power 2018). These EU actions are in the context of SDGs 8, 14 and 17, concerning sustainable economic growth, the conservation and sustainable use the ocean, sea and marine resources as well as enhancement of regional partnerships for sustainable development and the effective implementation of regulations.

The EU has recently expanded its ambitious agenda following the Green Paper. The newly elected President of the European Commission, Ursula von der Leyen, presented the European Green Deal on 11 December 2019 (European Commission 2019a). It sets an ambitious agenda to transform Europe into the 'first climate-neutral continent by 2050, boosting the economy, improving people's health and quality of life, caring for nature, and leaving no one behind' (European Commission 2019b). The European Green Deal directly contributes to a number of SDGs, namely SDGs 7, 8, 9, 11, 13 and 17. Sustainable economic growth (SDG 8) presupposes a shift to clean energy (SDG 7), infrastructure investments and fostering innovation (SDG 9). EU's target to become climate neutral by 2050 contributes to SDG 11 (sustainable cities and communities), builds on climate action (SDG 13) and calls for strengthening regional partnerships to promote sustainable development (SDG 17).

3.3 The EU's Contribution to the Human Element

The EU has considered the HE in shipping through the VII Research Framework and Horizon 2020. For instance, the EU funded CYCLADES (Crew-centred Design and Operations of ships and ship systems) project that ran between 2012 and 2015. The project considered 'human-centred design (HCD) as a process to create solutions that consider user requirements […] to be implemented by ship/equipment designers and operators' (European Commission 2020b). The EU also funded a similar project on Human Factors in Risk-Based Design Methodology (FAROS) between the same years, in order to analyse how ship design 'can adversely affect human performance, which may lead to maritime accidents', and proposed possible mitigation of human error based on that design (European Commission 2020c). The SEAHORSE project, running between 2013 and 2016, considered the HE and included organisational factors to enhance safety by applying lessons learnt from best practices applied to other sectors but mainly from the air industry (European Commission 2020d).

The European Commission and its decentralised maritime safety agency, EMSA, has integrated the HE in its projects. One of EMSA's goals is to assist EU Member States in implementing the STCW convention and its Code, the Maritime Labor Convention (ILO 2006) as well as Directive 2008/106/EC on the minimum level of training of seafarers (2008). The latter provides for 'special training requirements for personnel on certain types of ships' in its chapter V, setting out mandatory minimum requirements for the training and qualification of masters, officers and ratings and other personnel on tankers, ro-ro passenger ships as well as other types of vessels.

EMSA's SAFEMED IV project, running between 2017 and 2021, focuses on maritime safety, maritime security and the protection of the marine environment.

The EMSA acknowledges that 80% of marine accidents are caused or related to the HE. It is a technical assistance project that includes the following participant countries: Algeria, Egypt, Israel, Jordan, Libya, Lebanon, Morocco, Palestine and Tunisia. The project aims to implement the Union for the Mediterranean's Regional Transport Action Plan 2014–2020. EU Member States share best practices on the implementation of the MLC (2006), training on Port State and Flag State implementation to allow inspectors of beneficiary countries to apply the STCW, the MLC or the SOLAS convention's mandatorily applicable ISM Code, among other international instruments (EMSA 2020a).

The Connecting Europe Facility (CEF) for Transport is the funding instrument to realise European transport infrastructure policy. It aims to support investments on building new transport infrastructure in Europe or rehabilitating and upgrading the existing one (INEA 2020). Motorways of the Sea (MoS) is one of its top priorities regarding funding, and it is composed of three pillars—the third one is Traffic Management and the HE. It focuses on the carriage of people and goods by sea with 'investments in human capital, the digitalisation of ICT services' and safety operations such as icebreaking, hydrographic surveying, vessel control or contingency planning (European Commission 2018; EMSA 2020b). Many Actions from the first and second pillars, improving the environment and integrating the maritime transport in the logistics chain, respectively, focus on training, human capital and maritime safety (European Commission 2018).

EU instruments related to the enhancement of HE contribute to SDG 3 (ensuring healthy lives and promoting well-being for all at all ages), SDG 4 (ensuring an inclusive and equitable quality education and promoting lifelong learning opportunities for all), SDG 5 (achieving gender equality and empowering all women and girls) and SDG 8 (promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all).

3.4 EU Legislation on Technical Cooperation

Technical cooperation in the maritime field in the EU is cherished by EMSA. The Agency provides EU 'Member States and the Commission with technical and scientific assistance in the field of ship-sourced pollution' and has supported 'on request with additional means in a cost-efficient way the pollution response mechanisms of Member States' since the adoption of Regulation 724/2004 that amended the legal basis of the Agency (EMSA 2020c).

For instance, EMSA participates as part of the EU delegation in Regional Agreements on pollution preparedness and coordination response in case of large-scale marine pollution incidents. The reason is that the EU is part of many agreements, namely the Bonn Agreement (North Sea), the Helsinki Convention (HELCOM) in the Baltic Sea, the Barcelona Convention (Mediterranean Sea) and the Lisbon Agreement (North East Atlantic Ocean) and has expressed its interest to become a party to the Bucharest Convention (Black Sea) in the future (EMSA

2020d). EMSA supports the European Commission and participates as part of the Commission's delegation in IMO's technical group meetings, offers workshops where appropriate at the Artic Council's Emergency Prevention, Preparedness and Response (EPPR) Working Group on behalf of the European Commission's DG MARE (EMSA 2020d) and acts as the Secretariat for the Consultative Technical Group for Marine Pollution Preparedness and Response (CTG MPPR) that gathers pollution response experts from EU Member States, European Free Trade Association (EFTA)/European Economic Area (EEA) coastal States and EU candidate countries (EMSA 2020e).

The EU's work on technical cooperation in the maritime field is in the context of SDG 17 concerning strengthening the means of implementation and revitalising global and regional partnerships for Sustainable Development and contributes to the effective implementation of EU instruments related to maritime safety and security, marine environment and HE.

4 Conclusions

This chapter is an attempt to highlight maritime governance instruments focused on sustainability in the light of UN's SDGs. Although many IMO and EU instruments are related to safety and security, environmental protection, HE and technical cooperation, and contribute to the SDGs, there is not an explicit link between them. The recent Initial IMO strategy on reduction of GHG emissions from ships is an exception as commitment to the achievement of SDGs is directly addressed in this Strategy. At regional level, the European Green Deal is another case of maritime governance instrument that directly contributes to SDGs targeting to a climate neutral continent by 2050.

IMO's commitment to the implementation of the 2030 Agenda for Sustainable Development is stated in the vision statement of the Organization's Strategic Plan for the period 2018–2023 where the organisation recognises its leading role for the promotion of the 2030 Agenda for Sustainable Development among its Member States and the support for its effective implementation. In this direction, IMO's Strategic Plan for the period 2018–2023 includes seven SDs to facilitate the achievement of its vision statement.

Maritime safety and security lie at the centre of IMO's work. The SOLAS Convention was the first International Convention ever adopted by IMO, in 1959, and is the most important Convention on maritime safety issues. At the same time, the IMSBC and the IMDG Codes regulate the carriage of cargoes and dangerous goods by sea, while the IGC Code deals with the construction and safe operation of this maritime segment. With regard to security, the ISPS Code and the SUA Convention are core IMO instruments that aim to improve the security standards for maritime operations and enhance safe navigation and security of passengers and crews.

MARPOL is the most important international Convention contributing to the reduction of international marine pollution. It is divided into six Annexes, each dealing with different environmental challenges; MARPOL Annex I deals with the abatement of oil pollution and has resulted in significant safety improvements in the construction and operation of oil tankers; MARPOL Annex II and III include regulations for the Control of Pollution by Noxious Liquid Substances in Bulk and in packaged form respectively and aim to improve the safety standards for the sea transportation of chemicals and reduce the risk of environmental pollution; MARPOL Annex IV deals with the environmental pollution from sewage entering the sea to ensure the safe sewage discharge into the water and minimise the risk of marine pollution near the coast; the disposal of garbage from ships into the sea is considered in MARPOL Annex V; and MARPOL Annex VI deals with the abatement of air pollution and GHG emissions from ships and includes regulations targeting the reduction of local and global air pollutants from shipping.

The HE, as a multi-dimensional issue and a related cause of 80% of marine accidents that may cause pollution on the seas, is an undoubtedly relevant element to be considered when the IMO and its Member States develop international instruments and standards that need to be implemented. The STCW and STCW-F Conventions, the STCW Code, the MLC or the ISM Code have been a cornerstone in achieving those international standards to train seafarers, and consequentially minimise the risk of marine accidents and any pollution caused by these from shipping activities. Technical cooperation is one of the key areas where the IMO and its Technical Assistance Committee have excelled at improving the readiness of LDCs and SIDS on implementing IMO Conventions. The SDGs and IMO's SDs are undoubtedly linked and fully aligned with the four areas analysed in this chapter, maritime safety and security, marine pollution, marine environment and technical cooperation. IMO's strategic plan and the SDs provide the necessary direction for IMO's bodies' activities and set a benchmark for Member State's engagement in its vision.

The IMO's Code for the investigation of marine casualties and incidents and the Casualty Investigation Code are proof of the need for non-discriminatory measures in relation to maritime accidents. Increasing attempts to criminalise seafarers should be discouraged and the EU's zero tolerance policy on maritime pollution initiated in 2005 is in conflict with such an approach—the EU is a Contracting Party to UNCLOS, while its Member States have ratified MARPOL that already sets out a civil liability regime. The failed Framework Directive for criminal offences arising out of maritime pollution does not only show the EU's intention to step into an EU Member States' exclusive competence, but could have been harmful to seafarer's rights and casualty investigations—some minimum guarantees must be provided and IMO's Codes should be observed.

At regional level, EU instruments related to safety and security, environmental protection, HE and technical cooperation contribute to the SDGs and illustrate how some regions, particularly the EU, can go beyond IMO's legislative framework and adopt regulations to help implement IMO conventions. An example of EU instruments that has assisted in the practical implementation of MARPOL Annex V in European ports is the EU Directive on Port Reception Facilities (Directive 2000/59/

EC, repealed by Directive 2019/883) that requires them to put in place facilities to deal with the various categories of waste under MARPOL Annexes. While the IMO measures set out what ships must do, the EU Directive provides tools to allow them to do it.

The *Erika I, II* and *III* maritime safety packages build on the enhancement of maritime safety across the EU ports, while a number of EU Directives deal with various environmental challenges, ranging from the protection of fisheries to climate action. HE is also enhanced though EU regulations and relevant EU-funded projects, while technical cooperation has a central role in EU Directives and regulations as it is vital for the effective implementation of EU instruments related to maritime safety and security, marine environment and HE.

The main challenge for the fulfilment of the SDGs in the maritime sector in a coherent way lies with the need to adapt the SDGs in the maritime context, so that their 'uniform implementation' by all IMO and EU Member States becomes more transparent. Concrete goals and targets need to be developed for the maritime stakeholders in the context of the SDGs. Another critical issue for the commitment of the maritime sector to the SDGs is related to providing capacity building and enhancing technical cooperation among IMO's and EU's Member States to foster global implementation efforts for sustainable development.

