Kiel
Working Papers

Kiel Institute
for the World Economy

Establishing a Sustainable Development Goal for Oceans and Coasts to Face the Challenges of our Future Ocean

by Martin Visbeck, Ulrike Kronfeld-Goharani, Barbara Neumann, Wilfried Rickels, Jörn Schmidt, Erik van Doorn

No. 1847| June 2013

Web: www.ifw-kiel.de

Kiel Institute for the World Economy, Hindenburgufer 66, 24105 Kiel, Germany

Kiel Working Paper No. 1847 | June 2013

Establishing a Sustainable Development Goal for Oceans and Coasts to Face the Challenges of our Future Ocean

Martin Visbeck, Ulrike Kronfeld-Goharani, Barbara Neumann, Wilfried Rickels, Jörn Schmidt, Erik van Doorn

Oceans regulate our climate, provide us with natural resources such as food, materials, substances, and energy and are essential for international trade, recreational, and cultural activities. Free access to and availability of ocean resources and services, together with human development, have put strong pressures on marine ecosystems, ranging from overfishing and reckless resource extraction to various channels of careless pollution. International cooperation and negotiations are required to protect the marine environment and use marine resources in a way that the needs of future generations will be met. For that purpose, developing and agreeing on a Sustainable Development Goal (SDG) Oceans and Coasts could be an essential element for sustainable ocean management. The SDGs will build upon the Millennium Development Goals (MDG) and replace them by 2015. Even though ensuring environmental sustainability is one of the eight MDG goals, the ocean is not explicitly included. Furthermore, the creation of a comprehensive underlying set of oceanic sustainability indicators would help assessing the current status of marine systems, diagnose on-going trends, and provide information for forward-locking and sustainable ocean governance.

Keywords: sustainable development, ocean, sustainability indicators

JEL classification: Q56, Q57, Q58

Martin Visbeck
GEOMAR Helmholtz Centre for Ocean Research
Düsternbrooker Weg 20, 24105 Kiel
mvisbeck@geomar.de

Ulrike Kronfeld-Goharani
Institute of Social Sciences, Kiel University, Wilhelm-Seelig-Platz 2, 24118 Kiel, Germany,
kronfeld@ips.uni-kiel.de

Barbara Neumann
Institute of Geography, Kiel University, Ludewig-Meyn-Straße 14, 24098 Kiel, Germany
neumann@geographie.uni-kiel.de

Wilfried Rickels
Kiel Institute for the World Economy
Hindenburgufer 66, 24105 Kiel, Germany
wilfried.rickels@ifw-kiel.de

Jörn Schmidt
Department of Economics, Kiel University, Wilhelm-Seelig-Platz 1, 24118 Kiel, Germany
jschmidt@economics.uni-kiel.de

Erik van Doorn
Walther-Schücking-Institute for International Law, Kiel University,
Westring 400, 24118 Kiel, Germany
edoorn@internat-recht.uni-kiel.de

1 Introduction

The oceans cover more than 70 % of the surface of our planet and play a key role in supporting life on earth. They are our most diverse and important ecosystem, and contribute to global and regional elemental cycling. Oceans regulate our climate, and through climate, habitats are shaped that allowed humans to thrive and develop our societies. They provide us with natural resources such as food, materials, substances, and energy. Furthermore, they are essential for international trade, recreational and cultural activities.

Free access to and availability of ocean resources and services, together with human development, have put strong pressures on marine ecosystems, ranging from overfishing and reckless resource extraction to various channels of careless pollution. Irrespective of these threats, the mitigation of marine environmental problems and approaches to sustainable use and development of marine resources have a very low priority in many states. There is limited but quickly growing awareness of the life-supporting role of the oceans and the associated need for concentrating on ocean affairs in the context of overall economic and human development.

International cooperation and negotiations are required to protect the marine environment and use marine resources in a way that the needs of future generations will be met. To support this process we propose the creation of a Sustainable Development Goal (SDG) for oceans and coasts. The SDG should include the high seas as these are currently not adequately covered by legal treaties and international initiatives. Furthermore, the development of the SDG should be accompanied by a set of targets and a suitable set of oceanic and coastal indicators to monitor status and progress. An effective set of targets could be developed in the broader context of a marine spatial planning (MSP) approach to future development options in pursuit of the global goal of sustaining a functioning and life-supporting human-ocean system[1].

SDG Oceans and Coasts

Ensure a healthy and productive marine environment with all basic supporting and regulating functions and services, viewing the oceans and the subsequent provisioning of ocean services as a vital part of the Earth system. Develop suitable mitigation and adaptation strategies for climate and global change. Provide equitable access to ocean resources, and ensure that harvesting and extraction of living and non-living resources do not impair basic ecosystem functions. Encourage the development of sustainable and resilient coastal communities. Harmonize national and regional maritime policies and encourage cooperation in coastal and global marine spatial planning.

In this paper, we first contrast the services provided by the ocean for humankind with their implications for ocean health resulting from the overutilization of these services, and then turn to the coastal zones as the interface between humankind and the oceans and between land and sea (Section 2). In Section 3, we propose an SDG for oceans and coasts, and discuss the challenge of developing an indicator set to measure progress and guide future development options. Due to various uncertainties in the human-ocean system, safe minimum standards should be established in

[1] With human-ocean system we summarize all interactions and linkages between humankind and the entire ocean.

order to guide implementation. In Section 4 we discuss the potential for developing targets for sustainable development of the oceans, building on the concept of MSP and articulating further needs for the international legal framework with respect to the high seas. Section 5 concludes.

2 Challenges for our Ocean

2.1 Ocean Services

Because ocean services are essential for human life on earth, all development needs must consider planetary and ocean boundaries (e.g., Griggs et al. 2013). The oceans[2] regulate the global and regional climate system, the hydrological cycle, and the circulation of nutrients and other key substances. Doing so, they balance temperature distribution, influence precipitation, deliver oxygen to the air, and absorb anthropogenic carbon dioxide, also supporting mitigation of climate change.[3]

Moreover, it is expected that the growing world population will increasingly depend upon the wealth of marine living and non-living resources. Fish is an important resource for more than 1.5 billion people and contributes to around 19 % of their average protein supply (FAO 2010). The fishing industry and its associated infrastructure has become an important economic factor in coastal areas, including its harbours, fishing fleets, fish farms, and aquaculture production sites. The maritime industry thus supports many livelihoods around the globe. World fisheries directly employ 44.9 million people with over more than 150 million additionally employed in the processing sector (FAO 2010).

The oceans also serve as a huge laboratory and source for 'blue' biotechnology. Currently the oceans provide tremendous opportunity for ecological research and discovery since only a fraction of the living species of marine flora and fauna are known and most areas of the deep sea are still unknown (O'Dor 2004). More than 90% of marine biomass is composed of bacteria, fungi, microalgae, and viruses. Together with corals, sponges, and other marine organisms, this biomass contains an uncountable array of interesting substances for medical research, food additives and the cosmetic industry. Some of these active ingredients have already been approved as drugs (Leal et al. 2012).

