Part 1: The Marine Environment: Oceans under Threat

As an introduction to an analysis of an instrument which is designed to protect the marine environment, it is crucial to explore the main characteristics of the subject of protection – the world's oceans – as well as the threats it faces. Consequently, the first part of this treatise, which is subdivided into two chapters, carefully examines the relevant properties of the oceans and the major human activities in marine areas. Because most human activities, not least international shipping, generate adverse effects for the marine environment, it also introduces the main sources of pollution and major groups of pollutants.

Chapter 1: The Oceans – Utilisation and Conflicts

The first chapter is largely divided into two sections. The first will introduce the marine eco-system so that the main characteristics of the subject of protection are clear. As the world's oceans are by no means untouched areas, the second section shall shed some light on the various human activities that make use of the sea.

I. The Marine Environment: Subject and Purpose of Protection

The importance of environmental protection today is a widely accepted postulate. Issues only raised by a minority until two or three decades ago have now evolved into a mainstream position. This observation does not only apply generally. With regard to the scope of this book, it can be said that there is no disagreement over aiming – as a priority – for the preservation and protection of the marine environment. However, as will be shown in subsequent chapters, the consent as to "if" should not lead anyone to believe that there is consent as to "how" to achieve adequate protection. It is no mere conjecture to attribute the differences to the different stakes involved and to different perceptions of sound protection.

Nevertheless, I consider it necessary – not least in order to put the analysis of the PSSA concept into context – to take a swift look at what marine environment protection means. Therefore, the first part of this chapter is dedicated to the object of protection: the sea in general. What constitutes the sea? And what are its unique features that render it so important? Since ecosystems consist of both non-living (abiotic) components and biotic components, I shall look at the physical and chemical features of the oceans, as well as their biological features and functions.

1. Oceans and seas – main physical and chemical properties

Generally, it can be noted that 71 per cent of the Earth's surface is covered with water. That equals a volume of 1370 million cubic kilometres and amounts to a total mass of about 1.4×10^{21} kg (approx. 0.023 % of the Earth's total mass).[1] The world's oceans may be differentiated into open oceans[2], semi-enclosed seas and enclosed seas[3], all of which have different characteristics.[4]

Nevertheless, as virtually all waters are – to a varying extent – interconnected, they boast similarities with respect to their water composition. Oceanic water is a complex solution. Many solid substances, not only sodium chloride and other dissolved ions, are dissolved or suspended in sea water.[5] Substances included in oceanic water are usually divided into five categories: main elements, dissolved gases, biogenic substances, trace elements and organic substances.[6] Eleven main chemical elements are to be found in seawater, including chloride, sodium, sulphate and magnesium, accounting for more than 99 per cent of all dissolved ions in seawater.[7] Dissolved gases are nitrogen, oxygen, carbon dioxide, argon and hydrogen sulphide, which mainly derive from the atmosphere, from biochemical or geochemical processes, such as degassing of the mantle into the Earth's crust.[8]

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[1] For further details, see Joachim Marcinek and Erhard Rosenkranz, *Das Wasser der Erde – Eine geographische Meeres- und Gewässerkunde*, Second Ed. (Gotha: Justus Perthes Verlag 1996), p. 15 and p. 30 et seq., as well as Frank J. Millero, *Chemical Oceanography*, Third Ed. (Boca Raton London New York: Taylor & Francis 2006), p. 2 et seqq.

[2] The global body of salt water is usually divided into five main bodies: the Pacific Ocean, the Atlantic Ocean, the Indian Ocean, the Southern Ocean and the Arctic Ocean. The name "Southern Ocean" was officially sanctioned by the International Hydrographic Organisation (IHO) in 2000 but is still disputed.

[3] For a list of seas, divided by oceans, see the information available from <http://en.wikipedia.org/wiki/Sea#List_of_seas.2C_divided_by_ocean>; (accessed on 30 September 2006).

[4] Cf. Michael J. Kennish, *Practical Handbook of Marine Science,* Third Ed. (Boca Raton et al.: CRC Press 2001) p. 14 et seqq. A very informative table about the different European seas is to be found in BfN, *Biodiversität und Tourismus – Konflikte und Lösungsansätze an den Küsten der Weltmeere* (Berlin Heidelberg: Springer 1997) p. 83 et seqq.

[5] A detailed list of seawater components is to be found in Günter Dietrich et. al, *Allgemeine Meereskunde*, Third Ed. (Berlin Stuttgart: Gebrüder Bornträger 1975), p. 88. See also Frank J. Millero, *supra*, note 1, p. 62.

[6] UN-Oceans, "Chemical Structure and Main Physical Properties of Water", available from <http://www.oceansatlas.org/unatlas/about/physicalandchemicalproperties/background/seemore2.html>; (accessed on 30 September 2006), p. 1. Michael J. Kennish, *supra*, note 4, p. 45, subdivides seawater components into four phases: dissolved solutes, colloids, solids, and gases.

[7] Frank J. Millero, *supra*, note 1, p. 59 et seqq.

[8] UN-Oceans, *supra*, note 6, p. 1.

Biogenic substances, i.e. inorganic substances consumed by water plants, comprise nitrogen, phosphorus and silicon. As they are an essential part of the life and food cycle of the oceans their amount depends primarily on the occurrence of biological processes. Trace elements, such as cobalt, copper, iron and manganese have various sources – both anthropogenic (river influx, harbours) and natural (deep-sea hydrothermal vents).[9] Although trace elements exist at very low concentrations, they play a critical role in sustaining the life processes of marine organisms. Yet they may be toxic at high concentrations.[10] Finally, organic substances, including carbohydrates, amino acids and proteins, mostly derive from primary production of marine phytoplankton and their greatest concentrations thus occur in the surface layer of the oceans.[11]

As regards the concentration of dissolved constituents in seawater, the composition is usually described by the salinity S, which is defined in terms of electrical conductivity and quoted in units of ‰ or "practical salinity units" (psu).[12] The mean salinity of the world's oceans and seas is 34.7‰. It is lower in coastal areas with high river run-off and higher at tropical latitudes, where evaporation is greater than at other latitudes.[13]

The mean temperature of the world's oceans, which is 3.5°C, must be differentiated from the mean surface temperature, which is 17.5°C.[14] Whereas temperatures in waters of the deep zone below 2,000 m (that makes up about 75 per cent of the oceans) remain at a constant level of between 0 and 4°C, temperatures in the upper zone change due to varying surface conditions. It is this so-called active layer reaching down to 200 to 400 m, in which most hydrological, biological, and other processes occur.[15] The temperature decreases down to a depth of about 1,800 to 2,000 m (so-called thermocline), below which the deep zone begins.[16]

2. Functions of the Oceanic Ecosystem

The world's oceans are the most important sustainer of life on earth. They constitute a gigantic wildlife habitat, supply food for livestock and humans, and

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9 G.A. Cutter, "Metalloids and Oxyanions", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *Encyclopedia of Ocean Sciences* (San Diego et al: Academic Press 2001), Vol. 3, pp. 1737-1745, at 1737 et seqq.

