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# Threats to Coastal and Marine Ecosystems, and Conservation of the Ocean Environment – with Special Attention to Climate Change and Marine Plastic Waste


## Executive summary

A healthy coastal and marine environment is essential for the ongoing sustainable development of human society. The ocean is a large absorber of atmospheric heat and carbon dioxide, and provides a vital buffer against anthropogenic climate change. The ocean contributes to human well-being in many ways, such as providing protein from fisheries, maintaining various natural cycles and is also a source of recreation and spiritual comfort. However, coastal and marine ecosystems are also facing serious threats. There are major environmental concerns on a global scale, which include acidification, deoxygenation, warming and its associated sea level rise as well as frequent extreme weather conditions. High nutrient inputs and inflow of pollutants such as heavy metals and organic toxic materials deteriorate coastal environments. Accumulation of plastic waste in the ocean originating from both land and ocean is an emerging problem. Damaging fishing practices, including Illegal, Unregulated and Unreported (IUU), affect coastal and marine ecosystems. The role of science in minimizing these impacts upon nature and society should not be understated.

The G20 Academies of Sciences calls for:

1) use of expert, evidence-based advice and assessment using an ecosystem-based approach during further development of marine resources so as to minimize undesirable impacts on the marine environment;
2) redoubling actions aiming to reduce stressors on coastal and marine ecosystems such as climate change, overfishing and pollution;
3) establishment of more recycling and energy efficient practices at national, city and local levels, through stakeholder collaboration and science-based target setting and its follow-up;
4) capacity building for both essential research infrastructures (including research vessels and remote and autonomous observation and survey capabilities) and human capital through education;
5) establishment of an improved data storage and management system that ensures open access by scientists globally; and
6) sharing of information gained through research activities carried out under extensive and multinational collaboration, to expedite a comprehensive understanding of the global ocean and its dynamics.

The ocean is a key component of our global ecosystem. As the main heat reservoir in the climate system, it has contributed greatly to stabilizing atmospheric climate. The ocean's ongoing uptake of heat and carbon dioxide represents the single-most important natural buffer against man-made changes to the atmosphere.

The ocean also houses rich biological communities, encompassing more biological diversity than is found on land, providing a variety of contributions to human well-being. These benefits include 17~20% of food protein (FAO, 2018), approximately half of the annual oxygen production on Earth, as well as over 20,000 substances of pharmacological interest, while also being a source of recreation and spiritual inspiration.

Coastal and marine ecosystems, however, face serious and escalating threats from human activity. Climate change caused by an increase of atmospheric carbon dioxide concentration is warming, acidifying and deoxygenating the ocean. Plastic waste is now a widespread pollutant and the ocean is an accumulation point for other contaminants.

These crises have already been well recognized by various forums, and to overcome these threats, action targets have been set under various UN systems, such as the Aichi Biodiversity Targets in the Convention on Biological Diversity and Sustainable Development Goals (SDGs), especially SDG 14 focusing on conservation of the oceans and sustainable utilization of marine resources. To promote achievement of these targets, the General Assembly of the UN has designated the years 2021-2030 as the Decade of Ocean Science for Sustainable Development, based on the proposal prepared by the Intergovernmental Oceanographic Commission of UNESCO.

The ocean is one integrated global system, so collaboration across all nations and sectors is needed to accomplish the targets and to safeguard this vital ecosystem. The role for science in meeting them cannot be overstated.

## 1. Global warming, ocean acidification, and ocean deoxygenation – three threats to the ocean associated with human activity and global environmental change

The geographic distribution of marine species is rapidly changing in response to global warming and human activity. Species that fail to adapt or change their distributions and life cycles rapidly enough to cope with these changes may be at risk of extinction. Such disruptions to coastal and marine ecosystems may have as yet unknown consequences for the ecosystem processes upon which humans depend. Sea level rise caused by global warming also poses a serious threat to coastal and shallow-water ecosystems, such as coral reefs, mangrove swamps, salt marshes, macroalgal and seagrass beds, because intense human development in the coastal zone prevents landward migration of these valuable habitats. Furthermore, occasional extreme weather phenomena such as super-typhoons have frequently wreaked serious damage on local communities including fishing facilities. In polar regions, especially the Arctic, the rapid warming and loss of sea ice have already considerably reduced the habitat for marine mammals and other species.