Annex I. Relevant United Nations Instruments

United Nations Convention on the Law of the Sea (UNCLOS) (1982)	https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf
Maritime Labour Convention (MLC, 2006)	https://www.ilo.org/wcmsp5/groups/public/%2D%2D-ed_norm/%2D%2D-normes/documents/normativeinstrument/wcms_554767.pdf
Convention Relating to Wetlands of International Importance, especially as Waterfowl Habitat (RAMSAR) (1971)	https://www.ramsar.org/sites/default/files/documents/library/current_convention_text_e.pdf
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (1973)	https://www.cites.org/eng/disc/text.php
Bonn Convention on the Conservation of Migratory Species of Wild Animals (23 June 1979). 1651 UNTS 355	https://www.cms.int/sites/default/files/instrument/CMS-text.en_.PDF
Basel Convention on Transboundary Movement on Hazardous Wastes (1989)	http://www.basel.int/Portals/4/download.aspx?d=UNEP-CHW-IMPL-CONVTEXT.English.pdf

Agreement for the Implementation of the Provisions of UNCLOS relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (1995)	https://www.un.org/Depts/los/convention_agreements/convention_20years/1995FishStockAgreement_ATahindro.pdf
United Nations Convention on Biological Diversity (CBD) (1992)	https://www.cbd.int/convention/text
Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization to the CBD (2010)	http://www.cbd.int/cop10/doc/

Annex II. International Maritime Organizations' Instruments

International Convention for the Prevention of Pollution from Oil (OILPOL, 1954)	https://treaties.un.org/doc/Publication/UNTS/Volume%20327/volume-327-I-4714-English.pdf
International Convention for the Prevention of Pollution from Ships (MARPOL, 1973/1978)	https://treaties.un.org/doc/Publication/UNTS/Volume%201340/volume-1340-A-22484-English.pdf 2017 amendments: http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Marine-Environment-Protection-Committee-(MEPC)/Documents/MEPC.286(71).pdf
International Convention on Civil Liability for Oil Pollution Damage (CLC, 1969)	https://treaties.un.org/doc/Publication/UNTS/Volume%20973/volume-973-I-14097-English.pdf
Protocol to Amend the International Convention of Civil Liability for Oil Pollution Damage of 29 November 1969 (CLC, 1992)	https://treaties.un.org/doc/Publication/UNTS/Volume%201956/v1956.pdf
Amendment of the Limitation Amounts in the Protocol of 1992 to Amend the International Convention on Civil Liability for Oil Pollution Damage 1969 (2000)	http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Legal-Committee-(LEG)/Documents/LEG.1(82).pdf
International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND, 1971)	https://treaties.un.org/doc/Publication/UNTS/Volume%201110/volume-1110-I-17146-English.pdf
Protocol to the International Convention on the Establishment of an International Fund for Compensation of Oil Pollution Damage (FUND 1976)	https://iopcfunds.org/wp-content/uploads/2018/06/Text-of-Conventions_e.pdf

Protocol of 1992 to Aamend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND 1992)	https://treaties.un.org/doc/Publication/UNTS/Volume%201956/v1956.pdf
Protocol of 2003 to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage of 1992 (FUND 2003)	https://iopcfunds.org/wp-content/uploads/2018/06/Text-of-Conventions_e.pdf
International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC, 1990)	https://treaties.un.org/doc/Publication/UNTS/Volume%201891/volume-1891-I-32194-English.pdf
Protocol on Preparedness Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances (OPRC-HNS Protocol, 2000)	http://www.bsmrcc.com/files/legal7.pdf
London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972/1996), including amendments	http://www.imo.org/en/OurWork/Environment/LCLP/Documents/PROTOCOLAmended2006.pdf
Revised Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships (2003)	http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Marine-Environment-Protection-Committee-(MEPC)/Documents/MEPC.107(49).pdf
International Maritime Dangerous Goods (IMDG) Code (1965)	http://www.imo.org/en/Publications/Documents/IMDG%20Code/IMDG%20Code,%202,018%20Edition/IL200E.pdf
International Maritime Solid Bulk Cargoes (IMSBC) Code (2008)	https://www.mlit.go.jp/common/001249851.pdf
Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines, 2011)	http://www.imo.org/en/OurWork/Environment/Biofouling/Documents/RESOLUTION%20MEPC.207[62].pdf
Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life (2014)	https://cetsound.noaa.gov/Assets/cetsound/documents/MEPC.1-Circ%20883%20Noise%20Guidelines%20April%202014.pdf
International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code, 2014)	https://www.mardep.gov.hk/en/msnote/pdf/msin1547anx1.pdf

International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention, 2004)	http://library.arcticportal.org/1913/1/International%20Convention%20for%20the%20Control%20and%20Management%20of%20Ships%27%20Ballast%20Water%20and%20Sediments.pdf
International Convention for the Safety of Life at Sea (SOLAS, 1974)	http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx
International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code, 1993)	http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Assembly/Documents/A.741(18).pdf
Convention on Facilitation of International Maritime Traffic (FAL Convention, 1965)	https://euroflag.lu/wp-content/uploads/2019/03/Convention-on-Facilitation-of-International-Maritime-Traffic-1965-as-amended-FAL-Convention-2.7.4-Recommended-Practice.pdf
Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation (1988/2005)	https://treaties.un.org/doc/db/Terrorism/Conv8-english.pdf
Guidelines for the Prevention and Suppression of the Smuggling of Drugs, Psychotropic Substances and Precursor Chemicals on Ships engaged in International Maritime Traffic (1997/2006)	http://www.imo.org/en/OurWork/Security/Guide_to_Maritime_Security/Guidance/Documents/FAL.9(34).pdf
Djibouti Code of Conduct (DCoC, 2009)	http://www.imo.org/en/OurWork/Security/PIU/Documents/DCoC%20English.pdf
Code of Conduct concerning the repression of piracy, armed robbery against ships, and illicit maritime activity in West and Central Africa (Yaoundé Code of Conduct, 2013)	http://www.imo.org/en/OurWork/Security/WestAfrica/Documents/code_of_conduct%20signed%20from%20ECOWAS%20site.pdf
International Convention on standards of training, certification and watchkeeping for seafarers (STCW, 1978)	https://treaties.un.org/doc/Publication/UNTS/Volume%201361/volume-1361-I-23001-English.pdf The Manila amendments: http://www.imo.org/en/OurWork/HumanElement/TrainingCertification/Documents/32.pdf http://www.imo.org/en/OurWork/HumanElement/TrainingCertification/Documents/33.pdf
The Seafarers' Training, Certification and Watchkeeping (STCW) Code (1995)	http://www.imo.org/en/OurWork/HumanElement/TrainingCertification/Documents/34.pdf
International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F, 1995)	https://www.parliament.nz/resource/en-NZ/51DBHOH_PAP68717_1/5585574bc008491882bbe882a323d1a546d8140b

Cape Town Agreement of 2012 on the Implementation of the Provisions of the Torremolinos Protocol of 1993 relating to the Torremolinos International Convention for the Safety of Fishing Vessels, 1977 (2012)	http://www.imo.org/en/About/Conventions/ListOfConventions/Documents/Consolidated%20text%20of%20the%20Agreement.pdf
Code for the Investigation of Marine Casualties and Incidents (1997)	http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Assembly/Documents/A.849(20).pdf
Amendments to the Code for the Investigation of Marine Casualties and Incidents (1999)	http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Assembly/Documents/A.849(20).pdf
Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code, 2008)	http://www.imo.org/en/OurWork/MSAS/Casualties/Documents/Res.%20MSC.255(84)%20Casualty%20Iinvestigation%20Code.pdf

Annex III. Relevant European Union Secondary Legislation

***Erika I* package**	
Directive 2001/105/EC of the European Parliament and of the Council of 19 December 2001 amending Council Directive 94/57/EC on common rules and standards for ship inspection and survey organisations and for the relevant activities of maritime administrations. OJ L 19	https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32001L0105
Directive 2001/106/EC of the European Parliament and of the Council of 19 December 2001 amending Council Directive 95/21/EC concerning the enforcement, in respect of shipping using Community ports and sailing in the waters under the jurisdiction of the Member States, of international standards for ship safety, pollution prevention and shipboard living and working conditions (port State control). OJ L 19	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32001L0106
Regulation (EC) No 417/2002 of the European Parliament and of the Council of 18 February 2002 on the accelerated phasing-in of double hull or equivalent design requirements for single-hull oil tankers and repealing Council Regulation (EC) No 2978/94. OJ L 64	https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32002R0417

Regulation (EC) No 1726/2003 of the European Parliament and of the Council of 22 July 2003 amending Regulation (EC) No 417/2002 on the accelerated phasing-in of double-hull or equivalent design requirements for single-hull oil tankers. OJ L 249	https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32003R1726
Regulation (EU) No 530/2012 of the European Parliament and of the Council of 13 June 2012 on the accelerated phasing-in of double-hull or equivalent design requirements for single-hull oil tankers. OJ L 172	https://eur-lex.europa.eu/eli/reg/2012/530/oj
***Erika II* package**	
Directive 2002/59/EC of the European Parliament and of the Council of 27 June 2002 establishing a Community vessel traffic monitoring and information system and repealing Council Directive 93/75/EEC. OJ L 208	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32002L0059
Regulation (EC) No 1406/2002 of the European Parliament and of the Council of 27 June 2002 establishing a European Maritime Safety Agency. OJ L 208	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32002R1406
Regulation (EC) No 724/2004 of the European Parliament and of the Council of 31 March 2004 amending Regulation (EC) No 1406/2002 establishing a European Maritime Safety Agency. OJ L 129	https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32004R0724
Regulation (EU) No 100/2013 of the European Parliament and of the Council of 15 January 2013 amending Regulation (EC) No 1406/2002 establishing a European Maritime Safety Agency. OJ L 39	https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1497273295835&uri=CELEX:32013R0100
***Erika III* package**	
Directive 2009/16/EC of the European Parliament and of the Council of 23 April 2009 on port State control. OJ L 131	https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0016
Directive 2009/17/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2002/59/EC establishing a Community vessel traffic monitoring and information system. OJ L 131	https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0017
Directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009 establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council. OJ L 131	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009L0018
Directive 2009/20/EC of the European Parliament and of the Council of 23 April 2009 on the insurance of shipowners for maritime claims. OJ L 131	https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32009L0020

Directive 2009/21/EC of the European Parliament and of the Council of 23 April 2009 on compliance with flag State requirements. OJ L 131	https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0021
Regulation (EC) No 391/2009 of the European Parliament and of the Council of 23 April 2009 on common rules and standards for ship inspection and survey organisations. OJ L 131	https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009R0391
Regulation (EC) No 392/2009 of the European Parliament and of the Council of 23 April 2009 on the liability of carriers of passengers by sea in the event of accidents. OJ L 131	https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009R0392
Other EU secondary legislation	
Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues—Commission declaration. OJ L 332	https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:32000L0059
Directive (EU) 2019/883 of the European Parliament and of the Council of 17 April 2019 on port reception facilities for the delivery of waste from ships, amending Directive 2010/65/EU and repealing Directive 2000/59/EC. OJ L 151	https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32019L0883
Directive 2005/35/EC of the European Parliament and of the Council of 7 September 2005 on ship-source pollution and on the introduction of penalties, including criminal penalties, for pollution offences. OJ L 255	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32005L0035
Directive 2009/123/EC of the European Parliament and of the Council of 21 October 2009 amending Directive 2005/35/EC on ship-source pollution and on the introduction of penalties for infringements. OJ L 280	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009L0123
Council Framework Decision 2005/667/JHA of 12 July 2005 to strengthen the criminal-law framework for the enforcement of the law against ship-source pollution. OJ L 255	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32005F0667
Directive 2008/106/EC of the European Parliament and of the Council of 19 November 2008 on the minimum level of training of seafarers (recast). OJ L 323	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0106&from=EN

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Chapter 21
Putting the Pieces Together for Sustainable Shipping

Paul Topping

Abstract Marine shipping moves most of the world's trade. This plays a vital role for economic development around the world and has been incredibly successful in bringing more prosperity, lifting millions of people out of poverty and enabling better housing, health care, schooling and other social benefits. Ships, by virtue of their large cargo capacity, are the most efficient means of transport, emitting less to carry more. While successful in increasing economic development and relatively efficient, marine shipping's greenhouse gas emissions are nonetheless 3.1% of total global emissions; comparatively on par with major emitting countries such as Germany. In looking at targets of the Paris Agreement, the 174 member countries of the International Maritime Organization (IMO) set a global strategy with an overall aim for marine shipping to reduce its total carbon emissions by 50% from 2008 levels by 2050. To meet the strategy's goals, the industry needs to shift to new propulsion and power systems that do not use carbon-based fuels. This is a tectonic shift for which the required technology, as it stands now, barely exists. The same could be said for the rest of the global economy. It is a tall order, but a necessary one that does not have to mean an end to economic development—quite the contrary as a strongly developing global economy is one that is best positioned to make the changes needed for future generations. The marine industry is not waiting for new technology to be invented. It is currently working with governments on what can be done in the near term, as well as acting to support new necessary technologies it and the world need. In this way, our actions today can ensure sustainable global prosperity tomorrow.

