Synthesis Report
As part of the project
Biodiversity of the High Seas

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The project "Biodiversity of the high seas" was carried out by a consortium consisting of Wageningen IMARES, NILOS, LEI and Grontmij Nederland bv. Royal NIOZ and Framian were subcontracted. The project was coordinated by Wageningen IMARES.

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1 Introduction

Human activities in areas outside national jurisdiction (ABNJ) - which comprise the high seas and the 'Area' (the sea-bed beyond the limits of national jurisdiction) - are increasing and may threaten marine biodiversity in these areas. While fisheries are in general considered as the most threatening, other activities such as mining, shipping, tourism, bio-prospecting, marine scientific research, pollution, and military activities also play more or less important roles. Threats to biodiversity concern different components of the marine ecosystem (e.g. fish, seabirds, marine mammals and benthos), the ocean floor as a habitat, the food chain (functioning of the ecosystem) and ecosystem services (resources and processes supplied by natural ecosystems).

Alarming news about the decreasing biodiversity regularly hits the headlines of newspapers and leads to an increasing pressure on the international community to reach an effective protection. The Netherlands have committed themselves to the protection of biodiversity under the CBD[1] and during the World Summit on Sustainable Development in 2002. Within the Netherlands, several ministries are involved in the abovementioned international processes (Foreign Affairs; Transport, Public Works and Water Management; Agriculture, Nature and Food Quality). The research project 'Biodiversiteit van de Volle Zee' (*Biodiversity of the High Seas*) - financed by the Netherlands Ministry for Agriculture, Nature and Food Quality - is aimed at supporting these Netherlands ministries within these international processes, by means of a critical overview of human activities in ABNJ - their size and development and their impact on biodiversity - as well as on the existing international legal framework. This Synthesis Report summarizes the main conclusions of this research project.

The report continues with a concise discussion on the current relevant international legal framework in section 2. Subsequently, section 3 examines the relevant anthropogenic activities and their impacts on marine biodiversity in ABNJ. The following activities are examined: (i) fisheries; (ii) mining; (iii) shipping; (iv) iron fertilization; (v) CO_2 storage; (vi) tourism; (vii) infrastructure; and (viii) bioprospecting and marine scientific research. Subsection 3.10 examines impacts on marine biodiversity in ABNJ by diffuse sources, namely by human activities that take place in marine areas within national jurisdiction and on land. Section 3.11 offers a comparative analysis of the impacts of the human activities that are examined. Finally, section 4 contains some suggestions and options for addressing selected anthropogenic impacts. The annex to the report contains the full references to the cited literature.

[1] Convention on Biological Diversity, Nairobi, 22 May 1992. In force 29 December 1993, 31 *International Legal Materials* 822 (1992); <www.biodiv.org>.

2 Current international legal framework

The international legal framework for the protection and preservation of the marine environment and the conservation and sustainable use of marine biodiversity in ABNJ mainly consists of the LOS Convention,[2] its two Implementation Agreements - the Part XI Deep-Sea Mining Agreement[3] and the Fish Stocks Agreement[4] - and the CBD[5]. The LOS Convention was adopted more than 25 years ago and many of the provisions that are relevant to this report already received very broad support several years before. It is not surprising that some aspects of the regime appear to have significant gaps when confronted with the expansion of uses in ABNJ. Indeed, the mere existence of the two implementation agreements reflects that the international community was prepared to address what it perceived to be gaps at the time, particularly in the case of the Fish Stocks Agreement. In recent years, discussions and undertakings within the framework of the United Nations General Assembly (UNGA) and the CBD have attempted to address perceived gaps in relation to the governance of marine biodiversity in areas beyond national jurisdiction.

The UNGA established the United Nations Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction (UNWG BBNJ) in 2004. So far, the UNWG BBNJ has convened twice: in 2006 and in 2008. A group of independent researchers prepared several documents[6] in support of this second meeting and identified the following main regulatory gaps in the current regime:

- no regulatory regime for
    - several existing maritime activities, namely marine scientific research (& archeology), bioprospecting (qualitative & quantitative), laying of cables and pipelines, artificial islands and seabed constructions, and military activities; and
    - emerging and new maritime activities, such as deep sea tourism, activities relating to CO_2 sequestration, and floating installations.
- no requirement of integrated, cross-sectoral ecosystem-based ocean management;
- absence of modern regulatory tools, such as the precautionary approach per se, and in particular operationalized, environmental impact assessment (EIA) and strategic environmental assessment (SEA), and integrated, cross-sectoral marine protected areas (MPAs).
- no default mechanism for existing, emerging and new activities in absence of regional regimes.

In addition, the following were seen as the main governance gaps:

- no competent intergovernmental organisations (IOs) to regulate various maritime activities;
- no default authority;
- regional fisheries management organisations (RFMOs) & Arrangements with narrow mandates or substandard performance;
- sectoral governance, also reflected in the LOS Convention;
- an undesirable balance between user states and non-user states.

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[2] United Nations Convention on the Law of the Sea, Montego Bay, 10 December 1982. In force 16 November 1994, 1833 *United Nations Treaty Series* 396; <www.un.org/Depts/los>.

[3] Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982, New York, 28 July 1994. In force 28 July 1996, 33 *International Legal Materials* 1309 (1994); <www.un.org/Depts/los>.

[4] Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, New York, 4 August 1995. In force 11 December 2001, 34 *International Legal Materials* 1542 (1995); <www.un.org/Depts/los>.

[5] For an overview see E.J. Molenaar, "Managing Biodiversity in Areas Beyond National Jurisdiction", in M.H. Nordquist, R. Long, T.H. Heidar and J.N. Moore (eds) *Law, Science & Ocean Management* (Martinus Nijhoff Publishers: 2007), pp. 625-681.

[6] See K.M. Gjerde, "Regulatory and Governance Gaps in the International Regime for the Conservation and Sustainable Use of Marine Biodiversity in Areas beyond National Jurisdiction" (*IUCN Marine Law and Policy Paper* No. 1: 2008; available at <cms.iucn.org>) and K.M. Gjerde, "Options for Addressing Regulatory and Governance Gaps in the International Regime for the Conservation and Sustainable Use of Marine Biodiversity in Areas beyond National Jurisdiction (*IUCN Marine Law and Policy Paper* No. 2: 2008; available at <cms.iucn.org>).

