Chapter 3
Marine Ecosystems and the Blue Economy: Policies for Their Sustainable Exploitation

Anil Markandya

3.1 Background to Oceans and Coasts

The ocean is a critical part of Earth's life-support system and vital for the well-being of humanity. Nearly three billion people rely on fish as a major source of protein and fisheries and aquaculture assure the livelihoods of 10–12% of the world's population (WWF 2015).

This chapter reviews the information on the value of marine ecosystems, how these ecosystems have been changing in recent years and their likely changes in the future. It goes on to look at the role of different policies and measures to prevent their degradation. There is great interest in using the marine resources to promote the "blue economy and blue growth". The combination of high economic value and a declining and at risk asset base makes it critically important to have a sound understanding of where ecosystem service values are at risk, how they can be exploited sustainably, and what can be done to arrest the losses and overuse of the ocean that we currently observe.

3.2 The Use of the Ecosystem Approach

Much of the estimation of the value of the marine environment is based on work initiated by the Millennium Ecosystem Assessment (MEA 2005), which classifies values based on *ecosystem services* (*ESS*). These are derived from the complex

A. Markandya (✉)
Basque Centre for Climate Change in the Basque Country, Leioa, Spain

University of Bath, Bath, UK
e-mail: anil.markandya@bc3research.org

S. Hazra, A. Bhukta (eds.), *The Blue Economy*,
https://doi.org/10.1007/978-3-030-96519-8_3

biophysical systems and are classified under four headings: provisioning, regulating, cultural, and supporting, with a number of sub-categories under each heading. These services are provided by a range of different ecosystems within which different habitats can be found. An ecosystem where several habitats are present is referred to as a biome. The literature contains ten broad categories of which the ones relating to the marine environment are listed in Table 3.1.[1]

Before proceeding to look at the values of services provided by the ecosystems or biomes, two factors are worth noting.

First, as noted, one finds the planet has experienced major losses in the services derived from these ecosystems. During the last century, for example, the planet has lost 50% of its wetlands and around 60% of global ecosystem services have been degraded in just 50 years (Ten Brink 2011). Today 60% of the world's major marine ecosystems that underpin livelihoods have been degraded or are being used unsustainably. By 2100, without significant changes, more than half of the world's marine species may stand on the brink of extinction.[2]

Second, the benefits provided by ESS can be concentrated to a few people at one extreme or they can be global at the other. Fish food is an example of the former, while limiting GHGs is an example of the latter. The estimates of the benefits given later need to take account of who benefits, as that is important in determining the appropriate policies to protect the resources and particularly where the sources of finance to implement the policies should be mobilized. This issue also arises when the physical areas of the ESS are under national jurisdiction or beyond national jurisdiction. The methods of valuation for both types of areas are the same but it is important to have information on this question when determining the right policies.

Table 3.1 Marine biomes used in the ecosystem valuation literature

Marine (open oceans)
Coral reefs
Coastal systems
Coastal wetlands
Inland wetlands

Note: Coastal systems include estuaries, continental shelf areas, and sea grasses but not wetlands such as tidal marshes, mangroves, and salt water wetlands
Source: De Groot et al. (2012)

[1] Marine biomes include those in the polar regions although our understanding of these is even more limited than that of other regions because of their remoteness, hostile weather, and the multiyear (i.e., perennial) or seasonal ice cover. Coastal systems include and indeed pay special attention to those of small islands, where their role is of heightened importance.

[2] http://www.unesco.org/new/en/natural-sciences/ioc-oceans/priority-areas/rio-20-ocean/blueprint-for-the-future-we-want/marine-biodiversity/facts-and-figures-on-marine-biodiversity/

3.3 Global Estimates of the Value of Marine and Coastal Ecosystems

Going from the unit values of marine and coastal ESS presented above, there are two studies that estimate the global value of these services. The WWF has estimated these to be USD 2.5 trillion, from an asset base of at least USD 24 trillion (Hoegh-Guldberg et al. 2015). The authors note that only market based ESS are included, made up of direct output from the ocean (marine fisheries, mangroves, coral reefs, and seagrasses) of USD 6.9 trillion in asset value; shipping lanes, valued at USD 5.2 trillion; productive coastlines valued at USD 7.8 trillion; and carbon absorption of the ocean, thereby reducing global warming, valued at USD 4.3 trillion. Non-market values not covered include ecosystem services such as water filtration by mangroves, seagrass, and wetlands, and the value generated by ecosystems in terms of human culture and lifestyle. Furthermore, market based services may be undervalued. The economic importance of fisheries, for example, is often underestimated, because many of these fisheries are small-scale in nature, spatially dispersed and therefore poorly documented and/or under-reported.

The other major estimate of global values is from the work of Costanza et al. (1997) and Costanza (2014). The 1997 estimates were made for 17 ESS for 16 biomes, including open oceans and coastal areas. The result was a value of USD 11.6 trillion for open oceans and 17.3 trillion for coastal areas, making a total of USD 28.9 trillion. For 2011 the numbers made use of much more information on values for similar sites and included more ESS. The results showed a value of ESS provided of USD 49.7 trillion, of which USD 21.9 trillion was for ESS from the open ocean and USD 27.7 trillion from the coastal areas. The authors note that although the total value of ESS has gone up, a like for like comparison of values taking account of loss of area shows a decline in ESS values between 1997 and 2011 of 18%.

There is thus a big difference between these two estimates, with Costanza et al., being 20 times greater. It is more comprehensive (including more ESS), but it is also subject to more potential error, given the difficulty in valuing ESS across very different locations.