Keywords Marine shipping · International Maritime Organization · Domestic or short sea shipping · Climate change · Sustainability · Decarbonisation

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1 Introduction

This chapter seeks to assemble the many pieces that need to be in place for a sustainable shipping sector that contributes to a global sustainable economy. Marine shipping moves most of the world's trade, between 80 and 90% by most reckonings. The United Nations Conference of Trade and Development (UNCTAD) Annual Review of Maritime Transport shows continued growth in 2019, at 2.61% amounting to some 88,000 ships and an overall capacity of just under two billion deadweight tons—which represents how much tonnage a ship may carry (UNCTAD 2019a, b). As an industry, it is the most efficient form of transport in the world in terms of emissions for cargo carried, yet its total Greenhouse Gas (GHG) emissions between 2007 and 2012 comes in at just over a billion tonnes of carbon dioxide or 3.1% of global GHG emissions (IMO 2015), meaning that it ranks in the top 10 GHG emitters. Put another way, marine shipping's global GHG emissions can be compared to those of Germany (UNFCC 2019).

The International Maritime Organization (IMO) is the UN Specialized Agency which regulates global rules for safe shipping and marine environmental protection (IMO 2020). In its Initial GHG Strategy, IMO has committed to reduce 50% of shipping's GHG emissions by 2050 compared to 2008 levels in absolute terms (IMO 2018).

This means no matter how much the world economy expands and trade increases, marine shipping's total GHG output in 2050 must be half of its total output from 2008, with the ultimate goal to be off fossil fuels before 2100 (decarbonisation). Many countries are setting goals for decarbonisation by 2050, but the technology to do so does yet exist at the scale needed.

Trade is also an important societal goal, yet it is often seen as the driving source of increasing emissions in the climate change debate. In the last 60 years, trade has lifted more people out of extreme poverty than ever before and continues to contribute to the level of development of all countries; with people living better and longer (Rosling et al. 2018). UNCTAD (2019a, b) illustrates those countries with active marine trade that move goods with other countries far better than those who do not. This is not about people being able to get the latest consumer goods or fashion. Rather, it is about providing the opportunities for all countries to have the capacity to afford basic services for their citizens. Trade is also a key means to afford measures to reduce GHG emissions; both by creating the opportunities for funding as well as developing and distributing technologies.

Another element in the marine shipping sector's role in enabling countries to meet sustainability goals is regional short sea shipping or domestic shipping. Marine shipping is the most energy efficient way of moving freight, compared to other modes (RTG 2019). This is by virtue of a typical ship's engines being small relative to its large cargo capacity, a container ship may carry 8000 containers, yet a typical truck moves only one or two containers (WSC 2020). This efficiency is borne out in greenhouse gas emissions statistics. Sims et al. (2014) estimate that all transportation accounts for 23% of global emissions, while IMO (2015) found shipping to account for 3.1% of global emissions. In other words, marine shipping accounts for only 13% of global transport emissions. In most countries, transportation is a growing source of GHG emissions, positioning domestic ships in short sea trades to contribute to reducing emissions from a country's wider transportation system.

The upshot is marine shipping's GHG emissions are intricately and deeply tied into the activity of the wider global economy. As the global economy grows or contracts, so do shipping activities and with that the shipping industry's GHG emissions. So how do we reduce emissions to meet IMO and other goals? Ultimately, the marine shipping sector needs to change its energy source from fossil fuel combustion to a source that does not produce carbon dioxide or other greenhouse gases. This means new propulsion systems are needed, yet they do not now exist commercially, and there is the question of how the 88,000 ships in the world's fleet (UNCTAD 2019a) will be managed. (Similar questions affect all modes of transport and the entire global economy, but this chapter is focused on marine shipping.)

To make all this happen, significant research and development is required. While some theoretical options for new propulsion systems can provide starting points, they are considerably far from the point of being commercially available to be installed on large ships that carry international trade. But the good news is industry is moving in that direction. Key industry challenges include the availability of qualified mariners, other emerging ship technologies such as automation, and changes in demand for marine transportation. These issues and more are explored in detail in this chapter. The goal is to show the interconnectedness of the many pieces that will contribute to sustainable shipping now and into the future.

2 Marine Shipping, the Global Economy and People

This section explores the role of international marine shipping in the global economy and how it impacts people's lives.

2.1 Transoceanic Shipping Links the World

Trade has been increasing around the world between countries and is expected to continue as people around the world gain higher incomes and strive to improve things in their lives. This is more than being able to buy the latest smartphone or the newest car. It is about people all over the world affording decent food, housing, nutrition and healthcare.

Rosling et al. (2018) provide an excellent picture of where the world has come from and the general direction for where it is going, using current statistics to counter many negative perceptions held around the world. Suffice it to say for shipping, demand for its services will be increasing.

2.2 The Past

The modern institutions that enabled the largely peaceful global trade we have today emerged near the end of the Second World War. In 1944, at a conference in Bretton Woods, New Hampshire, international institutions were set up that enabled trade with the goals of sustaining peaceful relationships between countries (Department of State 2001). These institutions included the International Monetary Fund (IMF) and the International Bank for Reconstruction and Development (IBRD), which became the World Bank. About a year later in 1945, the United Nations itself was created, which led to its agencies and programs including IMO, which was established in 1948 (the original name of the IMO was the Inter-Governmental Maritime Consultative Organization and its name was changed in 1982 to IMO)[1] and in 1965 the UN Development Program also emerged. These global institutions have largely succeeded, enabling trade between countries and safer ships resulting in more ships voyaging around the world as the global economy grew. Demand for marine shipping also increased as it became safer and more reliable. The advent of standardised containers in the late 1950s revolutionised marine shipping and changed the world (Edmonds 2016). Marine shipping grew more efficient, the cost for transportation in the price of goods dropped and goods could be made anywhere and shipped anywhere.

2.3 The Present

Enhanced trade meant people around the world, at all incomes, began to be able to buy goods imported from other countries and sell exports as ships grew bigger and became safer, faster and more reliable. Better predictable international rules meant ships could be relied upon to keep a regular schedule—no matter how long the journey would be. This sets the basis for today's global production supply chains. Now, ships move raw materials for components of products to countries that can most efficiently produce them. Ships then distribute the completed components to countries or regions that can most efficiently assemble them into finished products, which in turn are moved by marine transport to where people buy them—completing the cycle.

A running shoe, for example, is typically made from components across the world. Synthetic rubber and plastics from China, cotton from Pakistan, canvas and laces from Bangladesh, assembled in Vietnam, and exported around the world globally. This distributes opportunities globally and focusses resource use more efficiently over the broader economy. A modern container ship operates in way that is very similar to a public bus. Ships ply regular routes visiting many ports on a

[1] For more information on the history of the IMO see: http://www.imo.org/en/About/HistoryOfIMO/Pages/Default.aspx

schedule with cargo being loaded and unloaded as needed. Cargo can be off loaded and transferred to another ship to reach its final destination (often several times). This intricate ballet of logistics has enabled the supply systems that supports the world's economic and social development. If you want to explore life as seafarer onboard a typical container ship as it voyages around the world, see *Ninety Percent of Everything* (George 2013).

The interconnected trading system has provided economic benefits to many countries and enabled people to improve their standard of living. Again, Rosling et al. (2018) shows how most people in the world have moved from extreme poverty to middle-level incomes. This has led to more children surviving childhood, better education and more opportunity for future generations. Countries are now better able to provide basic services; a dramatic improvement in water infrastructure from 1990 to 2010 saw more than two billion people gained access to improved water sources (UNICEF and WHO, 2012). However, there is still a long way to go, about 11% of the world's population—some 790 million people still lack access to clean water and some 2.5 billion people lack access to improved sanitation (CDC 2019). As more countries develop out of poverty and progress into middle incomes by trading with the world, marine shipping will continue to play a critical role to providing both the export trade opportunities and supply of imported goods for these growing societies.

Shipping costs for individual products have declined with the increasing efficiency of shipping. Now, in most parts of the world, shipping costs amount to a very small fraction of the retail prices people pay, with a recent (2020) study that found marine shipping costs amounted to $0.5/pound (Rodrique and Notteboom 2020). This means an average person can now afford to buy food and clothing for less money than before, or a small company can now reach customers around the world. More common medicines can be accessed globally. Materials to build roads and buildings are also more available. Technology such as cell phones and computers are more affordable. This has led to gains in the economic and social development of many countries.

Some may view this development as driving resource consumption to an unsustainable future, and thus one of the main drivers of increasing GHG and the climate change that is being observed today. However, with improved development and education, particularly for women, more people around the world no longer needed to rely on large families for survival. In the 1990s experts worried about a global population boom that would exceed the earth's capacity to support it. This drew on data showing that many societies around the world relied on people having large families for survival. With development and education, family sizes shrank to one or two children (Rosling et al. 2018).

Recent population data predicts a plateau in global population followed by a decline as succeeding generations opt for fewer children. This, in turn, may reduce some of the growth in GHG emissions as ultimately these emissions are a function of the collective decisions of some 7.5 billion human beings and rising (UN Statistics Division 2020). This prediction aligns with Demographic Transition Theory, where societies develop in four to five stages. First, there is a pre-industrial stage with are high birth and death rates, leading into the second stage of development with drops death rates as public health improves. This leads to the third stage of early industrial society where birth rates fall, owing to more education and less need for large families to ensure survival. The fourth stage represents advanced industrial and economic development, where birth rates are often less than death rates (Caldwell et al. 2006). The fifth stage is one that remains under debate, but posits that more advanced economies will see significant population declines as birth rates continue to fall.

In terms of GHG emissions and climate change, it is not global development that leads to these conditions, but rather how that development was achieved by burning readily available fossil fuels that were energy dense and had become relatively easy to produce. So, solutions lie not necessarily in stopping development, but rather doing so in a more intelligent and efficient way that conserves the world's resources and reduces GHG emissions. That has been the basis of thinking for sustainable development, or sustainability, for the last four decades (Brundtland 1987; UN Sustainable Development Goals Division 2020).

2.4 The Future

Choices in future fuels will be guided by their Energy Return On Investment (EROI). This is a means of measuring the quality of a fuel by calculating its ratio between the energy it delivers to society and the energy invested to capture and deliver its energy. Fuels that require more energy to produce and distribute them would pose a net energy loss, while fuels that deliver more energy to society than what it takes to produce and distribute present net energy gains to society (Hall et al. 2014). Thus, some alternative fuels that have looked promising may actually end up being less so.

The future is always hard to accurately predict. It will be no doubt interesting to read this book 20 or so years from now. However, the expected general direction of the global economy over history has been to expand and grow. Events periodically happen to reduce growth, the 2008 recession is one example, while the current pandemic of COVID-19 is having impacts at the time this chapter was being written, but economies recover and growth continues over the long term. Growth is not uniform for all; some countries will see economic decline and others still see extreme poverty, while other countries will see wild growth beyond expectations. However, looking at global data, most will see moderate growth decade over decade (World Bank 2018).

There is no doubt that the world's climate is changing and at a more rapid pace. Some see economic growth as the cause and may point to the dramatic reductions in emissions and pollution during lockdowns arising from the COVID-19 pandemic (Betts et al. 2020), where many factories and business shut down. Yet, economic growth is a key part of the solution, providing the resources to both change how the global economy develops and adapt to changes in climate we are seeing. Where will the billions needed for new technologies to transition to a zero-carbon economy come from? What will be needed is more efficient use of resources to sustainability support that growth, and intelligent use of different energy sources to build a zero-carbon emissions world.

3 Domestic and Short Sea Shipping

This section explores how domestic shipping within countries and between their neighbours provides opportunities for reducing GHG emissions from national transportation systems. Short sea shipping is not formally defined at IMO, but a number of definitions are used by national governments. A generally accepted working definition is maritime transport of goods over relatively short distances, as opposed to the intercontinental cross-ocean deep sea shipping (Eurostat 2019; van den Bos and Weigmans 2018).