Additionally, the oceans provide humankind with an abundance of non-living resources. Coastal waters provide sand and gravel and afford an opportunity to extract salt through the desalination of seawater. Minerals such as tin, titanium, gold and diamonds are exploited from the shallow coastal waters of Africa, Asia and South America (WOR 2010). Due to technological developments, marine mining is also expected to explore the large stocks of resources in the deep sea in the near future such as manganese nodules on the seabed, cobalt crusts along the flanks of undersea mountain ranges, and massive sulphides near undersea volcanic areas. The importance of raw materials from the deep sea is increasing because of i) the growing scarcity of resources on the continents, ii) the fact that they are often located in politically fragile states or in areas difficult to access, and iii) their higher degree of useful components than terrestrial minerals in the case of gold, silver, and copper (WOR 2010).

[2] The term ocean(s) here is inclusive, encompassing marine and brackish water systems, from the open ocean to coastal waters, the latter reflecting the immediate interface of land activities affecting the ocean.

[3] Since the beginning of industrialization 250 years ago, the oceans have taken up almost half of atmospheric CO_2 emissions (Royal Society, 2005:1).

The oceans are also an important source of renewable and non-renewable energy. They provide offshore wind, as well as ocean thermal and tidal power; hold the potential to facilitate algae-based production of hydrogen; and also hold extensive fossil fuel resources. At present, already the known sub-seafloor oil reserves which can easily and affordably extracted are estimated to represent about 26 % of the global oil reserves (WOR 2010). Increasing efforts to access and exploit reserves in deeper marine areas will increase the magnitude of marine fossil reserves for global energy provision.

Furthermore, the resources of the Arctic Sea region are attracting increasing attention, since the retreating ice masses are opening up new access to marine resources. According to a study of the U.S. Geological Survey 90 billion barrels of oil, 1,669 trillion cubic feet of natural gas, and 44 billion barrels of natural gas liquids (USGS 2008), as well as metals such as gold, silver and platinum may be found in the northern polar zone. Yet, our knowledge of the ocean system is in part still inadequate for conducting comprehensive environmental impact assessments, which are mandatory for comparable extraction activities on land.

Of immense importance is the use of ocean and coastal waters for maritime transport. As shipping has always been the most cost-effective method for transporting commodities over great distances, the shipbuilding industry and world trade routes have developed in parallel and today more than 90 % of global trade is carried by sea (IMO 2012). Since 2001, global shipping of raw materials and products has shown a rapid increase. From 2008 to 2012 the world fleet grew by 37 % (UNCTAD 2012). Tankers, container ships, bulk carriers, and cargo vessels transport large volumes of goods like oil and gas, coal, iron ore, phosphate and bauxite mainly between Asia and Europe and the United States (UNCTAD 2011). The passenger and roll-on roll-off cargo fleet increased on average by 2.9 % per year from 2008 to 2012 (measured in gross tonnage). Due to the growing popularity of cruises, the recent tonnage development of the passenger fleet grew on average by 5.5 % per year in the same period and is largely dominated by fleet additions of larger cruise vessels (ISL 2012).

New challenges are arising from the potential that new shipping routes might be established in the increasingly ice-free summer season across the Arctic Ocean.

Currently, more than 63,000 vessels (Marine Traffic.com 2013) use the oceans as transportation medium—free of charge. The free use of ocean waterways makes it possible to reduce transportation costs for everyday necessities to less than one percent of the sales price (IMO 2012). From today's perspective, shipping will remain the dominant means of transportation for the next few decades, being by far the most energy-efficient, inexpensive, and environmentally friendly way to move goods and people on our planet.

In addition to their natural resources, the oceans have fascinated humans since time immemorial with their aesthetic and cultural values, marine life and landscapes. Coastal waters are used for religious rituals and recreational purposes.

2.2 Ocean Health

The life-supporting provision of ocean services requires a healthy ocean. However, careless overutilization of these services, in turn, places ocean health at risk.

A significant fraction of ocean services rely on marine living resources. The oceans are the largest continuous ecosystem on earth, embracing all continents, and contain over 80% of the biomass on the planet. They provide a multitude of habitats, from the deep sea, seamounts and the open ocean to the continental shelf surrounding the landmasses. However, the unique characteristics of marine ecosystems are driven by their environment, making them very sensitive to changes in the oceans' physical and chemical characteristics. Such changes possibly lead to shifts in species distribution and to reshaping or displacement of ecosystems (Sarmiento et al. 2004).

From primary production to top predators, the incredible biodiversity of the ocean biosphere is collectively referred to as the marine ecosystem. Biodiversity is an abstract term, normally used to refer to species richness, which is measured by the number of different species in a given ecosystem. Changes in the abundance and diversity of species can decrease the ability to absorb shocks and may alter the functioning of ecosystems. On a global level, a decrease in primary production (Boyce et al. 2010), fish biomass (Worm et al. 2009) and whale abundance (Whitehead 2002) has already been observed. Changes in the relative abundance of species, the composition of habitats and in ocean functions are projected to become very significant in the coming decades.

This is certainly true for the world's fish stocks where catch levels over the last 20 years were maintained only by expansion to new species and new areas. Although expert calculations of the degree of overfishing vary, official FAO estimates show that roughly one quarter of all stocks are overfished and more than half of all stocks are fished at their maximum capacity. However, reliable numbers on the state of stocks are only available for roughly 500 of 1500 stocks currently fished on.

The major impediments for sustainable fisheries are non-existent or bad management, alongside the absence of compliance and control. Illegal, unregulated, and unreported fisheries (IUU fisheries) are a major threat, but existing international instruments addressing IUU fishing have not been effective due to a lack of political will, priority, capacity and resources to ratify and implement them.

Overfishing is just one of a multitude of threats to marine ecosystems and ocean functions caused by human activities, both directly on sea and on land. Other examples include pollution with chemicals, heavy metals, radioactive substances, and plastics, but also indirect effects like eutrophication caused by agricultural run-off. Today, undisturbed marine areas have largely, if not completely, ceased to exist. In addition to direct marine pollution, land-based waste, hazardous substances, and other kinds of pollution are finding their way into the oceans. Transported by currents, they can cause harm even in areas quite remote from the source of pollution.

The US National Academy of Sciences estimated in 1997 that around 6.4 million tonnes of litter enter the world's oceans each year. Most of this litter is made up of barely degradable plastics. Nonetheless, correct estimation is difficult because litter can enter the marine environment in a number of ways. The main sources of marine litter are shipping, fishing, offshore installations, and river runoff. The measure normally used when estimating plastic debris is the number of items per square kilometre or square meter. According to this measure, up to 4 million items have been found in Indonesian coastal waters and up to 1 million in the North Pacific Gyre. However most of these have been small items particles, only detectable using fine-meshed nets. Larger particles sink and, in European waters, up to 100,000 items have already been counted on the seafloor by visual count alone. Although theses larger particles are also detrimental to the environment, a larger threat might be the so-called microplastics—particles ranging from 20 to 50 micrometres, which are ingested by zooplankton and disperse into the food chain, not only in the digestive systems of living organisms, but also in their tissues and body fluids. The implications of microplastics are still unclear, but softeners and other chemicals might directly poison or act as hormones affecting the health and development of marine flora and fauna.