10 Aldo Viarengo, "Biochemical Effects of Trace Metals", 16 *MPB* (1985), pp. 153-158.

11 Günter Dietrich et al, *supra*, note 5, p. 91 et seqq.

12 Michael J. Kennish, *supra*, note 4, p. 59.

13 UN-Oceans, *supra*, note 6, p. 3. For a contour map of the global surface salinity field, see G. Lagerloef, "Satellite Measurement of Salinity", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 5, pp. 2511-2516, at 2512, Table 1.

14 Michael J. Kennish, *supra*, note 4, p. 167 et seq.

15 E.g. oxygen enters seawater as a result of photosynthesis in phytoplankton. See further M. Tomczak, "Upper Ocean Mean Horizontal Structure", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 6, pp. 3083-3093, at 3087 et seq.

16 Cf. W.J. Emery, "Water Types and Water Masses", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 6, pp. 3179-3187, at 3181 et seqq.

– last but not least – act as a buffer for the planet's climate cycle. These essential functions shall be looked at in a bit more detail in the following section.

a) Habitat for Flora and Fauna

Obviously, the oceans and seas are home to an abundance of plants, mammals, seabirds, fish, crustaceans, invertebrates and many other organisms. 140 different species of marine mammals occupy these habitats, more than 20,000 species of pelagic fish, around 5,000 species of larger zooplankton and almost 1,000,000 benthic species.[17] The marine environment is usually divided into benthos (bottom) and the pelagic environment (water column). The latter may further be subdivided into neritic (inshore) and oceanic zones.[18] To get a broad idea of the flora and fauna of the oceans, the major constituents of benthic and pelagic environments shall be introduced below. In addition, crucial habitat functions shall be illustrated by recourse to distinct characteristics of coastal areas and the deep sea, as these zones will feature prominently in the legal analysis in later parts of this treatise.

aa) Benthos

Benthos is defined as the assemblage of plants or animals that live in association with the seafloor. The benthic environment is usually divided up into different benthic zones, distinguished by depth: the supralittoral zone (above the high-water mark), the littoral and sublittoral zone (0 to 200 m), the bathyal zone (continental slope down to 3,000 m), the abyssal zone (from 3,000 to 6,000 m), and the hadal zone, extending downwards from 6000 m.[19]

Benthic communities are broadly divided into benthos of hard-bottom substrates and benthos of sediments. Hard-bottom substrate exists where the sea bed is not covered by soft sediments due to a specific surface structure, e.g. rocky shores or cliff slopes, or due to strong currents that constantly wash away sediments.[20] With respect to benthic animals (zoobenthos), two different groups can be found in both types of environment: the epifauna, encompassing all animals living on or attached to the surface of the sea floor, and the infauna, comprising all animals that live within the substratum.[21] Generally, the number of epifaunal species by far exceeds the number of infaunal species; infaunal species dominate, however, in sediment benthic communities.[22] Examples of epifaunal animals are

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17 Carol M. Lalli and Timothy R. Parsons, *Biological Oceanography: An Introduction*, Second Ed. (Oxford: Butterworth-Heinemann 1997), p. 76, at 147 et seqq., and 177.

18 *Ibid.*, p. 3, figure 1.1.

19 Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 176 et seq.; P.F. Kingston, "Benthic Organisms Overview", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 1, pp. 286-295, at 287. A percentage representation of each depth zone can be found in Figure 1 of the latter source.

20 Ulrich Sommer, *Biologische Meereskunde*, Second Ed. (Berlin et al: Springer 2005), p. 229 et seqq.; Michael J. Kennish, *supra*, note 4, p. 450.

21 P.F. Kingston, *supra*, note 19, p. 288.

22 Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 180.

corals, mussels and sponges; infaunal animals include crustaceans, clams, worms and other invertebrates.[23] Most zoobenthal infaunal species (95 to 99 per cent) are located within 5 cm of the sediment surface.[24]

Benthic plants (phytobenthos) are classified according to their size: macrophytes are large, visible plants, the most common of which are seagrasses and algae; microphytes are microscopic plants that can be extremely abundant even in deeper zones.[25] In contrast, the former typically grow in shallow waters, as they need a certain amount of light to grow. Yet, depending on the efficiency to capture blue-green light that does not penetrate very far, some macrophytes, such as red algae, may also be abundant in deeper water.[26] By and large, the vast majority of benthic organisms live in habitats in depths of 0 to 200 m.

bb) Pelagic Environment

The pelagic environment comprises *plankton*, a generic term used for organisms that are passively transported by ocean currents, and *nekton*, which is the sum of all pelagic organisms capable of actively swimming through the water independent of water movements.[27] According to their biological classification, the different categories of plankton are labelled as either phytoplankton (plants), zooplankton (animals), bacterioplankton (bacteria) or mykoplancton (fungi).[28] Flora and fauna making up plankton vary tremendously with respect to size; while there exist numerous unicellular organisms, some jellyfish species span several metres. In contrast to plankton, nekton merely encompasses animals. Fish form the largest fraction of nektonic organisms; others include crustaceans, marine reptiles and marine mammals.[29] It should be noted, however, that some species, at least at a young age, although classified as nekton may not have enough power to make their way against strong currents. The distinction between plankton and nekton is thus blurred in some instances.