3.1 Serving Domestic Trade Around the World

Vessels engaged in short sea shipping are an important component of many national fleets and of the global fleet. An earlier analysis estimated that worldwide close to 16,000 vessels with a combined deadweight tonnage (DWT) of 77 million tonnes are engaged in short sea shipping trade (RTG 2013). Cabotage laws require cargo or people being moved by ships between ports within a country to use ships registered in that country; some 91 countries around the world have cabotage laws (Fitzpatrick et al. 2018). Thus, short sea shipping is found around the world. Short sea shipping was introduced in Europe to divert road freight transportation away from the congested roads as its main purpose, whereas in Southeast Asian countries, it has been part of the initiative to ensure the attainment of a well-connected region of countries (Zakaria 2016).

Transportation is a critical part of any country's economic development and by consequence is a substantial source of air emissions; the IPCC estimates transportation accounts for 23% of all carbon emissions which is increasing (Sims et al. 2014). As marine shipping accounts for only 13% of global transport-related emissions, its efficiency offers opportunities for countries to reduce emissions in their national transportation systems.

A ship on short sea shipping trade has a number of differences from those engaged in transoceanic trade. It will have a design optimised to fit and operate in the local waterways and ports where it trades. It faces operational constraints unique to its environment, such as narrow channels, unique currents, areas of shallow depths or other navigational hazards. Finally, it is more likely to be subject to a greater range of national laws from labour practice to taxation.

A vessel operating in local waters, which can include fresh waters, may face conflicts with others who use or depend on those waters; from shoreline communities and property owners, to industrial water users, to fish harvesting and recreational activities. Local authorities may adopt a range of measures to manage user conflicts, which can include required routes to follow, reduced speed to avoid wake, or planning operations for reduced water levels if other users are seasonally drawing or diverting water, such as for hydroelectric dams, municipal water supply, industrial use or irrigation.

In inland waterways, short sea shipping often competes with other modes of moving cargo such as railways and trucking. It faces constant pressures; if cargo flows are impeded or face higher costs, cargo shippers can switch to other modes—depending on circumstances. Most of today's short sea shipping serve well--established trades for clients where marine mode provides the greatest efficiency.

3.2 Small Island States and Remote Regions

Small island states depend on marine shipping for survival. Ships bring goods they need for people's daily lives, materials, products, and equipment for economic development as well as carrying products to world markets for income. Countries with governments that invested in ports and supporting infrastructure have seen broad increases in trade. Nigeria, for example, has seen trade throughput in its ports rising from 13 million tonnes in 1995 to just under 75 million tonnes in 2010 (Jaja 2009).

In such a dependency, anything that increases costs for shipping has a knock-on effect on these parts of the world. Costs rise for products that people use and for the products that are exported. This is compounded by these areas' small populations, which means ships cannot deliver goods with the same cost efficiency of trade between major population centres (UNCTAD 2014).

As an example, in Canada's urban southern areas—where most Canadians live—the shipping component of typical retail prices often amount to a fraction of 1% of the price. Nunavut, Canada's Eastern Arctic territory, is sparsely populated with over 35,000 people over an area of 1.9 million square kilometres (Statistics Canada 2016); shipping is a major component of the price for retail goods. A 2017 study by Statistics Canada illustrated the economic challenges and food insecurity faced by Inuit communities in Northern Canada (Statistics Canada 2017).

4 Reducing GHGs

This section examines the risks posed by GHGs and their contribution to climate change. Emissions of GHGs from shipping are examined, together with measures of the IMO to reduce such emissions.

4.1 Keeping Global Warming to 1.5 °C from Pre-industrial Levels

The Intergovernmental Panel on Climate Change (IPCC), the United Nations expert body on science advice on climate change, released a special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global GHG emission pathways (IPCC 2019). It notes that human activities are estimated to have caused approximately 1.0 °C of global warming above pre-industrial levels, with a likely range of 0.8–1.2 °C and that global warming is likely to reach 1.5 °C between 2030 and 2052 if it continues to increase at the current rate.

As carbon emissions are continuing to increase, the world is also seeing more record setting temperatures; with 2016 being the hottest year on record and that 2019 was the second hottest (WMO 2020). Large parts of Europe, Asia and Australia have seen more record heat waves, and that trend is expected to continue (Bouwer 2019). Since 1980, according to NOAA, the United States alone has sustained 258 severe weather events with damages exceeding a billion dollars which collectively total to 1.75 trillion dollars. Of this, the years with ten or more separate billion-dollar disaster events include 1998, 2008, 2011–2012 and 2015–2019 (NOAA 2020). Trends related to the impacts of climate change are generally trending to more severe events—storms, heat waves, wildfires, and others, as WMO data shows greenhouse gas emissions continue to increase (WMO 2018).

If unmanaged, impacts that are expected to last for centuries will include rising sea levels, increases in mean temperature in most land and ocean regions, more hot extremes in most inhabited regions, more instances of heavy precipitation in several regions and increased probability of drought and precipitation deficits in some regions. This in turn has related impacts on ecosystems and the populations of species around the world, including species that humans depend on such as crops, fisheries and livestock. If action is taken to limit global warming to 1.5 °C, this will reduce these impacts compared to higher temperatures. However, mitigating effects would be expected to take place over decades.

4.2 Shipping's Contribution Is Small Yet Large

In 2014, IMO completed its third GHG study looking at 2012 data on the global emissions of marine shipping in both international and national contexts (IMO 2015). This study sought to provide an update to the second GHG study published in 2009 to account for the impacts of the global recession of 2008–2009. The first of these studies was published in 2000 (IMO 2020c).

The third GHG study on marine shipping's emissions found that both international trade and domestic trades accounted for 3.1% of global GHG emissions. The study also estimated future projections of marine shipping emissions out to 2050 based on a variety of economic growth scenarios that look at ranges of increased growth and possible impacts of future recessions. While many may see 3.1% of emissions being a relatively small contribution, on looking at IPCC data on national emissions, this figure would compare with Germany and would place shipping, if it were a country, within the top 20 major emitting nations. As it moves between 80 and 90% of the world's trade, marine shipping's emissions are a function of the global economy and tend to rise or fall with economic activities.

As discussed previously, as marine shipping supports global supply and production chains that produce the products people use around the world. Even if global supply chains shift to more regional supply chains, marine shipping will still be moving 90% of everything and still be on its growth in emissions if nothing is done. But action is being taken.

4.3 IMO Measures So Far

As a UN agency with a global mandate, IMO discussions among its membership, comprising some 174 member states, 80 observer organisations and 63 inter-governmental organisations, are often complex (IMO 2020a). A wide variety of interests needed to be reconciled with each other: countries with the highest levels of income, countries with middle-level incomes, countries with the lowest levels of incomes, small island states, countries with large registries of ships, countries with major ports, as well as countries and interests that face significant impacts from climate change.

Despite the complexities, IMO has developed a range of measures for ships to reduce their GHG emissions: adopting new rules under the International Convention for the Prevention of Pollution from Ships (MARPOL) (IMO 2020b). The first of these came into force in 2013. Since then, all ships must have onboard a Ship Energy Efficiency Management Plan and that new ships as they are built and commissioned must comply with efficiency targets under the Energy Efficiency Design Index—which provides a standardised formula to calculate a ship's energy efficiency. A new ship's attained energy efficiency must meet its target, and the targets are progressively phased in.

The efficiency targets set increases in energy efficiency over a baseline of known efficiencies of ships built between 1999 and 2009. New ships built in 2013 and onwards had to fall within the average of this baseline, and smaller ships generally have targets that are pro-rated to their size. From 2015 onwards, new ships must be 10% more efficient than their equivalent ship built during the baseline period. In 2020, new ships must be 20% more efficient over the baseline. In 2022, some new ships (mostly large container ships) will need to be 30% more efficient, while for other types (e.g. bulk carriers) this target will be applied in 2025 (IMO 2011; Hughes 2020). The attained efficiencies are reported to IMO and held in a database.

To know how one is meeting any target, one must measure the thing to be assessed. As experience was gained in attempting to assess annual emissions performance of the world's fleet, the limitations of the past GHG studies became clear.

They provided only snapshots in time, were based mostly on modelling and could not account for changes over time after the on study. The need for actual ship emissions data became clear. To this end, IMO members developed another rule under MARPOL for a Data Collection Systems, where ship owners must provide to the governments of the countries where their ships are registered (the flag States) a report on their annual fuel consumption that is audited and verified by a third party, who in turn is also subject to approval by the flag State (IMO 2016). These requirements entered into force on 1 March 2018. IMO will in turn produce an annual report summarising the data collected, the first is expected in 2020. As well, preparations are underway for a fourth GHG study in 2020 which is expected to use ship owners' fuel consumption data from the Data Collection System.

These measures are already subject to strengthening. In 2019, IMO determined that certain types of new ships will be required to meet the most stringent targets of its Energy Efficiency Design Index in 2022 rather than 2025 (Hughes 2020).

4.4 IMO's Goal of 50% Reduction by 2050

After extensive discussions, an agreement on an interim strategy to reduce GHGs from ships was reached at the 72nd session of IMO's Marine Environment Protection Committee in April 2018. The strategy provided agreed targets and an initial strategy for how to get there, including 15 candidate measures to be considered (IMO 2018). IMO expects to set a final strategy in 2023, but as measures are discussed, it is willing to adopt more readily developed measures earlier. There is a significant work underway at IMO to develop measures and finalise the Strategy in 2023 (Hughes 2020).

Some of these measures will be adopted and put in place while others will not. But shipping is moving on a path towards decarbonisation in the second half of the century. Some countries are not waiting that long. For example, the UK announced marine shipping will be included in requirements of its climate strategy and ships built after 2025 will be zero-carbon capable.

4.5 The Challenge of a Growing Economy and Need for Decarbonisation

There has been one consistent trend: as human population rises and countries develop; the global economy continues to grow. As an industry that moves 90% of everything, marine shipping's growth is directly correlated to that of the world's economy.

If the current marine fuels are used continuously, energy efficiency alone will not meet IMO's goal of reducing marine shipping's total GHG emissions 50% by 2050.

Even if the most efficient ships are brought into the fleet, there is still a basic energy need to move a mass through water, and emission sources will increase as more ships are built to serve the needs of the global economy. There is also an efficiency paradox: as individual sources of emissions become more efficient and emit less, and often cost less, more are brought into service to the point that total emissions are increased.

This paradox has been observed through history (Nordhaus 1998). Oil-related energy crises since the 1970s have driven energy efficiency and supported the need to look elsewhere for energy. Yet energy efficiency was generally seen as a cheaper solution, the last example of such an issue was “peak oil”.

Many experts in the early 2000s took the view that petroleum production reached its peak and that supplies of easily accessible oil were depleted or nearing depletion (Bardi 2019). Oil would become harder to extract; with supply coming from even smaller production sites over even more remote areas of the world. This led to increasing oil prices and drives to more efficiency, such as electric vehicles. However, the advent of fracking, oil sands extraction and new discoveries may have diminished this concern (for now). Hence, the world’s economy still depends on oil as its primary energy source.

Ships are also valuable assets that remain in use for some 26 years, on average—longer if they are used in freshwater. So, the reality is many ships being built with current technology will likely still be in service in 2050. Thus, with current fuels and propulsion technologies, even if they attain high energy efficiencies and emit less GHGs, the overall number of ships in service means emissions growth will slow or at best be reduced to a level that is still well above IMO’s Goal. New approaches are needed that will require significant innovation and investment (Hughes 2020; OCED/ITF 2018a, b).

To meet an absolute goal of reducing 50% of its GHG emissions by 2050, marine shipping needs to change to propulsion systems that do not use carbon-based fuels—known as decarbonisation. In this approach, the marine sector is joining the rest of the world’s economy. Though in nascent stages, decarbonisation is gaining momentum. Another challenge is that as transportation accounts for about 27% of overall GHG emissions and is growing, shifting to decarbonised forms of transportation would bring benefits to reducing oil dependency and dealing with climate change. As the global economy grows, so does automobile ownership, particularly in Asia (PwC 2015). This has led to the growth of electric vehicles worldwide, which are now beginning to enter mainstream use worldwide (IEA 2019).