Numbers in trillions of dollars are difficult to comprehend, so it may help to put them in perspective. Global GDP in 2014 was about 78 trillion, which means the WWF figure would imply marine ESS to be worth 3% of GDP, while the Costanza et al., figure would indicate that these services were worth 64%, a figure some might find hard to believe. Indeed, a number of criticisms of the Costanza estimates have been made (see Pendelton et al. 2016).

Global estimates such as these serve to raise public awareness and interest but are of little use in designing policies for conservation or protection of the marine assets. They are also subject to considerable errors and can be controversial, as the above discussion indicates. In order to support such policies what is needed is a detailed location-specific and thematic-specific valuation of ESS over time, so it can be compared with possible costs of policies that would encourage conservation.

3.4 Trends in Services Provided by Coastal and Marine Ecosystems and Reasons for the Trends

There is a lot of evidence that a range of the services provided by marine and coastal biomes has been declining in physical and value terms. The reasons are habitat degradation on account of encroachment/reclamation and general air and water pollution and climate change. The underlying factor behind these primate causes, however, is the fact that decisions on the use of these biomes do not place a value on the ESS they provide. The underlying policy indicators, such as GDP are flawed to the extent that they do not take these values into account. This section looks at the overall trends in services in physical and value terms and see the extent to which they have been valued and where the values can be linked to these phenomena.

3.4.1 Trends in Global Values

The work of Costanza and colleagues estimates a decline in the value of ESS over the period 1997–2011 (Costanza 2014). The global value from all marine and coastal ESS in 1997, based on 2011 unit values was estimated at USD 60.5 trillion; by 2011 this had fallen to USD 49.7 trillion, a decline of 18%. The main cause for the fall is the area of coral reefs, which are estimated to be less than half their 1997 levels. The other declines are in the area of estuaries, which are estimated to be 28% lower by 2011. As noted above, however, there is some dispute about these figures, especially the trends in coral.

3.4.2 Trends in Biomes

There is information on trends in wetlands and mangroves (Worm et al. 2006), marine populations (FAO 2011; Dulvy et al. 2003), coastal ecosystems (Jackson et al. 2001; Lotze et al. 2006), and sea grasses (Waycott et al. 2009). Worm et al. (2006) compiled long-term trends in regional biodiversity and services from a detailed database of 12 coastal and estuarine ecosystems. They examined trends in 30–80 (average, 48) economically and ecologically important species per ecosystem. Records over the past millennium revealed a rapid decline of native species diversity since the onset of industrialization.

The decline in coral reefs has been well documented. UN, 2016, notes that these reefs have been in a state of continual decline around the world over the past 100 years, and especially over the past 50 years. A recent study by the World Resources Institute calculated that more than 60% of the world's coral reefs are under immediate threat. Indeed, the latest Intergovernmental Panel on Climate Change (IPCC 2014) report suggests that "coral reefs are one of the most vulnerable ecosystem on Earth" and will be functionally extinct by 2050, without adaptation (worst case scenario), or by 2100 with biological adaptation of the whole ecosystem. Presently the level of threats varies considerably in different geographical regions; reefs of the Pacific Ocean are least threatened, but those throughout Asia and the wider Caribbean and Atlantic regions are under greater threats.

This serious and deteriorating status of coral reefs around the world is due in part to climatic factors, especially temperature rise, ocean acidification, and sea level rise; and in part to damaging stresses driven initially by new technologies commencing in the 1970s. The major threats include extractive activities, pollution, sedimentation, physical destruction, and the effects of anthropogenic climate change (UN 2016).

Kelp forests and seagrass meadows are important marine ecosystems that are suffering losses. Both provide food and habitat to many economically exploited species, have high productivity. Brown seaweeds, which are composed primarily of kelps, contribute about half of the total world seaweed production from aquaculture of about 6.8 million tons a year. Seagrasses are not presently harvested commercially but they are critical food sources for large herbivores, birds, and for many other species.

Seagrass beds are reported to be among the most threatened ecosystems on earth with an estimated disappearance rate of 110 km^2 per year since 1980; the rates of decline accelerating from a median of 0.9% per year before 1940 to 7% year—1 since 1990 (Waycott et al. 2009). According to their assessment, 29% of the known areal extent has disappeared since seagrass areas were initially recorded in 1879.

Apart from overexploitation, a number of factors are identified as causes. (UN 2016). Kelp forest distribution worldwide is reported to be affected by overfishing of high value predators that causes explosions in herbivore populations, such as sea urchins, which feed on kelps, resulting in massive reduction of kelp cover and consequently affecting other trophic levels. In addition, changes in the distribution of species have been reported due to increased seawater temperatures.

The environmental degradation of seagrasses has been valued in economic terms by Waycott et al. (2009), to be an estimated USD 1.9 trillion per year in the form of nutrient cycling; an order of magnitude enhancement of coral reef fish productivity; a habitat for thousands of fish, bird, and invertebrate species; and a major food source for endangered species such as the green turtle.

Fortuna and Wilkie (2007) complied a review of trends in mangroves from 1980 to 2005 under the auspices of FAO. They estimated global mangrove areas in 2005 to be 15.2 million hectares, with the largest areas found in Asia and Africa, followed by North and Central America. An alarming 20%, or 3.6 million hectares, of mangroves had been lost between 1980 and 2005. Human pressure on coastal ecosystems and the competition for land for aquaculture, agriculture, infrastructure, and tourism are major causes of the decrease in area reported. The relatively large negative change rates that occurred in Asia, the Caribbean, and Latin America during the 1980s were caused primarily by large-scale conversion of mangrove areas to aquaculture and tourism infrastructure. UNEP (2014) notes that this degradation and loss are predicted to continue into the future if a business-as-usual scenario prevails.