Another serious problem for coastal waters arises from eutrophication (Smith and Schindler 2009). Caused by an accumulation of nutrients in coastal waters originating from agriculture, industry, and sewage in surface waters, marine eutrophication can lead to more frequent and longer lasting algae blooms. Such algae blooms may change the turbidity of seawater and limit light penetration into deeper water layers. As the algae bloom recedes, degradation processes of plant material stimulated by bacteria consume large amounts of oxygen, which in turn can cause dead zones in deep water layers. Furthermore, some microscopic algae can cause harmful algae blooms (HAB) when occurring in large numbers, which have the potential of producing toxins with impacts for humans and animals (Glibert et al. 2005:137).[4]

In 1998, an intensive algae bloom wiped out 90 % of stocks in Hong Kong's fish farms, causing an economic loss of about 40 million U.S. dollars (Lu and Hodgkiss 2004: 232). At present, the most seriously affected areas are located in Western Europe, the Eastern and Southern coasts of the U.S., and East Asia, particularly Japan (Selman, Greenhalgh, Diaz and Sugg 2008:3).

Furthermore, continually increasing atmospheric carbon emissions are causing significant ocean warming and stress due to acidification. An increase in heat uptake leads to changes in the physical properties of the oceans, mainly direct increases in water temperature, stronger stratification, sea level rise, and changes in ocean currents. At the same time, warming and increased stratification leads to ocean deoxygenation and an expansion of oxygen minimum zones, especially off equatorial upwelling areas (Stramma et al. 2008).

Today the oceans provide the most important carbon sink in the global carbon cycle; this is, however, at the price of increasingly acidic conditions in the marine environment (e.g., Caldeira and Wickett 2003, 2005; Feely et al. 2004; Orr et al. 2005; Solomon et al. 2007). Ocean acidification is already measurable and has lowered surface ocean pH by 0.1 compared to pre-industrial values and is expected to further decrease by an additional 0.3-0.4 units by 2100 (Turley 2005, Royal Society, 2005, Freely et al., 2006, Wingenter et al., 2007, Doney et al., 2009).

Currently, it is not certain whether marine species and ecosystems will be able to adapt to changes in ocean chemistry, but due to the fact that pH values have dropped remarkably in the last century (Mackenzie et al., 2011, Porzio et al., 2011) there is great concern that ocean acidification poses a threat to the abundance, health, physiology, and biochemical properties of marine species. This could alter marine food webs, which could have far-reaching consequences for the oceans and millions of people depending on them for food resources (Doney et al. 2009).

Some experimental work by Hoegh-Guldberg et al. (2007) and Wood et al. (2008b) showed that coral calcification, structure and growth will be reduced by up to 40% with a doubling of atmospheric carbon concentration relative to pre-industrial levels.

---

[4] Hypoxia and HAB deteriorate the quality of water and can change or reduce species diversity or cause the deaths of fish, birds and marine mammals when toxins are produced (Glibert et al. 2005).

Combined with other stress factors impacting coral reefs such as extreme temperatures giving rise to coral bleaching, viral attacks, overfishing and pollution, this gives a dire prognosis for reef corals that provide important ecosystem services for millions of people. Their degradation and loss of mass would reduce protection for shorelines from erosion and flooding and impact local fisheries, tourism and recreation industries, as well as related maritime economies (Feely et al., 2006).

In recent decades it has become obvious that human activities are beginning to affect the oceans on both a regional and global scale. Thus a definition of ocean health can only be related to changes and must be understood in a functional context. We use the term ocean health to describe the framework of marine ecosystem services for the benefit of humanity.

2.3 Coastal Resilience

Having discussed the interplay between ocean services and ocean health, we now turn to coastal zones.[5] Several ocean services are realized in this area and several implications of reduced ocean health will manifest through impacts here. Accordingly, coastal zones constitute the most important interface between humans and the oceans and therefore provide the '…frontline in humanity's endeavour to learn to live sustainably in the face of global change" (Glavovic 2013 p. 912).

Coastal zones have always been of great interest to humankind: as a space for settlement, as a source of diverse natural products, for establishing global networks of trade and transport, for recreational activities and as tourist destinations. Because of this special attractiveness and human appreciation of coastal zones, significant human interventions have taken place in the coastal zone, accompanied by on-going population growth and coastal development. Approximately two-thirds of the world's megacities over eight million people are located in the coastal zone, with the largest share in Asia (Brown et al. 2013). Population growth, urbanization rates, and population densities have been found to be significantly higher in coastal than in non-coastal areas (Balk et al. 2009; McGranahan et al. 2007). In China, for example, the rate of land conversion is globally among the highest, with coastal urban areas growing at more than three times the national rate (McGranahan et al. 2007; Seto et al. 2011). This development is related to on-going rapid economic growth as well as specific policies driving trade-related coastal movement.

Coastal development is a critical driver of change. It leads to increased utilization or even over-exploitation of natural resources both on land and in the sea, and generates high pressures on the environment at the land-ocean interface (Patterson and Hardy 2008). For example, 90 % of global fishery activities actually occur within coastal jurisdiction, and the use of coastal space for wind energy generation is growing rapidly (WOR 2010). Other human interactions with the coastal zone that exert pressure on the environment include tourism and recreational activities, as well as burials at sea.

Physical interactions along coasts and in the hinterland such as dredging, damming of rivers and river deltas, extraction of liquids and gases from the ground, land reclamation, habitat modification, and coastal engineering greatly impact the coastal environment. Consequences range from changes in sediment supply and coastal dynamics to coastal erosion, subsidence and decrease in drinking water

[5] There is no standard definition of coasts or the coastal zone. Commonly, the coastal zone is understood as the interface or transitional area between terrestrial and marine environments and their mutual influences (Woodroffe, 2002). Yet, the complex coastal system is strongly impacted by human activity and is thus characterized by functional linkages between the environmental and the human system on land and at sea.

supply. Through land reclamation and other human activities, shallow-water coastal areas have also been greatly reduced. These areas are critical for ocean functions as light can penetrate to the sea floor and enable plants to grow and provide refuge to juvenile marine organisms.

Changes in storm patterns (e.g. intensity of hurricanes and typhoons) and storm surges due to climate change and sea-level rise (SLR) with its associated biophysical and socio-economic consequences are imposing further pressures on the coastal zone, especially on low-lying coastal areas, deltas and on small islands (IPCC 2012; Nicholls et al. 2007). Recent studies suggest that mean sea levels could rise one meter or more by 2100 (Nicholls and Cazenave 2010; Rahmstorf 2010). But even the much lower SLR projections of up to 59 cm in the 21st century brought forward by the IPCC (2007) could have severe impacts on coastal physical environments and ecosystems as well as on coastal human settlements and economies through inundation and flooding, coastal erosion and shoreline relocation, or salinization of aquifers (Brown et al. 2013; Nicholls and Cazenave 2010).

Major seaports like Guangzhou, Shanghai and Rotterdam are important industrial and maritime terminals for international trade. Their smooth operation and efficient cargo handling is of great regional and economic importance. Damage or destruction of port infrastructure by extreme weather events can strongly affect regional supply chains which could threaten the population's food security and health (Hanson et al. 2011). Because this affects all dimensions of human security, combined effects could induce long-term migration (Black et al. 2011a; Black et al. 2011b; Seto 2011).

Moreover, severe natural disasters such as Hurricane Katrina in 2005 not only pose a direct threat to human health but can also cause psychological trauma and displacement-related social problems (Legerski et al. 2012). In addition, loss of and damage to valuable ecosystems like mangroves, tidelands, or marshes also lead to a reduction in natural coastal protection and may increase the vulnerability of coasts to erosion.