The increase in the atmospheric concentration of carbon dioxide is acidifying ocean waters, which has been recognized as one of major causes of deleterious effects for life on the planet. The impact of ocean acidification may prove to be severe for marine calcifying organisms, such as reef-building corals, snails, oysters, mussels, sea urchins, crabs, lobsters, and others. The impact is especially severe for cold-water species, such as deep-sea corals and shell building planktonic animals. These and related ocean changes may transform the globally expansive open ocean plankton community, with attendant effects on the marine food web and also the exchange with the atmosphere of trace gases, including carbon dioxide.

Ocean warming is seriously affecting the world's coral reefs, which are the largest biodiversity hotspots in the oceans. When seawater temperature exceeds a critical threshold, the symbiosis between corals and their algal symbionts breaks down, causing coral "bleaching" events. In conjunction with the influence of ocean acidification, coral reefs are projected to decline by a further 70–90% at 1.5°C increase (high confidence) with larger losses (>99%) at 2ºC increase (very high confidence) by the end of this century (IPCC, 2018).

Ocean deoxygenation is also a threat to marine animals that respire aerobically. A number of animals pass through areas of low oxygen daily to feed at the surface. Any increase in thickness of this area, or further decrease in oxygen levels caused by climate change-induced stratification of the ocean surface increases risk.

Land-based human activity impacts on coastal and marine ecosystems through riverine discharge and nonpoint source pollution. Nutrient over-enrichment caused by high concentrations of nutrients such as nitrogen and phosphate, and contamination of rivers by toxic materials such as organic mercury, heavy metals, pesticides, drugs (e.g. antibiotics, contraceptives, and psychiatric drugs) and PCBs, can cause serious pollution and deoxygenation in brackish and other coastal environments near river mouths and estuaries. For rivers with large flows (e.g. the Mississippi), the area of the ocean impacted may be hundreds of square kilometers.

## 2. Marine plastic debris – an emerging new threat

Marine plastic debris is a growing concern with regard to pollution of the marine environment. Large sized plastic debris such as plastic bottles, shopping bags etc. can kill marine animals through accidental ingestion; unintended mortality is also caused by discarded fishing nets (Gall and Thompson, 2015). Small sized (<5 mm) plastic particles - so-called microplastics - are also harmful to marine animals. Furthermore, laboratory experiments suggest that microplastics can transfer to marine organisms any toxic organic pollutants that are easily adsorbed on their relatively large surface areas (de Sa et al., 2018). There is a risk that seafoods may become contaminated by such pollutants through biological concentration into the upper trophic levels (Setälä et al., 2014). Marine debris also carries alien species over long distances, which may dramatically modify regional ecosystems (Barnes, 2002).

More than 80% of the plastic debris in the ocean originates from the terrestrial wastes of human society (Ribic, 1998; Nakashima et al., 2011; Hardesty et al., 2017), driven by increasing human plastic consumption without adequate infrastructure for waste processing, and consequently degrading the marine environment. More active studies are necessary for quantitative understanding of the impact of plastic debris on ecosystems in ocean surface waters, in the water column and at the seafloor.

Besides the reduction of single-use plastics, an overall industrial innovation of the chemical composition of plastics is needed, avoiding any materials that may accumulate for centuries in the environment.

## 3. Need for enhanced fundamental research and cooperation between science and policy

Fishing activities have been seriously impacting the marine environment for many years. To promote sustainable fishing, the need is greater than ever for science-based national and international management of fisheries activities, including better enforcement and elimination of IUU (Illegal, Unregulated and Unreported) fishing as defined by FAO.

Establishment of fully and highly protected areas in the ocean can help preserve biodiversity, habitats, and in some cases also create jobs; such areas also store carbon, allow recovery of depleted fisheries and enhance resilience to climate change. Marine Protected Areas (MPAs) are a powerful but underutilized tool to help protect ocean ecosystems and ensure sustainable development (e.g. through the Aichi and SDG targets). International and interdisciplinary efforts are needed to better understand and incorporate use of MPAs – especially fully and highly protected areas that permit none or minimal extractive activity – into climate change mitigation and adaptation planning, fishery management, and marine spatial planning.

