



HEALTH, THE GLOBAL OCEAN AND MARINE RESOURCES

POLICY BRIEF



Key messages

Taking action on one SDG gets results in others: health runs through every SDG.



ENSURE HEALTHY LIVES AND PROMOTE WELL-BEING FOR ALL AT ALL AGES.



CONSERVE AND SUSTAINABLY USE THE OCEANS, SEAS AND MARINE RESOURCES FOR SUSTAINABLE DEVELOPMENT.

The global ocean (interconnected system of Earth’s oceanic waters) plays a central and positive role in human life, including through the climate system. Damage to the ocean is far-reaching in its effects, in terms of productivity, species diversity and resilience. Global ocean activities are putting populations at risk (1).

- /// The “health” of the global ocean is both affected by and a threat to human activities.
- /// People have lived in harmony with the ocean for generations and have relied on its bounty. Fish and seafood from a healthy ocean contribute to our health. The best-documented and direct benefits to human health and well-being from the ocean are linked to the consumption of fish and seafood, rich in omega-3 fatty acids, and non-terrestrial animal proteins. Indirect benefits to health also arise from marine-derived pharmaceuticals and vitamins.
- /// Society benefits from the seas. The coastal waters provide employment, commerce, cultural, social interaction and artistic activities. They offer a variety of social, economic, health, cultural and environmental benefits to human livelihoods (2).
- /// The global ocean helps people to feel good. There is increasing recognition of the value of coastal waters in promoting better mental health through decreased vulnerability to depression. Better physical and mental health is also gained through exercise, such as swimming, walking and sailing.
- /// Marine pollution and the loss of marine biodiversity are affecting the viability of marine ecosystems, the availability of fish stocks and the potential for the discovery of new pharmaceutical compounds and other marine natural products from marine bioprospecting. These impacts potentially affect human health and well-being in both the short and the long term.



- /// Marine pollution can poison us. Anthropogenic organic chemicals, fertilizers and faecal waste from humans and animals, as well as waste from intensified aquaculture, can lead to increasing concentrations of nutrients and microbial and chemical contamination of water and seafood.
- /// There is an increase in events linked to climate change such as cyclones and rising sea levels and the devastation caused by tsunamis is expected to be greater when sea levels rise, posing risks to human health settlements and security. The health of the global ocean is ignored at our peril.

Health, the global ocean and marine resources: the connections



The marine science community has traditionally emphasized the importance to human health and well-being of healthy seafoods rich in omega-3 fatty acids, non-terrestrial animal proteins, vitamins and marine-derived pharmaceuticals. Current research is exploring the importance and the potential benefits of interaction with “healthy” and diverse coasts and blue spaces, marine and other, to human health and well-being.



The connections are very fundamental and there is increasing recognition that the health of humans and the health of the global ocean are inextricably connected in a number of complex ways (3). The global ocean is the largest ecosystem on Earth. It covers around 71% of the Earth’s surface, is a single connected vast body of water (divided into distinct named regions) (4) and performs a vital regulatory function in global weather and climate systems. Even the livelihoods and lifestyles of people living far inland often depend directly on the rainfall and temperature patterns moderated by distant oceans. Rainfall patterns driven by the global ocean include the monsoons in the Indian subcontinent and the rainy season in western and central Africa. The ocean provides essential marine resources and services, giving them a central place in human activities. However, the health of these waters is being eroded by a range of anthropogenic pressures, such as fishing, transport and coastal activities, including industries and cities (5).

The marine science community has traditionally emphasized the importance to human health and well-being of healthy seafoods rich in omega-3 fatty acids, non-terrestrial animal proteins, vitamins and marine-derived pharmaceuticals. Current research is exploring the importance and the potential benefits of interaction with “healthy” and diverse coasts and blue spaces, marine and other, to human health and well-being (3). This includes the fostering of broader societal health-linking benefits such as employment, commerce, cultural and artistic activities (6).

Coastal waters also promote better mental health through decreased vulnerability to depression: better mental health and well-being have previously emerged as important outcomes in models of ecosystem services (6). The mental and physical health benefits from proximity to marine environments are difficult to define and to quantify (7), but studies have shown that individuals living near the coast are generally healthier and happier than those living inland, even when correcting for income and other socioeconomic factors (8).

Coastal waters also foster “societal health benefits” through supporting employment, commerce, and cultural and artistic activities. People living in cities can lose touch with the natural world, and maintaining contact with nature, whatever your age, can improve the immune system, reduce stress and counter loneliness (9,10).

There is now particularly interesting evidence that the ocean and coastlines, particularly those with good environmental status, have a strikingly beneficial effect on people with lower socioeconomic status (11,12). Nearly 50% of the European Union (EU) population lives less than 50 km from a coast, with access to the ocean and the resources and services provided (13). The sea after all is free (Case study 1). Possible mechanisms to explain this relationship include the appeal of aquatic environments, both inland and coastal; stress reduction and physical activity in an attractive environment; increased social interactions; and environmental quality, in particular air quality and ultraviolet exposure for vitamin D synthesis.