Climate change, natural disasters, and coastal development affect various aspects of the provisioning of coastal resources : through changes in size and distribution of fish stocks and other sea-based food sources, the introduction of invasive species, and changes in the quality of the resources (e.g. through contamination of sea-based food sources and coastal waters). This will lead to further impacts on livelihoods and economies (employment, structure of coastal communities, industry), and on food security and health (e.g. capture fisheries).

Regions where the observed impacts are especially severe include populated/urbanized coasts and megacities, river deltas, Arctic coasts, low-lying coasts and small islands (Newton et al. 2012; Syvitski et al. 2009). In Arctic coastal regions, for example, climate change already affects the security of indigenous people. The melting of permafrost and retreating sea ice in the Arctic directly threaten infrastructure, traditional livelihoods and human well-being in coastal communities, and cause increased coastal erosion and adverse effects on sensitive coastal habitats (Derksen et al. 2012; Forbes 2011; Lantuit et al. 2012).

Along with climate change and coastal hazards, these manifold human interventions, complex interactions and effects significantly increase levels of risk, exposure, and sensitivity of coastal communities and their environment and thus raise their vulnerability (Kron 2012; Nicholls et al. 2007). At the same time, there is an increasing human dependence on coastal resources, though with a globally unequal distribution of demands, provisioning, vulnerabilities, and threats. This all may seriously threaten the resilience and adaptive capacity of both the human and natural coastal sub-systems, especially in developing countries. Thus, coastal zones with their communities, resources and natural habitats require prudent management to build resilience[6] through successful adaptive strategies.

3 Ocean Sustainability and Sustainable Development

The definition of an SDG for oceans and coasts (SDG Oceans and Coasts), the formulation of a set of specific targets and the development of an underlying indicator set to measure these objectives are essential elements of a prudent ocean management strategy. Importantly, both the sustainable development goal and the corresponding indicator set should cover the coasts, the exclusive economic zones (EEZs), and the high seas. Furthermore, an SDG Oceans and Coasts should reflect the ecosystem approach and make reference to the polluter pays principle. The ecosystem approach, adopted as the primary framework for action under the Convention on Biological Diversity (CBD 1992), aims at managing the ecological system as a whole by integrating land, water, and living resources. It promotes conservation and sustainable use in an equitable way and incorporates the precautionary principle by urging stakeholders, especially States, to take action even under conditions of scientific uncertainty.

3.1 Sustainable Development Goal for Oceans and Coasts

The primary objectives of the proposed SDG OCEAN and COASTS should be to:

1) Ensure the basic life-sustaining and regulating functions of the oceans (oxygen production, key processes in the climate system, and in the hydrological cycle).
    a) Limit activities that alter these functions.
    b) Limit CO_2 emissions to reduce further ocean warming, acidification and de-oxygenation.
2) Ensure a healthy and productive marine environment to sustain all provisioning and non-provisioning (i.e. supporting and regulating) services of oceans and coasts

    a) Exploit all living resources within safe biological limits and in accordance with the ecosystem approach and the precautionary principle.
    b) Exploit all non-living resources in accordance with the ecosystem approach and the precautionary principle.
    c) Limit use and degradation of marine space in accordance with the ecosystem approach and the precautionary principle.
    d) Develop and distribute technical capacities for the sustainable use of ocean resources.
    e) Provide access to marine information and data and build global capacity for the assessment of oceans and for the management of ocean related activities.
    f) Report on the status of the oceans and coasts regularly against a set of ocean and coastal indicators.
3) Build resilient coastal communities through mitigation and adaptation strategies, innovation and sustainable development, by sharing benefits and responsibilities.

4) Engage in integrated and multi-level ocean governance.

    a) Develop a framework for MSP within EEZs and in areas beyond national jurisdiction.

---

[6] Resilience summarizes all factors and activities that support coastal communities in coping with threats, changes, and impacts, including mitigation / adaptation measures and disaster risk preparedness (cp. Chapin et al. 2009, Gibbs 2009, Halpern et al 2012b).

b) Improve and harmonize legal frameworks for oceans and coasts to take into account current and future uses.
c) Improve and harmonize the governance of ocean and coastal regimes.

For all these objectives, specific targets need to be developed and negotiated at a national, regional and global level. For that purpose, the proposed SDG OCEANS AND COASTS can be operationalized through the three dimensions OCEAN SERVICES, OCEAN HEALTH AND COASTAL RESILIENCE discussed in Section 2. Progress against the targets in these dimensions should be monitored through an adequate set of indicators to measure sustainable development for oceans and coasts.

3.2 Indicator Set for Ocean Sustainability

Implementation of a SDG OCEANS AND COASTS needs to be supported by suitable reference tools. However, a comprehensive assessment of the state of the marine environment and its future development is still in its infancy.

There are several initiatives underway such as the World Ocean Assessment (Regular Process for Global Reporting and Assessment of the State of the Marine Environment Including Socioeconomic Aspects, UNGA resolution 64/71), the Ocean Compact, launched by the Secretary-General to promote UN wide coherence in the delivery of ocean-related mandates and encourage synergies within the United Nations system, and the Global Ocean Partnership, an alliance of more than 100 governments, international organizations, civil society groups, and private sector interests committed to addressing the threats to the health, productivity and resilience of the world's oceans.

However, none of these initiatives has yet come up with a comprehensive measure covering human-ocean systems and internal ocean interactions. A notable exception is the Ocean Health Index introduced by Halpern et al. (2012a). They have defined ten public ocean-related goals and assess the performance of 171 states, including their EEZs, against these goals. Their assessment is not only based on the present status of the ten goals but also includes future status which is derived from the assessment of the pressures on and the resilience of the human-ocean system. For that reason the authors claim that their index also provides important information regarding the sustainability of the human-ocean system. Considering the large amount of data collected and applied, the study of Halpern et al. (2012a) provides a unique tool to assess the human-ocean system. Nevertheless, the applied index leaves out important issues such as the sensitivity of the result to the aggregation of conflicting goals and should therefore be seen only as one possibility for assessing the state of the human-ocean system.

Developing a comprehensive indicator set for measuring the sustainability of the human-ocean system requires a profound discussion how the term sustainability can be operationalized in the context of the oceans. The seminal work by Meadows (1972) emphasized that a broad concept of growth and wealth is necessary in the presence of finite resources. These thoughts and the following discussion related to the concept of sustainable development have become widely acknowledged—in particular since the publication of the Brundtland Report (WCED 1987; Schultz et al., 2008). From an economic perspective, sustainable development can be measured by determining whether the economy's productive capacity is maintained or growing so that the wealth of future generations does not decrease (e.g., Smith et al., 2001; Arrow et al., 2003; Alfsen and Greaker, 2007; Dasgupta, 2009; Arrow et al., 2012).

However, the capital approach does not cover all possible linkages between economic capital and other capital stocks like, for example, environmental capital stocks, whereby the latter still needs to be properly defined for ocean-related capital stocks. The Earth, with its oceans, continents, ice masses, currents, living and non-living organisms, forms an extremely complex system, whose partial systems and interactions are poorly understood (Van der Sluijs, 2012). Science, with its preference for linear projections, has limited capabilities to reproduce the non-linear and interactive system dynamics that characterize the future ocean. Consequently, it is necessary to pay attention to the possibility of substitution between the various capital stocks (Victor 1991) because sustainable development trajectories might otherwise be identified which do not properly account for the underlying trade-offs.