Interaction between plankton and nekton is vital for marine ecosystems. As part of the oceans' food network, plankton provides a major food source for pelagic fish and marine mammals. At the end of these digestion processes, egesta are released into the sea, and later – as dissolved organic matter – used by bacterioplankton as a source of carbon. These bacteria are consumed by unicellular animals, which in turn are eaten by larger zooplankton – closing this so-called microbial loop.[30] As carbon dioxide is needed for photosynthesis processes in

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[23] *Ibid.*, p. 180 et seq. An overview of major taxonomic groups is given in Table 7.1 on p. 183.
[24] P.F.Kingston, *supra*, note 19, p. 291.
[25] Ulrich Sommer, *supra*, note 20, p. 232 et seqq.
[26] Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 179 et seq.
[27] Ulrich Sommer, *supra*, note 20, p. 134.
[28] *Ibid.*, p. 133.
[29] Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 146 et seqq.
[30] H.W. Ducklow, "Bacterioplankton", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 1, pp. 217-224, at 222 et seq. For a schematic illustration, see Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 121, Figure 5.7.

phytoplankton as part of the food network, this creates a link with the Earth's climate system, which will be addressed, *infra*, in Section I.2.b).

cc) Example: Coastal Areas

Coastal areas comprise a wide range of highly productive ecosystems, such as beaches, mangroves, salt marshes, mud flats, swamps, coral reefs and river estuaries, all of which primarily consist of benthic communities. Their crucial habitat functions for the majority of marine life shall be exemplified by looking at the first three.

Sandy beaches, which make up about 75 per cent of the world's ice-free shores[31], are seemingly devoid of life, because tidal action creates conditions best met by infaunal organisms that are very small.[32] Although physical conditions are often unstable due to varying water movement, sand guarantees low temperature and salinity fluctuations and may act as a protective cover against intense solar radiation. Most epifaunal animals, such as polychaetes, crabs and clams, have adapted to the specific conditions, inasmuch as they are highly mobile and able to burrow into the sand.[33] In addition, since food supply may be scarce, most fauna are "opportunistic feeders and able to maximize the resource."[34] It should not be forgotten that sandy shores in tropical latitudes are the principal nesting site for eggs of most marine turtle species.

Mangroves are very common along the coastlines in tropical and subtropical latitudes. The term mangrove is used for a group of plants in the intertidal zone but also defines a habitat type that is characteristic of places in which mangrove plants dominate.[35] Mangrove plants are shrubs or trees that have developed specific adaptations to survive in or adjacent to the intertidal zone.[36] Their common features are salt tolerance and an ecological restriction to tidal swamps. Moreover, mangrove plants have both aerial and shallow roots in order to allow the plants to obtain oxygen from the atmosphere, since the substrate is usually poor in oxygen.[37] Even though mangrove forests are able to cope with salt, they have to rely on freshwater input from time to time. Three ecologically different zoning patterns may be distinguished: the above-tide forest, the intertidal swamp and a subtidal zone, each of which is inhabited by distinct fauna and flora.[38] The forest is populated by terrestrial species, such as birds, snails and insects. With respect to the intertidal swamp, diverse local microhabitats make it difficult to

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31 See A.C. Brown, "Sandy Beaches, Biology of", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 5, pp. 2496-2504, at 2496.

32 Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 205 et seq.

33 Cf. A.C. Brown, *supra*, note 31, p. 2501 et seq. While hard-bodied animals mostly dig themselves in, soft-bodied invertebrates use foot or head as an anchor for burrowing.

34 *Ibid.*, p. 2502.

35 M.D. Spalding, "Mangroves", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 3, pp. 1533-1542, at 1533 et seq.

36 For a list of (core) mangrove species, see M.D. Spalding, *supra*, note 35, p. 1534.

37 Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 223.

38 See Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 224 et seq.

give a general description of predominant biodiversity patterns. Barnacles and oysters usually represent the bulk of epifauna, while it is also home to crabs, snails, worms and sea cucumbers.[39] Red and green algae can be abundant. The faunal and floral characteristics of the subtidal zone are also highly diverse. Mangrove roots support a biodiversity-rich community of algae, sponges, tunicates, anemones, hydroids and bryozoans; they furthermore serve as a nursery ground for an abundance of species of juvenile fish, shrimps, lobsters and crabs.[40] Adults represent the basis for local fisheries. Finally, it should be mentioned that mangroves generally are vital for protecting coastlines from erosion and wind damage, as well as for accumulating sediment that provides habitats for many epifaunal and infaunal species.

Salt marshes are mud flats above mean sea level vegetated by higher plants.[41] Similar to mangroves, salt-marsh systems have aerial storage of plant biomass and provide habitat for both terrestrial and marine species; they are also resistant to erosion. However, they are more common in temperate and cold regions of the world. Salinity varies considerably, depending on the strength of the tides, the duration of flooding, rain and river influx.[42] The duration of flooding also controls the level of oxygen in the sediment, which is a precondition for the species of higher plant that dominate in a particular marsh. Faunal elements include crabs, worms and snails living in or on the sediment, but also fish are important in regularly flooded marshes.[43] Salt marshes possess crucial ecological functions, as they "produce animals and plants, provide nursery areas for marine fishes, modify nutrient cycles, degrade organic chemicals, immobilise elements with their sediments and modify wave action on adjacent uplands."[44] However, marshes are very prone to damage by human modifications, especially diking.

As has become apparent, coastal areas – this observation is not confined to those looked at in more detail above[45] – are both productive and fragile ecosystems that are very sensitive even to natural changes of their predominant ecological conditions. Human-induced changes, such as urban development or the discharge of polluting substances, are an even greater challenge for these areas to cope with. It is thus not a premature conclusion to note that coastal areas merit particular attention in all efforts to protect and preserve the marine environment.

