Chapter 54. Overall Assessment of Human Impact on the Oceans

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1. Overview of impacts

No part of the ocean has today completely escaped the impact of human pressures, including the most remote areas. One clear example of this is the universal presence of stratospheric fall-out from atmospheric nuclear-weapons testing, but many other pressures on the marine environment are nearly as widespread.

Human pressures impact on the ocean in many and complex ways. They can take effect directly (as when an oil spill kills sea-birds and sessile benthic biota) or indirectly (as when climate change results in changes to the stratification of seawater, with an adverse effect on the nutrient cycle and the production of the plankton on which fish feed). Equally, the effects can be seen both on the natural environment (as when populations of sea turtles are reduced by tourist development on or near their breeding beaches) as well as on human society and economic activities (as when the collapse of a fish stock removes the economic base of coastal communities). Human pressures can also vary widely in their intensity and spread. Sometimes they have a concentrated impact: for example, the annual expansion of a large dead zone in the Gulf of Mexico, resulting from the high level of inputs of nitrogen compounds in the run-off from the Mississippi and other catchments. Sometimes the effects of human pressures have a very widely distributed effect: for example, the diffusion of persistent organic pollutants over the Arctic zone by airborne volatilization (for both examples, see Chapter 20 on land-based inputs) (Halpern, 2008).

1.1 Summarizing the impacts

An analysis of the overall impact of all the human pressures examined in this Assessment has to start by looking at the direct impacts and collateral effects of each pressure and to examine where those impacts and effects are found. However (as argued below), although this is an essential first step, it is not enough. In addition, any review of the effects of human pressures on the marine environment has to look both at the effects on the marine environment and at the consequences for human society and economies. A taxonomy of the main sources of human pressures on the marine environment that need to be considered must include the following (though these are not listed in any order of priority):

(a) Climate change (and ocean acidification, including the resulting changes in salinity, sea-level, ocean heat content and sea-ice coverage, reduction in oxygen content, changes in ultra-violet radiation);

(b) Human-induced mortality and physical disturbance of marine biota (such as capture fisheries, including by-catch), other forms of harvesting, accidental deaths such as through collisions and entanglement in discarded nets, disturbance of critical habitat, including breeding and nursery areas);

(c) Inputs to the ocean (these can be broken down according to the nature of their effects: toxic substances and endocrine disruptors, waterborne pathogens, radioactive substances, plastics, explosives, excessive nutrient loads, hydrocarbons). Remobilization of past inputs also needs to be considered;

(d) Demand for ocean space and alteration, or increase in use, of coasts and seabed (conflicting demands lead to both changes in human use of the ocean and changes to marine habitats);

(e) Underwater noise (from shipping, sonar and seismic surveys);

(f) Interference with migration from structures in the sea or other changes in routes along coasts or between parts of the sea and/or inland waters (for example, wind-farms, causeways, barrages, major canals, coast reinforcement, etc.);

(g) Introduction of non-native species.

It is a matter of debate how any taxonomy should be structured. For example, all inputs might be classed together, since they are all the result of human activities affecting the ocean. However, there are important differences in the ways in which these pressures will affect the littoral, the water column and the benthos. In addition, the way in which these affect the environment and human societies and economies differs significantly. Hazardous substances may have toxic effects (either directly on animals which ingest them or through the food web on animals and humans that eat contaminated fish and seafood), may affect resilience to infections or may affect reproductive success. Waterborne pathogens may affect marine biota, but can be of particular concern when they are likely to affect humans who bathe in the sea or eat seafood. Excessive nutrients may lead to dead zones or cause blooms of algae that generate toxins. Explosives from past wars dumped into the sea may well not affect marine biota, but may kill or maim fishers who bring them up in trawls. Hydrocarbons may kill marine biota directly, but can also be broken down by bacteria and thus enter the food web. The worst effects of some emissions (such as exhaust fumes from ships) may not be the way that they enter the sea, but the way in which they contribute to damage to human health on land through air pollution. No taxonomy of these kinds of pressures, which are operating in very different fields, is likely to be beyond debate. Table 1 (at the end of this chapter) summarizes the varieties of human pressures on the marine environment, indicating the environmental and the social and economic effects. The categories of pressure aim to bring together the pressures resulting from various human activities that have similar effects, but keep separate some categories which have some effects of a very different nature, even though they may overlap with other categories in creating some effects.