In addition, mangroves are now threatened by climate change which could result in loss of a further 10–15% of mangroves by 2100.

A review of the state of the world's marine fishery resources (FAO 2011) notes the large increase in total fish production, which was only 19.3 million tonnes in 1950, but it increased dramatically to 163 million tonnes by 2009. Of the fish stocks assessed, 57.4% were estimated to be fully exploited in 2009. These stocks produced catches that were already at or very close to their maximum sustainable production. They have no room for further expansion in catch, and even some risk of decline if not properly managed. Among the remaining stocks, 29.9% were overexploited, and 12.7% non-fully exploited in 2009. The World Summit on Sustainable Development (WSSD) goal demands that all these overfished stocks be restored to the level that can produce MSY by 2015. This review suggests that this goal is very unlikely to be achieved, notwithstanding the good progress made in some countries and regions.

Looking at coastal ecosystems Lotze et al. (2006) observe that transformation of such areas is as old as civilization but has accelerated dramatically over the past 150–300 years. Looking back at 12 once diverse and productive estuaries and coastal seas worldwide, they find similar patterns of loss. Human impacts have depleted more than 90% of formerly important species, destroyed more than 65% of seagrass and wetland habitat, degraded water quality, and accelerated species invasions. The value of such losses is not assessed in detail, nor are the costs of conservation compared with the potential losses they arrest or recovery they achieve.

3.4.3 Potential for Use of Marine Ecosystems to Promote Sustainable Blue Growth

An important part of the discussion about marine ESS relates to the role they can play in extending the value of the services to develop new ones, thereby contributing to the sustainable development through the promotion of "blue growth".[3]

Before going into the options it is important to address the question of what is meant by blue growth and how it can be made operational. A useful definition is that provided by FAO, in its development of the *Blue Growth Initiative* (BGI), where it defines Blue Growth as "Sustainable growth and development emanating from economic activities in the oceans, wetlands and coastal zones, that minimize environmental degradation, biodiversity, loss and unsustainable use of living aquatic resources, and maximize economic and social benefits" (FAO 2014b). This requires growth to be measured in the right way, with actions that cause a loss of ESS to be debited with the value of that loss and with wealth accounts to reflect the changes in

[3] FAO has developed the *Blue Growth Initiative* (BGI) which is based on the principles enshrined in its Code of Conduct for Responsible Fisheries (CCRF), a key programme embedded in FAO's Strategic Objectives.

all forms of capital, including natural capital, which is the basis for the ESS that Blue Growth seeks to promote.

Critical to this interpretation of Blue Growth is an understanding of both the potential for using marine ecosystems to generate new services as well as possible damages to the natural capital from these services are derived. It is important to have information on the costs of different methods of exploiting the marine environment, so that it can be done sustainably. Areas where new or increased use of the marine environment is taking place that could be of interest to South Asia include:

- Multi-use offshore platforms
- Algae for biofuels
- Oil and gas extraction
- Aquaculture

3.4.4 Multi-use Offshore Platforms (MUOPs)

The world's oceans are being subject to massive development of marine infrastructure in the near future. This will include energy facilities, e.g. offshore wind farms, exploitation of wave energy, and also development and implementation of marine aquaculture. A key component of this infrastructure is the multi-use offshore platform. Such platforms require effective marine technology and governance solutions. There are around 16,600 oil and gas platforms.[4] Aquaculture, a fast growing sector has been increasing at an average annual rate of 6.2% in the period 2000–2012 (9.5% in 1990–2000), with corresponding growth in offshore platforms where it is located.

It is expected that the multiple functions of MUOPs have several environmental effects on Marine Ecosystem Services, directly or indirectly. Potential negative impacts range from loss of area and disturbance of biota, potential risk to affect the seabed, risks to jeopardize native habitats and species (biodiversity), including fish, mammals and birds, visual and noise impacts, use of marine space (otherwise used by marine communities), water or fish pollution because of toxic materials, coast modifications, etc. On the other hand, there are also some possible positive impacts created by the MUOPs which should be taken into account, such as the reef effects of the MUOPs' structures that can attract species and enhance biodiversity. In addition, MUOPs can help to mitigate for global warming, since they incorporate energy extraction technologies that do not emit greenhouse gases and substitute non-environmental friendly technologies. Accordingly, by going offshore coastal space is available for other uses (i.e. added value of open space), while offshore aquaculture does not affect the coastal water quality by creating eutrophication. The excess of continental nutrients in coastal waters causes eutrophication. Moving to the open

[4] http://www.infield.com/oil-gas-database/fixed-floating-platform-facilities

sea has naturally less nutrient values from coastal areas where the topography is more shallow and complex, restricting easy water exchange.

These factors have been reviewed by Koundouri et al. (2016). They set out the steps in an Environmental Impact Analysis for evaluating a potential platform site, which considers anticipated changes in the conditions, biology, and morphology before the platform and after. Factors also to be evaluated are biological diversity, existence of non-indigenous species, food web, eutrophication levels, seabed integrity, contaminants, marine litter, commercial fishing, and noise pollution.

3.5 Algae for Industry and Biofuels

Microalgae are currently cultivated commercially for human nutritional products around the world in several dozen small- to medium-scale production systems, producing a few tens to a several hundreds of tons of biomass annually. Total world production of dry algal biomass for these algae is estimated at about 10,000 tons per year. About half of this produced takes place in mainland China, with most of the rest in Japan, Taiwan, USA, Australia, and India, and a few small producers in some other countries (Benemann 2008).

