G7 Science Academies' Statement 2015:

Future of the Ocean: Impact of Human Activities on Marine Systems

Human activities are driving major changes in the oceans of the world. One key driver of changes is elevated carbon dioxide (CO_2) concentration in the atmosphere caused by human activities. This leads to ocean acidification, warming and deoxygenation, changes in ocean circulation, continued sea level rise, and an altered marine productivity and biodiversity. Other key drivers are pollution with nutrients, chemicals and plastic, overfishing and spreading of invasive species. All of the changes in the ocean have profound effects on human wellbeing and human societies in many regions of the Earth. The G7 Academies of Sciences call for: (1) changing the course of nations' CO_2 emissions, (2) reducing and further regulating man-made pollution of the sea, (3) ending overfishing and preserving marine biodiversity and ecosystem function through research-based management and (4) enhancing international scientific cooperation to better predict, manage and mitigate future changes in the ocean, and their impacts on human societies and the environment.

The ocean covers over two-thirds of the earth's surface, plays a vital role in global biogeochemical cycles and supports much of the planet's biodiversity. It provides a livelihood for millions of people and makes an increasing contribution to feeding a rapidly growing population. It now faces two categories of threat:

- Threats related primarily to greenhouse gas emissions, including ocean temperature and sea level rise, ocean acidification, stratification and changes in ocean circulation, which will alter the productivity of the ocean as a whole.
- Other threats that are regional to global, including flooding, chemical, nutrient and plastic pollution that ends up in the ocean, overfishing, extraction of resources such as oil, gas and minerals, habitat destruction and other human activity such as construction of large coastal infrastructures.

These and other changes are already imposing increasingly severe effects on biodiversity, marine productivity as well as on human populations and activities, especially in coastal zones and islands.

The ocean has a very large heat capacity and is currently storing more than 90 % of the additional heat associated with global warming, which it redistributes from one region to another on time scales ranging from years to several decades. The ocean is also currently absorbing one quarter to one-third of emitted fossil fuel CO_2. Net carbon uptake by the ocean will occur as long as human activities are adding CO_2 to the atmosphere and until the equilibrium between the atmosphere and ocean is re-established. Accordingly, the ultimate fate for most CO_2 derived from fossil fuel will be its dissolution in the world's surface waters, followed by its transfer into the deep ocean, where much of it will be neutralised by reaction with sedimentary carbonate on the deep sea floor. However, as this process takes tens of thousands of years, it is too slow to dampen the consequences of CO_2 increase for the coming generations.

The uptake of CO_2 into surface waters is causing a number of interrelated changes in ocean chemistry, including an increase in ocean acidity. The full impacts of these changes on key marine ecosystems are only beginning to be understood but include impacts on energy balance, physiology, behavior and survival of many marine organisms. Of particular concern is the ability of marine plants and animals to construct their calcium carbonate shells or skeletons. Thus the ocean's uptake of CO_2 comes with potentially serious impacts on biodiversity, food webs and marine ecosystem services, including fisheries.

Global warming itself is altering surface water temperatures and thus changing the solubility of CO_2 and oxygen (O_2) in ocean water, as well as altering the ocean's density stratification and circulation patterns. Global warming induces changes in ocean circulation especially in polar regions. This is highlighted by the retreat of summer sea ice in the Arctic Ocean and dramatic trends in climate and marine life in the coastal waters of the Antarctic Peninsula. These polar changes may lead to further changes in weather, climate and ecosystems throughout the world, as is already evident on a regional scale in the form of droughts and other weather extremes.

The global mean sea level is currently rising in response to ocean warming and the melting of land ice, and will continue to rise at an accelerated rate in the coming decades and centuries. By 2100, a global mean rise of at least 1 m above the present level and up to 1.4 m in some regions is likely. Societal impacts are likely to include shoreline recession, changes in extreme sea levels (e.g. flooding from storm surge), and loss of coastal infrastructure, natural resources and biodiversity. These impacts will lead eventually to increased costs, the displacement of people and the migration of environmental refugees.

The circulation and mixing of the ocean supplies oxygen and nutrients essential for growth of marine organisms. The expected physical changes will therefore impact ocean productivity, biodiversity, ecosystem functions and fisheries. Human activities on land are injecting pollutants into coastal marine environments, including nutrients that lead to excessive algae

blooms, which sink and decay, further lowering oxygen and creating “dead zones” in coastal waters. Waste products such as non-biodegradable marine litter and toxic chemicals can accumulate in the food chain with yet unknown consequences for the health of consumers of ocean products, including humans. Plastic debris accumulates in the ocean at all depths with detrimental consequences for marine life. Introduction of non-native species can disrupt ecosystems and impact fisheries and tourism.

Overfishing is a serious global problem that damages biodiversity and productivity, hence the future of fisheries as well as resilience of ocean ecosystems. Recent evidence suggests it is possible to end overfishing and recover many depleted fisheries resulting in economic, social and environmental benefits. Illegal, unreported and unregulated fishing undermines fishery management and threatens food security and ocean resilience. Human activities in coastal areas, including coastline alteration and aquaculture, also play a role in damaging marine ecosystems, increasing their vulnerability and exacerbating the often combined impacts of warming, ocean acidification, pollution and nutrient enrichment.

In order to avoid the most serious adverse impacts that are foreseen, the following actions are necessary:

1. Change the course of nations’ CO_2 emissions

- Accelerate the transformation to a carbon-free economy by reducing emissions at a national level.
- Include the ocean in environmental policies, including sustainability concepts for the use of materials and goods.
- Enforce the goals of the UN Framework Convention on Climate Change (UNFCCC), overcoming short-term economic considerations that ignore short- and long-term costs of climate and ocean changes.

2. Take actions to reduce and further regulate man-made pollution of the sea

- Reduce the use of fertilisers, the discharge of human and animal sewage, the generation of nutrients from aquaculture. Improve wastewater management in watersheds.
- Halt the dumping and regulate the discharge of waste and toxic materials. Take urgent action to reduce the input of plastic debris from all sources into the marine system.
- Reduce inadvertent transport of non-native species via global shipping and aquaculture. Strengthen the regulation of ballast water release.
- Implement high global standards in all aspects of maritime activities by national and international regulations, and improve the coordination of maritime surveillance and scientific ocean observation.

3. End overfishing and protect marine biodiversity and ecosystem function through research-based responsible management

- Conserve and restore natural fish populations and the ecosystems on which they depend and establish networks of marine protected areas, including the high seas.
- Manage fisheries in a sustainable way and strive to eliminate illegal, unregulated and unreported fishing.

4. Enhance international scientific cooperation to better predict, manage and mitigate future changes in the ocean and their impacts on human societies and the environment

- Provide leadership in strengthening and catalysing international collaborations. Improve access to study sites, and to data and models, to enhance our knowledge of the ocean’s physical, chemical and biological dynamics and interactions between human wellbeing and ocean ecosystems.
- Increase international coordination and provide required infrastructure and capacity building for sustained ocean observation.

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