As technologies emerge in other transport sectors, approaches may become transferable to the marine shipping sector. Some technologies, such as electric motors or hydrogen fuel cells, have been around for decades, but their performance does not match petroleum for cost, energy density and a distribution network that makes it readily available around the world. As well, transfer to the marine sector can be challenging (Walker 2019; Tirschwell 2019; OCED/ITF 2018a, b).

While some electric vessels are operating on specific short ferry runs in Canada, Denmark, Norway, the United States, and likely elsewhere (Fehrenbacher 2019; Lambert 2018; Loyalist Township 2020; ResearchAndMarkets.com 2019), these ships have been generally small, though larger ferries on short routes are being built (ForSea Ferries 2020). Such technology has yet to be applied to any large-scale, long-range commercial ships, such as transoceanic tankers, bulk carriers, or container ships. Decarbonisation is a transition that will take time, but one of critical importance.

4.6 Costs of GHG Reduction Measures

The Global Maritime Forum and others released a study in January 2020 that provided the first estimate ever of the total costs faced by shipping between 2030 and 2050: US$1.4 trillion (Krantz et al. 2019), a massive sum. However, that study also provided some context, noting total energy investments around the world each year amounts to US$1.85 trillion.

As well, the study further estimated some 87% of the costs related to new energy sources on land, with 13% spent on the ships themselves. For context, annual global impacts of climate change were estimated to reach US$7.9 trillion by 2050 (Ferguson 2019). That impact would be against a forecast total productivity of the world's economy at US$258 trillion.

5 What Shipping Needs to Do

There is no one "road map" to decarbonisation, nobody knows what the path will be; yet various policy bodies have set out road maps (Hughes 2020; OCED/ITF 2018a). However, a variety of approaches and technologies are going to emerge and compete. Some will succeed, some will fail—likely with a few doing so spectacularly. But as an optimist, this author sees things moving in an overall positive direction for one simple reason: the vast financial incentive to move to energy sources that are less costly.

In December 2019, the marine shipping industry proposed a mandatory global fuel levy of US$2 per tonne with the aim to create an international marine research fund of some US$5 billion to support development of zero-carbon technologies (ICS et al. 2019). The main driver decarbonisation will require a shift to a new technology, which does not yet exist for the marine sector. This investment only begins to scratch the surface of the costs involved.

As the entire world economy needs to shift away from fossil fuels to reduce GHG emissions, global investment and efforts have, to date, focussed on where the greatest returns are expected: land-based transportation. Although shipping is important to the global economy, it represents a fraction of overall energy demand. Adopting an energy source from the wider economy's efforts could help ensure availability of supporting infrastructure and commodities. However, building on or scaling up from rail or road technology takes time and has impediments. It is one thing to move 20 or 2000 tonnes of cargo, it is another to move 20,000 to 200,000 tonnes. Hence, there is a need for the industry to develop its own approaches.

Marine shipping also faces inherent barriers to adapting new technologies: high capital costs, long operational lives and non-standardised design and construction. Compared to other modes of transport, ships have higher capital unit costs and longer lifespans; only aircraft is comparable. However, a unique feature of ships has been a lack of standardisation in design. Most ships are individually built rather than mass-produced. Even ships of the same class vary between individual ships as engineers incorporate lessons learned and either build succeeding ships differently or make changes to existing vessels. Automobiles and other road vehicles are mass produced so they have lower unit costs and relatively short operating lives, allowing for more rapid succession of evolving technologies. Similarly, rail locomotives are lower cost and mass produced, though can have longer operating lives.

Ships, with 25–30 years of operating lives (or more for ships in freshwater trades), take a lot longer to adapt to new technologies and about 42% of the world's ships are over 20 years in age (UNCTAD 2019a, b). However, much of the world's fleet will need to be replaced over the next 20 years as a matter of course, providing an opportunity to adopt new technology.

Decarbonisation for shipping is not quite an unknown, as there are a range of options, but they are mainly at theoretical or prototype stages. Practical options have yet to emerge, and there are a number of gaps in both knowledge and capacity; such gaps are not necessarily barriers but show avenues for research and development. Decarbonisation requires selecting a completely different approach to propulsion, which takes time, historically has happened; from oars to sail, sail to coal powered steam boilers, coal to heavy fuel oil steam boilers, and steam power to modern diesel engines.

Decarbonisation is not only a question of propulsion, but encompasses the complete energy needs for a ship. Converting a ship to conventional sails, for example, would not provide the electricity needed for running all the systems of a ship, from ventilation, pumps, electronics, heating and cooling, cargo cranes, rudder control, anchor winches and other needs, which on larger vessels can be substantial.

6 What New Technology Needs to Do

A number of needs must be met for a new propulsion and energy source technology to succeed. These needs can differ dictated by the intended tasks for the ship. Additionally, the owners need to determine whether to convert an existing ship with the new technology or build a new one entirely designed for the new technology.

As a strategy to support development of such technology, smaller vessels with lower energy needs and simpler tasks provide a starting point. This has resulted in a number of ferries, on very short routes, being adapted for or built new with all electric engines for example. Additionally, instead of working on a whole ship, developing technologies for auxiliary systems provides opportunities for testing its suitability to marine application and future scale up. However, road- or land-based technologies are not always open to adaption to the marine environment aboard a ship, with issues of scale-up, vibration, shock, rough weather, extent of dependency on shore side facilities (when they may be few to zero) and other issues (Marinòm and Bucci 2018). The following explores six key considerations in selecting new energy and propulsion technology.

6.1 Scale

A new technology needs to be scalable to the energy requirements of the ship. This means the new technology must be adaptable to the sizes and energy needs of current ships, if one seeks to install a conversion. If designing a new ship, scaling a ship down to its propulsion technology is possible, but the ship owner's clients drive the scale. Additionally, the technology needs to provide a suitable energy density to meet the ships' needs for both propulsion and operations (e.g. cargo transfer, heating cargo, cooling cargo, ballast water management, workshops, accommodations, and other speciality needs), or else larger amounts will be required with increased impacts over its lifecycle. This can be a challenge for some new technologies. Solar cells, for example, at the current stage of development would still not generate enough electricity to meet propulsion needs for a large vessel (even covering most or all the surface area of a ship would be insufficient).

A large commercial ship, over 100,000 tonnes, requires an engine capable of propelling it at safe navigational speeds. Conventional diesel engines for such ships are also at a large scale, many exceed the size of a four-storey building. Needless to say, a technology only proven in small road vehicles will likely be impractical.

6.2 Supply

A new technology, and any related consumable parts or fuels, must also be in a global supply that can meet demand for shipping. If it depends on rare or hard to obtain materials, or its manufacturing capacity limits output, adopting that technology will be difficult. Restrictions on obtaining it (e.g. nuclear) are another aspect of supply. In the case of alternative fuels or land-based energy systems (shore power), they must be readily available around the world—or at least throughout a ship's overall trading area.

6.3 Robust Design

New technology must have robust design to withstand the typical operating conditions onboard a ship. If components are sensitive to heat (engine rooms are notoriously tropical) or vibrations, cannot handle large power demands or cannot be responsive or controlled to meet demands of ship manoeuvring, then the technology will likely fail and not be adopted.

6.4 Infrastructure

There needs to be sufficient infrastructure available to support the new technology. This would include distribution of fuel or other consumables; standardised methods for safely storing, handling, and transferring fuels to ensure interconnectivity between facilities and ships; maintenance capacity in terms of physical facilities, trained technical specialists; and the necessary specialised training for mariners. As ships navigate everywhere, either there are available land facilities on a ship's trading routes to support the technology or the technology is self-sufficient for the duration of extended voyages between necessary land-based support (nuclear-powered propulsion would be one example).

6.5 Lifecycle Emission Performance

A new technology must be shown to offer reductions in GHGs, both to reduce emissions from ships and over the product's lifecycle. A product that reduces GHGs from a ship, yet results in the same amount to produce it, only changes the source of emissions and offers no reduction of emissions. Hydrogen, as an example, is a zero-emission fuel, but currently most of it is derived from petroleum and requires as almost much energy to produce as one would derive from it. Enzymatic methods using biological or synthetic catalysts show some promise, but have yet to reach commercialisation.

6.6 Downside Risks

A new technology should pose less overall risk to the environment over its lifecycle. We are already seeing new technologies that promise one benefit, but then other concerns arise—scrubbers are one example; ballast water treatment systems with active substances are another. Even if a technology successfully meets the above criteria, if its production could create another environmental impact, such as pollution or other impacts, it could face substantial restrictions. Bio-ethanol offered substantial reductions in pollutant emissions, but later faced challenges owing to concerns around the world of competing land use for growing crops for fuel instead of food.

6.7 Cost

Finally, there is cost. It will be expensive, with the first initial estimate for costs over the 2030–2050 period coming in at US$1.4 trillion (Krantz et al. 2019). First there are initial costs to adopt new systems at the scale of ships involved. There may be a need to change business models, but ships exist to move the cargo of their clients in the amounts and to the destinations specified. Approaches that do not allow a ship owner to meet customer needs will not be supported. Another aspect is a successful novel technology that provides substantial energy with zero-carbon emissions may likely be adopted across all sectors of the global economy and as such become a scarce resource with the potential to be priced out of reach for many. In the end, there will likely be a range of technologies emerging to meet these demands. There will be no single technology at the outset, but it is likely one will prove more advantageous than others and will rise to the principle new means for shipping to meet its energy needs for propulsion and operations.

6.8 A Short List of Zero-Carbon Technologies So Far

The zero-carbon technologies listed in Table 21.1 are provided in alphabetical order with no one technology favoured over any other. These technologies continue to be under development and their status for use on large commercial ships may be more fully developed and assessed over the next decade.

As these are zero-carbon technologies, the list does not include currently favoured transitional approaches such as natural gas, methanol or biofuels which are still power combustion engines and produce GHGs. Also not included in the table are the significant additional technologies to assist energy efficiency such as optimising hull design, speed and routeing, air bubblers to reduce hull friction.

7 What Regulators Need to Do

So far, IMO and its member states have adopted three key measures aimed at reducing GHGs from shipping. The Energy Efficiency Design Index (EEDI) for new ships provides an accepted method for predicting the energy efficiency of a new vessel and comparing it to a baseline, then mandating targets from that baseline. The

Table 21.1 Options for zero-carbon emission propulsion and energy technologies for ships

	Advantages	Disadvantages
Batteries	• Various chemical-based products available • Power source to propel smaller electric vessels or large vessels on very short routes • Support new onboard electrical generation technologies (e.g. solar or wind) and shore power	• Currently not suitable for long routes • Some designs can require extended time for charging • Electrical hazards require safety protocols and crew training • Emission benefits depend on power sources having lower emissions than diesel engines—Renewables or plants with emissions management
Fuel cells	• Use hydrogen chemically to create electricity • Seven basic designs available to derive hydrogen from different fuels (methanol, ammonia, others) and use different chemical processes (USDOE 2020) • Power source for smaller electric vessels, scale up to larger vessels possible	• Not scaled for large commercial vessels, currently city buses, trains and trucks (Ballard Power 2019) • New safety hazards likely, if scaled up • Some types of fuel cells impractical for ships (high temperature designs that operate at 1000 °C)
Hydrogen	• High potential for clean energy • Use in fuel cells or direct fuel possible • Potential to use in existing combustion engines rated for natural gas • Economical, if electricity prices are low • Renewable processes possible	• If used in conventional combustion, secondary effects and NO_x emissions currently require after-treatment • Currently sourced primary from petroleum processes, production is energy intensive • Price dependent on electricity price • Renewable processes currently laboratory scale, likely a decade out (Carbon Brief 2019) • Some processes extract hydrogen from natural gas, but produce carbon dioxide and depend on carbon capture and storage
Nuclear	• Existing technology in government vessels, some commercial use (World Nuclear Association 2019) • Offers long operational lifecycle and vast amounts of energy	• Extremely expensive • Radiological safety procedures • Managing radioactive wastes creates numerous concerns
Solar	• Uses an abundant renewable source of energy • Currently augments power needs, notably for accommodations (heating, cooling, lighting) or other support systems • Solar cells declining in price and increasing in energy capture	• Current low energy density insufficient for propulsion of large commercial vessels • Need alternate power for ships operating in extended periods of darkness, i.e. polar waters
Wind	• Uses an abundant renewable source of energy • Currently augments power needs, notably for accommodations (heating, cooling, lighting) or other support systems • Aerofoil sail design can provide propulsion of some larger vessels	• Varies with wind intensity • Requires back up in low wind areas and manoeuvring in port or narrow channels

Ship Energy Efficiency Management Plan (SEEMP) sets out a general requirement for all ships to manage energy efficiency. The Data Collection System is a mechanism to collect information on the fuel consumption of the world's fleet in a standardised and comparable format (IMO 2020b).