1.2 Environmental effects

This chapter aims to summarize the overall impact of human activities on the ocean. The elements noted in Table 1 therefore relate very much to the impact of human activities on the marine environment. As the regional biodiversity assessments in chapter 36 of Part VI of this Assessment show, there are well-documented examples of cases where habitats, lower-trophic-level productivity, benthic communities, fish communities, or seabirds or marine mammal populations have been severely altered by pressures from a specific activity (such as over-fishing, pollution, nutrient loading, physical disturbance, or non-native species). However, many biodiversity impacts, particularly at larger scales, are the result of cumulative and interactive effects of multiple pressures from multiple drivers. It has repeatedly proven difficult to disentangle the effects of the individual pressures. This impedes the ability to address the individual causes.

Even in the Arctic Ocean, where human settlements are relatively few and small, the potentially synergistic effects of multiple stressors come together. And this is against a background of pressures from a changing climate and increasing human maritime activity, primarily related to hydrocarbon and mineral development and to the opening of shipping routes. These changes bring risks of direct mortality, displacement from critical habitats, noise disturbance, and increased exposure to hunting, which are superimposed on high levels of contaminants, notably organochlorines and heavy metals, as a result of the presence of these substances in the Arctic food web.

Likewise, in the open ocean (remote from land-based inputs), shifts in bottom-up forcing (that is, primary productivity) and competitive, or top-down forcing (that is, by large predators) will produce complex and indirect effects on ecosystem services. Stress imposed by lower oxygen, lower pH (that is, higher acidity), or elevated temperature can reduce the resilience of individual species and ecosystems through stressing organism tolerances or shifting community interactions. Where this happens, it retards recovery from disturbance caused by human activities such as oil spills and trawling and (potentially in the future) seabed mining. Acidification-slowed growth of carbonate skeletons, delayed development under hypoxic conditions, and declining food availability illustrate how climate change could exacerbate anthropogenic impacts and compromise deep-sea ecosystem structure and function, and ultimately its benefits to human welfare.

These multiple pressures interact in ways that are poorly understood, but that can amplify the effects expected from each pressure separately. The North Atlantic is comparatively rich in scientific resources. It has many long-term ocean-monitoring programmes and a scientific organization (the International Council for the Exploration of the Sea) that have functioned for over a century to promote and coordinate scientific and technical cooperation among the countries around the North Atlantic. Even here, however, experts are commonly unable to disentangle consistently the causation of unsustainable uses of, and impacts on, marine biodiversity. This may seem initially discouraging. Nevertheless many well-documented examples exist of the benefits that can follow from actions to address past unsustainable practices, even if other perturbations are also occurring in the same area.

Cumulative effects are documented for species groups of the top predators in the ocean, including marine mammals, seabirds, and marine reptiles. Many of these species tend to be highly mobile, and some species migrate across multiple ecosystems and even entire ocean basins, so they can be exposed in their annual cycle to many threats. Direct harvest occurs for some of these species, particularly some pinnipeds (seals and related species), seabirds and sharks, and bycatch in fisheries can cause significant mortality for many species. However, in addition to having to sustain the impacts from these direct deaths, all of these species suffer from varying levels of exposure to land-based pollution sources and increasing levels of noise in the ocean. Land-nesting seabirds, marine turtles and pinnipeds also face habitat disturbance, including invasive predators on isolated breeding islands, disturbance of beaches where eggs are laid, or direct human disturbance from tourism, including ecotourism.

Some global measures have been helpful in addressing specific sources of mortality, such as the global ban on high-seas drift-netting introduced by the United Nations General Assembly in 1994, which was a major step in limiting the bycatch of several marine mammal and seabird species that were especially vulnerable to entanglement. However, for seabirds alone, at least 10 different pressures have been identified that can affect a single population through its annual cycle, with efforts to mitigate one sometimes increasing vulnerability to other pressures. Because of the complexity of these issues, conservation and management must be approached with care and with alertness to the nature of the interactions among the many human interests, the needs of the animals and their role in marine ecosystems.