While there was no negotiated outcome of the 2nd Meeting of the UNWG BBNJ, attention should be drawn to some of the issues selected by the Co-chairpersons as issues which the UNGA may decide as suitable for consideration by a next meeting of the UNWG BBNJ, namely:

a) The strengthening of cooperation and coordination at all levels and across all sectors, including enhanced cooperation in capacity-building for developing countries;
b) The development and implementation of effective [environmental impact assessment (EIA)] as a tool for improving ocean management; [...]
d) Development and use of [area-based management tools (ABMTs)], including designation, management, monitoring and enforcement, consistent with [the LOS Convention];.[7]

Arguably, the reason why the Co-Chairpersons selected these issues is their perception that many states regard them as gaps in the current international law of the sea, despite disagreement on the appropriate means to address these gaps. Issues (b) and (d), read in conjunction, could be interpreted as support for integrated, cross-sectoral ecosystem-based ocean management, operationalized by among other things spatial measures or tools (e.g. MPAs). Such support has also been expressed by the UNGA in its 2006 and 2007 Resolutions on Oceans and the law of the sea.[8]

As regards the CBD, mention can be made of efforts in relation to MPAs in ABNJ. The 9th Conference of the Parties (CoP) to the CBD in May 2008 adopted scientific criteria for identifying areas in need of protection in open-ocean waters and deep-sea habitats as well as scientific guidance for designing representative networks of MPAs. Moreover, they agreed to convene an expert workshop that will provide guidance to Parties and the United Nations on identifying important areas that need protection in ANBJ as well as on the use and further development of biogeographic classification systems.[9] Despite these positive developments, however, there is no consensus in the international community yet on the process for designating such MPAs and the regulation of human activities therein. States that support the EU proposal for an Implementation Agreement to the LOS Convention[10] probably see integrated MPAs in ABNJ as one of its main elements.

In this context mention can be made of the test-case proposal for an OSPAR[11] MPA situated beyond 200 nm from the coast.[12] Success in achieving the integrated, cross-sectoral ecosystem-based ocean management objectives of this MPA is likely to require coordination and cooperation between the OSPAR Commission[13] with, *inter alia*, the North-East Atlantic Fisheries Commission (NEAFC), the International Maritime Organization (IMO) and the International Seabed Authority (ISA). Cooperation with NEAFC on this issue has already taken place. Another indication of the strengthening cooperation between the two organizations is the OSPAR/NEAFC Memorandum of Understanding (MOU) that entered into force in 2008.[14]

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7 UN doc. A/63/79, of 16 May 2008, 'Letter dated 15 May 2008 from the Co-Chairpersons of the Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction addressed to the President of the General Assembly', at p. 12, para. 54.

8 UNGA Resolution No. 61/222, at para. 119 and UNGA Resolution No. 62/215 'Oceans and the law of the sea', of 22 December 2007, para. 99.

9 Decision IX/20 (2008), 'Marine and coastal biodiversity', at paras 14 and 19

10 Cf. the Annex to the Statement by Austria, on behalf of the EU, at the 7th Meeting of the ICP (2006) and COM(2007) 575 final, of 10 October 2007, 'An Integrated Maritime Policy for the European Union', at p. 14, where it is noted that the "Commission will propose an Implementing Agreement of UNCLOS on marine biodiversity in areas beyond national jurisdiction and work towards successful conclusion of international negotiations on Marine Protected Areas on the high seas".

11 This refers to the OSPAR Commission established the OSPAR Convention (Convention for the Protection of the Marine Environment of the North-East Atlantic, Paris, 22 September 1992. In force 25 March 1998, <www.ospar.org>. Annex V, Sintra, 23 September 1998. In force 30 August 2000; amended and updated text available at <www.ospar.org>).

12 'Proposal for an OSPAR area of interest for establishing an MPA on the Mid Atlantic Ridge/Charlie Gibbs Fracture Zone. Presented by WWF, the Netherlands and Portugal" (Doc. OSPAR 08/7/9-E). See also Summary Record OSPAR 2008, OSPAR 08/24/1-E, at paras 7.16-7.24.

13 See note 11 supra.

14 The Draft adopted by the OSPAR Commission is contained in Annex 13 to Summary Record OSPAR 2008, OSPAR 08/24/1-E, at Annex 13. See also para. 7.23(f). The MOU entered into force on 5 September 2008.

Lastly, the CoP to the CBD also supported the need to develop scientific guidance for EIAs and SEAs in case of activities which may have a significant adverse impact on marine biodiversity beyond national jurisdiction - a task for which a working group was created at the 9th CoP.[15]

[15] Decision IX/20 (2008), 'Marine and coastal biodiversity', at paras 8 and 10.

3 Relevant anthropogenic activities and their impacts on biodiversity in ABNJ

3.1 Introduction

In order to assess the impact of various anthropogenic activities on marine biodiversity in ABNJ, a transparent and consistent methodology is needed (Rijnsdorp and Heessen, 2008). The ecosystem components considered represent different biota (fish, seabirds, benthos, sea turtles) or ecosystem properties (benthic habitats, food chain) which are expected to be affected to a different degree by the various anthropogenic activities. The impact of anthropogenic activities will be assessed using three aspects: (i) severity; (ii) recoverability; and (iii) extent (see Table 1 below).

Severity is the product of the intensity of the activity and the direct effect on the population dynamic response (change in intrinsic population growth rate due to a change in mortality or in the reproductive rate of a population). The effect on the mortality and reproduction induced by an activity is compared to the background level of natural mortality and reproductive rate, assuming no synergistic effects. Ideally, the intensity can be quantified in terms of the dose (e.g. trawling frequency, release of a chemical substance, noise, etc.) that can then be linked to the immediate population dynamic effect. In practice, however, quantifying intensity is difficult for many anthropogenic activities. Hence, we have estimated the severity by expert judgement and the percentages mentioned in Table 1 should be taken as rough indications. The effect of an impact on ecosystem components such as benthic habitats and food chain, has been interpreted in terms of the probability that the benthic habitat is damaged (benthic habitats) or that the food availability for higher trophic levels has been reduced (food chain).

Recoverability is evaluated as the time period (years) needed to recover after the activity considered has been stopped. The time-scale adopted matches the recovery time-scale of 2-20 years used in the FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas[16]. The local ecosystem impact of an activity is expressed as product of Severity and Recoverability. The absolute effect will further depend on the extent of the activity. If spatially explicit data on human activities and ecosystem components are available, the local impact can be mapped. The extent of the impact is evaluated against the proportion of the distribution area of the ecosystem component affected. The product of Severity*Recoverability* Extent gives an indication of the absolute impact of an activity in a certain sea area, such as an ocean basin (North Atlantic, Indian Ocean, etc). It is noted that the Severity and Recoverability are assessed from a population dynamic point of view by attempting to estimate the impact on mortality and reproductive rates of the population.

In the current report, the impact of the various user functions is assessed by means of the product of Severity*Recoverability. The index is expressed on a 4-point scale reflecting no impact (0), small impact (1), medium impact (2) and large impact (3).

