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Integrated ocean management for a sustainable ocean economy

Jan-Gunnar Winther[1,2]✉, Minhan Dai[3], Therese Rist[1], Alf Håkon Hoel[4,5], Yangfan Li[6], Amy Trice[7], Karyn Morrissey[8], Marie Antonette Juinio-Meñez[9], Leanne Fernandes[10,15], Sebastian Unger[11], Fabio Rubio Scarano[12], Patrick Halpin[13] and Sandra Whitehouse[14]

The rapidly evolving ocean economy, driven by human needs for food, energy, transportation and recreation, has led to unprecedented pressures on the ocean that are further amplified by climate change, loss of biodiversity and pollution. The need for better governance of human activities in the ocean space has been widely recognized for years, and is now also incorporated in the United Nations Sustainable Development Goals. Even so, many challenges relating to the implementation of existing governance frameworks exist. Here, we argue that integrated ocean management (IOM) should be the key overarching approach—building upon and connecting existing sectoral governance efforts—for achieving a sustainable ocean economy. IOM is a holistic, ecosystem-based and knowledge-based approach that aims to ensure the sustainability and resilience of marine ecosystems while integrating and balancing different ocean uses to optimize the overall ocean economy. We discuss examples of IOM in practice from areas where preconditions differ substantially, and identify six universal opportunities for action that can help achieve a sustainable ocean economy.

Human needs for food, energy, transportation, recreation and other services from the ocean are increasing rapidly. As a result, the ocean economy is growing at an unprecedented rate[1]. Existing ocean industries are expanding, and with innovation and technology, new ones are appearing[2,3]. Following the unprecedented growth in economic activities relating to the ocean, the need for a sustainable concept where socioeconomic development can occur without environmental degradation or inequity is widely recognized[4,5]. Today, sectoral interests and conflicts between short-term economic gains or immediate needs versus long-term prosperity and a healthy ocean are increasingly apparent, creating dilemmas for governance[6,7]. This situation is further complicated by compounding pressures such as climate change, pollution and widespread loss of biodiversity[8]. In light of this, opportunities for and challenges to achieving sustainable development of our ocean and seas have reached the top of the international agenda in forums such as the G20[9], the United Nations (UN) Ocean conferences, the World Economic Forum, the Our Ocean conferences[10], and the High Level Panel for a Sustainable Ocean Economy[8,11–13]. They are also prominent in the UN Sustainable Development Goals (SDGs)[14,15].

Here, we argue that there is an increasing need for a holistic, ecosystem-based and knowledge-based overarching approach that ensures the sustainability and resilience of marine ecosystems. This approach must at the same time integrate and balance different ocean uses to optimize the overall ocean economy, as well as maintain and further develop the sector-based management required for effective management of ocean industries (Fig. 1). Integrated ocean management (IOM) offers such an approach. We identify universal characteristics of successful IOM, and the need for tailor-made solutions to address different contexts including local knowledge, environmental conditions, scaling-up of local actions, and the need for data sharing and capacity building.

Opportunities for sustainable ocean management

The goal of IOM is to preserve the long-term health and resilience of marine ecosystems while improving livelihoods and creating jobs that support a sustainable ocean economy by managing ocean resources in an integrated way (Box 1)[16]. Developing an integrated and adaptive framework for IOM requires forming partnerships between public authorities, businesses, civil societies, academia and the financial sector—the so-called pentahelix model[17].

The global framework for ocean governance, the centrepiece of which is the UN Convention on the Law of the Sea (UNCLOS)[18], has evolved considerably over the last decades, responding to technological developments, increasing demands for natural resources and a growing use of ocean space for human activities[19]. The basis for UNCLOS is coastal state jurisdiction over their 200 nautical mile exclusive economic zones (EEZs) (Fig. 2). UNCLOS-related implementation agreements have been negotiated for deep seabed minerals[20] and for fisheries[21], and governance bodies and legal instruments are in place for a number of other specific ocean issues such as shipping and pollution[22,23]. The legal