1.3 Social and economic effects

Many of the human activities that affect the ocean affect not only its environmental condition, but also various social and economic aspects related to the marine environment. Most human activities in and around the ocean are aimed at getting some form of social or economic benefit from the ocean, and Chapter 57 (Overall value of the ocean to humans) attempts to pull together these aspects. Some human activities, in effect, can undermine their own success: capture fisheries and tourism are a good example of this: over-fishing results in keeping harvested species at less than the maximum sustainable yield, while tourism that attracts too many tourists can downgrade the environment that originally attracted them. In addition, many types of human activity may have adverse impacts on the success of other human activities. For example, marine noise from ships may cause the marine mammals to re-locate and thus undermine a previously successful whale-watching activity (see Chapters 27 and 37). The trade-offs among classes of interacting activities need careful consideration – especially as governance arrangements may make it difficult for such trade-offs to be easily considered together. This can happen either because the voices of some of those affected are not easily heard (for example, small-scale fishers) or because the governance arrangements do not address the same areas (for example, long-range aerial or riverine transport of pollutants may start in areas well away from any ocean). Some effects (such as ocean acidification) may only be capable of being addressed at a global scale, but the ecological effects may be much more localized, because of the uneven distribution of the environmental effects. Likewise, the social and economic impacts of such global pressures may be much more unequally distributed than the ecological effects, because of regional differences in uses of the ocean.

Many of the more serious cases of trade-offs of this kind affect food from the sea. As explained in Part IV, overfishing of certain fish stocks is a very clear example of the way in which an activity can undermine its own success in generating economic and social benefits in terms both of food from the sea and of employments and livelihoods. At the same time, excessive inputs of nutrients (among other things, from sewage discharges or agricultural run-off) can lead to dead zones or hypoxic zones, which can seriously affect the recruitment of fish stocks on which both large-scale and small-scale fisheries depend. To these adverse effects on fish stocks can be added further effects such as those from losses of breeding or nursery areas through land reclamation, the effects of hazardous substances on reproductive success and oil pollution from shipping. Since small-scale fisheries are in general less well studied than the larger, more commercial fisheries, the social and economic consequences of these multiple impacts are not easily quantified. Indeed, as noted above, even for larger, more commercial fisheries the overall way in which multiple pressures work together to produce adverse effects is not well understood. Nevertheless, it is clear that some problems are sufficiently well understood that remedial actions can have some success. For example, reductions in the occurrence of liver tumours in fish in Netherlands waters have been linked to decreases in the levels of organic pollutants (OSPAR 2010). On the other hand, improvements in aquaculture techniques have allowed substantially increased production with lower inputs of fishmeal (FAO, 2012).

The changes in marine biodiversity can have knock-on effects on other ecosystem services that humans obtain from the ocean. An illustration of this is the important link between the health of warm-water corals and tourism. Warm-water corals represent a major component of the attractiveness of many tourist resorts in the Caribbean, the Red Sea, the Indian Ocean, south-east Asia and the South Pacific. The competitive position of their resorts would be seriously undermined if the tourists could no longer enjoy the corals. The same applies to other resorts (even in cold-water areas) where one of the attractions is scuba diving to enjoy the marine ecosystems.

The disappearance (or, more commonly, the reduction in numbers) of iconic species can similarly adversely affect traditional practices. For example, native people on the north-east Pacific coast have seen their traditional whale-hunting halted, because of past over-harvesting by others of grey whales (see Chapter 8, Cultural ecosystem services from the ocean). This hunting was an integral part of their cultural heritage, and the affected tribes consider the cultural loss to be very serious. Pollution can have similar effects: for example, the Faeroese authorities are taking measures to control the traditional food obtained in the islands from pilot whales, because of the high levels of pollutants they contain (see Chapter 20, Land-Based inputs to the ocean). Demand for ocean space and alteration of coasts and seabed will lead to destruction of underwater cultural heritage (see Chapter 26 on land/sea physical interaction; and Chapter 27 on tourism and recreation).

2. Information gaps and capacity building gaps

2.1 Information gaps

Taking an overall view of the state of the world's marine environment presents many challenges, because it requires a large number of different sets of data to be brought together. Techniques for doing this are in their infancy, and many difficult problems need to be resolved.

In the first place, as the chapters in Parts III, IV, V and VI of this Assessment demonstrate, there are many gaps in the basic information necessary to build a reliable, world-wide, comprehensive, quantified survey of the state of the ocean. This Assessment shows that a qualitative view can generally be achieved of most aspects of the oceans and that some aspects can, at least in places, be quantified. More quantified information is needed to achieve a robust quantified assessment. The various chapters of Parts III, IV, V and VI of this Assessment identify major information gaps. Most of these will need to be filled before detailed methods of quantification can be developed that will achieve general acceptance.

In pursuing the aim of a more quantified integrated assessment of the ocean, it will therefore be important to try to improve the detailed information available.

2.2 Capacity gaps

At the same time, there is a more general gap in techniques for bringing information on the different aspects of the ocean together to give an overall picture. Various attempts have been made to do this at various levels, both as to the area to be covered and as to the degree of integration sought.