Table 1: Criteria used to score the three effects of anthropogenic impacts on ecosystem components

Effect of an impact	**0**	**1**	**2**	**3**
Severity (S)	Effect negligible	<1%	1-50%	>50%
Recovery (R) (time period in years)	<1 year	1-5	5-20	>20
Extent (E)	No interaction	present but small	significant regional	substantial global

16 Provisional draft contained the text as adopted by the Technical Consultation on 29 August 2008.

3.2 Fisheries

Fisheries will impact the marine ecosystem in a variety of ways (Jennings, Dinmore *et al.* 2001). The prime influence is the removal of target fish, which will lead to a reduction in the population biomass and a change in the species and size composition of the fish assemblage (Daan, Gislason *et al.* 2005). Fisheries will also impact non-target organisms which occur in the bycatch and may influence marine habitats such as sediments and benthic habitats (Groot 1984; Hall 1994; Pitcher, Poiner *et al.* 2000). The impact of fishing on biodiversity will strongly depend on the fishing gear and the intensity of fishing.

Fisheries resources that are exploited in the high seas consist of (epi-) pelagic species (tunas and sharks), bottom dwelling fish (e.g. orange roughy, hoki and toothfish) and the invertebrates squids and krill. Fishing activities on oceanic stocks has increased considerably since the 1950s. As a consequence, the proportion of fish stocks that are overexploited increased to just over 50% in deep water species and almost 40% in (epi-) pelagic species (Maguire, Sissenwine *et al.* 2006). There are suggestions that the increase in landings of oceanic species is mainly due to an increase in the number of species targeted. Also, there is an indication that fisheries successively deplete distinct fishing grounds and then move on to others ('boom-bust' fishery). This is reflected in the gradual shift of the proportion of fish taken in deeper waters (Morato, Watson *et al.* 2006). A difficulty in the assessment of fisheries is that the available data on fishing gears, fishing effort and the spatial distribution are difficult to obtain, if in fact available. Also, there are strong indications that illegal, unreported and unregulated (IUU) fishing occurs. The value of the IUU groundfish landings was estimated to be 10% of the value of the legal landings. Finally, no distinction can be made between catches made within exclusive economic zones (EEZs) and those made on the high seas. This is particularly relevant for species which are resident to certain habitats within the high seas, such as demersal species occurring on seamounts, and which require management on a more local scale than the highly migratory (epi-) pelagic stocks.

Reported landings in 2004 of oceanic species were 10 million tonnes, of which a substantial but unquantifiable part is taken within EEZs. A comparison with the global capture fisheries landings (about 80 million tonnes) tentatively suggests that high seas fisheries are of relative minor importance as compared to fisheries within EEZs.

To evaluate the biodiversity impact of fisheries, it is necessary to distinguish between several types of fishing and target species, and between the direct and indirect effects of fishing. The direct effect of fishing is the increase in mortality rate. The vulnerability of species for this additional fisheries mortality depends on the growth-rate and the age of first reproduction (Brander 1981). As deep-sea species are characterized by a low growth-rate and high age at sexual maturity, they are very vulnerable to over-exploitation. This applies in particular to the bottom dwelling and epi-pelagic fish, but is less important for krill and squids. Indirect effects of fishing relate to the changes in the ecosystem relationships in response to the reduction in abundance of the targeted species.

Pelagic fisheries
(Epi-) pelagic fish are targeted by longlines, gillnets, purse seine nets and trawls. Pelagic long line fisheries may cause a substantial bycatch of seabirds, sea turtles and other megafauna that are attracted to the baited hooks. The bycatch of seabirds can be reduced by technical adjustments to the gear. Gillnets may lead to accidental bycatch of marine mammals and sea turtles. Drift nets are well known for their bycatch of dolphins. Pelagic trawling targets fish schools but may catch larger animals that occur in association with the fish schools (Zeeberg *et al.* 2006).

Demersal fisheries
Demersal species are targeted by longlines, gillnets and trawls. Demersal longline fisheries may damage biogenic structures, such as corals. Demersal gillnets can potentially catch marine mammals and sea turtles, but this will very much depend on the depth at which the nets are applied. Bottom trawling is characterized by relatively high bycatch rates as this fishery targets a mixed bag. The bycatch of marine mammals and sea turtles will be less because the fishery occurs at depths where these animals are less likely to occur.

Krill is targeted by pelagic trawling. It forms a crucial component of the Antarctic ecosystem and provides food for a large number of top predators such as marine mammals, seabirds and fish. Hence, overexploitation of krill will impact the abundance of top predators as well.

Squids are targeted by hook and line. They are important predators in marine ecosystems. As they are characterized by relatively high growth rates and low age of first reproduction, they are less vulnerable for overexploitation.

The overall assessment of the fisheries impact is shown in Table 2. The fisheries impact is most severe on the targeted species, in particular the bottom dwelling fish. Severe impact on non-target species (benthos and benthic habitats) occurs in bottom trawling, Moderate impacts occur in longline fisheries (seabirds), epipelagic purse seine nets (marine mammals) and epipelagic gill nets (sea turtles).

3.3 Mining

Mining is the extraction of minerals and oil or gas. As regards entitlements to the exploration and exploitation of these non-living resources, a distinction should be made between the juridical continental shelf of the coastal state and the seabed beyond the juridical continental shelf ('the Area'). A coastal state has sovereign rights for the exploration and exploitation of these resources to the exclusion of others. Mining in the Area is subject to Part XI of the LOS Convention as modified by the Part XI Deep-Sea Mining Agreement and is governed by the ISA.

Oil and gas exploitation currently mainly occurs within areas under national jurisdiction. Recent advances in mining technology, however, allow oil and gas extraction from waters down to 3000m and imply that oil and gas activities may some day go seaward of the juridical continental shelf (UNEP, 2006). Other potential sources of energy are gas hydrates. Gas hydrates are ice-like crystalline solids formed by the entrapment of gas molecules in a hydrogen-bonded cage of water molecules. Methane is the gas that is most commonly entrapped, and its flammable nature suggests that hydrates could serve as a potential source of energy - once problems related to its commercial extraction are resolved (Plantegenest *et al.* 2005).

Mineral resources in the Area comprise (i) polymetallic nodules, also known as manganese nodules; (ii) polymetallic sulphides and (iii) cobalt-rich crusts. Manganese nodules lie strewn atop the seabed, notably in the central Pacific and Indian Oceans. Polymetallic sulphides are formed around hot springs in active volcanic areas. Cobalt-rich crusts are found around ridges and seamounts in all the world's oceans, fused to the underlying rock.

Although at present no mining activities occur in the Area, they may develop in the future and have an impact on the ecosystem due to potential emissions to water and air. Main emissions from oil and gas activities will be drill cuttings, drill fluid and produced water. Main emissions from mineral mining will be debris after separation on board. Besides emissions, mineral mining causes physical damage to the seafloor. The main effects of oil and gas activities are expected to be local, but a more widespread impact may come from the exploitation of subsurface gas hydrate deposits. Mineral mining will cause damage to seabed habitats, alteration of geological processes and the release of plumes of material into the water column. As long-lived vent fields that host the largest mineral deposits are likely to be the most ecologically stable and have the highest biodiversity, mineral mining activities are likely to produce local and even regional effects on biological processes and organism abundance. Table 2 shows that the potential impact will be moderate and restricted to the benthos and benthic habitats.