For that reason the differentiation between *strong* and *weak* sustainability has been introduced in the early 1990s, which is currently not reflected in the Halpern et al. (2012a) index framework. The concept of strong sustainability does not allow for any substitution between different capital stocks and therefore requires that all capital stocks must be maintained; the concept of weak sustainability, in contrast, allows for a certain degree of substitution and requires that the aggregate of the various capital stocks (valued with their respective shadow prices) does not decline (Pearce et al., 1989; Hartwick, 1990; Daly and Cobb, 1989; Asheim, 1994; Hamilton, 1994; Pezzey and Withagen, 1995; Ekins et al., 2003; Arrow et al., 2003; Ott and Döring, 2004; Dietz and Neumayer, 2007; Baumgärtner and Quaas, 2009).

Ekins et al. (2003) suggest starting with a concept of relative strong sustainability (i.e., assuming a low elasticity of substitution between capital stocks) to investigate the influence of non-market goods and capital stocks and, if appropriate, gradually moving towards a concept of weaker sustainability (i.e., assuming a higher elasticity of substitution between capital stocks).

Furthermore, it also needs to be discussed that the ocean should not only be seen as instrumental to humankind but also as having an intrinsic value, in and of itself. For that reason the indicator set should reflect the extent to which marine ecological processes in the oceans are maintained, biodiversity is preserved, and the utilization of ocean services is sustained.

Finally, the selection of appropriate indicators is restricted by data availability and is always a normative choice with important implications for the results (e.g. Krellenberg et al., 2010). These limitations need to be balanced against the requirement that status and development of the human-ocean system should be measured for the purpose of determining appropriate management activities. Consequently, the process of selecting, weighting, and aggregating appropriate indicators requires the involvement of various stakeholders in addition to the experts. For that reason the inclusion of the above mentioned initiatives and the UN ocean initiative is essential.

3.3 Definition of Safe Minimum Standards

The human-ocean system is characterised by a high degree of complexity. Humankind does not yet properly understand all interactions and feedbacks. Moreover the general concept of planetary (and ocean) boundaries defines additional constraints on future development options within a safe operating space (Rockström et al 2009).

It is very unlikely that probabilities can be assigned to the consequences of current actions for the future status of the oceans, or that these can even be defined at all. Certainly, system dynamics entail the possibility of irreversible development, which might be associated with significant losses. Accordingly, prudent management of the human-ocean system is not only confronted with reliable relations of cause and effect, but with a contingency to be guarded against (Ciriacy-Wantrup 1952). Ensuring sustainable development under uncertainty therefore requires attributing sustainability criteria to current actions instead of attributing them to future unknown states (Baumgärtner and Quaas, 2009).

For that reason, safe minimum standards of conservation can be achieved by avoiding potential critical zones for certain actions (Ciriacy-Wantrup 1952). Proper timing and appropriate management imply relatively small costs of maintaining safe minimum standards—compared to the loss that is being secured against. Inclusion of such minimum standards is particularly important when it is acknowledged that neither complete understanding of the human-ocean system nor complete data availability for measuring it will be available. For that reason the process of developing suitable indicators to measure the human-ocean system should be accompanied by the task of also discussing and defining such safe minimum standards for interventions into the system.

4 Integrated and multi-level Ocean Governance and Management

A framework to guide sustainable development of the oceans and coasts can be inspired by the MSP approach. According to the Intergovernmental Oceanographic Commission of the UNESCO, MSP is understood 'as a promising way to achieve simultaneously social, economic, and ecological objectives by means of a more rational and scientifically-based organization of the use of ocean space' (Douvere 2010:1, 60). The approach should be ecosystem- and area-based, integrated, adaptive, strategic, and participatory (Douvere 2010:59-67). Furthermore, MSP needs to be linked to Integrated Coastal Management[7] (ICM) in order to respect the transitional character and interdependencies of coastal and marine systems.

ICM and MSP provide useful policy arenas to frame and resolve spatial conflicts and conflicting interests in the pursuit of coastal resilience. Considering that there are growing national interests in securing resources and, in turn, increasing potential for conflicts, for example over maritime boundaries (Houghton et al. 2010), harmonized governance strategies at local, national and global levels are needed.

Currently, some initiatives following the MSP approach are already underway. In the USA, President Obama created a National Ocean Council[8] in 2010 (White House, 2010). MSP and ICM are named among the priority objectives and defined as 'a comprehensive, adaptive, integrated, ecosystem-based, and transparent spatial planning process, based on sound science, for analyzing current and anticipated uses of ocean, coastal, and Great Lakes areas. In practical terms, [coastal and marine spatial planning] provides a public policy process for society to better determine how these areas are sustainably used and protected' (White House Council on Environmental Quality, 2009).

---

[7] Integrated coastal (zone) management (ICM or ICZM) aims at fostering sustainable coastal development by integrating planning, decision-making and actions in the coastal zone in a holistic way. The aim is to avoid one-dimensional or overly sectoral approaches, and to facilitate participative management and consensus building instead (cp. Sterr & Colijn 1999, Glavovic 2006, Bruns 2010).

[8] The White House, Office of the Press Secretary (2010), Stewardship of the Oceans, our Coasts, and The Great Lakes, July 19, 2010, Executive Order, available at http://www.
whitehouse.gov/files/documents/2010stewardship-eo.pdf.

The ecosystem-based management approach applied to coastal and marine space should address ‘cumulative effects to ensure the protection, integrity, maintenance, resilience, and restoration of ocean, coastal, and Great Lakes ecosystems, while promoting multiple sustainable uses’ (White House Council on Environmental Quality, 2009). Emphasizing the versatile use of ecosystems, this approach reinforces a definition given earlier by US scientists and policy experts that defined ecosystem-based management for the oceans in a broader sense considering the entire ecosystem, including humans: ‘The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors.’ (McLeod, Lubchenco, Palumbi and Rosenberg 2005)

In 2008, the European Union published a ’Roadmap for Maritime Spatial Planning: Achieving Common principles in the EU‘. This and the 2010 communication ‘Maritime Spatial Planning in the EU – Achievements and Future Development’ paved the way for the recently proposed ‘Framework Directive on Maritime Spatial Planning and Integrated Coastal Management’ (EC 2013). Aware of the great opportunities offered by the maritime sector for innovation, growth, and employment, the ‘aim is to identify the most efficient and sustainable current and future utilization of maritime space’ on Europe’s way towards a Blue Economy. The Member States are invited to map all their maritime activities in maritime spatial plans in order to ensure more coherent planning of maritime activities in European seas.

Yet, there is criticism that MSP is not more than ‘… a tool that produces nice maps of how we use the oceans’ and that current MSP models are not capable of ‘addressing the questions MSP creates’ (Spalding 2011: 31 f.). Governing the oceans under global change and uncertainty needs a strategy that is inclusive, integrative, adaptive, science-based and capable of resolving conflicts while safeguarding the fragile global ocean commons, building resilience and allowing for sustainable development. Furthermore, improved disaster preparedness is as important as the implementation of effective mitigation strategies (e.g. building codes, restricted zones for coastal development) in order to prevent excessive loss of human lives and assets.