2.3 Ocean Health Index

One of these is the Ocean Health Index (OHI) (OHI, 2014; OHI, 2013; OHI, 2014). This index is mentioned as an illustration of the challenges in preparing even a semi-quantitative, but comprehensive, assessment of the ocean. There is a wide range of expert views of the robustness of this index – and, indeed, of other such indices. At the same time, it should be noted that many of the most important messages drawn from the OHI do correspond to conclusions drawn in this Assessment. Those conclusions have been drawn by other assessments as well.

The OHI is an attempt to produce a comprehensive assessment of the ocean in numerical terms at the highest possible level. Originally covering only coastal waters, it now covers all aspects of the marine environment and all parts of the ocean (220 areas within national jurisdictions and 16 much larger areas beyond national jurisdictions). Its aim is to convert all the information into numerical scores for the status of each of the goals and sub-goals (shown in Table 2). Some of these goals have clear gaps: for example, the "Clean Water" goal does not cover point source discharges. The exercise also derives figures for trends, pressures and resilience to allow forecasting of future status. Given the limitations of the data that are available, various statistical techniques have had to be applied to that data in order to achieve coherent, comprehensive outputs. A detailed study of the efforts involved in developing the Ocean Health Index quickly shows how difficult it is to gather full information.

Having derived numerical scores for the goals and sub-goals, the next step in the OHI process is then to aggregate the indices developed for each goal into a single index figure for the status of each area of sea covered by the exercise, and then into a single figure for the ocean as a whole. It is possible to allow for different weightings between the results for the different goals, based on expert judgement, in order to allow for different views on the balance between preservation and exploitation (OHI, 2013).

Table 2. Summary of the goals and sub-goals used for the Ocean Health Index

GOAL	SUB-GOAL	REFERENCE POINT TYPE AND BRIEF DESCRIPTION OF BASIS
Food Provision	Fisheries	Functional relationship (difference of total landed biomass from estimated maximum sustainable yield)
	Mariculture	Spatial comparison (sustainably harvested yield of mariculture normalised for the area of inshore waters)
Small-scale Fishing Opportunities		Functional relationship (level of demand for small-scale fisheries (estimated from poverty level and degree of regulation of such fisheries)
Natural Products		Temporal comparison (historical benchmark) (level of exports for the area of coral, ornamental fish, fish oil, seaweeds and marine plants, shells, and sponges compared with the highest level achieved, as a substitute for the maximum possible level)
Carbon Storage		Temporal comparison (historical benchmark) (Current area of mangroves, seagrass beds and salt-marshes compared with historical benchmark)
Coastal Protection		Temporal comparison (historical benchmark) (Current area of mangroves,coral reefs, seagrasses, salt marshes, and sea ice compared with historical benchmark and adjusted for the differing protective effects of each)

GOAL	SUB-GOAL	REFERENCE POINT TYPE AND BRIEF DESCRIPTION OF BASIS
Coastal Livelihoods & Economies	Livelihoods: jobs and wages	Temporal and spatial comparisons (moving target) (Number of jobs directly and indirectly supported by tourism, commercial fishing, marine mammal watching, aquarium fishing, wave and tidal energy, mariculture, transportation & shipping, ports and harbours, shipbuilding and boatbuilding, compared with average of last five years, and adjusted by the average wage in each sector)
	Economies	Temporal comparison (moving target) (contribution to Gross Domestic Product generated directly or indirectly by the sectors mentioned in the entry of the previous sub-goal, compared with historical benchmark)
Tourism & Recreation		Spatial comparison (Originally based on international tourist arrivals, but since 2013 based on employment in tourism, adjusted by for sustainability in line with the World Economic Forum's Travel and Tourism Competitiveness Index)
Sense of Place	Iconic Species	Known target (Percentage of species in the World-Wide Fund for Nature's lists of Priority Species and Flagship Species for the area that are classed by the International Union for the Conservation of Nature (IUCN) as threatened, weighted by the threat category)
	Lasting Special Places	Established target (The mean of (a) area of coastal marine protected areas as a percentage of an assumed target that 30% of the area within 3 nautical miles of the coast should be protected, and (b) the length of coastline within 1 kilometre of the shore that is protected as a proportion of an assumed target that 30% of such coast should be protected)
Clean Waters		Known target (Geometric mean of (a) number of people in the coastal area without access to enhanced sanitation, rescaled to the global maximum, (b) modelled index of land-based inorganic pollution from urban runoff from impervious surfaces, (c) modelled index of land-based organic pollution from pesticides and (d) modelled index of pollution from shipping and ports)
Biodiversity	Habitats	Temporal comparison (historical benchmark) (average of the assessed conditions of such of the range of mangroves, coral reefs, seagrass beds, salt marshes, sea-ice edge, and sub-tidal soft-bottom habitats as are present in the area; the assessments of conditions are drawn from a variety of wide-ranging assessments of these habitats)
	Species	Known target (Temporal comparison (historical benchmark) (IUCN Global Marine Species Assessment of the extinction risk status of 2,377 species for which distribution maps exist, calculated as the area- and threat-status-weighted average of the number of threatened species within each 0.5º grid cell)