Case study 1. Beneficial effects of marine and coastal settings on health and well-being (United Kingdom)

“I must go down to the seas again, the lonely sea and the sky” (John Masefield, 1913)

In the United Kingdom, retiring to the coast has long been very popular, and its beneficial effect on all ages is now well documented. As part of a focus of international research, the United Kingdom is investigating exactly how far marine and coastal settings support public health and help to tackle inequalities through physical activity on land or water. Data from two large, multiwave population representative datasets, the Health Survey for England and the Monitor of Engagement with the Natural Environment, revealed that approximately 271 million recreational visits were made each year in 2009–2016 to coastal environments in England (United Kingdom) (14–16). Every year since 2009, about 45 000 interviews have been conducted by the Monitor of Engagement. In terms of welfare gains, the annual benefit of water sports alone is estimated to be in the order of £176 million (7), with considerably higher benefits from more frequent on-land activities, such as walking and running along beaches and coastal paths (17). More recent work using the Health Survey for England has again demonstrated that this activity has positive outcomes mentally and physically (T Pasanen, unpublished data).

These studies highlight the need to protect and manage marine and coastal environments for the benefit of human health and well-being. Similar findings have been seen in Asia, Australia, Europe and North America (18–20). Local and national authorities, health-care providers, communities and other partners now have the opportunity to promote public health and prevent disease by creating and maintaining healthy blue spaces that are accessible to all, leaving no one behind.

The research findings to date largely stem from developed countries (8,20), so future research needs to explore whether the same benefits to health and well-being are found in developing countries. This is particularly important for the very poor populations living in many coastal areas globally threatened by marine pollution, climate change and the associated risks of flooding, storm surges and poor water quality.

In spite of the acknowledged benefits from the ocean and marine resources and services, these are being eroded by a range of anthropogenic pressures, such as fishing, transport, coastal industries and cities (5). Marine pollution and the collapse of fish stocks from overfishing can have direct impacts on nutrition and, therefore, on human health (9). In coastal areas particularly, where populations depend more on marine food sources, human health and well-being are directly linked to the health of their marine ecosystems. Health effects can be both acute and longer term, depending on the exposure level and duration as well as on the susceptibility of the exposed population (6).

Marine pollution has significant negative impacts not only on the health of marine life but also potentially on the quality of human food chains. Persistent pollutants, such as the pesticide DDT (dichlorodiphenyltrichloroethane), the industrial polychlorinated biphenyls (PCBs) and heavy metals, can directly affect the health of humans and marine mammals as they lead to immunosuppression, developmental and neurological diseases, and possibly the emergence of cancer, particularly in indigenous coastal human populations (6).



The use of antibiotics in humans and in agriculture and evolutionary environmental pressures can lead to the emergence of antibiotic-resistant organisms in coastal waters, seafood and marine mammals. Antimicrobial-resistant organisms such as methicillin-resistant *Staphylococcus aureus* have already been found in coastal environments and particularly on beaches, causing potentially untreatable infections.



Fertilizers and faecal waste from humans and animals as well as intensified aquaculture can also lead to increasing microbial contamination of water and seafood by bacteria, viruses, parasites and other organisms, including toxin-producing harmful algal blooms. These algal blooms and toxin-contaminated seafood can cause acute and chronic neurological illness and possibly cancer after seafood consumption, as well as acute and subacute respiratory illness through exposure to toxin-contaminated marine aerosols (6,21).

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Most marine pollution, ranging from microbial waste, anthropogenic chemicals and nutrients to plastics, is land sourced, with 90% of the nitrogen influx tending to be related to agriculture. Significant threats are posed by limited or lack of wastewater treatment plants and the growing flow of plastics in coastal systems bordering large urban areas, particularly in developing countries (22). Microplastics (particles <5 mm long and of mixed shape) are present in air, soil, freshwater, biota, various food components and in marine waters. Fragmentation and degradation of larger plastic items and of microplastics leads to the formation of nanoplastics.

The ubiquity of nano- and microplastics (NMPs), and the uncertainties with regard to the potential impacts on the environment and on human health, is a growing concern (23). A recent assessment of the risks associated with NMPs suggested that ecological risks are likely to be low at current concentrations, with some risks in coastal waters and sediments, but these risks will increase if levels remain constant or grow. Little is known about the effects of NMPs on human health. Although current evidence does not indicate widespread risk, high-exposure laboratory tests have demonstrated that NMPs can induce physical and chemical toxicity, giving rise to physical injuries such as blockage of the gastrointestinal tract, and a subsequent reduced energy intake, or impaired respiration and inducing inflammation and stress. These effects negatively influence food consumption, growth, reproduction and survival in aquatic organisms in the laboratory setting. It is not clear how applicable these results in laboratory conditions are to the natural environment (23). To date, the evidence base for adverse health effects of NMPs and other pollutant chemicals is sparse. The European Food Safety Authority has estimated that the consumption of around one portion of mussels would, even under worst case assumptions, contribute less than 0.2% to the dietary exposure for three well-known toxic chemicals (bisphenol A, PCBs and polycyclic aromatic hydrocarbons) (24).

Climate change and corresponding changes in the atmosphere have been linked with gradual and extreme weather events, rising sea levels and higher acidity and deoxygenation of the global ocean (22).