However, having set a goal of reducing 50% of shipping emissions by 2050 in absolute terms compared to 2008 levels, much more needs to be done and IMO is considering a list of some 15 possible short- and long-term measures. As IMO member states grapple with developing measures over the short- and long-term to get to that goal, it is useful to recall the general principles these countries agreed to in 2008 on what future regulations should be (IMO 2009):

1. *Effective in contributing to the reduction of total global greenhouse gas emissions*
2. *Binding and equally applicable to all flag States in order to avoid evasion*
3. *Cost-effective*
4. *Able to limit, or at least, effectively minimise competitive distortion*
5. *Based on sustainable environmental development without penalising global trade and growth*
6. *Based on a goal-based approach and not prescribe specific methods*
7. *Supportive of promoting and facilitating technical innovation and R&D in the entire shipping sector*
8. *Accommodating to leading technologies in the field of energy efficiency*
9. *Practical, transparent, fraud free and easy to administer*

Governments and their regulatory agencies need to create conditions for adopting technology: a predictable and supportive regulatory environment, conditions that ancient ship owners towards new technologies, and a level playing field. Simply prescribing specific technology or methods alone will not work. There will be cases where a given method may create a perverse effect—that is when a measure has the opposite effect than what was intended. More fundamentally, with the ultimate goal being to decarbonise the world's economy, regulators need to understand the technology to do so does not yet exist.

For now, it is only possible to work with existing measures, so measures that have general application and are straightforward would work best. Strengthening SEEMP requirements of the ship is one area for consideration. Including the SEEMP as part of a ship Integrated Safety Management system would place the SEEMP under a framework that is subject to an audit regime where ship owners are directed to resolve deficiencies.

New direction emerging from IMO includes new emission reduction measures for the existing ships. Two key approaches are an index-based measure and a goal-based measure. First, an Energy-efficiency for Existing ships Index or EEXI, which builds on the formula of EEDI, but modified to account for older existing ships, would set efficiency targets for ships to meet. Second, a goal-based approach would require ships to track and report Carbon Intensity Indicators (CIIs) and meet targets. While the EEXI is more developed than the CII approach, key concerns are the technical basis for both measures, how ships will be certified, collecting, tracking and reporting of data, and how enforcement would be implemented.

Speed has attracted a lot of attention, for on the surface, it seems to be a measure that can effectively achieve emission reductions across the board and in all sectors of the marine industry. For those vessels that normally voyage in excess of 15 knots, speed reductions could work in the short term to reduce current emission levels. However, setting a speed reduction as a general percentage would be less effective for those vessels that already voyage at slow speeds (such as 5–15 knots)—such as most inland water or river ships used in short sea shipping.

Thus, speed optimisation has gained more traction as it is seen as an option for ships to manage speed that reduces GHG emissions within their ship design, routes and trades. One option being explored is to control speed as an annual average for a ship or over a fleet. This would yield some near-term emission reductions while allowing for instances of safety or when speed is needed. IMO has developed technical guidance on speed management (GLOMEEP 2020).

Carbon levies were previously discussed at IMO and create a great deal of argument among members: Who pays? Who collects the funds? Is it tax? (which opens another debate). Who manages the funds? How are the funds to be spent? Who makes decisions on how they are spent? Do all countries get equal or proportionate access to the funds? Or only some? In previous discussions back in 2009, member states' views were widely divided and ended without advancing any new measures.

Carbon taxes are seen by many economists as the most efficient means of reducing emissions by getting people to change their behaviour. However, one failing about current carbon levies or taxes is that so far, they generally do not. A Norwegian study, some two decades ago, reviewed the effects of its carbon tax, which had been in place for 10 years at the time of the study and found it had only a modest effect owning to inelastic factors (Bruvoll and Larson 2002). A more comprehensive study in 2016 examined 19 carbon tax regimes worldwide in Canada, Australia and Nordic countries and found mixed results. Most regimes (some 63%) saw no significant change in energy consumption from prior to the tax (0.1–0.8% decrease); while other regimes saw declines in energy use of 10% or more. In countries where carbon taxes resulted in significant change, they were one component of a broader suite of measures to reduce GHG emissions (Nadel 2016).

Shipping is not so different and quite inelastic. It moves the world's trade and will continue to do so because that is the engine of economic growth—and that trade is the mechanism to fund the things societies must do to reduce and adapt to climate change.

In terms of an economic incentive to reduce emissions, marine shipping already has a major one: the IMO global sulphur cap that limits sulphur content marine fuels to 0.50% (entered into force on 1 January 2020). While carbon levies which typically average around 6–14% of fuel prices (Nadel 2016), the sulphur cap means ships had to shift to distillate fuels that are 40% more expensive (Transport Canada 2013; Shipandbunker.com 2020). Scrubbers can reduce this impact, but they too have capital and operating costs, and while their adoption has been increasing as of late, they are currently estimated to amount to only about 5–6% of the global fleet (DNV-GL 2020).

While carbon levies may not be that effective for marine shipping as an incentive measure they could be used to collect funds to invest in the technologies needed. Investment in research and development is critical to realise the decarbonisation goal. This was the reasoning behind the industry proposal for an international maritime research fund to look at zero-carbon technologies (ICS et al. 2019). However, a key element will be for regulators to ensure the funds are directed to their intended needs: developing zero carbon technologies.

A final element for regulators to consider is that shipping itself is the most efficient mode in the world to move freight. Short sea shipping within countries can still provide opportunities to increase the energy efficiency of the wider transportation system. This has been demonstrated by programs around the world, such as the EU's Marco Polo program (INEA 2020). Any transport system needs all four modes (air, road, rail and marine) to operate efficiently, but optimising for moving the most freight over the most efficient mode available can bring reductions in GHGs as all modes pursue decarbonisation.

All of these measures will take time, time to develop across 174 member states and time to implement across some 88,000 ships currently in service. There remains a wide debate among IMO members—some advancing very ambitious approaches, others being more conservative. Industry is participating as they will have to implement these future rules on ships.

8 Conclusions

The global economy will still require marine shipping to carry the majority of trade and marine shipping will continue to be the most efficient mode of transportation; carrying the most cargo for the least energy and emissions. Domestic marine shipping or short sea shipping offers efficiencies and opportunities for countries to reduce air emissions from their national transportation systems. Further investments to support infrastructure for domestic marine shipping can provide benefits that reduce air emissions, energy use, traffic congestion and road infrastructure deterioration.

However, efficiency alone is not enough, for any mode, as transport demand continues to rise. Shifting away from technology that produces carbon emissions, or decarbonisation, is necessary to meet these targets set under both IMO and UNFCCC. However, such technology does not yet exist at a commercial scale.

The IMO is developing a framework strategy to reduce GHG emissions from marine shipping, but its success depends on government implementation. Governments need to adopt smart policies that optimise all modes for efficiency and to support decarbonisation efforts. They will need to ensure that perfection does not become the enemy of the good, especially in the current transition phase leading to 2050.

Overall, the marine shipping industry has its role to play in the wider effort to shift the world to zero carbon emission energy sources. It is working towards these goals, and real progress is likely in the coming years as new propulsion systems are prototyped and tested. The marine shipping industry itself needs to develop new propulsion technology. Some new technologies from other modes may hold promise, but there are scale and practical implementation issues. The industry needs to carry out its own research—for which it has advanced a proposal to finance just that.

Widespread commercial adoption for zero-carbon emission technology will take time. As such, measures to increase efficiency of the current global fleet, adopt new lower carbon fuels or fuels with low carbon emissions over their lifecycle will be transition measures to bring about reductions while the zero emission technology is developed and commercialised.

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Chapter 22
Conclusions: Connecting Sustainable Development Goals to the Maritime Domain

Angela Carpenter, Jon A. Skinner, and Tafsir M. Johansson

Abstract Given the UN Decade of Ocean Science for Sustainable Development, which is to run from 2021 to 2030 (UN Educational, Scientific and Culture Organization, undated), together with the United Nations Sustainable Development Goals (SDG) and Agenda for 2030, many chapters of this volume highlight the pressing issues concerning sustainability in maritime niche areas with a sharp focus on ways forward aligned with the concept of good ocean governance. This concluding chapter provides a holistic overview of pertinent overarching interlinkages that bind the different SDG, by identifying areas where the targets contained within those SDG can be directly, or partially, related to various aspects of the maritime domain—shipping, ports, fisheries, climate change, renewable energy, for example. It also highlights the diverse and varied nature of the chapters contained in this volume, covering areas where sustainability strategies are needed not only at the current time, but also extending beyond 2030.

Keywords Gender equality · Climate change · Marine pollution · Ports · SDG targets

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1 Context for the Conclusions

The United Nations' 2030 Agenda for Sustainable Development (UN Sustainable Development (SD) 2015) set out a plan of action for people, the planet and prosperity. At the same time the Agenda sought to strengthen universal peace and freedom and to eradicate poverty—which it considered the greatest global challenge for sustainable development. In its Agenda for 2030, it presented 17 Goals for Sustainable Development (see Fig. 22.1), together with a range of targets associated with each goal. The goals and associated targets were *"the result of over two years of intensive public consultation and engagement with civil society and other stakeholders around the world, which paid particular attention to the voices of the poorest and most vulnerable"* (UN SD 2015, para. 6).

Subsequently, at a June 2017 meeting of the United Nations Conference to Support the Implementation of Sustainable Development Goal 14—Life Life Below Water, the SDG most directly associated with the Marine Domain—the UN General Assembly adopted its "Our Ocean Our Future: Call for Action" (UN General Assembly 2017). Paragraph 2 of that Call for Action highlights that *"the ocean is critical to our shared future and common humanity in all its diversity"*. Paragraph 3 goes on to identify that *"the oceans … connects our populations and markets and forms an important part of our natural and cultural heritage, … supplies nearly half the oxygen we breath, absorbs over a quarter of the carbon dioxide we produce, plays a vital role in the water cycle and the climate system and is an important source of our planet's biodiversity and of ecosystem services. It contributes to sustainable development and sustainable ocean-based economies, as well as poverty eradication, food security and nutrition, maritime trade and transportation* [and]

Fig. 22.1 UN Sustainable Development Goals for 2030. Source: UN Department of Economic and Social Affairs (UN DESA undated)

decent work and livelihoods" (UN General Assembly 2017, Para. 3). While the Call for Action places a particular focus on SDG 14, it also acknowledges the *"integrated and indivisible character of all the Sustainable Development Goals as well as the interlinkages and synergies between them"* (UN General Assembly 2017, Para. 6).

In this conclusion, we look at those interlinkages and synergies, presenting each SDG where the SDG or its targets appear to have relevance to the Maritime Domain, defined as *"all human activities occurring both above and below the sea surface, as well as activities on and below the seabed"* (Carpenter et al. 2021).

2 The SDGs and Targets as They Apply to the Maritime Domain

For the SDGs, the text discussing each individual SDG is taken from a document outlining the goals and targets (UN Sustainable Development 2019), which expanded on and set in context the original goals and targets identified in "Transforming our World: The 2030 Agenda for Sustainable Development" (UN Sustainable Development 2015). That Agenda has been examined and adapted to amplify only the SDGs and targets which can be directly or indirectly linked to the maritime domain. For some of the SDG, therefore, all of the targets are considered to be applicable (for example SDG4 on ensuring equitable access to quality education and, obviously, SDG14 on life below water), whereas for others only some (or even only one) are considered applicable.