3.4 Shipping

Shipping is an important economic maritime activity, which is mainly concentrated in coastal waters. Shipping activities on the high seas are related to merchandise trades (tankers, bulk carriers and containerships) and the tourist industry (transcontinental shipping and cruises). Emissions from these activities may affect the biodiversity of the high seas.

Shipping activities on the high seas are mainly concentrated within the maritime routes. Highest activities occur between 60°N and 30°S. In large parts of the oceans, the density is estimated to be 40 or less vessels per one-degree cell per month. The North Atlantic Ocean has a higher estimated density of 50-140 vessels per one-degree cell per month, the same as the major shipping routes in the Indian Ocean and Pacific Ocean. The main cargo is oil, representing 37% of the total goods in 2005.

Operational shipping activities lead to a range of emissions to the sea, including anti-fouling substances (TBT), which are slowly released from the hull; the discharges of tank sludges; oil discharges; ballast water; and litter. Although it is unlikely that TBT will accumulate considerably in the oceans' sediments, bio-magnification and related effects of TBT on marine mammals and seabirds could be considered relevant for the high seas. Oil is not regarded as a significant pollutant on a global scale, although it is a highly visible pollutant and, when spilled in large quantities, can cause severe local effects. As for mineral oil, effects of vegetable oils are mainly physical and can cause severe local effects. It is, however, not expected to have a significant impact on high seas biodiversity.

Two of the main threats to the world's oceans are invasive species and litter. Invasive species can be introduced into new environments through ships' ballast water and the fouling of ships' hulls. It has been estimated that ca. 10% of introduced species will lead to an invasion and that ca. 10% of these invasions will lead to a plague. However, these figures refer to coastal ecosystems, and it is unlikely that open ocean ecosystems will respond in a similar way. Ca. 5 million pieces of garbage, which are thrown overboard or lost from ships, enter the seas and oceans every day. Of particular concern are mass concentrations of marine debris in high seas convergence areas (see also section 3.10). The main ecological effects of litter are physical (trapping or ingestion of litter). Seabirds, sea turtles, marine mammals and fish are known to be affected. Litter may form floating rafts or may accumulate at the bottom of the oceans where it can suffocate fauna. Ecological resources are considered not to recover and the affected area is considered large.

Shipping contributes significantly to the world's total greenhouse gas emissions and may have a serious impact on biodiversity through global warming as well as acidification. Acidification caused by gaseous ship emissions could occur in the proximity of major shipping lanes. Emissions of noise and the physical presence of ships could also affect ecological resources. Effects of shipping noise on birds and fish are to be expected within the maritime routes (few kilometers wide). Marine mammals can be affected by noise up to tens of kilometers distance.

3.5 Iron fertilization

The world's oceans play an important role in the regulation of the global climate through the uptake of greenhouse gases such as carbon dioxide. In order to increase the uptake, open oceans could be fertilized with iron to increase plankton production (IMO, 2007). Based on controlled scientific experiments, estimations of future large-scale fertilization are 0.5 to 6 million ton iron/year requiring an area of 84 to 1000 million km^2. There is no information on the impacts of iron fertilization on the marine ecosystem. Potentially, effects can be expected such as a change in the composition of the plankton community and marine food webs, a change in biogeochemical cycles, and through contaminated source material. In coastal waters, reduced oxygen levels and harmful algal blooms have been observed in relation to increased nutrient concentrations, but it is unknown whether such phenomena may occur in open ocean areas.

3.6 Carbon dioxide storage

The storage of carbon dioxide (CO_2) is considered as a possible measure to reduce the emissions of greenhouse gases and mitigate global warming. There are several forms of permanent storage of which liquid storage in deep ocean masses (ocean storage) is a potential technique for ABNJ. Because the development of ocean storage technology is generally at a conceptual stage, the potential impacts are inferred from general principles of the potential activities.
Technologically, ocean storage is possible by injecting CO_2 into the ocean at a minimum depth of 3000 m. It is expected that the CO_2 injected in the deep ocean would equilibrate with the atmosphere over a time scale of 300 to 1000 years. There is no known mechanism for the sudden or catastrophic release of stored CO_2 from the ocean to the atmosphere. CO_2 injection strategies ultimately will produce large volumes of water with somewhat elevated CO_2 concentrations.

The elevated CO_2 concentrations will increase the problem of acidification which is known to negatively affect the growth, survival and reproductive success of marine organisms. The stored CO_2 may contain other contaminants, such as H_2S, which may have an impact on biological processes.

Annexes II and III to the OSPAR Convention[17] were amended in 2007 to allow the storage of carbon dioxide (CO_2) streams in geological formations under the seabed, combined with a decision to ensure environmentally safe storage and guidelines for risk assessment and management of this activity.[18] In 2007 the OSPAR Commission adopted a decision prohibiting the storage of CO_2 streams in the water column or on the seabed.[19] These measures are consistent with those adopted in relation to CO_2 storage within the framework of the London Convention[20] and its 1996 Protocol[21].

3.7 Tourism

Biodiversity impacts of tourism will mainly occur in Antarctica. In other ABNJ, tourism is virtually non-existent and is unlikely to develop in the near future.

Since the early 1990s, the number of visiting passengers to Antarctica has increased fivefold. Currently about 35000 passengers visit the Antarctic by ship during the Nov-Mar austral summer season. Not included in this figure are crew members, which may number more than half of the number of passengers. Most tourist ships make landings at interesting sites. The type of tourist ships visiting Antarctic waters is extremely variable and ranges from small sailing yachts to huge cruise-liners. The largest ships, carrying over 500 passengers, usually make no landings but only cruise in the area. However, also these very large ships navigate along the interesting spots close inshore, maneuvering in narrow channels and between islands close to dense concentrations of wildlife like penguin breeding colonies.

Antarctic tourism concentrates in the area around the Antarctic Peninsula which is the richest in animal life. Biodiversity risks of Antarctic tourism mainly occur through shipping related effects, with specific concerns for: (i) accidents resulting in prolonged sources of pollution close to biodiversity hotspots; and (ii) risks from introduced diseases from (legal) discharges of large quantities of sewage, grey water and food-wastes close to biodiversity hotspots.

Eco-tourism, also that to the Antarctic, has a definite positive role to play in protection and management of nature and the conservation of biodiversity (Lamers and Amelung, 2005). The personal experiences from visitors contribute to public, political and policy support for conservation and protection of the Antarctic. However, such positive effects are extremely difficult to quantify. But an excellent example is that the status as Antarctic Treaty Consultative Party (ATCP) of the Netherlands was triggered by political lobbying by the late W. Thomassen (Thomassen, 1983) after having visited the Antarctic as a tourist.

Relevant shipping regulations are largely based on the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), but in this specific situation a more proactive role of the Antarctic Treaty system might be considered.