Extreme weather events and natural disasters increase the risks of drowning, injury and long-term mental health effects, as well as forced migration (25). Seawater intrusion into groundwater in coastal aquifers, potentially exacerbated by extreme weather events, can contaminate freshwater resources and pose concomitant health risks (9). Climate change will exacerbate the health impacts of extreme events and pollution by pathogens and toxic wastes, particularly in coastal areas and in the marine food chain.

Facts and figures

Fish and seafood stocks



- Currently, wild caught and farmed seafood provides more than 3.1 billion people worldwide with almost 20% of their average per capita intake of animal protein, as well as essential nutrients, such as omega-3 fatty acids, vitamins, calcium, iron and zinc (22).
- The global share of marine fish stocks that are within biologically sustainable levels declined from 90% in 1974 to 69% in 2013 (26).
- Overfishing now threatens about 33% of the world's fish stock, whereas in the 1970s, less than 10% was overfished (5,27).
- Globally, the market value of fish stocks is estimated at US\$ 3 trillion per year, or about 5% of global gross domestic product (22).
- Small-scale artisanal fisheries account for a large percentage of full-time or part-time work in developing countries, with 50% of fishers being women. Over 90% of the catch is destined for local human consumption (22).
- Developed countries need the seafood they import from developing countries to be of high quality and so should be very interested in the quality of the water from which it comes. Meanwhile, developing countries are bearing the brunt of the environmental costs while the yield is mostly being exported to the developed countries.
- Global production from aquaculture, currently at 77 million tonnes, continues to grow, particularly in developing countries (22).

Marine pollution and health



- Global trends point to an ongoing deterioration of coastal waters through pollution and eutrophication. Without concerted efforts, coastal eutrophication is expected to increase in 20% of large marine ecosystems by 2050 (26).
- The Biodiversity Research Institute reports that methylmercury levels in fish and marine mammals exceed one part per million on a wet weight basis in many samples from the North Sea, the Baltic Sea, the Atlantic Ocean and the Mediterranean Sea (28).
- To date, marine ecosystems, and particularly coastal ecosystems, have lost 19–35% of foundational habitats globally, such as seagrass meadows, coral reefs and mangroves (22).

- // Studies at open ocean and coastal sites around the world show that levels of marine acidity have increased by about 26%, on average, from pre-industrial levels. Moreover, marine life is being exposed to conditions beyond previously experienced natural variability (26).
- // Pollution from anthropogenic organic chemicals and specific heavy metals pose severe risks to human health (6).
- // The overall global burden of human disease caused by microbial sewage pollution of coastal waters alone has been estimated at 4 million person-years lost annually, particularly affecting young children and immunosuppressed individuals (29).

Extreme weather events



- // Climate change and corresponding changes in the atmosphere have been linked with gradual and extreme warming events, rising sea levels and higher acidity and deoxygenation of the global ocean (22).
- // Furthermore, 90% of excess anthropogenic heat has been accumulated in the global ocean; superimposed on anomalous ocean-warming events, this excess heat significantly impacts vulnerable marine resources and habitats. Impacts on both will be long lasting even if the current carbon dioxide emission trends are reversed (22).
- // Extreme weather events and natural disasters increase the risks of drowning and injury, and can have long-term mental health effects; they also can lead to forced migration (25). Seawater intrusion into groundwater in coastal aquifers, potentially exacerbated by extreme weather events, can contaminate freshwater resources and pose health risks (30). Climate change will exacerbate the health impacts of extreme events and pollution by pathogens and toxic wastes, particularly in coastal areas and in the marine food chain.

Marine protection



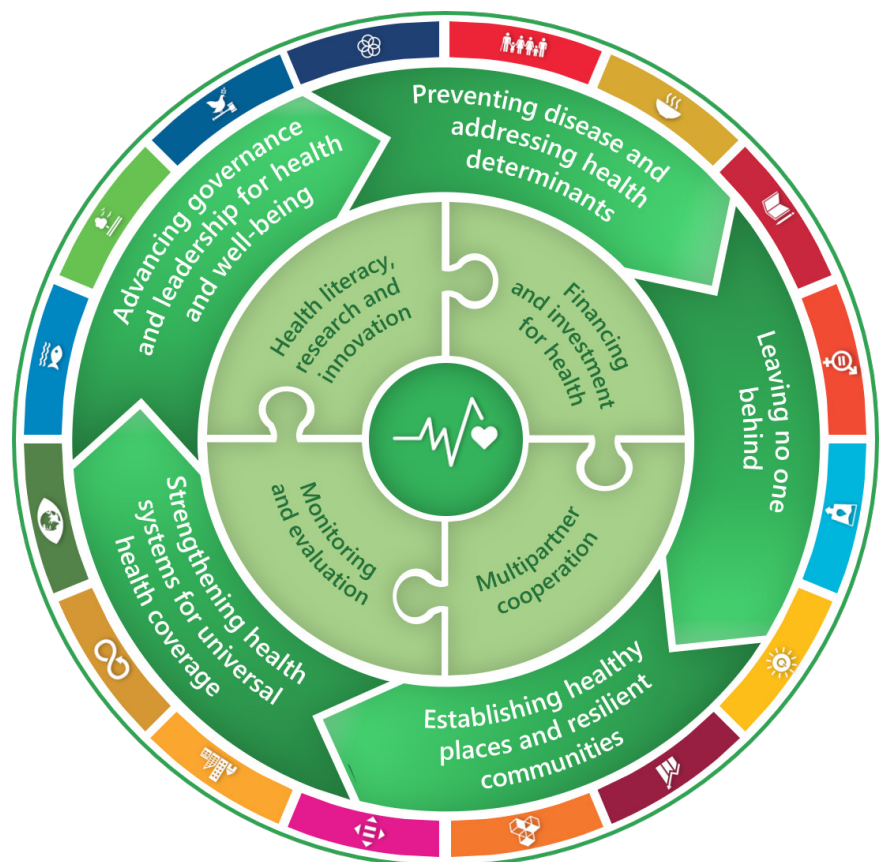
- // There is some progress. As of January 2018, 16% (or over 22 million km²) of marine waters under national jurisdiction (i.e. 0–200 nautical miles from shore) were protected areas. This is more than double that in 2010. The mean coverage of marine key biodiversity areas that are protected has also increased, from 30% in 2000 to 44% in 2018 (26).