Algae biofuels may provide a viable alternative to fossil fuels; however, this technology must overcome a number of hurdles before it can compete in the fuel market and be broadly deployed (Hannon et al. 2010).

3.5.1 Oil and Gas Extraction

Oil and gas extraction is a growing activity, with a number of impacts on marine ESS, including those relating to oil discharges from routine operations, the use and discharge of chemicals, accidental spills, drill cuttings, low level naturally occurring radioactive material, noise, and to some extent the placement of installations and pipelines on the sea bed (OSPAR 2009).

Protection of the marine assets can be partly but not wholly provided by the use of appropriate technology. For example, for exploration one can switch from oil based and synthetic based drilling fluids to water based drilling, which is less harmful when discharged. However, the discharge of water based fluids and associated drill cuttings are still a concern in areas with sensitive benthic fauna, for example, cold water corals. The desirable level of protection can be determined by comparing the costs in terms of damages to the costs of more protective methods. In making such comparisons, it is important to recognize the uncertainty in the state of knowledge and to apply the precautionary principle in setting the regulations.

3.6 Aquaculture

As noted under the multi-use platform discussion aquaculture has grown continuously in the past decades, increasing its global share of total fish production to close to half total production in 2012 (42%). It has already overtaken wild caught species in Asia. World aquaculture production can be categorized into inland aquaculture and mariculture. Inland aquaculture generally uses freshwater, but some production operations use saline water in inland areas (such as in Egypt) and inland saline-alkali water (such as in China). Mariculture includes production operations in the sea and intertidal zones as well as those operated with land-based (onshore) production facilities and structures (FAO 2014).

The environmental effects of aquaculture have been assessed in some detail in physical but rarely in economic terms. They include some positive and some negative factors:

- *Mangrove clearance*: In the past this was a major issue with respect to shrimp farming but the practice has practically been stopped. In fact, it has been estimated that less than 5% of mangrove areas have been lost due to shrimp farming, most losses occurring due to population pressures and clearing for agriculture, urban development, logging, and fuel (Da Silva and Soto 2009).
- *Effects on wild fish and habitats*: Aquaculture can diminish wild fisheries indirectly by habitat modification, collection of wild seed stock, food web interactions, introduction of exotic species and pathogens that harm wild fish populations, and nutrient pollution (Naylor et al. 2000).
- *Wild fish overexploitation*: Expanding aquaculture production can alleviate pressure on wild fisheries stocks; for example, increasing the production of farmed fish that compete directly with wild fish (such as shrimp, salmon, and molluscs) could reduce prices and create conditions that can lower investments in fishing fleets and fishing effort over time. Other farmed fishes, such as tilapia, milkfish, and channel catfish, provide alternatives to ocean fish such as cod, hake, haddock, and pollock (Naylor et al. 2000).

- It has also been argued that high fixed costs of fishing fleets, inelastic supplies of labour in the fishing industry, and continued subsidies to the fisheries sector (that approach 20–25% of gross revenue globally) may mean that increased aquaculture production will not result in lower catches of wild fish in the short term. Examples by Naylor et al. (2000) showed little obvious effect of aquaculture production on capture rates of wild fish.[5] In summary, aquaculture is a possible

[5] In the case of salmon, increased farm production has not resulted in reduced capture levels despite 30–50% declines in international prices for four of the five main species of wild salmon (chinook, coho, pink, and chum) during the 1990s. Salmon catches worldwide actually rose by 27% between 1988 and 1997. Similarly, despite rapid growth in alternative farmed fish like tilapia, wild capture of hake and haddock remained relatively stable during the past decade (Naylor et al. 2000).

solution, but also a contributing factor, to the collapse of fisheries stocks worldwide (Naylor et al. 2000).

A positive aspect of aquaculture involving mussels and oysters is that they are filter feeders and grow only on the basis of available nutrient and available carbon in the environment. A large amount of research and monitoring has demonstrated that mussel culture has a positive effect on the environment by removing the excess of nutrients from the water column by biofiltration (Massa et al. 2016). An example of a success story in carbon trading took place in the North Adriatic Sea, in the district of Venice and Emilia Romagna, where in the last few years about 50 mussel farmers have collectively introduced a system of ISO 14064 certification for carbon credits. In 2011, they produced about 32,000 Mt of mussels, worth about 20 million Euro, and were able to generate 4269 Mt of CO_2 credit in 2011 and 5883 Mt in 2012 (*data from MAA—Mediterranean Aquaculture Association*).

Thus while the jury is out on the overall environmental effects of aquaculture on fisheries and the marine environment, it is clear that site selection is a key process in any aquaculture development and suitable locations to undertake farming activities require sites with appropriate environmental characteristics, good water quality and enabling legal and economic conditions and where social acceptability and social responsibility are two essential components of aquaculture development (Massa et al. 2016). Through the establishment of specific zones dedicated to marine aquaculture, for example, allocated zones for aquaculture (AZA), the aquaculture site selection process would be improved while reducing negative aquaculture externalities, thus protecting aquaculture itself from adverse environmental conditions. The adoption and implementation of AZA would also improve the integration of aquaculture with other coastal activities thus preventing conflicts among stakeholders on the use of the marine resources.