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39 *Ibid.*
40 *Ibid.*, p. 225.
41 J.M. Teal, "Salt Marshes and Mud Flats", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 5, pp. 2490-2495, at 2491 et seq.
42 *Ibid.*
43 For a concise overview of flora and fauna in salt marshes and mud flats, see *ibid.*, p. 2492.
44 *Ibid.*, p. 2493.
45 For a recent account of threats to fragile coral reef ecosystems, see Wiebke Rögener, "Untergang unter Wasser", *Süddeutsche Zeitung*, No. 122, 26 September 2006, p. 18.

dd) Example: Deep Sea

The majority of both benthic and pelagic environments are located in the bathyal, abyssal and hadal zones. Compared with the bathyal and sublittoral zones, relatively little is known about deeper areas of the sea. High costs are the chief limiting factor for deep-sea research. Still, even basic observations show that faunal and floral composition is very diverse and particular sites, such as sea mounts or hydrothermal vents, may host fascinating benthic communities.[46]

The deeper pelagic parts of the sea are completely dark (apart from certain instances of bioluminescence), since sunlight is only detectable to depths of 1,250 m.[47] Available food for pelagic fauna decreases with increasing depth, because it is derived from photosynthesis in the active surface layer; many organisms in the deep sea thus feed on detritus.[48] Fish cease to be the dominant component of the nektonic biomass below 2,500 to 2,700 m for physiological reasons.[49] As well as shrimps, they have not been collected from depths of more than 7,500 m, although scientists have observed some species even below 10,000 m.[50] The benthos is typically characterised by large plains of soft sediments, although small parts of hard substrate habitat exist.[51] While the total number of macrobenthos faunal species may decrease in areas below 3,000 m, the opposite is true for faunal species of microbenthos and meiobenthos: small burrowing polychaetes make up more than 50 per cent of the macrofauna in soft-sediment deep- sea benthos; meiofauna in these areas is dominated by nematodes.[52] Rather unusual benthic communities are to be found on sea mounts and around so-called hydrothermal vents.

Sea mounts are of volcanic origin and break up the landscape of abyssal plains.[53] Usually, their hard substrate and a relatively high flow of water supports a different set of species than in other parts of the deep sea. For instance, epifaunal suspension feeders that obtain food by filtering particles out of the surrounding water (e.g. sea anemones, mussels) flourish on these hard substrates, in contrast to deep-sea soft-bottom sedimentary areas, where their abundance is usually low. As most of them are passive feeders, relying on external water currents to convey

[46] An informative overview of deep sea flora and fauna was given by the CBD Executive Secretariat on the occasion of the first meeting of the ad hoc open-ended WG on protected areas, cf. UNEP/CBD/WG-PA/1/INF/1, *Scientific Information on Biodiversity in Marine Areas Beyond the Limits of National Jurisdiction*, 17 May 2005.

[47] Martin V. Angel, "The Pelagic Environment of the Open Ocean", in P.A. Tyler (ed.), *Ecosystems of the Deep Oceans* (Amsterdam et al: Elsevier 2003), pp. 39-79, at 39.

[48] Cf. J.D.M. Gordon, "Deep-Sea Fishes", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 2, pp. 687-693, at 690.

[49] Martin V. Angel, *supra*, note 47, p. 59 et seqq.

[50] Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 229.

[51] *Ibid.*, p. 226.

[52] *Ibid.*, p. 227 et seq.

[53] P.V.R. Snelgrove and J.F. Grassle, "Deep-Sea Fauna", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 2, pp. 676-687, at 678 et seq.; Ulrich Sommer, *supra*, note 20, p. 261 et seq.

food to feeding appendages, they only survive in environments with a fast and stable water flow.[54]

Hydrothermal vents and cold sweeps create environments that are entirely maintained by geothermal rather than solar energy.[55] Their predominant feature are fluids of up to 400°C with a large proportion of hydrogen sulphide (H_2S) that are released either through cracks in the sea floor or emerge as plumes from chimney-like vents ("black smoker"). H_2S, a reduced compound, is utilised by sulphur-oxidising bacteria, which thereby represent the primary producers of the food chain in this particular ecosystem; chemosynthesis instead of photosynthesis thus is the basis for life around the vents.[56] Hydrothermal vent systems support a unique biomass of large organisms, in particular when compared with surrounding deep-sea environments. Since hydrothermal vents were first discovered in the vicinity of the Galapagos archipelago in the 1970s, more than 500 new species, some of them large macrofauna (e.g. tube-dwelling worms up to 1.5 m long and clams that reach a length of 30 to 40 cm), have been discovered there and around similar sites in other oceans.[57] Because vents were discovered at a depth of 2,000 m and below, they have changed the perception of deep-sea ecology considerably.

To sum up, the deep sea boasts a high species diversity while the biomass is low; it features patchily distributed and distinct microhabitats.[58] It has been observed that most species found in the hadal zone below 6,000 m are endemic to it.[59] Complementing this observation, estimates say that many benthic deep-sea species have not yet been discovered and that their total numbers may exceed 1,000,000. If the protection of biological diversity is a true priority on the global agenda, then the deep sea is undoubtedly an important subject of protection.

b) Buffer within the Climate System

The climate system ensures that there is enough oxygen to sustain life on earth. Very broadly, oxygen that is consumed by respiration turns into carbon dioxide. Together with carbon dioxide that is created by both natural processes and fossil-fuel combustion, it is converted to oxygen again through photosynthesis processes in plants and trees. However, the so-called carbon cycle must not be reduced to respiration, fossil-fuel burning and photosynthesis. It is used to describe inter-

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54 Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 230.

55 Verena Tunnicliffe, S. Kim Juniper and Myriam Sibuet, "Reducing Environments of the Deep-Sea Floor", in P.A. Tyler (ed.), *supra*, note 47, pp. 81-110.

56 For an explanation of the biochemical processes, see Ulrich Sommer, *supra*, note 20, p. 262. These bacteria may form symbioses within specialised faunal hosts.

57 Around 95 per cent of the animals around vent sites were previously unknown, cf. Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 239. See further R.A. Lutz, "Hydrothermal Vent Biota", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 2, pp. 1217-1227. Nevertheless, as the degree of sulphur oxide is toxic for most species, biodiversity at vent sites is quite low.

58 Carol T. Stuart, Michael A. Rex and Ron J. Jetter, "Large-Scale Spatial and Temporal Patterns of Deep-Sea Benthic Species Diversity", in P.A. Tyler (ed.), *supra*, note 47, pp. 295-311, at 296 et seqq.

59 *Ibid.*, table 8.1.

actions between four major Earth reservoirs of carbon: the atmosphere, lithosphere, biosphere and hydrosphere.[60] In the end, the amount of carbon dioxide in the atmosphere is vital, not least because of problems associated with global warming due to increasing amounts of carbon dioxide in the atmosphere, known as the "greenhouse gas effect."