Source: adapted from Halpern et al., 2012 and OHI, 2013.

The OHI depends crucially on the availability of satisfactory data across many fields, and on the expert judgements made about the weighting to be given to the different fields covered. Much of the necessary data is not available, and estimates of various kinds have to be used instead. The scale of the expert judgements needed means that there is a substantial subjective component in any results.

2.4 Water-quality indexes

At a much less aggregated level, as described in Chapter 20 (Land-based inputs to the ocean), some regional seas organizations and some States have tried to produce a single index of water quality in the parts of the ocean with which they are concerned. Such efforts, too, require judgements on the relative importance of the effects of hazardous substances and of eutrophication problems, and therefore rely to a substantial degree on expert judgement.

2.5 Ecological quality objectives

An alternative approach accepts that there will inevitably be an element of expert judgement involved, and legitimate differences in views on the appropriate weights given to various types of impacts and benefits, and therefore develops measures along a number of axes. There is no attempt to convert these various measures into a single quantified measure. Rather, users are left to apply their varying expert judgements on how much importance to attach to each axis, and on how to interpret what the different measures show. One version of this approach, developed by the regional seas organization for the North-East Atlantic, has been to try to find a suitable set of ecological quality objectives (EcoQOs) for an ocean area (OSPAR, 2007). These EcoQOs are derived by considering successively:

(a) What are the important ecosystem components that collectively reflect a high ecological quality?

(b) What are the human impacts on this component and how can they be monitored?

(c) What are the objectives to be achieved, taking into account existing policies?

These EcoQOs may be quite numerous, and no attempt has yet been made to specify what the relation among them should be: the aim is to develop a set of measures that can be used for diagnosing whether there are problems. So far, a pilot project has looked at 11 such EcoQOs for the North Sea (OSPAR, 2007).

2.6 European Union's Marine Strategy Framework Directive

A related approach is being developed for the implementation of the European Union's (EU) Marine Strategy Framework Directive (MSFD) (EU, 2008). As a starting point, this involves each EU coastal Member State assessing the state of its waters against a list of eleven descriptors, shown in Table 3. The European Commission has produced a set of criteria and indicators to assist in developing common approaches to making these assessments. An initial assessment should then be made whether assessments show that the waters of the Member States have "good environmental status". Environmental targets, associated indicators and a programme of measures to maintain that state, or to achieve it by 2020, should then be established by 2015. A preliminary report by the European Commission suggests that much work remains to be done to deliver this programme, and agreement on the relative or absolute benchmarks for good environmental status on many of the descriptors has not been reached (EU, 2014).

Table 3. Descriptors of Good Environmental Quality for the European Union Marine Strategy Framework Directive

DESCRIPTOR	TITLE	DETAIL
1	Biodiversity	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.
2	Non-indigenous species	Non-indigenous species (NIS) introduced by human activities are at levels that do not adversely alter the ecosystems.
3	Fish and Shellfish stocks	Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4	Food webs	All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
5	Eutrophication	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
6	Benthos	Sea floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
7	Hydrography	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8	Contaminants	Concentrations of contaminants are at levels not giving rise to pollution effects.
9	Fish and seafood quality	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
10	Marine litter	Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
11	Energy introduction	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Source: EU, 2008, Annex I

Unlike the Ocean Health Index, however, these EcoQO and MSFD approaches do not specifically integrate social and economic aspects, although the effects of sustainable uses are taken into account in setting their benchmarks for good environmental status.

2.7 Conclusion on capacity-building gaps

Some attempts have been made to develop ecosystem-based approaches to managing human activities that affect the ocean. Even here, however, much work remains to be done to develop systems for assessing the overall impacts of human activities on the ocean. There thus remains a general need to develop methods for integrated assessments of the marine environment that can deliver an assessment of the marine environment that is not only (1) integrated across environmental, social and economic aspects, (2) integrated across sectors of human activities, and (3) integrated across all the components of the marine environment, but also gives reliable, quantified information about all parts of the world. There is therefore a general need for capacities to develop and implement such assessment methods.