Unfortunately, hardly any economic assessments are available of the trade-offs between the economic benefits of different sites and potential economic costs. Such an analysis would need to include possible effects of climate change on different locations, as well as considerations raised above of impacts on wild stocks. A wider economic analysis looking at the interactions between farmed and capture fisheries, including the use of fishmeal and fish oil in aquaculture (Massa et al. 2016).[6]

[6] Compound aqua feeds for farmed high-trophic level finfish and crustaceans are still strongly dependent on fishmeal and fish oil. In 2012 FAO estimated that, although on a declining trend, 14% of world fisheries production was destined to non-food uses, of which 75% (16.3 Mt) was reduced to fishmeal and fish oil (FAO 2014a). The use of fish-derived products in feed formulas raises the issues of whether this fish could directly be utilized as human food, or that a rising demand for fish as animal feed would eventually lead to an even higher overexploitation of marine resources. Sustainability efforts by industry and research are being made to identify more cost-effective dietary fishmeal and fish oil substitutes.

3.7 Policies that Impact on Marine Ecosystems

This section looks at the kinds of policies and investments that can be undertaken to manage marine ecosystems, so as to get the most sustainable use out of them in the long term. It also considers current inhibitors of development and drivers of change that need to be addressed, such as subsidies to damaging actions, subsidies to fisheries and others. In some cases, these instruments can have a bigger effect on marine ecosystems than conservation policies. The discussion here is not intended to be comprehensive in covering the policies, but rather it focuses on how the valuation of marine ecosystem services can help to better design such policies.

The review is divided into two sections. The first looks at policies specifically targeting conservation and management of the marine environment. These include:

- Regional governance
- Private governance
- Design of specific measures: MPAs; Closing high seas to fisheries; Co-management of fishing regimes

The second subsection looks at the role of policies that have as a primary goal an economic target, such as employment protection or growth, but that also impact on marine ESS. There is a role for valuing these impacts so that the policies can be designed to be more effective for both the environmental and economic goals of the government. Cases examined include:

- Fiscal reforms (Mohammed et al. 2016)
- Subsidies for fisheries (World Bank and FAO 2009)

In each case the discussion focuses on what role, if any, economic valuation has had or could have in policy design and decision-making and how greater use of economic valuation could strengthen the decision-making process.

3.8 Policies Targeting Conservation

3.8.1 Regional Governance

A major effort has been made by national and regional governments to address marine and coastal conservation. Given that most marine ecosystem cross national boundaries and include international waters, the focus is often at the regional level.

Billé et al. (2016) note that the regional seas programmes have had limited success, attributed to a lack of systematic implementation of agreements, problems of coordination between the three mechanisms, lack of finance for the programmes, and a lack of capacity. Notwithstanding these problems a few programmes have used economic valuation at least in part to obtain information on where priorities for action should lie and designed action plans based on that (implementation may, however, still be a problem). The following are some examples.

South China Sea and Gulf of Thailand A review of measures to reverse environmental degradation trends has been carried out in the nine countries in this region.[7] UNEP (2009) undertook a major exercise to value the degradation by setting up an economic valuation Task Force, which collected economic data assembled by national focal points. It concluded that the information gathered was superficial and inadequate from the perspective of conducting a cost-benefit analysis of the costs of action versus no action in implementing the regional Strategic Action Programme. The group then took a pragmatic approach to the problem and developed an initial listing of all the goods and services provided by specific coastal habitats. On the basis of an extensive dataset of national economic values for coastal goods and services it developed a method for determining regional economic values that could be used in a cost-benefit analysis of regional programmes or activities and it used that framework to support its decisions. The latter represents a significant intellectual input to economic analysis of ecosystem goods and services at the regional level since the values are derived through application of a formula that takes account of both local and intra-regional variations in market price and relates prices to the total stock.

The Guinea Current Ecosystem This ecosystem extends from the Bijagos Archipelago (Guinea Bissau) in the north to Cape Lopez (Gabon) in the south. The program had as a primary focus the priority problems and issues identified by the 16 affected countries that have led to unsustainable fisheries and use of other marine resources, as well as the degradation of marine and coastal ecosystems by human activities. As part of this it undertook a valuation of marine and coastal ESS under present conditions and under possible degradation. Using a combination of local valuation studies and benefit transfer from studies in other regions, an estimation was made of the use and non-use values of marine ecosystems (sustainable fishery, biodiversity, and non-use values); as well as coastal ecosystems (valuing timber and non-timber forest products, tourism, carbon sequestration, coastal protection, coastal protection, sewage treatment, drinking water, fish nurseries, and biodiversity). Values per hectare per year were obtained and based on those estimates made of the national value of ESS from these areas. The data, however, have not been used in designing specific actions, policies, and measures. As the report notes, decision makers need to make use of this information, taking account of its strengths and weaknesses.

3.8.2 Private Governance

For oceans, a range of sustainability governance arrangements have emerged in the last decade that see new kinds of interaction between public and private actors (Groeneveld et al. 2016). These interactions have arisen, in part, from the realization that ocean governance involves more than just management. It also requires diverse institutions that support sustainable practices. Prominent examples of such

[7] Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Vietnam.

initiatives are fisheries certification and seafood recommendation lists, where consumers are informed on sustainability aspects of fisheries and aquaculture products, and traceability schemes, where consumers can obtain detailed information on how and where their fish was caught. Rather than being strictly commercial or idealist, these sustainability initiatives are often the result of cooperation between private companies and civil society. Certification and traceability are now major activities involving private data providers and public agencies that promote sustainable fisheries.

There remains a risk that such practices limit the trade of some products for producers who cannot afford to obtain the necessary certification and some developing countries see the procedures as a form of protection on the part of the richer consumer markets. Developing countries are also creating national standards, but unlike Iceland and the US these efforts are motivated by concerns that segments of their fishing and aquaculture industries are unable to comply with the international standards, and as such be excluded from the market. These issues affect countries in South Asia and South East Asia as well. For example, in Thailand the government has developed the government-run and certified Thai Shrimp Label, while other governments in Southeast Asia have invested in Better Management Practice (BMP) and/or Good Aquaculture Practice (GAP) standards. Both these schemes are more inclusive of small-holders than the international schemes, but they are also constrained by a lack of recognition in export markets. Moreover, as noted by Vandergeest and Unno (2012), the standards imposed on fisheries and environmental policy by international certification bodies (often based in developed countries) have resonated with notions of an extension of protectionism.