Priorities for action: what now?

Sustainable Development Goal (SDG) 14 aims to manage the pressures put on the global ocean and focuses on the potential environmental, economic, sociocultural, health and well-being benefits that a “healthy” ocean provides (22). All 10 targets specified under SDG 14 are relevant to human health and well-being, and key measures towards SDG 14 targets specifically promote potential benefits for SDG 3 targets (e.g. 3.4, 3.9, 3b and 3d). Tackling marine challenges (including pollution, overfishing, reduction of plastic and other lethal litter in the ocean) will take time and requires inter- and transdisciplinary science, with cross-sectoral action and multiscale integrated governance (30). To achieve the targets of SDG 14, it is crucial that governments, businesses and ordinary people are aware that blue spaces directly affect health and well-being and have spillover effects on other SDGs, such as those focusing on health, inequalities and life on land.

Member States of the WHO European Region have committed to the United Nations’ 2030 Agenda for Sustainable Development (31) and their Roadmap for implementing it (32). The Roadmap proposes ways in which countries can address health and its determinants and make investments for health and well-being through evidence-informed policies across sectors. The Roadmap has five strategic directions and four enablers (Fig. 1).

Fig. 1. The strategic directions and enablers of the WHO SDG Roadmap





Advancing governance and leadership for health and well-



Strengthening dialogue with and between public agencies, spatial planners, nongovernmental organizations, business, industry and all the other actors is a prerequisite for tackling the shared challenges of both ocean health and human health; better use can be made of existing and emerging economic tools to assess ongoing and diverse costs and benefits of the choices that are made.

Achieving the SDGs will be easier if local people are engaged, whether through schools, local enterprises or communities. It is crucial to encourage a wider public debate and direct involvement in the responsible use of blue space environments, which benefits both human health and marine ecosystems. People need to better understand the benefits they receive from marine environments and the negative impacts they experience – and their children will experience even more – from degradation to these same environments (33). The use and spread of plastics, for example, depend largely on human decisions and behaviours. Emissions to the environment are mainly driven by the economy and behaviours of citizens and other stakeholders. Future risks will be related to the high volumes, high emission profiles and/or intrinsic hazardous properties of the plastic materials.

Close interdisciplinary collaboration between the natural, social and behavioural and regulatory sciences is needed in moving forward to address the complex issue of plastic waste and pollution. Useful measures for addressing and reducing plastic pollution include fees, bans, environmental protection regulations and voluntary agreements (23). Following the precautionary principle, it is important to communicate and inform in a transparent way about the uncertainties in the scientific evidence rather than assuming a lack of risk to human health (23). Apart from regulating emission of plastics, the focus can be on the development and use of less-hazardous materials. The evidence suggests that circular economy approaches, away from linear processes and end-of-life clean-up, will achieve more (23).

Fundamental reporting of annual national catch statistics needs additional support to increase quality and resolution, including enhancing on-the-ground capacity, to reduce harmful fishing. Decreasing the impacts of illegal, unreported and unregulated fishing alone has been estimated to reduce losses worth US\$ 23.5 billion, or 20% of all wild marine catches (22).

Fishery subsidies – occurring as grants, low-cost loans, guarantees, tax breaks, price supports and the direct provision of goods and services – amount to US\$ 35 billion worldwide, of which US\$ 20 billion is categorized as contributing to overcapacity and overfishing (22). These subsidies are offered to encourage economic growth, fisheries development, crew safety, enabling value addition, financing less harmful fishing methods and so on. However, where they are demonstrated to cause more harm than good, the use of subsidies should be reconsidered.



Preventing disease and addressing health determinants



The determinants of health and well-being are not to be found just in clinics and hospitals. Whether people are healthy or not is determined by their circumstances and their environment. The targets of SDG 14, a healthy marine environment and the sustainable use of its resources, involve the physical environment, employment and working conditions, income and social status, as well as food and nutrition. Reducing marine pollution, which affects marine and human health, will require cross-sectoral interventions for further impetus to deal with the transboundary pathways to decrease the input of pollutants and increase the clean-up of these pollutants on the coasts and in the marine environment.