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[17] See note 11 supra.

[18] See, *inter alia*, OSPAR Decision 2007/2 and OSPAR Agreement 2007-12 'Guidelines for Risk Assessment and Management of Storage of CO_2 Streams in Geological Formations'.

[19] OSPAR Decision 2007/1.

[20] Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London, Mexico City, Moscow, Washington D.C., 29 December 1972. In force 30 August 1975, 11 *International Legal Materials* 1294 (1972); as amended, consolidated version available at <www.imo.org>.

[21] London, 7 November 1996. In force 24 March 2006, *Law of the Sea Bulletin* No. 34 (1997), p. 71; as amended in 2006, consolidated version at <www.imo.org>.

3.8 Infrastructure

Infrastructure in the Area is restricted to fibre-optic cables for telecommunication. Power cables and pipelines are only laid within areas under national jurisdiction. This undersea network interconnects all the world's continents except Antarctica and is currently the backbone of intercontinental data and voice transmission. The fraction of trans-Oceanic voice and data transmitted over undersea cables has grown from 2 percent in 1988 to as high as 80 percent in 2000. The submarine fibre-optic cables are of high economic importance. The total worldwide investment in undersea fibre-optic cable systems was $46 billion between 1987-2007.

Submarine fibre-optic cables typically have only the diameter of a garden hose (i.e., up to 2,5 cm) and in trajectories where extra protection is required up to 6,5 cm. The ecological impacts are associated with the installation and the operation of the cables. Installation of the cables causes some disturbance to animals and habitats, but these effects are local and only occur once. Operation of cables may affect marine organisms, such as rays and sharks, for which electrical fields play a role in their migration, feeding, or navigating behavior. It is unlikely that the cables will have an impact on the population level.

3.9 Bioprospecting and marine scientific research

Deep-sea organisms have adapted to extreme conditions in the deep sea, in particular to unique environments such as hydrothermal vents, cold seeps and seamounts. These organisms are of particular interest for biotech companies that hope to find unknown genes, proteins, and other compounds that could be exploited commercially.

Following Arico and Salpin (2005), 'bioprospecting' is defined as research for commercial purposes. This definition excludes the potential large-scale harvesting of organisms. In practice, however, bioprospecting is closely related to 'marine scientific research'. Research vessels for deep-sea research are commonly owned by public organisations. The involvement of commercial organisations in sample extraction from the deep sea is limited to funding scientific expeditions and collaborations in laboratories once samples have been collected. At least 14 biotechnology companies have so far been involved in research and product development, and/or collaboration with research institutions in relation to derivatives of deep-sea genetic resources. Only very few states have access to the technologies needed to explore the deep sea.

There is no evidence of commercial applications derived from genetic resources collected in areas beyond national jurisdiction. However, the economic potential for these resources is high.

Among the hundreds of hydrothermal vents discovered so far, only a few are visited each year. Most studied sites are located in the Pacific and Atlantic Oceans. Since the mid-ocean ridges are known to circle the globe for about 75,000 km, it is expected that the number of vents is much higher (Leary 2004). There is no substantiated evidence that any company has mounted its own dive to the deep sea - or any ABNJ - to collect samples for the purpose of research and development in relation to biotechnology derived from deep-sea genetic resources (Vierros *et al.* 2007). Samples of microbes from the high seas are also sold via national culture collections, where samples are deposited by research organisations.

Knowledge on the effects of bioprospecting is virtually unavailable. The following considerations are based on theoretical reasoning. Ecological impacts will be due to damage to underwater structures caused by submersibles. Also, the use of light in a dark environment may have a negative effect on deep-sea organisms (Herring *et al.* 1999). A special reason of concern is the potential impact from species introductions. As hydrothermal vents occur at distinct sites, the fauna may be genetically distinct from that of other vents. Bioprospecting several sites could potentially contaminate the unique fauna. Although some reports suggest that the species composition or the genetic characteristics of viral assemblages at distinct sites are rather similar within several hundred kilometers, this topic needs careful attention.

The exploration phase of bioprospecting involves very small samples and the damage by submersibles is expected to be local. Once marine organisms that contain substances that are of interest to the biotechnological industry become the target of exploitation, the impact of the activities may become high.

As the concentrations of the substances that are of interest for biotechnological applications are often very low, large quantities of an organism are necessary to produce the required quantity. This could easily lead to overexploitation, similar to the overexploitation in fisheries.

3.10 Diffuse sources

Biodiversity in ABNJ is not only affected by human activities taking place in these areas but also by human activities in marine areas within national jurisdiction and on land. Air pollutants are transported in the atmosphere and may be deposited in the open ocean. Also, water-borne pollutants may be transported with water currents and reach the open ocean. Persistent organic pollutants that originated from land-based emissions have been recorded in oceanic animals (de Boer, *et al.* 1998).

The increased level of CO_2 due to the use of fossil fuels has already reduced the pH of the ocean and jeopardizes marine life; in particular animals that produce calcareous skeletons will be affected and may reduce or even completely disappear from impacted areas (Orr, 2005; Favry et al. 2008). This may have serious implications for both the structure and the functioning of marine ecosystems.

Climate change itself will have a major impact on biodiversity. The impact of climate change will differ between regions, the impacts may well be the most extensive and serious in the Arctic. Receding sea-ice coverage (both in thickness and geographical extent) and melting permafrost are regarded by many as the preludes of an irreversible Arctic 'meltdown'. This will without doubt allow increasingly more human activity in the Arctic; perhaps within a shorter time-span than anticipated earlier. The rapid warming of the Arctic climate was the first and most prominent of the 10 key findings of the 2004 Arctic Climate Impact Assessment (ACIA)[22]. On 15 September 2007, the Arctic ice cap was 22% below the last record set in 2005.[23] Perhaps even more important than ice-coverage as such, is the increasing percentage of first-year sea-ice. Of particular importance are ACIA's key findings No. 4: "Animal species' diversity, ranges and distribution will change" and No. 6: "Reduced sea ice is very likely to increase marine transport and access to resources". While the former predicts changes in the composition of the Arctic marine ecosystem in quantitative, qualitative, spatial and temporal terms, the latter predicts increased pressure on this ecosystem due to more intensive exercise of existing maritime uses as well as new uses. Examples of these are shipping, exploration and exploitation of living (e.g., fishing) and non-living (e.g., oil and gas) marine resources, construction of artificial installations, laying of cables and pipelines, overflight and marine scientific research (including bio-prospecting).

Of special interest is the pollution with litter. It is estimated that the main source of marine litter is land-based pollution (GESAMP, 1990; Sheavly, 2007)

3.11 Comparative analyses

The quantification of the impacts of anthropogenic activities on marine biodiversity proved to be a major challenge, due to the lack of quantitative information on both the activities as well as the biodiversity. Quantitative data on the nature of the activities, the scale of operation and the impact on specific ecosystem components is largely lacking. For activities for which information is available, such as fishing, no distinction is made between areas within and beyond national jurisdiction. In addition, our knowledge of the biodiversity in ABNJ is limited and many areas are still unexplored.