Because the hydrosphere is part of the carbon cycle and because it is able to remove "anthropogenic" carbon dioxide from the atmosphere, the oceans' functions in the global climate system are crucial. It is believed that more CO_2 is absorbed by the sea than is lost to the atmosphere.[61] Most CO_2 enters the oceanic sphere by photosynthesis of the phytoplankton, which is consumed by zooplankton and nekton. CO_2 is reproduced by respiration and mineralization processes. It may be removed from the carbon cycle by dead organic materials, such as skeletons, that sink to the ground. It has been observed that the majority of CO_2 of anthropogenic origin is eventually stored in the deep waters of the oceans, although the exact quantity is unknown.[62] Whether it is possible to enhance the natural capability of the oceans to store CO_2 by injecting dissolved CO_2 directly into the deep sea is currently being investigated and may be part of a future strategy to mitigate the effects of anthropogenic greenhouse gas production.[63]

Another aspect directly relates to the Earth's climate. The sea ice of the Polar regions, in particular, "mediates transfers of heat, fresh water and salt water between the oceans and the atmosphere."[64] Surface and deep-sea currents furthermore distribute heat and water around the world and thus influence temperature and precipitation patterns of all continents and climate zones. If strong currents change because of human-induced modifications, it may thus entail severe climatic impacts for large areas.

c) Food Repository

In describing the prevailing conditions of certain coastal area types above, I have already touched on the importance of the sea as a food repository. Probably billions of people inhabiting the world's coasts, especially in developing countries, rely on local fishery activities to ensure food security. These activities should not be understood to be limited to catching fish but also encompass catching shrimps, crabs and other crustaceans, as well as harvesting mussels, oysters and shellfish. Human consumption exceeds 100 million tonnes of fish in total, which equals a

[60] For an instructive figure, see C.A. Carlson et al, "Carbon Cycle", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 1, pp. 390-400, at 391.

[61] Carol M. Lalli and Timothy R. Parsons, *supra*, note 17, p. 142.

[62] Cf. IOC, "Climate Change", available from <http://ioc.unesco.org/iocweb/climateChange.php>; (accessed 30 September 2006) and C.A. Carlson et al, *supra*, note 60, p. 391 et seq.

[63] See IOC, "Ocean Storage", available from <http://ioc.unesco.org/iocweb/co2panel/CaptureStorageOcean.htm>; (accessed on 30 September 2006).

[64] IOC, *supra*, note 62, para. 2.

per capita edible fish supply of 16.3 kg.[65] The value of this catch amounts to almost US$ 80 billion.[66]

Although about 80 per cent of global fish stocks are located within the 200 nautical mile zone, over which states may exercise jurisdiction with respect to fisheries[67], high-sea fisheries, too, have developed into a flourishing industry within the last three decades. Large-scale fishing in these areas has resulted in extensive overfishing and left many fish stocks exhausted.[68] The decrease in traditional stocks, such as cod and herring, have given rise to deep-sea fishing below 400 m, which already yields similar problems.[69] However, fish and other marine animals will arguably continue to be a major source of food for human beings. During the last few years, the share of fish proteins in global animal protein supply has remained stable at around 16 per cent.[70] It is thus important to protect the marine environment in order to ensure sound conditions for fish to breed, mature and dwell within their natural habitats.

d) Intrinsic Value

Describing the functions of the sea alluded to above has revealed the importance of the oceanic ecosystem for all life forms on Earth. Yet this approach may inadequately limit our awareness and may contribute to overlooking another important dimension, the value of the sea detached from a value duly expressed in numbers and economic factors. In other words, it does not seem worthwhile maintaining the biological, chemical and hydrological functions of the world's oceans without preserving the beauty, uniqueness and vibrancy of many marine areas.

While I do not attempt to explore this philosophical question, my intention is to highlight the strong influence that the sea has on people's well-being and on the development of cultural values. The oceans have always been fascinating, as they both separated and united human beings; they have shaped today's culture and cultural values to an enormous extent. "Onomatopoetic to the highest degree"[71], the sea has inspired numerous musicians and composers, but of course other artists as well – poets, painters, sculptors – were profoundly susceptible to the mysteries the oceans bear. Their work in turn evoked repercussions among their audiences,

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65 Cf. FAO, *The State of World Fisheries and Aquaculture 2004 – Part 1: World Review of Fisheries and Aquaculture* (2004), available from <ftp://ftp.fao.org/docrep/fao/007/y5600e/y5600e01.pdf>; (accessed on 30 September 2006), p. 3. Moreover, 32.2 million tonnes are used for non-food products such as oil or fishmeal.

66 *Ibid.*, p. 7.

67 See, *infra*, Sec. III.2.b) of Chapter 4.

68 FAO, *Review of the State of World Marine Fishery Resources* (Rome: FAO 2005), p. 10 et seqq.

69 Cf. Odd Aksel Bergstad, John D. M. Gordon, and Philip Large, "Is the time running out for deep sea fish?", available from <http://www.ices.dk/marineworld/deepseafish.asp>; (accessed on 30 September 2006).

70 FAO, *supra*, note 65, p. 3.

71 Elisabeth Mann Borgese, *The Oceanic Circle* (Tokio New York Paris: United Nations University Press 1998), p. 50 et seqq.

challenging perceptions of the sea. Moreover, marine areas are an important refuge for seeking recreation and recovery. Amenities in coastal areas, such as lagoons and marshes, may prove to be most refreshing for body and soul.

One may argue that preserving the intrinsic value of the sea will inevitably lead to preserving its functional value. Of course, hardly anyone is fascinated by eroded coasts and marine areas devoid of life. However, the critical issue is that the protection of the environment must not be reduced to protecting something that we as human beings have to protect for *our* own good. It is especially true for the marine environment that it must be protected for *its own* good!

II. Conflicting Uses of the Oceans

Apart from sustaining life on earth, oceans – on a more practical note – also constitute a medium which is used by the world's people for numerous purposes. Mankind has always used the sea, long before people were able to understand oceanographic and geographical subtleties and biological-physical interactions.[72] From early on, fish have been caught as a prime food source for coastal communities. Later, after ships had become large enough to carry goods, trade was conducted by using vessels. Over the course of the last century, various new uses emerged: mining and tourism, aquaculture and energy production. In addition, the intensity of both traditional and new uses of the sea grew extraordinarily. It is apparent that the current situation has departed tremendously from what it was two or three hundred years ago. New situations often bring new problems; and the means that need to be developed to tackle them require sound understanding of the nature of the problems.