[1]Centre for the Ocean and the Arctic, Tromsø, Norway. [2]Norwegian Polar Institute, Tromsø, Norway. [3]State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China. [4]College of Fisheries Science, UiT The Arctic University of Norway, Tromsø, Norway. [5]Institute of Marine Research, Tromsø, Norway. [6]Key Laboratory of Ministry of Education for Coastal and Wetland Ecosystems, College of the Environment and Ecology, Xiamen University, Xiamen, China. [7]Ocean Conservancy, Washington, DC, USA. [8]The European Centre for Environment & Human Health, University of Exeter, Exeter, UK. [9]The Marine Science Institute, University of the Philippines, Quezon City, Philippines. [10]International Union for Conservation of Nature, Suva, Fiji. [11]Institute for Advanced Sustainability Studies (IASS), Potsdam, Germany. [12]Ecology Department, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil. [13]Duke University, Durham, NC, USA. [14]Ocean Conservancy Consultant, Washington, DC, USA. [15]Present address: College of Science and Engineering, James Cook University, Townsville, Queensland, Australia. ✉e-mail: winther@havarktis.no

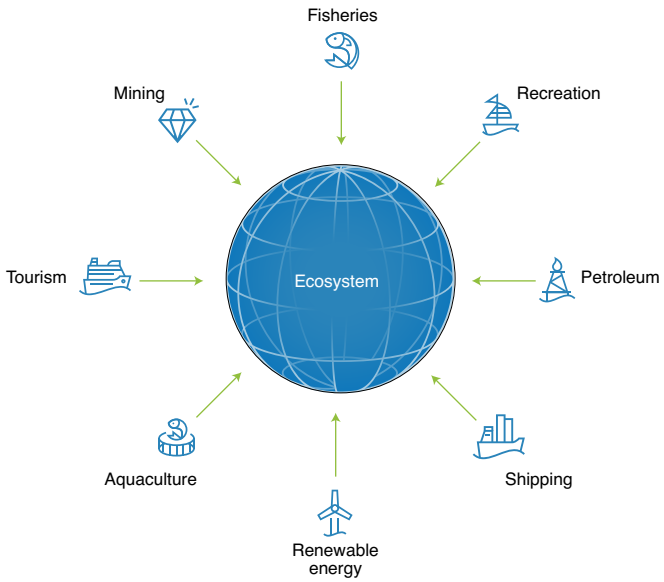

Fig. 1 | Integrated ocean management as the hub for balancing various ocean uses and the marine environment. The goal of IOM is to integrate and balance various ocean uses and environmental aspects to obtain a 'healthy and wealthy' ocean: long-term, sustainable use of ocean resources in ways that preserve the health and resilience of marine ecosystems and improve livelihoods and jobs, balancing protection and production. IOM brings together relevant actors from government, business, academia and civil society from the entire spectrum of ocean-related human activities (for example, fishing, recreation, petroleum, shipping, renewable energy, aquaculture, tourism and mining) to interact toward a sustainable future for our ocean environment. A key to successful IOM is the use of a knowledge-based and ecosystem-based approach. Stakeholder engagement and coordinated decision-making, particularly with ocean businesses, is another central aspect of successful IOM. Credit: Centre for the Ocean and the Arctic.

framework, however, remains inadequate with regard to protecting marine biodiversity in areas beyond national jurisdiction, and was not devised with the effects of climate change in mind[24]. Overall, implementation is hindered by inadequate knowledge and capacity shortages, incomplete legislation and enforcement failures, and a lack of political will to prioritize the actions needed to implement the international agreements[4]. Ocean management currently often occurs in silos, sector by sector, with poor coordination between ministries and other government bodies that do not have an overarching mandate or mechanism to harmonize the actions and policies. With increasing use of and pressures on the ocean, we now also need mechanisms to address the cumulative effects of economic development and environmental change, as well as adaptive management tools to address climate change impacts (Fig. 3).

In 2015, the UN General Assembly adopted 17 SDGs as part of the 2030 Agenda. Several of the interlinked SDGs are essential in relation to the ocean and seas and contain specific targets and timetables for achieving them. Goal 14—'Life Below Water'—addresses marine issues specifically[14]. This goal provides opportunities to both facilitate concrete actions for ocean sustainability and foster greater integration in ocean governance.