Our idea is to engage in a global MSP exercise for the year 2050 and 2100 that takes into account the above-mentioned requirements. From the exercise one can identify hotspots of conflict, new opportunities to use oceans and coasts and, most importantly, derive a set of plausible sustainable development scenarios for the oceans. Quantitative targets can be deduced and governance options developed. One could evaluate the potential of integrated MSP as the means for defining and reaching the goal of ecosystem-based management in line with an SDG for oceans and coasts.

4.1 A New Law of the Sea

Various measures and initiatives on an international and regional level have been taken to protect the marine environment in the last ten years —for example in the Baltic Sea or in the EU. There is still a need to advance governance structures for the high seas as these are currently governed by a patchwork of international conventions and treaties[9], most of which have only recently emerged (e.g. Haas, Keohane and Levy 1993; Skjeerseth 2002b; Wang 2004).

MSP is a policy strategy that is largely applied by coastal States to support local development at present. Most ocean areas are, however, high seas and the legal framework in place is very limited with respect to governing these 'global commons'. It should be noted that the international law of the sea is just one part of the larger marine policy picture. The United Nations Convention on the Law of the Sea (LOS Convention) adopts a zoning approach that is characterised by the idea that coastal States have less rights the further one moves from the coast.

The LOS Convention was concluded in 1982 after almost a decade of negotiations and now forms the most comprehensive treaty that the international community has ever developed. Although over 80 % of the world's States ratified the LOS Convention, ensuring further ratification remains a primary objective (e.g. the USA has not yet ratified). Nevertheless, LOS represents customary international law.

There is growing recognition that a reformed or amended law of the sea might be required because of implementation issues and the age of the LOS Convention. Climate change, the polar zones, and overfishing are just a few issues where the LOS Convention has proved to be inadequate. Notwithstanding these weaknesses, the LOS Convention deserves credit for its comprehensiveness after being negotiated such a long time ago. It is unlikely that the international community would undertake another endeavour of this scale. Therefore, interpreting the current law of the sea in conjunction with the legal framework for climate change, international shipping and the conservation of biological diversity, as well as the implementation of marine protected areas, appears to be a more feasible option for policymakers.

5 Conclusion and Outlook

Developing and agreeing on an SDG OCEANS AND COASTS would be essential for promoting a robust, healthy, and productive marine environment and encouraging the development of sustainable and resilient coastal communities. Furthermore, it would also be in line with the Millennium Development Goals 1 (Eradicate extreme poverty and hunger), 7 (Ensure environmental sustainability) and 8 (Develop a global partnership for development).

The creation of a suitable set of oceanic sustainability indicators will help assess the current status of marine systems, diagnose ongoing trends, and give tools for looking forward. Different ocean development pathways will influence the future status of the oceans. A well-chosen set of indicators can play an important role in evaluating the potential of alternative development pathways towards ocean sustainability.

Harmonization of governance regimes towards an integrated, multi-level ocean governance framework is indispensable for protecting the oceans as a life-support system and for encouraging cooperation in coastal and global MSP. Furthermore, extending the legal framework to properly

---

[9] E.g. Helsinki Convention 1972, OSPAR Convention 1992, CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973, CMS Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1973, UNCLOS United Nations Convention on the Law of the Sea 1982, CBD Convention on Biological Diversity 1992, WSSD World Summit on Sustainable Development 2002, IMO Maritime Conventions, EU: Bird Directive 2009, Habitats Directive 1992, Marine Strategy Framework Directive 2008.

include the high seas and ensuring universal ratification is necessary for sustaining our marine environment.

Above all the establishment of adequate marine scientific, technical and governance capacity around the globe will require a targeted, enduring and efficient capacity-building effort.

Acknowledgements

The authors wish to thank Katherine Richardson for constructive comments and suggestions and Kate Houghton for proof reading.

References

Adams WM (2006) The Future of Sustainability: Re-thinking Environment and Development in the twenty-first Century, The World Conservation Union. Available from: http://cmsdata.iucn.org/ downloads/iucn_future_of_sustanability.pdf (access 20.08.12).

Alfsen K, Greaker M (2007) From natural resources and environmental accouting to construction of indicators for sustainable development. Ecological Economics 61, 600–619.

Arrow KJ, Dasgupta P, Goulder L, Mumford K, Oleson K (2012) Sustainability and the measure of wealth. Environment and Development Economics 17, 317–353.

Arrow KJ, Dasgupta P, Mäler, K (2003) Evaluating projects and assessing sustainable development in imperfect economics. Environmental and Resource Economics 26, 647–685.

Asheim G (1994) Net national product as an indicator of sustainability. Scandinavian Journal of Economics 96, 257–265.

Balk D et al. (2009) Mapping urban settlements and the risks of climate change in Africa, Asia and South America. In: Guzmán JM, Martine G, McGranahan G, Schensul D, Tacoli C (eds.), Population Dynamics and Climate Change. United Nations Population Fund (UNFPA), International Institute for Environment and Development (IIED), New York, London, pp. 80-103.

Baumgärtner S, Quaas MF (2010) What is sustainability economics? Ecological Economics 69: 445:450.

Black R et al. (2011a) The effect of environmental change on human migration. Global Environmental Change, 21(Supplement 1), S3-S11.

Black R, Bennett SRG, Thomas SM and Beddington JR (2011b) Climate change: Migration as adaptation. Nature, 478(7370), 447-449.

Boyce DG, Lewis MR, Worm B (2010) Global phytoplankton decline over the past century. Nature 466(7306): 591-596.

Brown S et al. (2013). Sea-Level Rise Impacts and Responses: A Global Perspective. In: Finkl CW (Ed.), Coastal Hazards. Coastal Research Library, Springer Netherlands, pp. 117-149.

Bruns A (2010) Governance im Küstenraum, Europäische Umweltpolitik im Wandel; Die Umsetzung des Integrierten Küstenzonenmanagements und der Wasserrahmenrichtlinie an der Westküste Schleswig-Holsteins. Dissertation, Christian-Albrechts-Universität zu Kiel, Germany. URN: urn:nbn:de:gbv:8-diss-50595. Available from: http://eldiss.uni-kiel.de/macau/receive/dissertation_diss_00005059

Caldeira K, Wickett ME (2003) Anthropogenic carbon and ocean pH, Nature, 425-365.

Caldeira K, Wickett ME (2005) Ocean model predictions of chemistry changes from carbon dioxide emissions to the atmosphere and ocean, J. of Geophys. Research, VOL. 110: 1-12.

Chapin FS III et al. (2009) Principles of Ecosystem Stewardship - Resilience-based Natural Resource Management in a Changing World. Springer, 401 p.

Cicerone R et al. (2004) Research Priorities Reports: Priorities for Research on the Ocean in a High-CO2 World, http://www.ocean-acidification.net/Symposium2004/Symp2004Docs/Research%20Priorities%20Report-Final.pdf (02.08.2011).

Ciriacy-Wantrup, Siegried von (1952): Resource conservation: Economics and policies, University of California Press, Berkeley, US.

Convention on Biological Diversity (adopted 22 May 1992, entered into force 29 December 1993), 31 ILM 822., Art. 2.

Dabelko GD (2008) An Uncommon Peace. Environment, Development, and the Global Security Agenda. Environment, 50/3, 32-45.

Dalby S (2009) Security and Environmental Change, Cambridge: Polity Press.