Comparison of the current activities suggests that the impact is largest from fishing. The analysis also shows that the anthropogenic activities should not be pooled in too broad categories, as the impact may differ between different types of fisheries. For instance, seabirds are impacted by longline fishing, but not by demersal trawling, while marine mammals will be mainly affected by pelagic purse seining. Further, garbage from shipping may have a substantial impact on benthos and benthic habitats. In Antarctica, tourism is a threat to marine mammals and birds due to disturbance and the risk of species introductions. In the future, bioprospecting and CO_2 storage could have major impacts. Bioprospecting could potentially

22 The Overview Report and the Scientific Report are available at <www.amap.no/acia>.

23 See info at National Snow and Ice Data Centre <nsidc.org/arcticseaicenews>.

lead to the exploitation of a variety of other organisms for biotechnological use, although at present this does not occur. A comparison of the impact of various activities within an ecosystem component again shows the dominant impact of fishing for all ecosystem components considered.

It is noted that fishing, bioprospecting and Antarctic tourism are activities that will be concentrated in areas of high biomass or high biodiversity. This is in contrast to other activities such as shipping or infrastructure that will be unrelated to biodiversity hotspots.

*Table 2: Local ecosystem impact of different activities estimated by the product of Severity*Recovery (0 - none, 1 - small, 2 - medium, 3 - large). Based on Rijnsdorp and Heessen, 2008.*

		Fish	**Benthos**	**Benthic habitats**	**Birds**	**Marine mammals**	**Turtles**	**Food chain**
Fisheries	Epipelagic longline	2	0	0	2	0	2	2
	Epipelagic gillnet	2	0	0	1	1	2	2
	Epipelagic purse seine	2	0	0	0	2	0	2
	Epipelagic trawl	2	0	0	0	1	1	2
	Demersal longline	3	1	1	2	0	1	2
	Demersal gillnet	3	1	1	1	1	0	2
	Demersal trawl	3	3	3	0	0	0	2
Mining		1	2	2	0	0	0	0
Shipping	Oil	0	0	0	1	0	0	0
	Chemicals	0	0	0	1	0	0	0
	Garbage	1	1	2	2	1	2	1
	Antifouling	0	0	0	0	0	0	0
	Exotic species	0	0	0	0	0	0	0
	Air pollution	0	0	0	0	0	0	0
	Noise	0	0	0	0	1	0	0
Iron fertilisation		0	1	1	0	0	0	1
CO_2 storage	CO_2	0	2	3	0	0	0	0
	Contaminants	0	1	1	0	0	0	0
Tourism	Tourism	0	0	0	2	2	0	2
Infrastructure	Data cables	0	1	1	0	0	0	0
	Power cables	1	0	1	0	1	0	0
	Pipelines	0	1	2	0	0	0	0
Bioprospecting	Exploration	0	1	1	0	0	0	0
	On shore isolation, testing	0	0	0	0	0	0	0
	Exploitation	0	3	3	0	0	0	0
	Bioprospecting MSR	0	2	2	0	0	0	0

4 Addressing selected anthropogenic impacts

4.1 Introduction

The comparative analysis in section 3.11 shows that the threats to biodiversity in ABNJ are manifold and of a diverse nature. Some can be linked to anthropogenic activities, such as fisheries, mining and shipping. These threats primarily occur locally (i.e., at the impacted sites), although indirect effects may occur via the influence on the mobile components of the ecosystem. Other threats are caused by activities that cannot be defined or localized easily (such as air-based pollution, littering, acidification). Even more complex is the accumulation of effects due to multiple activities in the same area. Methods for such assessment are currently under development. The diverse nature of the threats implies that management of biodiversity in ABNJ needs to be tackled from several angles.

4.2 Fisheries

Management of marine capture fisheries within areas under national jurisdiction has a poor track-record for achieving sustainable management of exploited resources, let alone the wider ecosystem (Jackson et al., 2001), (Pauly et al., 1998) (Worm et al., 2006), although there are a few exceptions (Hilborn et al. 2003). Although fisheries management bodies have been established as a result of international cooperation, amongst others within the framework of the FAO, to manage fish stocks that occur in waters beyond national jurisdiction in a sustainable manner, the often vulnerable nature of high seas fish species, makes it unlikely that high seas fisheries resources will be sustainably managed. Recent FAO figures indeed indicate that many high seas fish stocks are overexploited or fully exploited.

Fisheries can be managed using a wide variety of instruments. Although many of these instruments can in theory manage the fishery in an efficient manner, there are many factors that can jeopardize their effectiveness. For instance, single-species catch quota imposed on mixed fisheries may lead to increased discarding of over-quota fish, or to high-grading of the landings by discarding a part of the catch of marketable but least valuable fish (Rijnsdorp et al., 2007). Lack of enforcement may lead to illegal landings. In many places misreporting is known to occur: wrong areas, wrong species may be reported, and this influences the assessments and thus management of several species.

Catch and effort controls
Catch and effort control may be an effective way to reduce the mortality imposed by fishing. However, the efficiency of this management system will depend on the nature of the fisheries. If the management system is properly enforced, it may be an effective way to manage single-species fisheries, as shown for instance by the successful management of North Sea herring in the 1980s and 1990s. Catch controls can also manage mixed fisheries (targeting at a mix of several commercially important species) effectively if the fishery is monitored closely by on-board observes (Branch and Hilborn, 2008). If the catch is only controlled when landed, catch control may lead to discarding of over-quota fish. Also, mixed fisheries have the problem that the optimal mesh size differs between various target species. As a consequence, catch control in mixed fisheries is not able to prevent discarding of part of the catch.

Effort control may be a good option for managing mixed fisheries. However, effort management may create an incentive to increase the efficiency of the fishery within the management constraints for instance by investing in auxiliary equipment or by targeting the most valuable species of the portfolio. Neither catch nor effort control address the ecosystem impacts on other than the targeted species. Hence, additional measures may be needed to prevent the fisheries causing harm to the ecosystem.

Technical measures
Several technical measures can be developed to reduce the negative impacts of fishing on the marine ecosystem. Technical modifications to the gear, such as excluder panels in large pelagic trawls (Zeeberg *et al.*, 2006), may reduce the bycatch of large megafauna. The use of pingers on gillnets may scare off

marine mammals and hence reduce their bycatch (Barlow and Cameron, 2003). These measures cannot be developed in a general manner but need to be fine-tuned to the specific fisheries and bycatch species.

In bottom trawl gear, the possibilities of reducing bycatch or the damaging effect on benthic habitats and vulnerable benthic biota are limited. In fact, the technological developments (sturdier gear, rock hopper gear) have allowed the fishery to extend its activity area and fishers can now trawl in areas and at depths which were previously untrawlable.