Since PSSAs are designed to abate vessel-source environmental degradation, the second part of this chapter is to shed some light on the context in which shipping takes place in today's world. It is arguably the most important use of the oceans. However, it cannot be seen uncoupled from other uses of the sea, because different human activities – especially in cramped parts of the world's oceans – often compete and sometimes conflict. Numerous uses may be identified, including fisheries and aquaculture, recreation, tourism, transportation, telecommunication, anthropogenic coastal development, offshore mining, military activities, scientific research, dumping of waste and disposal of waste from the land.[73] The following section shall identify and describe the major human activities at sea.

[72] Cf. Richard Gwynn, *The Way of the Sea – the Use and Abuse of the Oceans* (Green Books Bideford 1987). Such an approach treats land as "origin" and the sea as the "unknown" that humans started to explore and exploit. Elisabeth Mann Borgese, *supra*, note 71, p. 4 argues in favour of changing perspectives: life started in the sea and invaded the land.

[73] Co-management of multiple uses of marine areas is exemplarily described by Bela H. Buck, Gesche Krause and Harald Rosenthal, "Extensive Open Ocean Aquaculture Development within Wind Farms in Germany: the Prospect of Offshore Co-Management and Legal Constraints", 47 *Ocean & Coastal Management* (2004), pp. 95-122, at 97 et seqq.

1. Shipping

Carriage of goods (and people) by sea is a traditional and arguably the most important use of the sea.[74] Shipping today is common in all parts of the world apart from those waters permanently covered with ice. At the beginning of 2006[75], the total world merchant fleet stood at 41,110 ships with a tonnage of 944.5 million dwt. Compared with the figures for 2005, tonnage increased by 6.4 per cent. This reflects the highest growth rate for many years. Three major sectors can be identified. Capacity of the tanker fleet carrying oil, oil products, chemicals and gas amounted to 387.7 million dwt, which is a share of 41.1 per cent. Bulk carriers contributed 36.2 per cent (341.7 million dwt) to the world merchant fleet. Capacity of the container fleet accounts for 11.8 per cent (111.7 mill dwt). Despite its long tradition, shipping is a flourishing and seminal industry. During 2005, orders from the world's shipyards increased by 16 per cent. Outstanding orders in total have now reached an all-time high: 4,787 vessels with 236 million dwt.

Shipping is also a fairly dangerous business. In 2004, 592 persons – both crew members and passengers – were reported killed or missing.[76] The loss of ships due to accidents amounted to 0.56 million dwt. While losses for owners and charterers are mostly covered by insurance, adverse environmental impacts caused by groundings or spillages are more difficult to mitigate. A simple reference must suffice here. Threats to the marine environment by international shipping by both accidents and operational activities will be dealt with in the next chapter.

2. Tourism

Tourism can be understood as "the activities of persons travelling to and/or staying in places outside of their usual environment for leisure, business or other purposes"[77], either individually or in a group. Tourism activities have grown rapidly in recent decades and are expected to increase further.[78] Europe has the biggest share of world tourism, although the share of the East Asian/Pacific area and Africa is consistently increasing.[79] As has been noted with respect to Europe – and it may also be true for other parts of the world – coastal and marine areas have

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[74] For an outline of the development of shipping, see Richard Woodman, *The History of the Ship – The Story of Seafaring from the Earliest Times to the Present Day* (London: Conway Maritime Press 1997), p. 9 et seqq.

[75] Data for this section is taken from ISL, "ISL Market Analysis 2006 – World Merchant Fleet Development", 50 *SSMR* (January/February 2006). Excerpt available from <http://www.isl.org/products_services/publications/pdf/COMM_1-2-2006-short.pdf>; (accessed 10 April 2006). The statistics include ships of 300 gross tonnage and more.

[76] Information on maritime casualties are taken from ISL, "World Shipbuilding and Maritime Casualties", 49 *SSMR* (August/September 2005), pp. 1-5, at 5.

[77] UNEP/CBD/WS-Tourism/3, *Overview of Tourism and Biodiversity Issues, and Appropriate Management Approaches*, 30 April 2001, para. 61.

[78] World Tourism Organization, *Compendium on Tourism Statistics – 2005 Edition (Data 1998-2003)*, (Madrid: WTO Publications 2005), p. 25 et seqq.

[79] BfN, *supra*, note 4, p. 31 et seq.

proven to be especially attractive for tourists.[80] The types of activities that occur most frequently in these areas are surfing, yachting and boating; scuba diving and underwater fishing – especially in coral reefs; motorised boating; angling and collection of mussels and other molluscs; as well as wildlife observation.[81]

Tourism has long been considered to have only a very limited impact on the (marine) environment. Today, it has become clear that tourism, too, puts pressure on natural resources in various ways. Tourism sites and their infrastructure require the use of land which may have indirect impacts on the marine prolongation of the coastal zone.[82] Furthermore, tourists' activities not only exploit water resources but also lead to increased discharges of polluted water into rivers and oceans.[83] Some forms of tourism even have a direct impact on the marine environment, especially on marine wildlife: yachting and boating, in particular, have the potential to disturb wild species and alter or destroy habitats.[84]

In response to a request by the UN General Assembly[85], expert groups, under the auspices of the CBD Secretariat and various other international institutions, have started to elaborate guidelines on sustainable tourism.[86] These models aim to reconcile economic benefits with ecological and cultural values. If applied, they have the potential to lower the environmental impacts of tourism.[87] However, tourism as a *use* of the sea still occurs and competes with other uses.

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80 European Commission, *Towards Quality Coastal Tourism* (2000), available from <http://europa.eu.int/comm/enterprise/services/tourism/tourism-publications/documents/iqm_coastal_en.pdf>; (accessed on 30 September 2006).

81 BfN, *supra*, note 4, p. 45.

82 OSPAR Commission, *Background Document on Tourism* (2003), available from <http://www.ospar.org/documents/dbase/publications/p00184_Background%20document%20on%20tourism.pdf>; (accessed 30 September 2006), p. 8 et seq. With respect to the German Wadden Sea, cf. Christiane Gätje, "Tourismus und Erholung im Wattenmeer", in J.L. Lozán et al (eds.), *Warnsignale aus Nordsee und Wattenmeer* (Hamburg: Wissenschaftliche Auswertungen 2003), pp. 117-121, at 119 et seq.

83 OSPAR Commission, *supra*, note 82, p. 9 et seq.

84 *Ibid.*

85 A/Res/S-19/2, *Programme for the further Implementation of Agenda 21*, 19 September 1997, para. 70. An important preceding event was the World Conference on Sustainable Tourism, Lanzarote, 1995.