Table 1. Pressures and Impacts of Human Activities on Environmental and Socioeconomic Aspects of the Marine Environment

No	Pressures from Human Activities[1]	See	Impacts on Environmental Aspects of the Marine Environment	Impacts on Socioeconomic Aspects of the Marine Environment	Mgt[2]
1	**Acidification of the ocean** (arising from increased CO_2 emissions)	Ch 5 Ch 7 Ch 36 A-H Ch 42 Ch 43 Ch 46	Reduction of reproductive success, recruitment, growth and survival of some species, especially those with (calcareous) exoskeletons (shells etc). Reduced resilience of coral reefs to other stresses. Second-order loss of habitat for other species if coral reefs degrade.	Losses in livelihoods in some small-scale fisheries. Lower production of some commercial fisheries. Loss of competitiveness for tourism dependent on corals. Potential loss of coastal protection services where coral reefs are degraded. Potential costs of reducing CO_2 emissions.	Not yet

[1] In alphabetical order, not in any order of importance.

[2] Mgt = Management possibilities: "Yes": examples are known of successful management strategies to reduce this pressure generally; "Some": examples are known of successful management strategies to reduce some aspects of this pressure; "Not yet": no such examples are yet known. NOTE – this marking does not allow for measures that ADAPT to changes: for example, the way in which some aquaculture facilities are mitigating some impacts of acidification.

No	Pressures from Human Activities[1]	See	Impacts on Environmental Aspects of the Marine Environment	Impacts on Socioeconomic Aspects of the Marine Environment	Mgt[2]
2	**Changes in sea temperature**	Ch 4 Ch 5 Ch 7 Ch 34 Ch 36 A-H Ch 42-50 Ch 43 Ch 15	Increased sea-surface temperature will probably increase stratification and thus affect nutrient cycling, with effects on productivity. Changes in species distribution and productivities, bottom up ecosystem productivity and community structure. Coral bleaching. Reduction of sea-ice cover in Arctic and Antarctic will impair species dependent on that habitat.	Adverse changes in weather patterns, including increased storms in higher latitudes. Fisheries and aquaculture potential may have to relocate or change preferred species. Changes in high latitude temperature regimes increase access for many industries with the potential for major impacts on Arctic communities.	Not yet
3	**Changes in the salinity of seawater** (arising from climate change)	Ch 4 Ch 6 Ch15 Ch 34 Ch 36 A-G	Changes to the thermohaline circulation of the ocean, in some places leading to increased up-welling of nutrients (see also Item 14). Increased likelihood of stratification of seawater, with consequent adverse effects on primary production that supports fish and seabirds.	Potential fundamental changes in availability of fishery resources with implications for food security and other important ecosystem services. Changes in currents may alter the way that ocean moves heat around the planet, with widespread consequences	Not yet
4	**Creation of underwater noise** (arising from shipping, offshore prospecting, offshore renewable energy installations and tourism and recreation)	Ch 17 Ch 21 Ch 22 Ch 23 Ch 27 Ch 36 Ch 37	Disturbance of fish, macro-invertebrates, and marine mammals. Mortality due to noise rare but disruption of behaviour may have consequences for life history activities including feeding, migration, recruitment and social behaviour.	Potential costs of reducing noise emissions, including potential closure of sensitive areas to certain activities seasonally or permanently, thus limiting economic activity. .	Yes