Besides global warming, any increase in atmospheric carbon dioxide concentrations inevitably causes ocean acidification. Ocean acidification will not naturally reverse on timescales in excess of tens of thousands of years. Therefore, international efforts to reduce carbon dioxide emissions should be supported and enacted even more proactively.

The problems concerning coastal pollution in addition to plastic waste-based impacts - such as excessive nutrient inputs from land-based runoff - can be significantly reduced if basic infrastructure such as sewage treatment facilities are constructed as necessary and the use of fertilizers in agriculture is optimized by improving fertilization techniques and planting of more nutrient efficient cultivars. Fertilizer runoff can be reduced by using plantings to absorb these nutrients; this could include vegetation buffers along streams and rivers, and wetlands in estuaries and bays. However, understanding the impact of global climate change on pollutant remobilization is an urgent research priority.

In light of the increase of plastic debris pollution on a global scale, research on a variety of plastic waste-related topics should be carried out through collaboration among international scientists with diverse backgrounds, and with harmonized methodologies. More research is needed on the origin and transport of plastic waste to the ocean, its distribution once it reaches the ocean, prediction of future amounts of plastic debris and particularly its impact on ocean ecosystems, as well as methods to mitigate harmful effects on the ocean.

To realize an innovative society with minimal plastic waste pollution, new materials are needed that are degradable and which cannot accumulate in the environment. Capacity building in the collection, processing as well as recycling systems for plastic waste is necessary, thereby enhancing the cooperation of researchers, industry engineers and policy makers. Also necessary are research and development activities on designs for environmentally friendly plastic products, as well as developing materials to replace plastics in order to expedite solutions to the plastic waste problem. Progress in this issue will require a change in the attitudes and behaviors of citizens and the private and public sectors through collaboration between governments, companies, researchers and citizens. In this regard, establishment of reuse, recycling and energy efficient practices at national, city and local levels is a key approach for tackling plastic waste pollution. It is vital to enhance the capacity at city and local levels to help curtail the use of single-use plastics, implementing the 3Rs (Reduce, Reuse, Recycle) and proper waste management through stakeholder collaboration, science-based target setting and monitoring to assess effectiveness. Enhanced collaboration and further understanding between developed and developing economies are indispensable for the effective management of the currently alarming high amount of plastic waste pollution globally.

In the future, human impacts on the marine environment are likely to increase through offshore wind farm construction, deep-sea mining and mineral resource development, the opening of the Arctic passage to shipping due to global warming, coastal development and tourism. It is the paramount role of science to serve society by providing expert, evidence-based advice before and during the development of these activities so that they do not cause unwanted impacts on the marine environment. It is also important to redouble efforts aiming to reduce stressors on coastal and marine ecosystems - such as overfishing, pollution and marine noise - in order to increase resilience to ocean impacts from these new activities as well as to changes in the global environment more generally.

Strong international collaboration among researchers will help ensure that scientific advice incorporates the information gained through research activities carried out under solid international collaboration. Capacity building, both through education and in the form of research infrastructure, will be necessary to advance global ocean science. Infrastructure such as research vessels, remote and autonomous observation and survey platforms and techniques to provide more precise and cost-effective data, and data storage and management systems to ensure open access by scientists globally will be the keys to realizing a comprehensive understanding of the ocean ecosystem under the spirit of reciprocity.

The ongoing rise in atmospheric carbon dioxide is impacting the ocean not only through warming but also through the biogeochemical effects of ocean acidification. From this perspective, ocean acidification represents an important extra impetus for international efforts to mitigate carbon dioxide emissions. Human impacts on the ocean, from fishing to coastal pollution, are pressing issues. Without discounting these challenges, the rise in the atmospheric concentration of carbon dioxide due to fossil fuel burning is an overwhelming concern for the future of the ocean and indeed affects all of Earth's habitats. If our central goal is to improve the prospects for humanity on our planet for decades and centuries into the future, then ambitious steps must be taken to limit the atmospheric accumulation of greenhouse gases.

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