86 See e.g. The Plan of Action on Sustainable Tourism (PASTA) developed by UN Economic and Socia Commission for Asia and the Pacific, available from <http://www.unescap.org/ttdw/index.asp?MenuName=Pasta> (accessed 30 September 2006). Furthermore, the endeavours made by the World Tourism Organisation, information available from <http://www.world-tourism.org/frameset/frame_sustainable.html> (accessed 14 April 2005). Regional developments include efforts by the Caribbean Environment Programme (CEP); cf. CEP, *Improving Training and Public Awareness on Caribbean Coastal Tourism*, available from <http://www.cep.unep.org/issues/panos.PDF>; (accessed on 30 September 2006).

87 See generally Hansruedi Müller, *Tourismus und Ökologie – Wechselwirkungen und Handlungsfelder*, Second Ed. (München Wien: R. Oldenbourg Verlag 2003) p. 247.

3. Off-shore Mining

At first sight, mining in marine areas may seem odd, as the term evokes the image of miners working underground. But offshore mining is a generic term which encompasses several flourishing industries exploiting natural resources under the waterline, most of which use cutting-edge technologies. The main mining activities include extraction of marine sediments, drilling for oil and gas, and deep-sea minerals exploitation.

The most basic form of offshore mining is the extraction of marine sediment, typically conducted in the form of dredging. Marine sediments mostly contain sand and gravel, which are primarily used for the production of cement and concrete.[88] Modern dredging is carried out by purpose-built ships, in water depths of up to almost 100 m; typical trailing suction dredgers can carry more than 15,000 m^3.[89] Historically, drilling and production of oil and gas occurred only in shallow waters. Within the last few decades, scientific and technical developments have made it possible to set up installations designed to drill in depths of almost 3,000 m.[90] Offshore oil and gas production has become the world's biggest marine industry, generating massive revenues.

Offshore mining was long thought to be limited to the exploitation of sand/gravel and conventional hydrocarbon resources. In the 1960s, scientists started to recognise the potential value of non-hydrocarbon resources – mineral deposits, in particular, but gas hydrates, too.[91] Building on promising scientific results, engineers started to develop technologies to lift these minerals. As most of the minerals appear to be concentrated in extraordinary environments[92], there are still a lot of myths about their real value.[93] However, the exploitation of these re-

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88 ICES Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem, *Effects of Extraction of Marine Sediments on the Marine Ecosystem, ICES Cooperative Research Report No. 247* (Copenhagen: ICES Publishing 2001), p. 12 et seq.

89 *Ibid.*, p. 7.

90 For an overview of deep-sea drilling possibilities, see Paul L. Kelly, "Deepwater Resources: The Expanding Frontier", in M.H. Nordquist, J.N. Moore and T.H. Heidar (eds.), *Legal and Scientific Aspects of Continental Shelf Limits* (Leiden Boston: Martinus Nijhoff Publishers 2004), pp. 413-419, at 413 et seq. For recent developments, see Gerald Traufetter, "Jackpot unterm Meeresgrund", *Der Spiegel*, No. 37, 11 September 2006; available from <http://www.spiegel.de/spiegel/0,1518,436939,00. html>; (accessed on 30 September 2006).

91 For the different mineral compounds, see F.C.F. Earney, *Marine Mineral Resources* (Routledge: London New York 1990) p. 71 et seqq. For gas hydrates (or clathrates), see information provided by <http://www.gashydrate.de>; (accessed on 30 September 2006) and R. Matsumoto, "Methane Hydrates", in J.H. Steele, K.K. Turekian, and S.A. Thorpe (eds.), *supra*, note 9, Vol. 3, pp. 1745-1757.

92 For instance, polymetallic sulphide deposits are located around hydrothermal vents; cf. Lindsay Parson, "Non-Hydrocarbon Resources", in M.H. Nordquist, J.N. Moore and T.H. Heidar (eds.), *supra*, note 90, pp. 423-429, at 427.

93 The introduction of rather odd names for some of the minerals found, such as "ferromanganese nodules", contributed to firing people's imagination about what could

sources is no longer fiction but fast becoming reality, even though the revenues can not yet be compared with those from oil and gas drilling.

4. Fishing and Exploitation of other Living Marine Resources

Probably the most traditional use of the sea is fishing by using vessels. In the last century, due to excessive overfishing of existing wild stocks, large-scale fish farming, so-called aquaculture or mariculture, has also become very popular, because it has proved to be technically feasible and economically attractive. Both aspects will be dealt with here. Since I have already touched upon fisheries in Section I.2.c) of this chapter, I will only add some important information.

Global fisheries comprise small-scale fishing by local and indigenous communities in coastal areas, as well as industrialised high-sea and long-distance fishing by the fleets of developed and some developing countries, first and foremost Chile and China. The world's fleet of large marine fishing vessels encompasses about 24,000 vessels, which equals 15.6 million gross tonnage.[94] With the average age of the fleet increasing, concerns have been expressed over the safety of vessels and crew.[95] Fishery as a use of the oceans does not only have impacts in terms of the numbers and activities of fishing vessels but also in terms of the fishing gear used. Most importantly, high-sea drift nets, gill nets that drift with currents, sometimes exceed several kilometres in length and thus occupy large areas.[96] Despite a 1992 global moratorium on large-scale drift nets (exceeding 2.5 km in length) that was designed to abate adverse effects on non-targeted marine mammals[97], the use of drift nets is still common in most parts of the world.[98]

Aquaculture is the cultivation of fish or shellfish in some form of confinement in fresh or marine water, with mariculture being its specific marine subset. Aquaculture production is very ancient, but has grown rapidly in recent years; the bulk of pens for maricultured fish and shellfish, which make up about 30 per cent of the world's total supply of fish, are located in the coastal waters of developing

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possibly be found at the bottom of the sea. The reality was harder: in some places, commercial exploitation was suspended because pilot mining tests could not successfully demonstrate sufficient economic advantages; see Peter M. Herzig, "Seafloor Massive Sulfide Deposits and Hydrothermal Systems", in M.H. Nordquist, J.N. Moore and T.H. Heidar (eds.), *supra*, note 90, pp. 431-456, at 442 et seqq.