No	Pressures from Human Activities[1]	See	Impacts on Environmental Aspects of the Marine Environment	Impacts on Socioeconomic Aspects of the Marine Environment	Mgt[2]
5	**Increased demands for marine space for potentially conflicting uses** (arising from fisheries, aquaculture, shipping routes, submarine cables and pipelines, offshore hydrocarbon and mining operations, solid waste disposal, tourism)	Ch 11 Ch 12 Ch 14 Ch 18 Ch 19 Ch 21 Ch 22 Ch 23 Ch 24 Ch 26 Ch 27 Ch 48	Depending on the human activity, the ecological functions of natural habitats in the marine space allocated for human use may be altered, degraded, or destroyed (including by removing or smothering marine plants and benthos). Consequent reductions of habitat available for nature. Changes in habitat productivity can alter ecosystems. Disposal of disused offshore installations can create new habitats.	Conflicts among potential uses of a place may arise, causing problems in finding most suitable allocation of space among potential uses, and increases in costs to manage conflicts. Development pressures may favour higher impact uses such as ports or energy production, with negative implications for lower impact uses such as small-scale subsistence fishing, impacting food security. Secondary impacts on harvesting and tourism are possible, if the permitted uses decrease biological productivity or make the area unavailable.	Yes
6	**Increased direct mortality of marine animal populations**, including those not directly targeted (arising particularly from fisheries, including recreational fisheries)	Ch 11 Ch 15 Ch 17 Ch 27 Ch 36 Ch 37 Ch 38 Ch 39 Ch 40	Decline in populations if the mortality is unsustainable. Alterations in population structures towards ones composed of smaller and younger individuals, with broader impacts on productivity. Potential alterations to ecosystem balance through differential effects on species.	Unsustainable mortality rates imply declines of living marine resources, with implications of decreasing food security, reduced livelihoods in coastal areas, and reduction in recreational enjoyment. The costs of restoring over-exploited resources are generally very high compared to those of preventing overexploitation from occurring.	Yes
7	**Increased disturbance of fauna and flora,** arising from increased numbers of people in the coastal zone, and increased amounts of shipping	Ch 17 Ch 18 Ch 21 Ch 23 Ch 26 Ch 27 Chs 37 – 44	High levels of the presence of people affect animal behaviour, including breeding, rearing, feeding, and migration. May reduce the carrying capacity of the coastal zone for marine biota.	Need to manage access of people to ecologically significant places can impose costs on development, and limit scale of industries such as eco-tourism	Yes

NO	PRESSURES FROM HUMAN ACTIVITIES[1]	SEE	IMPACTS ON ENVIRONMENTAL ASPECTS OF THE MARINE ENVIRONMENT	IMPACTS ON SOCIOECONOMIC ASPECTS OF THE MARINE ENVIRONMENT	MGT[2]
8	**Increased ultra-violet radiation** (arising from reductions in ozone layer)	Ch 6	Possible adverse effects on primary production and on fish larvae. Effects on titanium dioxide nanoparticles, creating biocides affecting phytoplankton, and thus potentially the food web.	Potential effects on harvesting if fish stocks are affected.	Yes[3]
9	**Input of explosives and hazardous gases in containers** (from dumping)	Ch 24	Additional source of hazardous substances and seabed smothering: see Items 12 and 17.	Harm to fishers who catch such dumped material in their nets, and to pipeline- and cable-laying in affected areas.	Yes
10	**Input of hydrocarbons** (from land-based sources, offshore installations, pipelines and shipping)	Ch 12 Ch 17 Ch 19 Ch 20 Ch 21 Ch 23 Ch 27 Ch 37 Ch 38 Ch 39	Killing of benthic biota, fish, marine mammals and reptiles and sea birds. Adverse effects on their later reproductive success.	Consequent damage to aquaculture and fisheries. Fouling of beaches and consequent adverse impact on tourism	Yes
11	**Input of nutrients, both airborne and water-borne** (arising from land-based activities, shipping, solid waste disposal).	Ch 6 Ch 12 Ch 17 Ch 20 Ch 24 Ch 25 Ch 27 Ch 36 A-H Ch 43 Ch 44 Ch 48	Coastal eutrophication, leading to dead zones, hypoxic zones and algal blooms (including toxic algal blooms). Shifts of ecosystem regimes. Consequent loss of benthic diversity and adverse effects on fish and shellfish stocks and on seabirds and marine mammals and reptiles. Algal smothering of coral reefs	Adverse effects on human health, especially through shell-fish poisoning and waterborne pathogens. Adverse effects on fisheries and shellfisheries from dead zones and hypoxic areas. Adverse effects on tourism from beaches covered in algae, and loss of competitiveness from reduced marine wildlife (especially where coral reefs are affected) Increased costs of treatment of inputs.	Some

[3] There has been some success in reducing the ozone-depleting effects of certain chemicals, with consequent improvements in the UV-filtering effects of the ozone layer.