Marine protected areas
MPAs can be powerful tools to protect biodiversity hotspots from local fishing activities. The utility of this tool is restricted to the biota and ecosystem functions that reside in the protected area, although ecologists generally expect that MPAs will have a spill-over effect to the surrounding areas. It is important to distinguish between the MPAs designed as a fisheries management measure to improve the sustainability of exploited resources and MPAs designed to protect or conserve non-target species, including benthic habitats. In the context of high seas biodiversity, the focus will be on the latter application.

Enforcement (control and surveillance)
Fisheries activities can be monitored using satellite tracking systems. This technique is widely used, amongst other in the European Union, and allows the recording of fishing activities at spatial scales of not only the management units, but also on much finer spatial scales that are relevant for the protection of localized biodiversity hotspots, such as vulnerable benthic habitats.

4.3 Mining

Although the impact of mining operations may be substantial in the impacted area, the current level of activity is negligible. Increasing demand for minerals, however, may lead to a further development of these activities in the Area. Possible options for the ISA are the identification (or development) of more selective mining equipment and area-based management tools.

4.4 Shipping

Greening of maritime transport has become a global issue. Most emphasis is currently on the reduction of air pollution (e.g., reducing sulphur content and switching from heavy to lighter fuel oils). Antifouling is a continuous issue for research from the perspective of drag reduction (and therewith reduction of fuel consumption). Environmental performance of coatings is, although secondary, an area where research is warranted. Ballast water treatment equipment could be installed on board to prevent the risk of species introductions. As it is unlikely that the introduction of exotic species will be a serious risk in the open ocean system, this seems to be a low priority area.

It must be noted that all these measure are fragmentary. More effort might be gained from the introduction of harbor taxes based on the environmental performance of the vessels. Indexes to express the overall environmental performance are not yet available, although research is ongoing (e.g., Milieubalans project of the Maritime Knowledge Centre).

4.5 Iron fertilization

Iron fertilization may be a potential technique to reduce the amount of greenhouse gas (CO_2) in the atmosphere by enhancing primary production in the open ocean. Concerns have, however, been raised about the possibility of negative impacts on the marine environment. In theory iron fertilization could also be used to enhance fish production. Knowledge on these effects is poor and any future activity in this area needs to be preceded by research. The economics of these activities will depend to a great extent on international agreements. Under the current Kyoto Protocol, carbon emission rights are an economic commodity and may trigger commercial enterprises to step into this activity.

4.6 Diffuse sources

Climate change is high on the international agenda and subject of negotiations for a follow up agreement for the Kyoto Protocol. The impact of climate change on marine ecosystems may contribute to these international discussions and decision-making processes. In particular the effect of acidification on benthic organisms that build biogenic structures may be severe since these are ecological engineers providing habitat for many other species (coral reefs). The effects, however, are not restricted to this.

Recently, there has been much attention for the problem of litter in the ocean, in particular the high seas. Although the scientific basis for a credible evaluation of this impact is still lacking, reports suggest that about 80% of the litter in the high seas originates from land-based sources. This would imply that the litter problem can only be partly solved by managing the emission of litter by shipping and other ocean based activities.

4.7 Marine protected areas

MPAs can be powerful tools to protect biodiversity hotspots from local human activities. The most obvious application of MPAs is to protect local biodiversity hot spots that are related to the occurrence of spatially fixed environmental conditions, such as certain benthic habitats (coral reefs, seamounts, vents, etc) (Worm et al. 2003). On a larger scale, certain hydrographic environments can also be protected by MPAs, such as frontal systems and upwelling areas as these provide areas of high biological productivity extending through all trophic levels.

The efficiency of MPAs will depend on the nature of the biota to be protected. Sessile biota, such as benthic invertebrates, will be particularly suitable biota to protect through an MPA. The effectiveness of MPAs to protect mobile biota such as fish will depend on the mobility of the biota. Nevertheless, mobile biota can be (partly) protected if they remain in the MPA for a considerable amount of their time. As such, MPAs will also play a role in the protection of migratory fish species as these may concentrate during parts of the year in identifiable local areas of high production (Worm et al., 2003).

References

Arico, S. and C. Salpin, 2005. UNU-IAS Report. "Bioprospecting of Genetic Resources in the Deep Seabed: Scientific, Legal and Policy Aspects", United Nations University. UNU-IAS Institute of Advanced Studies.

Barlow, J. and Cameron, G.A., 2003. "Field Experiments Show That Acoustic Pingers Reduce Marine Mammal Bycatch in the California Drift Gill Net Fishery", *Marine Mammal Science*, 19, ps 265-283

Branch, T.A. and Hilborn R. (2008) "Matching catches to quotas in a multispecies trawl fishery: targeting and avoidance behavior under individual transferable quotas", *Canadian Journal of Fisheries and Aquatic Sciences* 65:1435-1446

Brander, K. (1981), "Disappearence of the common skate, Raia batis, from the Irisch Sea", *Nature* 290: 48-49.

Daan, N., H. Gislason, J.G. Pope & J.C. Rice (2005), "Changes in the North Sea fish community: evidence of indirect effects of fishing?", *ICES Journal of Marine Science* 62: 177-188.

de Boer, J., W., P. G. Wester, H.J.C. Klamer, W.E. Lewis & J.P. Boon. (1998), "Do flame retardents threaten ocean life?" *Nature* 394: 28-29.

Fabry, V. J., B. A. Seibel, et al. (2008), "Impacts of ocean acidification on marine fauna and ecosystem processes", *ICES Journal of Marine Science* 65(3): 414-432.GESAMP 1990. The state of the marine environement.

Gjerde, K.M. (2008), "Options for Addressing Regulatory and Governance Gaps in the International Regime for the Conservation and Sustainable Use of Marine Biodiversity in Areas beyond National Jurisdiction (*IUCN Marine Law and Policy Paper* No. 2: 2008; available at <cms.iucn.org>)

Gjerde, K.M. (2008), "Regulatory and Governance Gaps in the International Regime for the Conservation and Sustainable Use of Marine Biodiversity in Areas beyond National Jurisdiction" (*IUCN Marine Law and Policy Paper* No. 1: 2008; available at <cms.iucn.org>)

Glass, C.W. (2000), "Conservation of fish stocks through bycatch reduction: a review", *Northeastern Naturalist* 7: 395-410

Groot, S.J.D. (1984), "The impact of bottom trawling on the benthos fauna of the North Sea", *Ocean Management* 9: 177-190.

Hall, S.J. (1994), "Physical Disturbance and Marine Benthic Communities - Life in Unconsolidated Sediments", *Oceanography and Marine Biology* 32: 179-239.