94 FAO, *supra*, note 65, p. 24.

95 In some developing countries, fishing fleets have an average age of over 30 years; *ibid.*, p. 25.

96 Otto Gabriel et al, *Fish Catching Methods of the World*, Fourth Ed. (Oxford: Blackwell Publishing 2005), p. 279 et seq.

97 See A/Res/46/215, *Large-scale pelagic drift-net fishing and its impact on the living marine resources of the world's oceans and seas*, 20 December 1991, para. 3.

98 The EU introduced a ban on all drift nets in 1992: see Nina Wolff, *Fisheries and the Environment – Public International and European Community Law Aspects* (Baden-Baden: Nomos Verlagsgesellschaft 2002), p. 157 et seq.

countries.[99] Yet, compared to their economic revenues, mariculture installations cover only a small share of the world's coastal and open-water areas.[100]

5. Energy Production

Recent decades have witnessed the advent of new technologies to overcome dependence on non-renewable resources for energy production, such as coal and oil. Marine energy production has an important role to play in this development, since it became apparent that natural forces such as currents, winds, tides and waves could be used to propel turbines to produce electricity.

Off-shore wind energy plants are the easiest to run, as the basic techniques have already been tested and used on land. Technical challenges are confined to anchoring the plant in the sea bed. Tidal energy plants and wave energy plants, in contrast, are specifically designed to use oceanic forces. The practical application of these techniques has so far not gone beyond the status of pilot projects at a few experimental sites. Several different methods are currently being tested.[101] Wave-power devices, mostly floating on the water, may be used at the shoreline, off-shore and in deep waters.[102] Tidal energy plants usually attempt to capture energy from tidal currents.[103] At high tide, the water is trapped by a barrage, creating a tidal lagoon. If the water level outside the lagoon falls, the water is released and the difference in height is used to drive turbines. Tidal power plants are thus only used in coastal areas with a high tidal range.[104] It is estimated that less than 3 per cent of ocean areas are suitable for tidal power generation.[105]

Coastal areas of developed countries, in particular, are increasingly used as locations for marine energy plants, in particular wind-energy farms. For instance, after the German federal government in 2002 had created a legal basis for issuing

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99 FAO, *supra*, note 65, p. 18.

100 However, conflicts with other uses may occur in some areas without proper planning mechanisms in place, see, e.g., FAO/NACA, *Report on a Regional Study and Workshop on the Environmental Assessment and Management of Aquaculture Development* (Bangkok: NACA Environment and Aquaculture Development Series 1995), No. 1, Annex II-4, para. 2.

101 Cf. information available from <http://en.wikipedia.org/wiki/Tidal_power> and <http://en.wikipedia.org/wiki/Wave_power>; (both accessed on 30 September 2006).

102 For instance, the planned 30 MW *Pelamis wavefarm* off Portugal will occupy 1 km^2 of ocean. Cf. <http://www.oceanpd.com/Pelamis/default.html>; (accessed on 30 September 2006). Tidal power potential in general is enormous: see information available from <http://www.bwea.com/marine/resource.html>; (accessed on 30 September 2006).

103 P.L. Fraenkel, "Power from Marine Currents", *Journal of Power and Energy* (2002), Vol. 216, pp. 1-14.

104 It is currently being contemplated to construct a barrage power station 16 km long in the Severn Estuary (UK), see DTI, *The Severn Barrage – Definition Study for a New Appraisal of the Project* (January 2002), available from <http://www.dti.gov.uk/files/file 15363.pdf>; (accessed on 30 September 2006). Obviously, ships would have to navigate through locks.

105 For details, see A. Clive Baker, *Tidal Power* (London: Peter Peregrinus 1991), p. 195 et seqq.

permits for wind-energy installations in the EEZ of the North and the Baltic Sea, the competent agency (Federal Maritime and Hydrographic Agency – *BSH*) was faced with an enormous number of applications. Concerns were expressed that Germany's EEZ and territorial sea would be filled with wind-energy plants with just a few spots and some sea lanes kept free for nature protection purposes and shipping respectively.[106] As of today, in the German EEZ of the North Sea 10 wind farms have been approved with a total number of 697 wind-energy plants.[107] It is widely accepted that wind farms constitute a danger for shipping and that accidents may have severe consequences.[108]

It is not difficult to predict that the use of marine energy production will increase, as it is part of a solution to become independent of conventional non-renewable energy sources that are finite and, indeed, will be exhausted in probably fewer than one hundred years. Furthermore, using renewable forms of energy does not emit any CO_2 and thus does not contribute to the greenhouse-gas effect driving global climate change. Proliferation of their use and further investment in technical development can be expected. With less marine space available, navigation for ships will become even more complex.

III. Concluding Remarks

It has become apparent throughout this chapter that the oceans are a vital source of life on the planet Earth. They host a plethora of both floral and faunal species, some of which, in particular deep-sea species, still need to be properly identified and described. Oceans play a pivotal role in maintaining the climatic cycle and in providing food for billions of people all over the world. In the light of these observations, the need for continuous protection is patently obvious. Nevertheless, the world's oceans are under threat. An ever more diversified range of uses today competes for limited marine space, including activities such as mining and energy production that were once largely confined to terrestrial areas. Shipping is still the most important use in both economic and ecological terms. Human activities are leaving their marks on the oceans, with the pollution of seawater and degradation of marine habitats being the most obvious. These threats to the marine environment, in particular the contribution of international shipping, will be looked at thoroughly in the next chapter.

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[106] SRU, *Windenergienutzung auf See, Stellungnahme vom April 2003*, available from <http://www.umweltrat.de/03stellung/downlo03/stellung/Stellung_Windenergie_April2003.pdf>; (accessed on 30 September 2006), p. 1 et seq. A detailed account of the manifold utilisations of the German Bight is given by Bela H. Buck, Gesche Krause and Harald Rosenthal, *supra*, note 73, p. 97 et seqq.

[107] See BSH, "Windparks" (2006), available from <http://www.bsh.de/de/Meeresnutzung/Wirtschaft/Windparks/index.jsp>; (accessed on 30 September 2006).

[108] Cf. Edmund Brandt and Karsten Runge, *Kumulative und grenzüberschreitende Umweltwirkungen im Zusammenhang mit Offshore-Windparks* (Baden-Baden: Nomos Verlagsgesellschaft 2002), p. 73.