In this analysis, a set of case studies from places ranging from developed coastal states to small island developing states illustrates differences in implementation goals, jurisdiction types and management scales of IOM in practice. These case studies provide insights into how locally tailored governance can be implemented. In addition, we identify general opportunities for action for achieving successful IOM.

Integrated ocean management in practice

The starting point for this analysis is a study of IOM in practice in different parts of the world: China, the Coral Triangle (Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor-Leste), Norway, the Seychelles and the United States. The five case studies represent vastly different situations with respect to climatic and oceanic conditions, geographical scales, the nature of economic activities, and political contexts and regulatory environments. Nevertheless, there are important commonalities that provide lessons for other contexts. The common denominator is that increasing uses of and pressures on marine and coastal ecosystems drive the need to consider the totality of pressures on the entire ocean space (Fig. 1).

The first lesson learned is that climate change is manifesting itself in each of the areas studied—in tropical, temperate and Arctic marine environments—posing a major challenge to ocean management. In this respect, IOM is a way of addressing multiple ocean uses while integrating the impacts of climate change into management. The Seychelles is an example of a state that has incorporated climate change adaptation into a marine spatial planning process to support both its ocean economy and environmental goals. The goals of the Seychelles Marine Spatial Plan Initiative are to address climate change adaptation, protect 30% of the Seychelles' waters, and support the Blue Economy Roadmap and other national strategies[25].

Second, information is key. It is critical to have robust data series on the evolution of essential environmental variables as well as on economic activities. Also, such data must be translated into information that is useful for management. Information should be transparent, accessible, scientifically sound, updated and in appropriate formats. The Coral Triangle Initiative is an example where formal and informal platforms for data sharing and capacity building have been important for facilitating regional and broader-scale policy support and frameworks to harmonize various national action plans[26].

A third lesson is that implementation—moving from paper to practice—is essential. Foundation in law is, however, not a prerequisite for successful IOM. In some cases, legal authority can make it easier to define objectives and goals, as was the case with Massachusetts in the United States. In other places, such as Rhode Island in the United States, reinterpreting existing legal frameworks created the mechanism for IOM and has been a constructive way forward[27]. A different example is Norway, where sector-based legislation combined with overarching management plans rely on political will rather than on a separate legal basis for IOM[28].

Fourth, stakeholder involvement is critical to both ensure that the practical information needed to develop IOM measures is available, and build the legitimacy required for effective implementation. For example, in the Coral Triangle, stakeholder engagement has been ensured by letting local community members manage marine protected areas (MPAs)[29,30]. This approach has successfully alleviated the previous perception of MPAs as serving conservation or protectionist interests, not human interests, thus driving a top-down, nature-centric agenda that alienates local communities and ends up marginalizing conservation. In community-based MPAs in Papua New Guinea that protect grouper spawning aggregations, there was a tenfold increase in the reproductive population compared with an unprotected site after five years, as a result of the initiative[31].

Fifth, IOM needs to be institutionalized. There has to be a designated process for determining how to consider the various pressures on and uses of ocean space in a comprehensive manner and make decisions on that basis. For example, in Xiamen, China, the municipality initiated an integrated coastal management leadership group consisting of the mayor and officials from different governmental departments, under which an ocean office was established and

Box 1 | Definition of integrated ocean management and related planning and management approaches

Integrated ocean management (IOM) is a holistic, ecosystem-based and knowledge-based approach to planning and managing the use of ocean space, with the goal of balancing various uses and needs to achieve a sustainable ocean economy along with healthy ecosystems[13]. Hence, stakeholder engagement is essential to IOM. The tools to achieve IOM are plentiful and the large number of concepts related to IOM can be confusing, but ecosystem-based management and marine spatial planning are at its core.

The below list is not exhaustive but provides an overview of the key means to achieving thoughtful planning and management in coastal and marine areas. IOM uses a variety of these tools. These ideas, terms and concepts have evolved through time and have had different histories in different places. They are not necessarily interchangeable, and they often overlap.