No	Pressures from Human Activities[1]	See	Impacts on Environmental Aspects of the Marine Environment	Impacts on Socioeconomic Aspects of the Marine Environment	Mgt[2]
12	**Input of plastics** (from shipping, fishing, offshore installations, poor control of land-based waste disposal, dumping).	Ch 6 Ch 11 Ch 17 Ch 24 Ch 25 Ch 37 Ch 38 Ch 39	Potential effects from breakdown into nanoparticles on food web, through effects on plankton and on filter-feeding species, resulting in changes in productivity. Mortality from ingestion by, and physical entanglement of, fish, marine mammals, reptiles and seabirds. Loss of habitat contaminated with durable debris.	Potential effects on fish and shellfish stocks through changes in the food web. Loss of vulnerable species may impact tourism or cultural needs. Loss of amenity and fouling of beaches. Consequent adverse impacts on tourism. Costs for cleanup of plastics, lost fishing gear etc., are very high.	Yes
13	**Input and transfer of waterborne pathogens** (arising from land-based activities, open-pen aquaculture, shipping and offshore installations).	Ch12 Ch 17 Ch 20 Ch 25 Ch 37 Ch 43	Possible adverse effects on marine fish, bird, turtle and mammal populations due to introduction of diseases. Coral diseases leading to death and impacts in coralline communities.	Damage to human health from the spread of diseases and from contaminated food from the sea.	Yes
14	**Input, or remobilization, of hazardous substances, by both airborne and waterborne routes** (arising from land-based activities, dumping, offshore installations and shipping).	Ch 17 Ch 20 Ch 21 Ch 23 Ch 24 Ch 15	Reduction in reproductive success and in ability to resist disease of marine biota. In extreme cases, killing of marine biota. Bio-accumulation of toxins in organisms that are subsequently harvested.	Damage to human health from contaminated food from the sea. Adverse effects on fisheries and shellfisheries from effects on stocks.	Yes
15	**Interference with aerial migration routes** (from wind-farms)	Ch 22 Ch 38	Potential damage to seabird population from deaths and injuries from collisions with rotors of wind-farms during migration.	Benefits of increasing non-carbon-intense energy sources involve trade-off with risk of increases from a new source of direct mortality.	Yes
16	**Introductions of non-native species or genetic strains** (arising from aquaculture, shipping and recreational boats)	Ch 12 Ch 17 Ch 27 Ch 36 A-H Ch 43	Degrading genetic pools, Reduction in biodiversity. Destruction of existing wild stocks. Potential for disruptions of natural populations and biotic communities.	Interference with fisheries and shellfisheries. Interference with operation of plant. Aquaculture benefits greatly from the use of strains of fish adapted for culture, which are often different genetically from natural populations.	Yes[4]

[4] Transfers of foreign species in ships' ballast water can be managed. It is difficult to impose regimes to protect against transfer of species through attachments to the hull, especially on recreational boats.

No	Pressures from Human Activities[1]	See	Impacts on Environmental Aspects of the Marine Environment	Impacts on Socioeconomic Aspects of the Marine Environment	Mgt[2]
17	**Physical alteration of sea-bed habitats** (arising from bottom-fishing, aquaculture, dredging for shipping, ports, submarine cables and pipelines, offshore hydrocarbon industries and mining, coastal defences, land reclamation, solid waste disposal and tourism and recreation).	Ch 11 Ch 12 Ch 18 Ch 19 Ch 21 Ch 22 Ch 23 Ch 24 Ch 27 Ch 36 A-H Chs 42-50	Direct mortality by physical impacts or smothering. Reduction in three-dimensional habitat structure can reduce biodiversity and productivity. Disturbance of sediments can reduce water quality and/or release contaminants, also impacting biotic communities and populations.	Costs of reducing impacts: some activities necessarily require habitat impacts as part of the business (mining, aggregate extraction); other activities result in habitat impacts as a collateral, but sometimes unavoidable, consequence (fishing with mobile bottom-contacting gears).	Some
18	**Sea-based emission of air-polluting substances (nitrogen oxides etc)** (arising from shipping, fishing vessels, offshore hydrocarbon and mining operations).	Ch 17 Ch 20 Ch 21 Ch 23	Additional source of nutrients, and thus of the problems related to them (see Item 14).	Damage to human health from coastal air pollution. Potential costs of controlling emissions.	Yes
19	**Sea-level rise** (arising from climate change).	Ch 4 Ch 7 Ch 26 Ch 36 Ch 43 Ch 47	Changes in coastal habitats. Contaminants from frequent coastal flooding are likely to add to toxics and nutrient pollution. Loss of costal ecosystems such as sea grasses due to increase in turbulence.	Inundation of low-lying States. Inundation of low-lying cities and other areas resulting in loss of property and population displacement. Critical infrastructure built in low lying areas is highly vulnerable (airports, sea ports, highways and train routes). Potential costs of protecting the built environment.	Not yet (Env) Yes (S/E)

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