Effective prevention will require strengthening the surveillance of exposure to environmental hazards and quantification of related health impacts (6). It is vital to address issues such as microbial pollution and antimicrobial resistance, chemical pollutants and pharmaceutically active products, plastics and NMPs, and toxins from harmful algal blooms, and to consider how these will potentially interact with growing ocean acidification (25).

Although methylmercury has been known as a fish contaminant for many years, it continues to put humans, particularly children and pregnant women, at risk. Exposure to mercury (particularly in the form of methylmercury) is acknowledged to produce significant adverse neurological and other health effects, with harmful effects most evident on unborn children and infants. The formation of methylmercury and its accumulation in the food chain (fish, seafood and wildlife) is an important aspect of human exposure, with elevated methylmercury levels found in many fish-eating populations, notably among coastal, island, river and lakeside populations and those living near reservoirs, as well as in people who eat large quantities of commercially sold high-end predators. In the context of the Minamata Convention, new protective approaches have to be complemented with efforts to prevent excessive exposures in the short term (34). There are several recommended limit values for mercury in fish (from the Food and Agriculture Organization of the United Nations (FAO), United States Environmental Protection Agency and WHO). From these, dietary fish/seafood advice can be tailored to local conditions and individual vulnerabilities. WHO recommends a limit for mercury consumption of 1.6 µg/kg body weight per week, especially for pregnant women to protect the fetus and for children (35). Pregnant women and other people caring for young children need to be informed about what types of fish are a good choice for frequent consumption to avoid harmful mercury exposure (36,37). Dietary fish/seafood advice tailored to local conditions is a specific tool to reduce human exposure to methylmercury from fish and seafood (36). Biomonitoring requires capacity-building in the health sector and the strengthening of the health sector's role in sustainable chemicals management (35,38). Determination of mercury in hair, for example, is a recommended and feasible biomarker of exposure, both to assess national and regional exposure levels and to identify individuals at risk, particularly pregnant women and children (Case study 2).

Case study 2. Assessment of exposure to methylmercury from fish and seafood on the Croatian coast

The coast of Croatia, bordering the Adriatic Sea, is heavily polluted with metals, including mercury, from oil refineries, thermal power plants, energy conversion plants, natural gas production and processing plants, the petrochemical and cement industries as well as fertilizer production (36). For example, on the north-eastern coast of the Adriatic Sea, an estimated 56 tons of mercury were released into the sea by a chloralkali plant over its 41 years of activity. Elevated mercury concentrations in sediments and the bioaccumulation of methylmercury in marine organisms have been found in this area: 41% of the captive Atlantic Bluefin tuna farmed in the Adriatic Sea contained mercury above the level considered safe under EU and Croatian legislation.

A case study was undertaken on selected sites in Croatia, bordering the Adriatic Sea, to test hair and blood samples of the Croatian population for mercury levels. The frequency of consumption of certain fish species showed a significant positive association with the measured mercury levels (36).

While fish consumption is a source of valuable nutrients, such as omega-3 fatty acids, folic acid and selenium, it can also be the source of methylmercury. Consequently, intersectoral efforts to inform local communities (especially pregnant women) regarding local fish consumption and some of the pollution issues, and continuous monitoring of fish and people in the affected area will help to tackle SDG 3.9 (reduce the number of deaths and illnesses from hazardous chemicals) and SDG 14.1 (prevent and significantly reduce marine pollution, in particular from land-based activities).

Further studies should be undertaken, including human biomonitoring, in a wider population, with a specific focus on areas where environmental pollution and higher exposure have been identified.



Leaving no one behind



The determination to leave no one behind underlies all the SDGs. In the context of SDG 14, this includes contributing to improving the situation of small-scale fisheries and achieving sustainable economic growth and the expansion of the ocean (“blue”) economy and its businesses through the long-term sustainable use of the global ocean.

Small-scale fisheries predominantly provide food for local consumption, thus contributing healthy food for the community. But they also have an effect on the local population through a range of social determinants of health, such as the provision of jobs and income.

Small-scale fisheries can be reformed through a greater understanding of the sector, additional documentation around catches, basic management infrastructure and capacity support (22) to improve the access of small-scale fisheries to resources and opportunities for trade.

The expansion of the blue economy can support future economic growth; however, it is essential that this growth is achieved through the long-term sustainable use of the ocean. Many businesses both affect and are affected by the health of ecosystems, as well as the subsequent impacts on human health and well-being such as coastal tourism and fisheries, including aquaculture.



Establishing healthy places, settings and resilient communities



It is important to establish marine protected areas and ecosystem-based marine and land management programmes. Tracking the impact achieved with these protected areas and management programmes is challenging, but with harmonized assessment approaches marine protected areas can be monitored within integrated spatial management frameworks and effective marine and land area management for the conservation of biodiversity. Changes in human health and well-being and other impacts of marine protected areas need to be tracked for both local and distant populations, as well as for their impact on the sustainability of healthy ecosystems.