- **Ecosystem-based management (EBM)**, also referred to as an '**ecosystem approach**', is central to IOM and defined as the management of natural resources focusing on the health, productivity and resilience of a specific ecosystem, group of ecosystems, or selected natural assets as the nucleus of management[81–83]. It recognizes the full array of interactions within an ecosystem, including with humans, and seeks integration of management planning and implementation across sectoral agencies[84].
- **Marine spatial planning** (**MSP**), also known as '**maritime spatial planning**' and '**coastal and marine spatial planning**', is a process used to create geospatial plans that identify what spaces of the ocean are appropriate for different uses and activities. MSP is widely used for setting targets for and implementing ecosystem-based management[85].
- **Integrated coastal zone management** (**ICZM**), also called '**integrated coastal management**', is 'the process of managing the coast and nearshore waters in an integrated and comprehensive manner with the goal of achieving conservation and sustainable use'[85]. ICZM covers the full cycle, including information collection, planning, decision-making, management and implementation[86].
- **Adaptive ocean management** is 'a systematic process for continually improving management policies and practices toward defined goals by learning from the outcomes of previous policies and practices'[85]. By scheduling periodic reviews of and updates to management plans, adaptive ocean management acknowledges that policies must be adjusted as conditions and knowledge change.
- **Area-based measures** are important tools in ocean management and can be used in all approaches outlined here. Area-based management tools include **marine protected areas (MPAs)**—'clearly defined geographical space[s], recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values'[87].

tasked with organizing regular meetings with ocean-related sectors within aquaculture, transportation, construction, and science and technology[32].

A final lesson is that due regard needs to be given to context. It is critically important to tailor IOM to the characteristics and needs of the region in question. The concrete economic activities, community needs, societal goals and environmental pressures should be the point of departure for the development of IOM. This is a shared experience across all the case studies.

Based on these complementary case studies—which call for tailor-made solutions—and the scientific literature in the field, we have also identified six general opportunities for action for achieving successful IOM: harnessing knowledge, establishing partnerships between public and private sectors, strengthening stakeholder engagement and stewardship, improving capacity building, implementing regulatory frameworks, and encompassing climate change and other environmental changes in adaptive management systems (Fig. 4).

Harnessing knowledge

There are large knowledge gaps in the following areas: the abundance of and biological interactions among marine living resources; the consequences of existing and future human activities; the opportunities in the digital and technological revolutions; and the consequences of climate change, biodiversity loss and marine litter on marine ecosystems[30,33]. The upcoming UN Decade of Ocean Science for Sustainable Development (2021–2030)[34] is an opportunity to strengthen the knowledge system needed for ocean policy and action at various levels of governance. The Decade seeks to secure the clean, safe, healthy, resilient, productive, predictable, transparent and accessible ocean we need for the future we want.

The 2017 *Global Ocean Science Report* demonstrates clearly that many countries lack fundamental scientific capacity to support their efforts on ocean governance[35]. In these cases, scientific capacity is needed to assemble the information required to manage marine ecosystems and economic activities, and to underpin the establishment and implementation of regulatory measures. Tools are needed to develop, strengthen and coordinate the management of human activities in marine ecosystems. These include increasing science and monitoring efforts, knowledge sharing, and the transfer of technology and digital infrastructure—tools that are especially crucial in the least-developed countries and small island developing states[35]. Relevant and accessible data and clearly defined goals for management, coupled with research and science plans, are important for achieving and advancing IOM[36].

To address this, we recommend strengthening the global ocean knowledge system—including social science, which is often lacking[37]—and building on the UN Regular Process[38] and the efforts of the Intergovernmental Oceanographic Commission (IOC)[35,39]. An important initiative could be to follow up on the 2015[40] and 2020[41] editions of the UN World Ocean Assessment. Strengthening the role of the IOC would also build on already existing structures to enhance the attention given to marine science and help generate the resources needed to develop scientific knowledge, scientific capacity building worldwide, and effective frameworks for transferring knowledge to decision-makers and other key societal actors in developing countries. A process and platform could be the UN Decade. To be effective, such efforts at the global level need to be complemented by actions at the regional and national levels. The International Council for the Exploration of the Sea is a good model for how regional ocean science cooperation can benefit actual ocean management.