2.1 SDG1: End Poverty in All Its Forms Everywhere

SDG1 highlights that *"poverty is more than the lack of income and resources to ensure a sustainable livelihood. Its manifestations include hunger and malnutrition, limited access to education and other basic services, social discrimination and exclusion as well as the lack of participation in decision-making. Economic growth must be inclusive to provide sustainable jobs and promote equality"*. While its seven targets include eradicating extreme poverty by 2030 and reducing by at least half the proportion of men, women and children living in poverty, the three SDG1 targets which appear to have the most relevance to the maritime domain are as follows:

- *By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.*

  - Partially relevant: in the maritime domain context economic resources (including natural resources) can be considered to include aquaculture and fisheries resources for local populations, including small island state populations and indigenous populations. Aquaculture and fisheries contribute to employment, food security and economic and sustainable growth, all of which also contribute to reducing poverty.

- *By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.*
  - Directly relevant: populations in coastal and low-lying areas are directly impacted by sea-level rise and extreme weather events. Resilience, for example by developing new methods to build houses for those populations, or barriers to prevent flooding may be areas to consider in order to protect people and reduce the impacts of such events.
- *Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions.*
  - Directly relevant: measures could be taken to protect local populations access to fisheries, to guarantee an adequate food supply (perhaps by limiting exports of fish out of an area) and to increase female participation in fisheries activities.

2.2 End Hunger, Achieve Food Security and Improve Nutrition and Promote Sustainable Agriculture

SDG2 notes that *"if done right, agriculture, forestry and fisheries can provide nutritious food for all and generate decent incomes, while supporting people-centred rural development and protecting the environment"*. SDG2 therefore explicitly identifies fisheries as a vital tool in ending hunger and achieving food security and improved nutrition. It also links to SDG1 where those fisheries activities also contribute to poverty reduction in coastal, small island and indigenous communities. SDG2 further notes that *"our soils, freshwater, oceans, forests and biodiversity are being rapidly degraded. Climate change is putting even more pressure on … resources* [and there are] *increasing risks associated with disasters such as … floods"*. SDG2 has eight targets of which the first two are to end hunger and malnutrition by 2030 and 2025, respectively. Of the remaining six, one mentions fishers, one mentions food commodities markets, and the remaining four apply specifically to agriculture and so are not relevant to the maritime domain. The two that are at least partially applicable are discussed below.

- *By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists* *and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.*

  – Partially applicable: while this target explicitly mentions fishers, it is within the context of doubling productivity and incomes for all small-scale food producers. As with the targets to reduce poverty, this target discusses access to resources—for the maritime domain this would be fishing grounds—and also includes access to knowledge, financial services and opportunities to add value. In this case, access to knowledge might include passing on information on the migratory patterns of fish stocks within indigenous populations.

- *Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility.*
  – Partially applicable: in this case the export of fish and shellfish from poorer areas may bring monetary benefits to that area, but may also mean that the local population can no longer access much needed protein sources. The need to ensure that the local populace has access to food reserves for their own use, before selling to other, richer, markets, should be considered in planning for food security in the future.

2.3 SDG3: Ensure Healthy Lives and Promote Well-Being for All Ages

SDG3 covers areas such as maternal health, increasing life expectancy, increasing access to clean water and sanitation, reducing the incidence or malaria, tuberculosis and other communicable diseases, and promoting mental health and well-being. Of its 11 targets, only three appear to have direct and specific relevant to the maritime domain, although issues such as mental health and well-being and also treatment of substance abuse (drugs and alcohol) may also be considered problems for seafarers working for long periods at sea. The two targets that appear to be most directly relevant are:

- *Achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all.*
  – Partially relevant: Under this target could be considered the needs of seafarers who work for long periods of time at sea and only infrequently access services on land. Access to healthcare and medicines may be limited by the fact that they operate away from their home base and can only access such facilities when visiting a port. The issue of vaccination is, however, directly relevant in the time of COVID-19. Seafarers have had to remain on ships far outside their

usual contract period as they have not been allowed to disembark in many ports, and it has been difficult to find replacements and transport them to ships. Vaccinations for the coronavirus may be difficult to obtain, and to provide to seafarers, and yet the global supply chain depends on those seafarers—90% of global trade is transported at sea (UNCTAD 2019) and any interruption in that supply chain could have significant impacts on the global economy. For further information, see LeClerc et al. (2021; Chap. 15 in this volume).

- *By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.*
  - Directly relevant: When considering water pollution, there has been a long history of both accidental oil pollution coming from ships, and from oil exploration and production activities (see for example Aldosari 2021; Chap. 10 in this volume). There are also multiple intentional and illegal discharges from those sources, and from other sources, every year. Marine pollution can have a direct impact on the food chain, especially when they occur close to land. Oil pollution is visible so action can be taken to prevent contaminated shellfish, for example, from entering the food chain. However, chemical spills may not visible and, if unreported or done illegally, substances can enter the food chain and be hazardous to human health. Actions by the International Maritime Organization (IMO) (see Christodoulou and Echebarria Fernández 2021; Chap. 20 in this volume), plus regional regimes, are therefore vital to prevent oil and chemicals from entering the marine environment, thus reducing the potential for deaths, or health problems caused by food contamination, from occurring.
- *Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.*
  - Potentially relevant for coastal states: Cooperation through the IMO and the International Labour Organization (ILO) is important to manage global health risks facing seafarers and fishers who work for long periods of time at sea. As noted above, there may be difficulties in these individuals being allowed to land in ports to access medical facilities, including vaccinations for the coronavirus. International collaboration for developing a vaccination strategy for this group will be important moving forward. An example of the need is how rapidly COVID-19 spread on cruise ships in the early months of the pandemic, and the issues this raised on how to evacuate passengers and quarantine them, but ships' crew were generally forced to remain on board. Multinational action was taken to successfully evacuate and repatriate passengers. It is far less clear what actions were taken to help crewmembers.

2.4 SDG4: Ensure Inclusive and Quality Education for All and Promote Life-Long Learning

SDG4 indicates that *"[o]btaining a quality education is the foundation to improving people's lives and sustainable development"* and that *"progress has been made towards increasing access to education at all levels and increasing enrolment rates in schools particularly for women and girls"*. SDG4 has ten targets, five of which are global targets for everyone, inclusive of workers in the maritime domain. Target 1 relates to equal access to free, equitable and quality primary and secondary education; target 2 to equal access to quality early childhood development, care and preprimary education; target 6 to a substantial proportion of all adults achieving literacy and numeracy; target 8 to building/upgrading education facilities that are child, disability and gender sensitive and are inclusive for all; and target 10 to increasing the number of qualified teachers and improved teacher training, including for least developed countries and Small Island Developing States (SIDS). For SDG4, the remaining five targets set out below can be considered at least partially relevant to the maritime domain and to meet the education and training needs of individuals working in the sector (see Sharma et al. 2021; Chap. 11 in this volume, for a broader discussion on maritime education and training).

- *3. By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.*
- *4. By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.*
- *5. By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations.*
- *7. By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development.*
- *9. By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries.*

With changes in the maritime sector, particularly with the introduction of technology such as Artificial Intelligence and Robotics in ports and on some ships (see Sharma et al. 2021; Chap. 11 in this volume; Ozturk 2021; Chap. 16 in this volume, for example), there is less need for manual labour and increased need for a more highly skilled workforce. Both women and men need to receive appropriate training, including vocational training (target 5), to fill jobs in ports and on ships (this also relates to SDG5 on gender equality). Developing scholarships and vocational training for SIDS (target 9), where many people depend on the sea for their employment and for economic sustainability and access to nutrition, is also an area which cuts across multiple SDGs including SDG2 on food security and SDG8 on decent work and economic growth, for example. For more information on SIDS, see Echebarria Fernández (2021; Chap. 18 in this volume).

2.5 SDG5: Achieve Gender Equality and Empower All Women and Girls

SDG5 identifies that *"while the world has achieved progress towards gender equality … women and girls continue to suffer discrimination and violence in every part of the work"*. It also notes that *"Providing women and girls with equal access to education, health care, decent work, and representation in political and economic decision-making processes will fuel sustainable economies and benefit societies and humanity at large"*. SDG5 has nine targets, including ending all forms of discrimination against women and girls, enhancing access to information and communication technology, and adopting and strengthening "*sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels"*. Of the nine targets, the majority cover all women and girls. There, however, can also be directly or indirectly related to the maritime domain.

- *Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation.*
  - Directly relevant: women on board ships face risks of harassment (including sexual harassment) (International Transport Workers Federation 2020). Indirectly relevant: Trafficking of women for the sex industry, as drug mules, or to work in low paid indentured jobs—much of this trafficking takes place by sea, requiring action by countries to patrol their sea borders (e.g. Naval actions), rescue individuals on small boats (e.g. Navy, Coastguard, NGO actions) or exploitation prevention activities (e.g. Border Patrol, National Police, International Police actions).
- *Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.*
  - Directly relevant: the proportion of women employed in the ports and shipping sectors are very low, and their participation at director or board level is even lower (see Pastra and Swoboda 2021; Chap. 19 in this volume). That lack of participation is an area that needs to be addressed in the maritime

domain, including through educational opportunities (SDG4) or greater access to decent work and economic opportunities (SDG8).

- *Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws.*
  - Partially relevant: while this target specifies access to ownership and control over land, it does not specify what other forms of property might be. Options might include ownership of boats or ships used for fishing activities, or the right to sell fish to have financial security. Inheritance and natural resources in this example could be passing down access to aquaculture activities or fishing grounds to women.

2.6 SDG6: Ensure Access to (Clean) Water and Sanitation for All

SDG6 relates to clean accessible freshwater for all, irrespective of where they live. Issues around water scarcity, poor water quality, inadequate sanitation, and droughts are some of the issues highlighted in this SDG. Its eight targets include achieving universal and equitable access to safe and affordable drinking water, equitable access to sanitation and hygiene, and also protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes. Two of the targets appear directly linked to the maritime domain and also to SDG3 on ensuring healthy lives (see Sect. 2) which highlights the need to reduce the number of deaths and illnesses from hazardous chemicals and reduce air, water and soil pollution. The two targets are:

- *By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.*
  - As noted Sect. 2.3, pollution from shipping and offshore activities can occur at sea but come ashore, leading to contamination of water sources. Wastewater from ships (sanitary waste, and greywater (from showers for example)), may also be discharged by ships when in port if there are no regulations to prevent that from happening. In tidal estuaries, contaminated seawater can travel inland on the tide, causing issues further upstream. Actions to minimize waste from ships and in ports in an area that should be considered when adopting measures for clean water.
- *By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes,*

including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.

- Directly related: where seawater is used to provide freshwater through desalination measures, it is vital to ensure that chemicals from maritime activities do not enter the marine environment and cause contamination and potentially hamper or damage the desalination process.

2.7 SDG7: Ensure Access to Affordable, Reliable, Sustainable and Modern Energy for All

SDG7 notes that sustainable energy is an opportunity to change live, economies and the planet. Its five targets cover ensuring access to affordable, reliable and modern energy services, increasing the use of renewable energy, improving energy efficiency and enhancing international cooperation to access clean energy research and technology. Each of these targets are relevant to every nation, as they promote the development, introduction and use of alternative energy sources. They are also directly relevant to activities across the maritime domain, for example by promoting increased use of sustainable engine or fuel types as ships are required to reduce energy use and related GHG emissions. Further, ports are also looking at measures to electrify their own—and visiting ships'—activities to reduce emissions to air. SDG7 also includes a target which specifically requires expanding infrastructure and upgrading technology in SIDS which has direct relevance:

- *By 2030, expand infrastructure and update technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and landlocked developing countries, in accordance with their respective programmes of support.*
  - Directly relevant: the development and growing use of offshore energy generation as a source of renewable energy—wind, wave, tidal—is already contributing to energy grids in developed countries. Offshore wind farms have become a common sight off the coastline of the United Kingdom, for example. Such technologies have the potential to benefit least developed countries that are also coastal states, together with SIDS. As renewable energy generation becomes more widespread, and as battery storage technology improves, these countries and States could see a reduction in their need for fossil fuel sources for energy.