The private sector is becoming increasingly involved in management and operation of marine protected areas, where its financial resources are a welcome contribution. The factors governing private sector choices are a combination of profit and a desire to contribute to sustainability through corporate social governance. It is not always the case, however, that these factors ensure the greatest social good. Hence the public sector has a responsibility to ensure that sites where private sector investments are made comply with practices that meet overall national and global sustainability goals. In doing this the valuation of social costs and benefits in economic terms has an important role to play.

3.9 Fiscal Reforms

The links between the state of marine ESS and macroeconomic and sectoral policies are very important; arguably such policies can have a bigger effect on these ESS than measures focussing on conservation.

Though fiscal reforms are not necessarily designed to meet the three dimensions of sustainability (economic, social, and environmental), if well designed and used in combination with other policy instruments, they can play an important role in sustainable management of fisheries (Bostock et al. 2004; Slunge and Sterner 2012, p. 107).

Three types of fiscal reforms are of particular importance for ESS—taxation, subsidies, and ecological fiscal instruments (Mohammed et al. 2016).

3.9.1 Taxation

Taxation is often used as a control instrument in fisheries: to regulate input (fishing effort) and output (fish landing). In practice, the experience of taxation in the marine area is mixed. On the one hand, it can provide valuable revenue to be re-invested for better marine management, for example, with fisheries, for regulating fishing input and output. On the other hand, taxation often prioritizes short-term budgetary needs over sustainable resources management. In Morocco, for example, the tax regime has led to under-declaring of catch levels and increased sales in informal markets—making the instrument less efficient in terms of resource management. This points to the fact that taxation is often not popular among fishers and therefore politically costly for many national governments to pursue.

A more successful example is that of Pacific license fees for tuna. Fishery taxes for the rich tuna fishery of the Pacific are governed by the 1982 Nauru Agreement among eight Pacific Island countries. The Nauru Agreement members moved to a minimum fee for fishing per vessel day which was set at a minimum amount of USS$6000 effective in January 2014. Initial data suggest that overall fishing license fee revenue almost quadrupled, from about US$60 million in 2010 to US$230 million in 2012 have increased fourfold to $230 million in 2012. This contributes to better management of the fishery in the area.

3.9.2 Subsidies

Subsidies are direct or indirect financial contributions made by governments to promote a specific activity or policy. Global fisheries subsidies are estimated at US$30–34 billion annually, with fishing equipment and fuel subsidies accounting for US$20–24 billion of that sum (Mohammed et al. 2016). Fish stock depletion globally has been driven in part by high levels of fishing subsidies (Sumaila et al. 2014; FAO and World Bank 2009). In many regions, subsidies are provided when costs exceed revenue, making too many fishing activities artificially viable financially, leading to overfishing. Such capacity enhancing subsidies are called *harmful* subsidies—from a sustainable management of fisheries point of view. A retreat from this approach would make a difference to the conservation and sustainable use of fish stocks.

Harmful subsidies provided by high income countries and their impacts on low income countries' fisheries are significant. For example, the EU provides up to €3 billion (USD 3.3 billion) of harmful subsidies annually to the fisheries sector. Such subsidies have enabled many fishing fleets to exploit fisheries beyond the territorial jurisdiction of the EU.

However, not all subsidies are harmful. There are some positive subsidies that can be used to promote sustainable management of marine fisheries. Such 'good' subsidies may include financing for monitoring and assessment of fisheries resources, effective policing and enforcement, and research and development for sustainable fishing gears and post-harvest loss reduction. According to Sumaila et al. (2014), the proportion of good subsidies to total subsidies varies from region to region. In their assessment of global fisheries for the year 2003, bad subsidies made up USD16.2 billion, while just USD 8 billion constituted good subsidies. The balance of subsidies were classified as ambiguous. This shows that despite the encouraging trend in the increase of 'good' subsidies, bad subsidies still dominate. The same paper notes that the developed world provides most of the world's subsidies. Since most of the world's small-scale fishers are in the developing world, it follows that small-scale fishers generally receive relatively less subsidies compared to large-scale fishers.

It should be noted, however, that some "good" fishery subsidies provided in the developing world have made positive contributions to the overall well-being of fisher communities and poverty alleviation. Bangladesh provides a good learning example to demonstrate how some EFTs can be successfully implemented. In this case the government needed to restrict the catch of Hilsa (the largest single species of fish in Bangladesh) to allow stocks to recover. Since Hilsa is very important in the livelihoods of the poor, the government also compensated them for lost earnings, by providing "affected" fisher communities (more than 210,000 households) with 40 kg of rice per household and alternative income generating activities. Even though no impact evaluation of the scheme has been done, increased fish catch levels suggest that the compensation scheme has had positive impacts both on hilsa population and the livelihoods of thousands of fishers in the lower Meghna Basin.

Overall, there has been limited progress in moving away from harmful subsidies, towards beneficial subsidies such as incentives for monitoring and enforcement. Therefore, international frameworks that tackle the wide use of subsidies particularly by high income countries need to be strengthened. At national level, governments should have clear targets to curb harmful subsidies and eventually eliminate them. This is timelier now than it has ever been, as the Open Working Group proposal for Sustainable Development Goals calls up on countries "by 2020, (to) prohibit certain forms of fisheries subsidies which contribute to overcapacity and over-fishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies".