Daly H, Cobb J (1989) For the common good. Beacon Press, Boston.

Dasgupta P (2009) The welfare economic theory of green national accounts. Environmental and Resource Economics 42, 3–38.

Derksen C et al. (2012) Variability and change in the Canadian cryosphere. Climatic Change, 115(1), 59-88.

Dietz S, Neumayer E (2007) Weak and strong sustainability in the SEEA: concepts and measurement. Ecological Economics 61, 1212–1217.

Doney SC, Fabry VJ, Feely RA, Kleypas JA (2009) Ocean Acidification, the other CO2 problem. Annu. Rev. Marine Sci. 1:169-192.

Douvere F (2010) Marine spatial planning: Concepts, current practice and linkages to other management approaches. Ghent University.

EC, EUROPEAN COMMISSION (2013) Proposal for a Directive of the European Parliament and of the council establishing a framework for maritime spatial planning and integrated coastal management, Brussels, 12.3.2013, COM (2013) 133 final, 2013/0074 (COD).

Ekins P, Simon S, Deutsch L, Folke C, Groot R d (2003) A framework for the practical application of the concepts of critical natural capital and strong sustainability. Ecological Economics 44 (2-3), 165–185.

FAO (2010) State of World Fisheries and Aquaculture (SOFIA). Available from: http://www.fao.org/docrep/013/i1820e/i1820e.pdf (access 25.04.12).

Feely RA, Alin SR, Newton J, Sabine CL, Warner M, Devol A, Krembs C, Maloy C (2010) The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary, Estuarine, Coastal and Shelf Science 88:442.

Feely RA, Sabine CL, Fabry VJ (2006) Carbon dioxide and our ocean legacy, http://www.pmel.noaa.gov/pubs/PDF/feel2899/feel2899.pdf (01.08.2011).

Feely RA, Sabine, CL, Lee K, Berelson W, Kleypas J, Fabry VJ, Millero, FJ (2004) Impact of anthropogenic CO2 on the CACO3 System in the oceans, Science, Vol. 305, No. 5682:362-366.

Forbes DL (Ed.) (2011) State of the Arctic Coast 2010 – Scientific Review and Outlook. International Arctic Science Committee, Land-Ocean Interactions in the Coastal Zone, Arctic Monitoring and Assessment Programme, International Permafrost Association, Geesthacht, Germany, 178 pp.

Gibbs MT (2009) Resilience - What is it and what does it mean for marine policy makers? Marine Policy 33 (2009) 322–331.

Glavovic B.C. (2006) ICM as a transformational practice of consensus building: A South African perspective. Journal of Coastal Research SI 39 1706 - 1710 ICS 2004 (Proceedings) Brazil.

Glavovic BC (2013) Coastal innovation paradox. Sustainability, 5, 912-933;

Glibert PM, Anderson DM, Gentien P, Graneli, E, Sellner KG (2005): The Global Complex Phenomena of Harmful Algae Blooms, Oceanography, Vol. 18: 136-147.

Griggs D et al. (2013) Sustainable development goals for people and planet. Nature, 495(7441), 305-307.

Haas PM, Keohane RO, Levy M (1993) Institutions for the earth: sources of effective international environmental protection, Cambridge, MA: MIT Press, 33-182.

Halpern BS, Longo C, Darren H, McLeod KL et al. (2012a) An index to assess the health and benefits of the global ocean. Nature, 488, 615-620.

Halpern BS, Longo C, Darren H, McLeod KL et al. (2012b) An index to assess the health and benefits of the global ocean. Supplementary Information. Nature, 488, 615-620. doi:10.1038/nature11397

Hamilton K (1994) Green adjustment to GDP. Resources Policy 20, 155–168.

Hanson S et al. (2011) A global ranking of port cities with high exposure to climate extremes. Climatic Change, 104(1), 89-111.

Hartwick J (1990) Natural resources, national accounts, and economic depreciation. Journal of Public Economics 43, 291–304.

Hoegh-Guldberg O, Mumby PJ, Hooten AJ, Steneck et al. (2007) Coral reefs under rapid climate change and ocean acidification, Science, 318, 1737–1743.

Houghton KJ, Vafeidis AT, Neumann B and Proelss A (2010) Maritime boundaries in a rising sea. Nature Geoscience, 3(12), 813-816.

IMO (2012) Sharing Maritime Knowledge - International Shipping, Facts and Figures, Information Resources on Trade, Safety, Security, Environment. Maritime Knowledge Centre, March 2012.

IPCC (2012) Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

IPCC, Climate Change (2007) The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, S. Solomon et al. (eds.), Cambridge Univ. Press, Cambridge.

ISL Statistical Publications (2012) Shipping Statistics and Market Review, Vol. 56, No. 8.

Krellenberg K, Kopfmüller J, Barton J (2010) How sustainable is Santiago de Chile? Current performance, future trends, potential measures. Synthesis report of the Risk Habitat Megacity research initiative (2007-2011). UFZ-Report, Vol. 4 (2010), UFZ, Leipzig.

Kron W (2012) Coasts: the high-risk areas of the world. Natural Hazards (Online First), 1-20.

Lantuit H et al. (2012) The Arctic Coastal Dynamics Database: A New Classification Scheme and Statistics on Arctic Permafrost Coastlines. Estuaries and Coasts, 35(2), 383-400.

Leal MC, Puga J, Sero dio J, Gomes NCM, Calado R (2012) Trends in the Discovery of New Marine Natural Products from Invertebrates over the Last Two Decades – Where and What Are We Bioprospecting? PLoS ONE 7(1): 1-15.

Legerski JP, Vernberg EM and Noland BJ (2012). A Qualitative Analysis of Barriers, Challenges, and Successes in Meeting the Needs of Hurricane Katrina Evacuee Families. Community Mental Health Journal, 48(6), 729-740.

Lu S and Hodgkiss, IJ (2004) Harmful algal bloom causative collected from Hong Kong waters, Hydrobiologia, 512: 231-238.

McGranahan G, Balk D and Anderson B (2007) The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environment and Urbanization, 19(1), 17-37.

Meadows, DH, Meadows, DL, Randers, J Behrens, WW, (1972) The Limits to Growth: A report for the Club of Rome's Project on the Predicament of Mankind, New York: Universe Books.

McLeod KL, Lubchenco J, Palumbi SR and Rosenberg AA (2005) Scientific Consensus Statement on Marine Ecosystem-Based Management, Signed by 221 academic scientists and policy experts with relevant expertise and published by the Communication Partnership for Science and the Sea,

available at http://compassonline.org/
?q=EBM.

Newton A, Carruthers TJB. and Icely J (2012) The coastal syndromes and hotspots on the coast. Estuarine Coastal and Shelf Science, 96, 39-47.

Nicholls RJ and Cazenave A (2010) Sea-Level Rise and Its Impact on Coastal Zones. Science, 328(5985), 1517-1520.

Nicholls RJ et al. (2007) Coastal systems and low-lying areas. In: Parry M, Canziani O, Palutikof J, van der Linden P and Hanson C (Eds.), Climate Change2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 315-356.O'Dor, R (2004) A Census of Marine Life. BioScience 54(2): 92-93.

Orr JC, Fabry VJ, Aumont O, Bopp L, Doney, SC et al. (2005) Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms, Nature, Vol. 437, 681-686.