2.8 SDG8: Promote Inclusive and Sustainable Economic Growth, Employment and Decent Work for All

SDG8 notes that low progress towards decent work opportunities and an improved pay and working conditions remains one of the major challenges for economies moving forward when trying to eradicate poverty (SDG1). *It further notes that sustainable economic growth requires "societies to create the conditions that allow people to have quality jobs that stimulate the economy while not harming the environment"*. Its 12 targets include suggested levels of per-capita economic growth of 7% gross domestic product annually for least developed countries; higher levels of productivity through diversification, innovation and technological upgrades; and improvements in global resource efficiency in consumption and production. While there are overlaps with other SDGs such as gender equality and human trafficking (SDG5) in the area of jobs for women, and improving education (SDG4) which have been discussed previously as they relate to the maritime domain, only one target of SDG8 appears to have direct relevance not previously discussed.

- *Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment.*
  – Directly relevant: the preponderance of jobs in ports, particularly in less developed or less mechanized small ports, is occupied by men and mostly involve low skilled manual labour (Van Hooydonk 2014). Labour rights may also be limited where there is a plentiful supply of temporary, low paid workers, and there is no pressure to improve the safety of such workers. In the shipping sector, manual jobs may also be carried out by poorly trained and low-wage workers. In both these examples, improved labour rights and safe, secure working environments, including for women, are clearly necessary, particularly for less developed countries.

2.9 SDG9: Build Resilient Infrastructure, Promote Sustainable Industrialization and Foster Innovation

SDG9 particularly focuses on investing in infrastructure such as transport, irrigation, energy and information and communication technology, in order to achieve sustainable development and to empowering communities. It indicates that *"Inclusive and sustainable industrial development is the primary source of income generation, allows for rapid and sustained increases in living standards for all people, and provides the technological solutions to environmentally sound industrialization"*. SDG9 has eight targets covering areas such as developing quality, reliable, sustainable and resilient infrastructure; promoting inclusive and sustainable industrialization; increasing access of small-scale industries to financial services; and enhancing scientific research and upgrading technological capabilities of industry sectors. Target 7 does mention SIDS when it discusses facilitating sustainable and resilient infrastructure. However, generally, while the targets relate to infrastructure and industrialisation in general terms, there is no single target that can be viewed as explicitly relevant to the maritime domain.

2.10 SDG10: Reduce Inequality Within and Among Countries

SDG10 returns to the theme of poverty as set out under SDG1. It highlights that inequality persists within least developed countries, landlocked developing countries and SIDS, particularly since there remain large disparities in access to health and education services, for example. In particular, it identifies that *"economic growth is not sufficient to reduce poverty if it is not inclusive and if it does not involve the three dimensions of sustainable development—economic, social and environmental"*. The targets of this SDG indicate that in order to reduce inequality, policies need to *"pay attention to the needs of disadvantaged and marginalized populations"*. None of its ten targets, covering areas such as achieving and sustaining income growth for the bottom 40% of the population, ensuring equal opportunities and reducing inequalities, regulating and monitoring global financial markets and institutions, and ensuring enhanced representation for developing countries in decision-making, can be directly and explicitly related to the maritime domain, although they may in some cases be indirectly related.

2.11 SDG11: Make Cities Inclusive, Safe, Resilient and Sustainable

As the title of SDG11 suggests, its main focus is on cities as "*hubs for ideas, commerce, culture, science, productivity, social development and much more"* together with the challenges cities face so that they can be maintained *"in a way that continues to create jobs and prosperity while not straining land and resources"*. Targets included in this SDG range from the provision of adequate, safe and affordable housing, protecting and safeguarding the world's cultural and natural heritage, and providing universal access to green and public spaces.

While this SDG will have relevance to port-cities particularly as they move forward together to become more sustainable (Carpenter and Lozano 2020), SDG11 can be viewed as only tangentially related to the maritime domain, mainly through its discussion at target 2 around *"provid*[ing] *access to safe, affordable, accessible and sustainable transport systems for all, improving road safety"*. The broader context for this target is transport within the city, but transport through the city of containers to and from ships on road transport may fall under this heading. Measure to improve air quality (target 6) might also be relevant here and also connect to SDG7 on energy consumption and emissions from ships in port or from road transport. Finally, some port cities are home to significant cultural heritage sites, so this is another area where the SDG may have some relevance to the maritime domain.

2.12 SDG12: Ensure Sustainable Consumption and Production Patterns

SDG12 defines sustainable consumption and production as *"promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty"*. It is a process which involves stakeholders from business, consumers, policy makers, researchers, scientists, etc.—effectively everyone involved in the lifecycle of consumption and production—together with cooperation across the supply chain from producer to consumer. SDG12 has 11 targets covering aspects such as achieving the sustainable management and efficient use of natural resources by 2030; achieving the environmentally sound management of chemicals and all wastes throughout their life cycle and significantly reducing their release to air, water and soil; promoting public sustainable public procurement practices; and supporting developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production. One target appears particularly relevant to the maritime domain:

- *Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle*.
  - This target is directly relevant to shipping and port companies which play a major role in the global supply chain, with 90% of global trade being transported at sea (UNCTAD 2019). The adoption of sustainable practices for ships might include speed reduction measures to cut GHG emissions and also reduce noise generated during a voyage (see Lancaster et al. 2021 l Chap. 14 in this volume; Pastra et al. 2021; Chap. 17 in this volume). For ports this might include technological solutions such as "Blockchain", a system of tracking goods throughout the supply chain, or enhanced security measures to reduce the time goods are retained in port (see Edgerton 2021; Chap. 8 in this volume).

2.13 SDG13: Take Urgent Action to Combat Climate Change and Its Impacts

SDG13 highlights that climate change affects every country, disrupts national economies and affects lives and has impacts that are likely to get worse in the future. Those impacts include changing weather patterns, sea level rise and more frequent severe weather events—as has been seen during the 2020 hurricane season in central America and the southern United States, for example. Those climate events are driven by GHG emissions from human activities, and global warming is forecast to get worse if measures are not taken to reduce emissions, impacting on the poorest and most vulnerable people. The SDG text highlights that *"climate change is a global challenge that does not respect national borders. Emissions anywhere affect people everywhere. It is an issue that requires solutions that need to be coordinated at the international level and it requires international cooperation to help developing countries move toward a low-carbon economy"*. The five targets under SDG13 are relevant across all countries, irrespective of whether they are developed or less developed countries, and cover aspects such as integrating climate change measures into national policies and promoting mechanisms for effective climate change-related planning and management in least developed countries and SIDS. One target appears to have specific relevance to the maritime domain:

- *Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.*
  - Directly relevant: ports are at risk from sea level rise and severe weather events, which might prevent ships from accessing a port, causing disruptions in the global supply chain. Harbours and anchorages in SIDS are also at particular risk of disruption from sea level rise, for example during hurricane season in the Caribbean, putting populations at risk of lack of access to food and other supplies or disruption of tourist activities, often a key economic resource in those states. Another example might be ships facing increased iceberg activity in the northern Atlantic causing navigational hazards.

2.14 SDG14: Conserve and Sustainably Use the Oceans, Seas and Marine Resources

SDG14, more commonly referred to as Life Below Water, highlights that *"The world's oceans—their temperature, chemistry, currents and life—drive global systems that make the Earth habitable for humankind"*. It further notes that *"Careful management of this essential global resource is a key feature of a sustainable future"*. This SDG has ten targets, some of which were due to have occurred by 2020. As all of the targets are directly relevant to the maritime domain, they are presented without commentary or examples below.

- *By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.*
- *By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.*
- *Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.*
- *By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.*
- *By 2020, conserve at least 10% of coastal and marine areas, consistent with national and international law and based on the best available scientific information.*
- *By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation.*
- *By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.*
- *Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries.*
- *Provide access for small-scale artisanal fishers to marine resources and markets.*
- *Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want.*

2.15 SDG15: Sustainably Manage Forests, Combat Desertification, Halt and Reverse Land Degradation, Halt Biodiversity Loss

SDG15, more commonly referred to as Life on Land, covers issues such as deforestation and desertification caused by human activities and climate change, those issues posing *"major challenges to sustainable development and* [affecting] *the lives and livelihoods of millions of people in the fight against poverty."* Its' 12 targets cover issues such as implementing sustainable management of forests (halting deforestation, forest restoration, reforestation), combating desertification, conserving mountain ecosystems including their biodiversity, and taking action to end poaching and trafficking of protected species of flora and fauna, for example. One target has some relevance to the maritime domain:

- *By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.*
  - Partial relevance: invasive species in aquatic ecosystems are often transported in the ballast water of ships and are unintentionally released into the sea or in a port when that ballast water is discharged. Species transported in this way may subsequently enter freshwater ecosystems, particularly in tidal estuaries. They may also enter ecosystems when small ships trade between sea ports and ports further inland via rivers and canals.

2.16 SDG16: Promote Just, Peaceful and Inclusive Societies

SDG16 is *"dedicated to the promotion of peaceful and inclusive societies for sustainable development, the provision of access to justice for all, and building effective, accountable institutions at all levels"*. Targets under this SDG cover areas such as reducing all forms of violence and related deaths, reducing illicit financial and arms flows, reducing corruption and bribery, and ensuring public access to information and protecting fundamental freedoms. All the SDG16 targets apply to every individual, institution and country globally.

2.17 SDG17: Revitalize the Global Partnership for Sustainable Development

SDG17, more commonly known as Partnership for the Goals, highlights the need for partnerships between governments, the private sector, and civil society to achieve the sustainable development agenda.

Those inclusive partnerships need to *“built upon principles and values, a shared vision, and shared goals that place people and the planet at the centre* [and] *are needed at the global, regional, national and local level”*. This SDG sets out a range of targets under specific headings—finance, technology, capacity building, trade, and systemic Issues (this final heading covering policy and institutional coherence, multi-stakeholder partnerships, and data monitoring and accountability).

SDG17 provides over-arching targets for all countries, including measures for richer countries to support poorer developing countries, for increased cooperation in providing access to science, technology and innovation through knowledge sharing and promoting a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, for example. As such, SDG17 presents a range of high-level targets which will influence and impact on the maritime domain as countries take actions and implement measures to become more sustainable in the future.

3 Chapter Summary

In this chapter, we have sought to show how the various UN Sustainable Development Goals can be connected to the maritime domain. By examining each of the 17 Goals and their associated targets, there are clear areas where a target is directly (or partially) relevant to maritime activities such as shipping or the ports industry. Others have links to the welfare of individuals working in the maritime sector, or highlight the need for a more educated and better trained workforce—including increased female workers—as jobs on ships and in ports change due to the introduction of new technologies, artificial intelligence and automation. For certain SDGs, other chapters in this book are highlighted as they provide a more detailed overview of how an SDG relates to the maritime domain. However, not all chapters in the book are highlighted here.

The range of topics covered in this book are wide and diverse—ranging from Greening the Blue Economy (Spalding et al. 2021; Chap. 2 in this volume) to Maritime Security (Skinner 2021; Chap. 6), and from Maritime Governance of Small Island Developing States in the Wider Caribbean (Echebarria Fernández 2021; Chap. 18) to Sustainable Maritime Labour Governance and Seafarer Welfare (Shan and Zhang 2021; Chap. 13).

The intention of this book is to respond in a timely way to developments in the maritime domain, i.e. the acceleration of developments in multiple maritime sectors (e.g. shipping, oil exploration) and associated issues (maritime security, gender inequality and sustainability). The maritime domain is the backbone of the current world economy and for the future development of blue economy as it provides the infrastructure and supporting activities for freight transport, fisheries, (deep) seabed mining, scientific research among others. Given the UN Decade of Ocean Science for Sustainable Development, running from 2021 to 2030 (UN Educational, Scientific and Culture Organization, undated), and the SDGs goals and Agenda for

2030, an exploration of sustainability strategies that are not only needed now, but also extend beyond 2030 are an important added value that this book aims to provide.

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Index

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