Action is also needed to mitigate climate change. This includes making monitoring and research on the effects of climate change on ocean ecosystems part of mainstream activities and providing better information to policy-makers to guide meaningful adaptation and mitigation options as part of their national determined contributions. Extreme events and natural disasters on coasts and shorelines pose high risks to human safety and health, and these risks are growing with the increasing effects of climate change and human population pressures. Consequently, health system capacity in all countries, particularly developing countries, needs to be strengthened for early integrated warning, risk reduction and management of such national and global health risks. Governments have a role in promoting activities that encourage and allow countries to meet and exceed commitments made under the Paris Agreement under the United Nations Framework Convention on Climate Change (39). Investment is needed into interdisciplinary and trans-institutional training and education of future scientists, policy-makers and citizens in relation to climate change, the global ocean and human health and well-being (25,29).

New approaches toward sustainable development can produce benefits as well as adverse effects on marine and/or human health. These effects need to be continuously explored and assessed. Examples are the applications of marine renewable energy, marine bio- and geoprospecting (including at the poles) and polar exploration and exploitation.



Strengthening health systems for universal health coverage



Member States in the WHO European Region have committed to progress towards universal health coverage. The aim is to ensure that all people obtain and have equal access to high-quality health promotion, disease prevention, curative, rehabilitative and palliative services without experiencing financial hardship. The health system can support ocean health by promoting pro-marine behaviour that carries benefits for human as well as for marine health, such as opting for sustainable fish choice, reducing the use of plastics and avoiding littering the marine environment. As a healthier marine environment supports healthier people, this may diminish strain on health systems. Conversely, more pollution and destruction of the global ocean will pose additional burdens on health systems through an increase in morbidity and mortality in populations.

A marine mindset describes the mental readiness to address marine environmental problems (33). People are more likely to have this mindset of environmental concern if they feel connected and attached to the places where they live or work and feel responsibility for them.

Opportunities for research and innovation



The metadiscipline of ocean and human health involves investigating and emphasizing the risks and benefits to human health and well-being from interactions with the global ocean; there is increasing recognition that the health of humans and the health of the global ocean are inextricably connected in a number of complex ways (3). While several interconnections are established, others need to be investigated further (6,25).

In October 2014, the European Marine Board's Rome Declaration stated that Europe urgently needed: "A coordinated, cross-disciplinary and integrated programme on *Ocean and Human Health*, targeted at understanding and managing the risks and benefits to human physical and mental wellbeing from interactions with the seas" (40). Scientific communities need to work in close collaboration with policy-makers, fishermen, recreational users, private enterprise and other stakeholders, including the general public, to come together to address the impacts of human activities on the marine environment and how these, in turn, affect the stability and sustainability of human populations and their activities (3).

Generally, more inter- and transdisciplinary training and research is desirable for the dual endpoints of the health of the environment and the health of humans in the marine (and terrestrial) ecosystems. These are inextricably linked but often investigated by researchers focused on one or the other but not both. Currently, opportunities are unfolding for nations to benefit from technological and scientific advances to support such interactions, from fundamental data collection to the sharing of information, infrastructure, skills and learning and through to capacity development. Scientific understanding of the short- and long-term responses of the global ocean to the various pressures and measures is fundamental for sustainable management; for example, there is a need for better understanding of the effects of climate on coastal systems and of the systemic interactions between humans and developments in coastal demographics and climate-affected ocean systems. Insights from sociology, psychology, media and communication studies and management studies need to be brought together to improve understanding of the interplay between natural science evidence and the implementation of effective social responses (23).

Ocean observations and research are also essential to predict the consequences of change, design mitigation measures and guide adaptation to cope with the many ways the marine environment affects human lives and infrastructure at different spatial and temporal scales. A coordinated, continuous and long-term system of ocean observations is key for a better understanding of ocean climate and ecosystems and related human impacts and vulnerabilities. Ocean observations (through both satellite imagery and in situ), modelling and access to big data can all play a vital role in monitoring, analysing and predicting ice cover, sea level, ocean currents and acidification, oxygen levels and algal blooms, and for informing climate services. The Global Ocean Observing System (GOOS) coordinates observations around the global ocean for three critical themes: climate, ocean health and real-time services. These correspond to its mandate to contribute to the United Nations Framework Convention on Climate Change (41), the United Nations Convention on Biodiversity (42) and the Intergovernmental Oceanographic Commission/World Meteorological Organization mandates to provide operational ocean services (1). It is important to begin to integrate human activity and human health indicators into these global observing systems in order to fill gaps in existing knowledge of relevant linkages between environmental change and human health (43).

Another key area is intensifying international collaboration and data sharing on the health of marine ecosystems. Quality-controlled, integrated global data products and inventories with both marine and human indicators need to be made widely available (e.g. through data portals for ocean data and information networks such as EMODnet (44)) to allow human indicators to be integrated into the marine ecosystem indicators, databases and models. This would avoid monitoring in separate parallel processes. Recently, countries worldwide are increasing their investment in ocean observations and research, which is reflected in increased data coverage; increased numbers of marine scientists and research and education institutions; and significant infrastructure investments. This work will be advanced and highlighted by the upcoming United Nations International Decade of Ocean Science for Sustainable Development, starting in 2021, with the strapline, *The Ocean We Need for the Future We Want* (45).