Ott K, Döring R (2004) Theorie und Praxis starker Nachhaltigkeit. Metropolis, Marburg.

Paehlke R (2005) Sustainability as a Bridging Concept. Conservation Biology, 19, 36–38.

Patterson M and Hardy D (2008) 9. Economic Drivers of Change and their Oceanic-Coastal Ecological Impacts. Ecological economics of the oceans and coasts, 187.

Pearce D, Markandya A, Barbier E (1989) Blue print for a green economy. Earthscan, London.

Pezzey J, Withagen C (1995) The rise, fall and sustainability of capital-resource economics. Scandinavian Journal of Economics 100, 513–527.

Porzio L, Buia MC, Hall-Spencer JM (2011) Effects of ocean acidification on macroalalgal communities, J. of Exp. Marine Biology and Ecology, 400, 278-287.

Rahmstorf S (2010) A new view on sea level rise. Nature Reports Climate Change, 4, 44-45.

Rahmstorf S and Richardson K (2009) Our threatened oceans. Haus Publishing Ltd., London.

Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, III, E. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. Foley. 2009. Planetary boundaries:exploring the safe operating space for humanity. Ecology and Society 14(2): 32. Sabine, CL, Feely RA, Gruber N et al. (2004) The oceanic sink for anthropogenic CO2, Science 305, 367–371.

Sarmiento JL, Slater R, Barber R, Bopp L, Doney SC, Hirst AC, Kleypas J, Matear R, Mikolajewicz U, Monfray P, Soldatov V, Spall SA, Stouffer R (2004) Response of ocean ecosystems to climate warming. Global Biochemical Cycles 18.

Schultz J, Brand F, Kopfmuller J, Ott K (2008) Building a theory of sustainable development: two salient conceptions within the German discourse. International Journal of Environment and Sustainable Development 7 (4), 465–482.
Scientific Consensus Statement on Marine Ecosystem-Based Management. Prepared by scientists and policy experts to provide information about coasts and oceans to U.S. policy-makers, 21 March 2005. Available at:
http://www.compassonline.org/sites/all/files/document_files/EBM_Consensus_Statement_v12.pdf (access: 16.05.13) 1.
Selman M, Greenhalgh S, Diaz R and Sugg Z (2008): Eutrophication and Hypoxia in Coastal Areas: A global Assessment of the State of Knowledge, WRI Policy Note, No. 1, 1-6.

Seto KC (2011) Exploring the dynamics of migration to mega-delta cities in Asia and Africa: Contemporary drivers and future scenarios. Global Environmental Change, 21, Supplement 1(0), S94-S107.

Seto KC, Fragkias M, Güneralp B and Reilly MK (2011) A Meta-Analysis of Global Urban Land Expansion. PLoS ONE, 6(8), e23777.

Skjeerseth JB (2002b) Toward the end of dumping in the North Sea: The case of the Oslo Commission, in: Miles, EL et al. (Ed.), Environmental regime effectiveness: confronting theory with evidence, Cambridge, MA: MIT Press, 65-86.

Smith R, Simrad C, Sharpe A (2001) A proposed approach to environment and sustainable indicators based on capital.

Smith VH, and Schindler DW (2009) Eutrophication science: where do we go from here?, Trends in Ecology and Evolution, 24: 201-207.

Sterr H, Colijn F (1999) Perspectives for Integrated Coastal Zone Management: German and International Issues. In: Gee K, Kannen A, Sterr H (eds.) Integrated Coastal Zone Management: What lessons for Germany and Europe? Berichte aus dem Forschungs- und Technologiezentrum Westküste der Universität Kiel 21 (ISSN 0940-9475), Germany.

Stramma L, Johnson GC, Sprintall J, Mohrholz V (2008) Expanding oxygen-minimum zones in the tropical oceans. Science 320: 655-658.

Syvitski JPM et al. (2009) Sinking deltas due to human activities. Nature Geoscience, 2(10), 681-686.

The Royal Society (2005) Ocean acidification due to increasing atmospheric carbon dioxide", Policy document 12/05: 1-58. Available from: http://royalsociety.org/Ocean-acidification-due-to-increasing-atmospheric-carbon-dioxide/ (access 01.08.2011).

Turley C (2005) The other CO2 problem, open Democracy free thinking for the world, http://www.opendemocracy.net/globalization-climate_change_debate/article_2480.jsp (01.08.2011).

U.S. GEOLOGICAL SURVEY (2008) Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle. USGS Fact Sheet 2008-3049. Available from: http://pubs.usgs.gov/fs/2008/3049/fs2008-3049.pdf (access 30.04.12).

UNCTAD (2011) Review of Maritime Transport. New York and Geneva.

UNCTAD (2012) Review of Maritime Transport. New York and Geneva.

UNEP/UNESCO-IOC (2009) An Assessment of Assessments (AoA), Findings of the Group of Experts Pursuant to UNGA Resolution 60/30. Start-up Phase of a Regular Process for Global Reporting and Assessment of the State of the Marine Environment including Socio-economic Aspects.

Van der Sluijs J (2012) Uncertainty and dissent in Climate Risk Assessment: A Post-Normal Perspective. Nature and culture 7(2), 174-195.

Victor PA (1991) Indicators of sustainable development: some lessons from capital theory. Ecological Economics 4, 191–213.

Wang H (2004) Ecosystem Management and Its Application to Large Marine Ecosystems: Science, Law, and Politics, Ocean Development & International Law, 35: 41-74.

WCED, World Commission on Environment and Development (1987) Our Common Future. Oxford, New York: Oxford University Press, 43.

Whitehead H (2002) Estimates of the current global population size and historical trajectory for sperm whales. Marine Ecology Progress Series 242: 295-304.

White House (2010) Executive Order 13547 --Stewardship of the Ocean, Our Coasts, and the Great Lakes, 19 July 2010. Available from: http://www.whitehouse.gov/the-press-office/executive-order-stewardship-ocean-our-coasts-and-great-lakes (access: 16.05.13).

White House Council on Environmental Quality (2009) Interim Framework for Effective Coastal and Marine Spatial Planning. Interagency Ocean Policy Task Force, 9 December 2009. Available from: http://www.whitehouse.gov/sites/default/files/microsites/091209-Interim-CMSP-Framework-Task-Force.pdf (access: 16.05.13) 1 and 7.

Wingenter OW, Haase KB, Zeigler M et al. (2007) Unexpected consequences of increasing CO2 and ocean acidity on marine production of DMS and CH2CII: Potential climate impacts, Geophysical Research Letters, Vol. 34.

Woodroffe, C.D., 2002. Coasts: form, process and evolution. Cambridge Univ Pr.

WOR, World Ocean Review (2010) World Ocean Review 2010: Mit den Meeren leben / World Ocean Review 2010: Living with the oceans. Maribus gGmbH (Ed.), Hamburg. Available from: http://worldoceanreview.com/wor-1/.

Worm B, Hilborn R, Baum JK, Branch TA, Collie JS, Costello C, Fogarty MJ, Fulton EA, Hutchings JA, Jennings S, Jensen OP, Lotze HK, Mace PM, McClanahan TR, Minto C, Palumbi SR, Parma AM, Ricard D, Rosenberg AA, Watson R, Zeller D (2009) Rebuilding global fisheries. Science 325(5940): 578-585.