Establishing partnerships between public and private sectors

Currently, investments, infrastructure and businesses are developed within ocean industries that have differing definitions of and standards and visions for achieving sustainability and governance[4]. In practice, long-term sustainability can be achieved only if best practices are applied across the public, scientific and private sectors and where productive partnerships are established (Fig. 1). IOM is an approach that brings together relevant actors from government, business, academia and civil society, from the entire spectrum of activities—including petroleum, fishing, aquaculture, shipping, renewable energy, mining, tourism and recreation—to collaborate

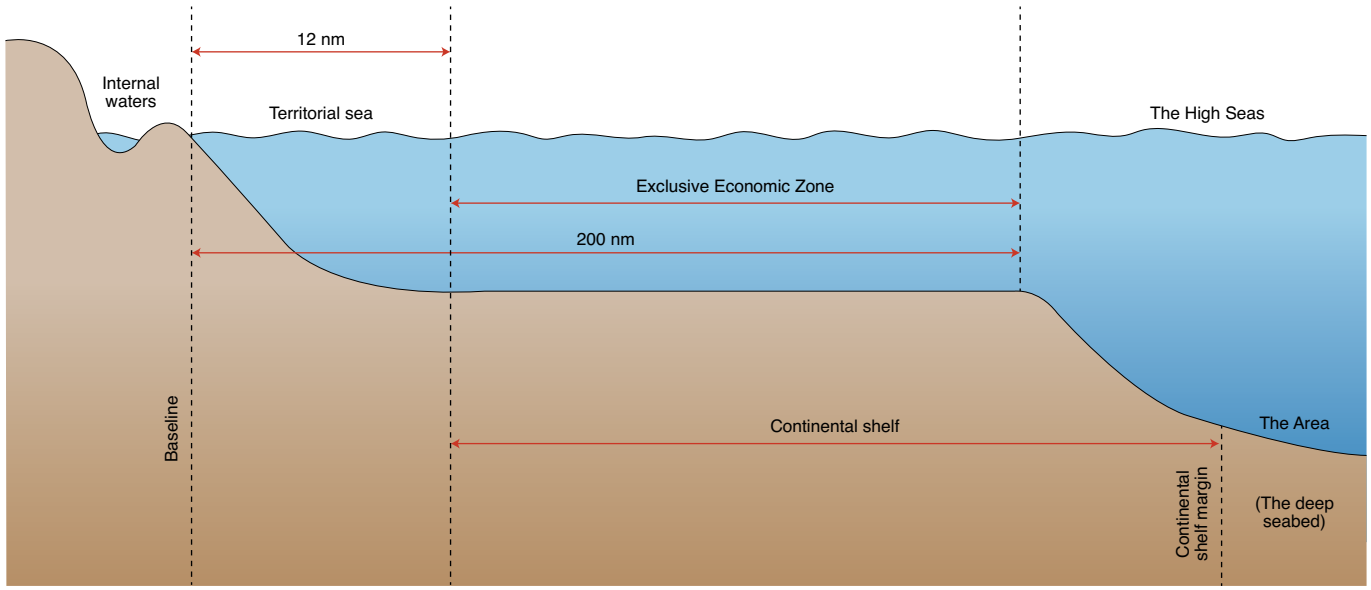

Fig. 2 | Overview of maritime zones including the Exclusive Economic Zone (EEZ) and High Seas. The United Nations Convention on the Law of the Sea (UNCLOS) is the basis of the global framework for ocean governance. It establishes a legal order for the oceans and seas where coastal states have sovereign rights over the natural resources in a 200 nautical mile exclusive economic zone and on the continental shelf also beyond 200 nautical miles. The mineral resources on the deep seabed beyond national jurisdiction ('the Area') are the common heritage of mankind, and the International Seabed Authority is tasked with their management. Integrated ocean management can be implemented across several ocean economy sectors, jurisdictions and spatial scales. This may take the form of localized ocean management within national waters, sector-defined ocean management across adjacent jurisdictions, at regional seas or at ocean basin scales, or international ocean management occurring across large ocean areas in areas beyond national jurisdiction, including in the Area. Credit: Norwegian Polar Institute.

for a sustainable future for our marine environment. Good governance and partnerships can bring long-term solutions that advance the economy, develop societies and ensure environmental health in accordance with the SDGs[15,42].