Research is only at its initial stages on the potential long-term effects on humans of NMPs and other novel compounds that accumulate in the global ocean, marine mammals and seafoods. Specifically, there is a need for improved quality of data and international harmonization of the methods used to assess exposure and effects of NMPs on biota and humans. While there is a reasonable amount of knowledge about NMP concentrations in freshwaters and the ocean surface, little is available about the concentrations and implications of NMPs below the ocean surface (23). Better knowledge on food and airborne concentrations of NMPs will be essential for estimating their health effects. In addition, research is needed on the toxicokinetics and toxicity of NMPs, including studies on local effects as well as on the degradation of microplastics and potential formation of nanoplastics in the human gastrointestinal tract (24). However, increasing body burdens of persistent chemicals are expected, especially for longer living human populations. This may lead to an increased risk of certain cancers and possibly dementia and other chronic diseases (6).

Some localized negative impacts on marine ecosystems and aquaculture have been observed from growing ocean acidification; however, the potential impacts of ocean acidification on the stability of the marine food chain and possible effects on the interactions with anthropogenic chemicals are only just starting to be explored (25).

There is a new field of interdisciplinary research that quantifies the effects and investigates the underlying mechanisms of health and well-being from sustainable coastal interactions for both humans and marine ecosystems (7). The additional possible contributions of evolutionary, environmental and cultural factors at the individual and community levels need to be evaluated systematically. The involvement of public health and medical researchers as well as social scientists in working with marine scientists and diverse stakeholders would strengthen the interdisciplinarity of work.

All 10 targets specified under SDG 14 are relevant to human health and well-being. For sustainable development, research and action should be applied not only to preventing risk but also to exploring opportunities. Human interactions with marine environments, if sustainable, could bring about new benefits. Improved governance and strengthened international collaboration are the main pillars of action towards SDG 14.

Commitments to act

Governments have signed many international treaties, agreements and protocols on restoring and protecting the marine environment, and many of them also address impacts on human health

- /// The London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1975) and its Protocol (1996) (46)
- /// The United Nations Convention on the Law of the Sea (1982) (47)
- /// The Bucharest Convention on the Protection of the Black Sea against Pollution (1992) (48)
- /// The Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (1992) and its Action Plan (2007) (49)
- /// The OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic (1992) (50)
- /// The Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (1995) and its Protocols (2005) (51)
- /// The Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea (2009) (52)
- /// The Minamata Convention on Mercury (2013) (34,53)
- /// The United Nations Decade of Ocean Science for Sustainable Development (2021–2030) (45,54)

Legislation addressing plastic pollution

- // Measures to protect the marine environment, such as the EU Marine Strategy Framework Directive (55)
- // Measures focused on waste, such as the EU Directive on Waste (56)

The Ocean Conference, 2017 (57)

Voluntary commitments (1400) to concrete action to advance implementation of SDG 14 were made by 193 Member States, the United Nations system, civil society organizations, academia, the scientific community and the private sector (58), with progress updated online. Examples of commitments include:

- // The **Norwegian Ocean Acidification** monitoring project, which collects and monitors carbon cycle data in Norwegian waters (the North Sea, the Norwegian Sea and the Barents Sea) to identify trends and characteristics of ocean acidification in these areas
- // The **Fish Homes** project in the Maremma Region of Italy grew out of long years of battling by artisanal fishermen against the encroachment of industrial fishing that destroys fish stock. It supports action to provide complete protection from illegal fishing in the entire area and to create an artistic and cultural attraction for seaside tourism and diving
- // The **Marine Adventures Respecting Environment (MARE)** is a European voluntary project promoted and coordinated by the Marine Protected Area of Punta Campanella, which protects the sea and around 40 km of coastline. The project hosts young people from different nations to support its activities of environmental education and protection
- // **π³=Plastic Pollution Prevention**, an organization based in Greece, aims to prevent and restore the marine environment from plastic pollution as well as to inform and raise awareness, particularly with young people, through developing sustainable sports events and voluntary beach clean-ups

The WHO European Region has also made a number of commitments

- // The European environment and health process, driven by a series of ministerial conferences held every five years (59)
- // The Parma Declaration on Environment and Health (2010), working towards safe environments, preventing exposure to harmful substances and ensuring access to safe water and sanitation (60)
- // Health 2020: A European Policy Framework and Strategy for the 21st Century (2013) (61)
- // The Ostrava Declaration (2017) (62), emphasized efforts to improve environmental health conditions in line with the 2030 Agenda (31)
- // The Roadmap to implement the 2030 Agenda for Sustainable Development (2017) (32)

Resources

Codex Alimentarius

The Food Code is a collection of standards, guidelines and codes of practice adopted by the Codex Alimentarius Commission. The Commission is the central part of the Joint FAO/WHO Food Standards Programme and was established by FAO and WHO to protect consumer health and promote fair practices in food trade (63).