Halpern, B.S., Walbridge S., Selkoe K.A., Kappel C.V., Micheli F., D'Agrosa C., Bruno J.F., Casey K.S., Ebert C., Fox H.E., Fujita R., Heinemann D., Lenihan H.S., Madin E.M.P, Perry M.T., Selig E.R., Spalding M., Steneck R., Watson R. (2008), "A global map of human impact on marine ecosystems", *Science* 319:948-952

Herring, P.J., Gaten, E. and P.M. J. Shelton (1999), "Are vent shrimp blinded by science?" *Nature* 398, 116.

Hilborn R., Branch T.A., Ernst B., Magnussson A., Minte-Vera C.V., Scheuerell M.D., Valero J.L. (2003), "State of the world's fisheries", *Annual Review of Environment and Resources* 28:359-399

ICES (2007), ICES Working Group on Ecosystem Effects of Fishing Activities (WGECO) 11–18 April, 2007. ICES CM 2007/ACE:04

IMO (2007): Convention on the prevention of marine pollution by dumping of wastes and other matter, 1972 and its 1996 protocol. Statement of concern regarding iron fertilization of the oceans to sequester CO2. Ref. T5/5.01. LC-LP.1/Circ.14, 13 July 2007

Jackson, J.B.C., Kirby M.X., Berger W.H., Bjorndal K.A., Botsford L.W., Bourque B.J., Bradbury R.H., Cooke R., Erlandson J., Estes J.A., Hughes T.P., Kidwell S., Lange C.B., Lenihan H.S., Pandolfi J.M., Peterson C.H., Steneck R.S., Tegner M.J., Warner R.R. (2001), "Historical overfishing and the recent collapse of coastal ecosystems", *Science* 293:629-638

Jennings, S., Dinmore T.A., et al. (2001), "Trawling disturbance can modify benthic production processes", *Journal of Animal Ecology* 70(3): 459-475.

Lamers, M., and Amelung, B. (2005), "The future of tourism in Antarctica. The Hague 23 September 2005. Workshop Report", International Centre for Integrated assessment and Sustainable Development (ICIS), Maastricht. 36pp.

Leary, D.K. (2004), "Bioprospecting and the Genetic Resources of Hydrothermal Vents on the High Seas: What is the Existing Legal Position, Where are we heading and What are our options", *Macquarie Journal of International and Comparative Environmental Law* 1: 137-178.

Maguire, J., M. Sissenwine, et al. (2006), "The state of the world, highly migratory straddling and other high seas fishery resources and associated species", *FAO Fisheries Technical paper* 483: 54.

Molenaar, E.J., "Managing Biodiversity in Areas Beyond National Jurisdiction", in M.H. Nordquist, R. Long, T.H. Heidar and J.N. Moore (eds) *Law, Science & Ocean Management* (Martinus Nijhoff Publishers: 2007), pp. 625-681

Morato, T., R. Watson, et al. (2006), "Fishing down the deep", *Fish and Fisheries* 7(1): 24-34.

Orr, J.C., V. J. Fabry, et al. (2005), "Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms", *Nature* 437(7059): 681-686.

Pauly D., Christensen V., Dalsgaard J., Froese R., Torres F. (1998), "Fishing down marine food webs", *Science* 279:860-863

Pitcher, C.R., Poiner I.R., et al. (2000), "Implications of the effects of trawling on sessile megazoobenthos on a tropical shelf in northeastern Australia", *ICES Journal of Marine Science* 57(5): 1359-1368.

Plantegenest, M. M. Iosipescu and R. Macnab (2005), "The French Islands of Saint-Pierre et Miquelon: A case study for the construction of a discontinuous juridical continental shelf?" Downloaded from http://st-pierre-et-miquelon.org/docs/marc_plantegenest.pdf, on February 1st 2008.

Rijnsdorp, A.D., Daan N., Dekker W., Poos J.J., Van Densen W.L.T. (2007), "Sustainable use of flatfish resources: Addressing the credibility crisis in mixed fisheries management", *Journal of Sea Research* 57:114-125

Rijnsdorp, A.D., Heessen H.J.L. eds. (2008), "Biodiversity of the high seas. Final Report Lot 1", Wageningen IMARES Report C085/08. 256 pp.

Sheavly, S.B. and Register K.M. (2007), "Marine Debris & Plastics: Environmental Concerns, Sources, Impacts and Solutions", *J Polym Environ* (2007) 15:301–305.

Thomassen, W. (1983), "Antarctica: nu - in 1991 – later", Uitgave: Stichting IUCN-Ledencontact, Werkgroep Antarctica, Utrecht.

UNEP (2006): Ecosystems and biodiversity in deep waters and high seas. UNEP Regional seas reports and studies no. 178. UNEP/IUCN, Switzerland 2006.

Vierros, M., Hamon, G., Leary, D., Arico, S. and C. Monagle (2007), "An update on Marine Genetic Resource, Scientific Research, Commercial Uses and a Database on Marine Bioprospecting", United nations Informal Consultative Process on Oceans and the Law of the Sea. Eight Meeting, New York 25-29 June 2007.

Worm. B., Barbier E.B., Beaumont N., Duffy J.E., Folke C., Halpern B.S., Jackson J.B.C., Lotze H.K., Micheli F., Palumbi S.R., Sala E., Selkoe K.A., Stachowicz J.J., Watson R. (2006), "Impacts of biodiversity loss on ocean ecosystem services", *Science* 314:787-790

Worm, B., Lotze H.K., Myers R.A. (2003), "Predator diversity hotspots in the blue ocean", Proceedings of the National Academy of Sciences of the United States of America 100:9884-9888

Zeeberg, J., A. Corten, & E. de Graaf. (2006), "Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa", *Fisheries Research* 78(2-3): 186-195.

Glossary

ABMTs	area-based management tools
ABNJ	areas beyond national jurisdiction
ACIA	Arctic Climate Impact Assessment
ATCP	Antarctic Treaty Consultative Party
CBD	Convention on Biological Diversity
CoP	Conference of the Parties
EEZ	exclusive economic zone
EIA	Environmental Impact Assessment
FAO	United Nations Food and Agriculture Organization
IMO	International Maritime Organization
IO	Intergovernmental Organisation
ISA	International Seabed Authority
IUU	illegal, unreported and unregulated
LOS	Law of the Sea
MARPOL	International Convention for the Prevention of Pollution from Ships
MOU	Memorandum of Understanding
MPA	marine protected area
NEAFC	North-East Atlantic Fisheries Commission
RFMO	Regional Fisheries Management Organisation
SEA	Strategic Environmental Assessment
TBT	Tributyltin
UNEP	United Nations Environment Programme
UNGA	United Nations General Assembly
UNWG BBNJ	United Nations Ad Hoc Open-ended Informal Working Group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction

Justification

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The scientific quality of this report has been peer reviewed by a colleague scientist and the head of the department of Wageningen IMARES.

Approved: dr. C.M. Deerenberg
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Date: October 2009

Approved: dr. ir. T.P. Bult
Head of Fisheries Department

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