In the context of IOM, it is particularly important to engage ocean businesses at the global, national and local levels. In recent years, ocean businesses have repeatedly joined forces for sustainability[43]. One example is the UN Global Compact Sustainable Ocean Business Action Platform (the 'UN Global Compact'), which has developed principles and guidelines for sustainable ocean businesses that several of the largest ocean-related enterprises globally have signed on to[44].

We suggest advancing and clarifying the responsibilities of the private sector through a set of 'Ocean Principles' for a sustainable ocean economy, modelled after the Carbon Principles and developed by the businesses themselves. The UN Global Compact could serve as a starting point and inspiring model. A further development would be to give market benefits to private companies that are able to develop transparent and traceable supply chains demonstrating sustainability and contributing to the implementation of the SDGs. By doing so, businesses would empower consumers to change the markets[8,12].

Strengthening stakeholder engagement

Defining and implementing sustainable solutions in local communities requires the knowledge, involvement and stewardship of local stakeholders[45]. Further, one could argue that the agreement made by the world community on achieving the SDGs will fail if we are unsuccessful in implementing a large number of locally relevant projects[4].

The case studies demonstrate that active community participation and inclusion of traditional and local knowledge have proven useful at the local level for establishing and operating ocean governance[13].

Fig. 3 | Increasing uses and pressures on the ocean space illustrated by the Norwegian Arctic. The ocean economy is growing alongside our need for food, energy, transportation and recreation from the ocean. Existing ocean industries expand while new ones, such as offshore floating wind and sub-sea mineral extraction, appear. This is illustrated here by the Norwegian Arctic, where a number of business sectors share the same ocean space. At the same time, new challenges are emerging as a result of climate change, loss of biodiversity, pollution and extractive activities. Thus, our ocean is now facing these pressures at unprecedented rates and magnitudes. In this study, we find the common denominator is that increasing uses of and pressures on marine and coastal ecosystems drive the need to consider the totality of pressures on the ocean. Credit: Norwegian Oil and Gas Association.

Planning at the local level—especially in developing countries—requires taking approaches that are tailored to the diverse environmental and socioeconomic contexts and governance systems

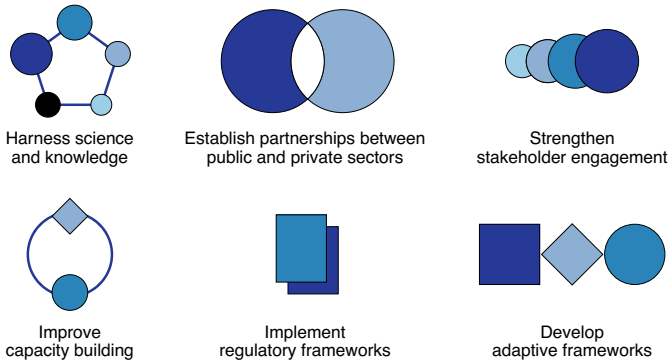

Fig. 4 | Opportunities for action. Although successful implementation of IOM needs to reflect local conditions, we suggest the following six universal opportunities for action to help achieve integrated ocean management for a sustainable ocean economy: harness science and knowledge; establish partnerships between public and private sectors; strengthen stakeholder engagement and stewardship; improve capacity building; implement regulatory frameworks; and encompass climate change and other environmental changes in adaptive management systems. Credit: Centre for the Ocean and the Arctic.

in these regions[7]. For example, the approaches need to address the complexity of different governance regimes, ecological scaling and context-specific situations[46]. Developing such strategies and implementing them also requires time, resources and political will that sometimes are limited or absent[47,48].