EMODnet (European Marine Observation and Data Network)

EMODnet is a network of organizations, supported by the EU's integrated maritime policy, that work together to observe the sea, process data according to international standards and make that information freely available as interoperable data layers and data products. The website offers rapid access to reliable and accurate information needed for addressing threats to the marine environment, for the development of policies and legislation to protect vulnerable areas of coasts and the global ocean, and for understanding trends and forecasting future changes (44).

Ocean Literacy Portal

The Portal is a worldwide one-stop shop run by the Intergovernmental Oceanographic Commission to provide resources and content available to all, with the goal of creating an ocean-literate society able to make informed and responsible decisions on ocean resources and ocean sustainability (64).

Sea Change: Our Ocean, Our Health

This project funded by the EU's Horizon 2020 programme aims to establish a fundamental sea change in the way European citizens view their relationship with the sea, by empowering them, as ocean-literate citizens, to take direct and sustainable action towards a healthy global ocean, healthy communities and ultimately a healthy planet (65).

The Ocean Economy in 2030

This report exploring the growth prospects for the ocean economy, its capacity for future employment creation and innovation, and its role in addressing global challenges (66).

Key definitions

DDT (dichlorodiphenyl- trichloroethane)

A broad-spectrum and long-lasting insecticide developed in the 1940s as the first of the modern synthetic insecticides. It was initially used with great effect to combat malaria, typhus and the other insect-borne human diseases. It also became used for insect control in crop and livestock production both commercially and in gardens. Its use led to many insect pest species becoming resistant, with resistant mosquito populations emerging, and it also killed useful insects such as the honey bee (67). DDT has been recommended as part of the arsenal of insecticides available for indoor residual spraying until suitable alternatives are available. Approximately 14 countries use DDT for disease control, and several countries are preparing to reintroduce DDT. Concerns about the continued use of DDT are fuelled by recent reports of high levels of human exposure associated with indoor spraying amid accumulating evidence on chronic health effects (68).

Excessive plant and algal growth due to the increased availability of one or more limiting growth factors needed for photosynthesis, such as sunlight, carbon dioxide or nutrient fertilizers. Eutrophication occurs naturally over centuries as lakes age and are filled in with sediments but human activities have accelerated the process through discharges from a single source, such as a sewage treatment plant, and excess input of limiting nutrients, such as nitrogen and phosphorus, into aquatic ecosystems (i.e. cultural eutrophication). Eutrophication has dramatic unwanted consequences for drinking-water sources, fisheries and recreational water bodies (69).

Eutrophication

Global ocean

The vast body of water that covers 71% of the Earth's surface and includes all marine water (apart from the two inland seas, Black and Caspian). The global ocean is geographically divided into distinct named regions with boundaries that have evolved over time for a variety of historical, cultural, geographical and scientific reasons. Historically, there are four named oceans: the Arctic, Atlantic, Indian and Pacific. However, most countries now recognize the Southern (Antarctic) Ocean as the fifth ocean (4).

Proliferation of some taxa of the normal aquatic photosynthetic organisms to levels that may cause harm to humans and other organisms. Aquatic ecosystems are supported by photosynthetic organisms (e.g. macrophytes, benthic and planktonic microalgae and cyanobacteria) that fix carbon, produce oxygen and constitute the base of food webs. Harmful algal blooms can occur in all aquatic environments (e.g. freshwater, brackish and marine) and at all latitudes (70).

Harmful algae blooms

Heavy metal

Any metallic chemical element that has a relatively high density and is (usually) toxic at low concentrations (e.g. cadmium, copper, mercury, nickel, silver or zinc). Although the term heavy metal is common, there is no standard definition assigning metals as heavy metals (71).

Protective management of natural areas in order to keep them in their natural state for reasons including economic resources, biodiversity conservation and species protection. Delineating zones have permitted and non-permitted uses (72).

Marine protected areas

Ocean acidification

Absorption of carbon dioxide by seawater leads to reduction in seawater pH, carbonate ion concentration and saturation states of biologically important calcium carbonate minerals. Ocean species are expected to be impacted in varying ways. Calcium carbonate minerals are the building blocks for the skeletons and shells of many marine organisms (e.g. oysters, clams, sea urchins, shallow water corals, deep sea corals and calcareous plankton) and continued acidification has been shown to have a dramatic effect on these species, with negative impacts on marine ecosystems and aquaculture. Photosynthetic algae and seagrasses may benefit from higher carbon dioxide absorption as they require carbon dioxide just like plants on land (73).

These essential polyunsaturated fats must be obtained from the diet and are required for fetal development, for the regulation of cell activity and for healthy cardiovascular function. They also deliver health benefits such as lowering elevated blood cholesterol levels. Eicosapentaenoic acid and docosahexaenoic acid are primarily found in certain fish. Alpha-linolenic acid is found in plant sources such as nuts and seeds (74).

Omega-3 fatty acids

Polychlorinated biphenyls

Very stable oily liquids or solids that are resistant to extreme temperature and pressure. They were widely used since the 1930s as dielectric fluids in capacitors and transformers and for other applications such as flame retardants, ink solvents and plasticizers (75). In the 1970s, their adverse effects on the immune system, liver, skin, reproductive system, gastrointestinal tract and thyroid gland became prominent and their use was phased out (76).

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