3.9.3 Ecological Financial Transfers

While taxes and subsidies mainly target the behaviour of individuals or private agents, neither of these instruments necessarily support local administrators in providing incentives for the promotion of sustainable marine management. This is particularly important in countries where natural resources management falls under the jurisdiction of sub-national administration levels such as provinces and districts and costs of marine management are borne by local administrations.

Ecological fiscal transfers (EFTs) have been proposed and introduced in a number of countries (e.g. Germany, Brazil, Switzerland, and India) to compensate decentralized jurisdictions for the costs of providing ecological goods and services which generate spill over benefits beyond their boundaries. This is done by incorporating an environmental performance indicator to fiscal transfers from central governments to local or sub-national levels of the administrative hierarchy.

In marine and costal ecosystems management context, EFTs can be introduced in multiple ways. For example, imposition of no-take-zones or marine protected areas (MPAs) may impose loss in revenue to adjacent local governments which could be compensated by EFTs. One of the main reasons given for limited use of EFTs in developing countries is the limited financial capacities of national governments. However, there are existing social safety net programmes such as conditional social transfers in many developing countries (e.g. Bangladesh, Brazil, and India). Adding an ecological performance indicator to such existing programmes could be a cost-effective way of delivering both social and ecological objectives.

Lastly, we have the case of Payment of Environmental Services as a fiscal mechanism that can help sustainable management of environmental resources (PES). In the marine context one recent example is a study by Barr (2012) who examines its use in the context of artisanal fisheries. She notes that small-scale artisanal fisheries are identified as amongst the world's most vulnerable and display a high occurrence of poverty; many still live on the margins of human dignity and 20% are thought to earn less than $1 a day. At the same time small-scale fisheries are one of the major factors affecting coastal and coral reef health. Persistent overfishing and a rising use of destructive fishing gear—in an effort to catch whatever fish remain—result in the untiring and increasing degradation of these areas.

In areas of prevalent poverty, justifying interventions which serve to reduce fishers' effort, catch and ultimately income proves to be difficult. Indeed, in the past, many 18 marine conservation efforts met with high resistance and low compliance for failing to deal with the socioeconomic aspects of many of these fishing communities.

The use of PES to capture 'blue carbon' in coastal wetlands and mangroves has also been studied recently. Such beginning to feature prominently on the international agenda, under programs such as the International Blue Carbon Initiative, coordinated by the *International Union for Conservation of Nature*, UNESCO, and Conservation International. Local schemes have also emerged, such as Mikoko Pamoja, a 107-hectare mangrove conservation project in Kenya. PES schemes and proposals are also emerging to protect a range of other coastal and marine ecosystems for services associated with fisheries, marine biodiversity, and coastal protection. Payments are made in such cases for avoided destruction and thereby the continued storage of carbon. Friess et al. (2015) note, however, that a number of difficulties can arise from a number of external stressors that can result in damage to the PES site and a failure of the scheme. These include changes in sediment input, agricultural pollution, and pest infestations. Such risks effect the market price of the payments that buyers of the ESS are willing to pay and measures to address them would make the schemes more effective.

3.10 Conclusions

This chapter has reviewed the trends in marine ecosystems from an economic perspective. The value of services derived from these ecosystems, while subject to considerable uncertainty, is significant. Unfortunately, the value has been declining in recent years, in spite of higher levels of exploitation, because of the degradation to the ecosystems in many locations. The causes of the degradation are over exploitation, misuse of the marine biomes as a waste sink, conversion of coastal systems, and loss of habitat and climate change.

This degradation is not inevitable and can be reversed. A key role in doing so is to value the costs and benefits of marine-related activities and the incorporation of those costs in setting regulations and designing policies to manage the marine environment. If this is done, increased value can be obtained from the marine environment to promote blue growth.

The chapter has reviewed a range of instruments, to see how they can help to move the use of these ecosystems towards a more sustainable use. At present, while there are some developments that indicate a shift in a more encouraging direction, we also have government interventions, particularly some subsidies, that are harmful to the marine environment. There is also a greater need to increase cooperation in setting regulations that apply across extra-territorial jurisdictions. Finally, management in this area has to take account not only of the overall costs and benefits of different interventions, but also pay special attention to the way in which they impact on the many vulnerable groups that depend on marine resources for their livelihoods. Sadly, their conditions are worsening in many countries.

References

Barr, R.F. (2012). Marine Payments for Environmental Services in an artisanal fisheries context. Doctoral Dissertation to the London School of Economics.

Benemann, J.R. (2008). “Opportunities and Challenges in Algae Biofuels Production”, Position Paper, FAO: Rome.

Billé, R. et al., (2016). “Regional Oceans Governance: Making Regional Seas Programmes, Regional Fishery Bodies and Large Marine Ecosystem Mechanisms Work Better Together” in P. Nunes et al. (eds.), Handbook on the Economics and Management for Sustainable Oceans, Edward Elgar: Cheltenham.

Bostock T, Cunningham S and Bennett E (2004) Political economy of fishery fiscal reforms, Fishery fiscal reforms and poverty reduction, http://www.odi.org/sites/odi.org.uk/files/odi-assets/publicationsopinion-files/3115.pdf.

Costanza, R., et al., (1997). The value of the world’s ecosystem services and natural capital. Nature 387, 253–260.

Costanza, R. et. al. (2014). “Changes in the global value of ecosystem services”, *Global Environmental Change*, Volume 26, May 2014, Pages 152–158.

Da Silva, S.S. and Soto, D. (2009). “Climate change and aquaculture: potential impacts, adaptation and mitigation”. In K. Cochrane, C. De Young, D. Soto and T. Bahri (eds). Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper. No. 530. Rome, FAO. pp. 151-212.

Dulvy, N.K. et al., (2003). Extinction vulnerability in marine populations, *Fish and Fisheries*, 4, 1, 25-64.

de Groot, R.S. et al. (2012). “Global estimates of the value of ecosystems and their services in monetary units”, *Ecosystem Services* 1 (2012) 50–61

FAO (2011). “Review of the state of the world marine fishery resources”, FAO Paper 569, FAO: Rome.

FAO (2014a). “The State of World Fisheries and Aquaculture: Opportunities and challenges.” Food and Agriculture Organization of the United Nations, Rome, 2014.

FAO (2014b) Global Blue growth initiative and Small Island Developing States - Fisheries and Aquaculture Resources Use and Conservation Division (FIR) 7 pp. http://www.fao.org/3/a--i3958e.pdf.

Friess, D.A., Phelps, J., Garmendia, E., Gómez-Baggethun, E. (2015). Payments for Ecosystem Services (PES) in the face of external biophysical stressors, Global Environmental Change, 30, 31-42.

Groeneveld, R.A. et al., (2016). “Private Governance of Ocean Resources” in P. Nunes et al. (eds.), Handbook on the Economics and Management for Sustainable Oceans, Edward Elgar: Cheltenham.

Hannon et al., (2010). “Biofuels from algae: challenges and potential”, *Biofuels,* 1, 763-784.

MEA (Millennium Ecosystem Assessment), (2005). *Millennium Ecosystem Assessment: Ecosystems and Human Wellbeing: Current State and Trends*. Washington DC, Island Press.

Fortuna, S. and M.L. Wilkie, (2007). “The Worlds Mangroves: 1980-2005”, FAO Forestry Paper 153, FAO, Rome.

Hoegh-Guldberg, O. et al. 2015. Reviving the Ocean Economy: the case for action - 2015. WWF International, Gland, Switzerland., Geneva, 60 pp.

IPCC, (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Massa, L. et al. (2016). “Aquaculture in the Mediterranean and the Black Sea: a Blue Growth perspective” in P. Nunes et al. (eds.), Handbook on the Economics and Management for Sustainable Oceans, Edward Elgar: Cheltenham.

Mohammed E.Y. et al., (2016). “Fiscal reforms for sustainable marine fisheries governance: Institutional frameworks and design essentials” in P. Nunes et al. (eds.), Handbook on the Economics and Management for Sustainable Oceans, Edward Elgar: Cheltenham.

Jackson, J.C.B. et al. (2001). “Historical Overfishing and the Recent Collapse of Coastal Ecosystems”, *Science,* Vol. 293, Issue 5530, pp. 629-637.

Koundouri, P. et al., (2016). “A Socio-Economic Framework for Integrating Multi-Use Offshore Platforms in Sustainable Blue Growth Management: Theory and Applications” in P. Nunes et al. (eds.), Handbook on the Economics and Management for Sustainable Oceans, Edward Elgar: Cheltenham.

Lotze, H.K. et al. (2006). “Depletion, Degradation and Recovery Potential of Estuaries and Coastal Seas”, *Science*, 312, 1806–1809.

Naylor, R. L. et al. (2000). “Effect of aquaculture on world fish supplies”. Nature, 405: 1017-1024

OSPAR Commission (2009). “Assessment of impacts of offshore oil and gas activities in the North-East Atlantic”: OSPAR, London

Pendelton, L.H. et al. (2016). “Has the value of global marine and coastal ecosystem services changed?” *Marine Policy,* 64, 156-158.

Slunge, D. and Sterner, L. (2012). Environmental fiscal reform in East and Southern Africa and its effects on income distribution. In Castelluci, L. and Markandya, A. (eds.) Environmental taxes and Fiscal reform. Central Issues in Contemporary Economic Theory and Policy. Palgrave Macmillan. London, UK.

Sumaila UR, Dyck A, Baske A (2014) Subsidies to tuna fisheries in the Western Central Pacific Ocean. Mar Policy 43:288–294.

Ten Brink, P. (ed.) (2011). *The Economics of Ecosystems and Biodiversity in National and International Policy Making*, Earthscan, London and Washington.

United Nations (2016). First Global Integrated Marine Assessment (First World Ocean Assessment). Available at http://www.un.org/Depts/los/global_reporting/WOA_RegProcess.htm.

UNEP (2009). Reversing environmental degradation trends in the South China Sea and Gulf of Thailand. UNEP.

UNEP (2014). The Importance of Mangroves to People: A Call to Action. van Bochove, J., Sullivan, E., Nakamura, T. (Eds). United Nations Environment Programme World Conservation Monitoring Centre, Cambridge. 128 pp.

Vandergeest, P. and A. Unno (2012). A new extraterritoriality? Aquaculture certification, sovereignty, and empire. *Political Geography* 31:358-367.

Waycott, M. et al. (2009). “Accelerating loss of seagrasses across the globe threatens coastal ecosystems”, Proceedings of the National Academy of Sciences, 106, 12377-81.

World Bank and FAO. (2009). “The Sunken Billions: The Economic Justification for Fisheries Reform”.

Worm, B. et al. (2006). “Impacts of Biodiversity Loss on Ocean Ecosystem Services”, *Science*, Vol. 314, 787-790.

WWF (2015). Living Blue Planet Report: Species, Habitats and Human Well-Being. WWF, Gland, Switzerland.