When building strong local stakeholder involvement, it is important to design well-managed engagement processes that consider the cultural, scientific, societal, economic and political contexts that underpin robust stakeholder participation[49]. An example of such an approach is the Coral Triangle Initiative, a formal intergovernmental partnership[26,50]. We suggest that governments support the active involvement of local and traditional communities in all stages of IOM planning and development at the local level.

Improving capacity building

Capacity building enhances scientific and regulatory proficiency as well as institutional and collaborative capabilities. It is widely recognized that capacity building is critical to strengthening ocean governance[51,52]. In many cases, the ability to implement existing rights and obligations following from international agreements is hampered by inadequate science, weak regulatory frameworks and the poor enforcement of those frameworks due to a wide variety of factors including lack of political will[53]. The importance of building resilient and effective institutions capable of performing these tasks can hardly be overstated[54]. Ocean literacy and education pertaining to ocean uses and management are also critical[55].

In this regard, it is imperative to make use of knowledge about climate change, biodiversity loss and marine pollution[11]. The scientific capacity needed to implement the management principles embodied in international governance frameworks is severely lacking in many countries[35]. Capacity building, primarily based on but also amplifying the provisions of existing regional and intergovernmental organizations and institutions, therefore needs to remain at the top of the international agenda.

At the national level, it is essential that government agencies involved in ocean management are properly institutionalized, and have the skills, knowledge, resources and authority to address challenges relating to the ocean and communities depending on them in a long-term, integrated manner[56,57]. New technologies combined with public transparency creates opportunities for monitoring inappropriate behaviour at sea, including practical and inexpensive solutions such as Global Fishing Watch, which supports governmental enforcement efforts against illegal fishing, among other needs[58]. Additionally, the ocean science enterprise is advancing technologies that allow us to collect scientific data with less cost and higher efficiency than ever before[59,60]. One example is the complex adaptive systems framework, which acknowledges the interconnectedness of social and ecological systems[42]. Having transparency; solutions tailored to the local context; data standards and metadata in place; and new, innovative ways of extracting data are key to capacity building[61]. The Northeast Regional Ocean Data Portal is an example of transparent data within an IOM framework. Regional cooperation can also be an effective vehicle for strengthening the role of science and providing advice for management, as demonstrated by, for example, the International Council for the Exploration of the Sea in the North Atlantic and the Western Indian Ocean Marine Science Association in the Western Indian Ocean[62,63].

Implementing regulatory frameworks

Failure to implement existing international instruments is perhaps the most important weakness of ocean governance systems[64]. The global ocean governance framework is supplemented by many regional instruments[46], often combined with national legislation. However, implementation of the existing legal frameworks is often inadequate and ineffective[65], and important legal gaps with regard to the conservation and sustainable use of marine biodiversity beyond national jurisdiction (BBNJ) remain (Fig. 2)[24].

There is also a need for subnational action plans and strong leadership to achieve successful implementation of IOM[25]. Important work is underway to address these shortcomings at the global and regional levels of governance, including efforts to strengthen the implementation of regulations from regional fisheries management organizations, negotiations on BBNJ, and the development of a seabed mining code by the International Seabed Authority[66].

A leading principle should be the effective implementation of international agreements in domestic legislation and practices, including for activities in the high seas. In this respect, regional cooperation is essential. In practice, we suggest that regulations for managing human activities in the high seas[67] be coherent and compatible with—and at least as strict as—those that apply in areas under national jurisdiction. Developing a strong, legally binding instrument for BBNJ, as well as ratifying the key international instruments for ocean governance and coordinating implementation of their provision, including UNCLOS and related instruments, is a precondition for this. Furthermore, we recommend that regulatory frameworks for areas both beyond and under national jurisdiction reflect the connectivity of ecosystems, which cross borders and jurisdictions, building on the best available science.

Developing adaptive solutions

Marine ecosystems are by nature very dynamic over space and time[68]. There are strong variations in physical, chemical and biological characteristics with depth as a third dimension, unlike in terrestrial systems[69]. Thus, ocean governance needs to reflect the dynamism of the ocean[64,70].

Today, the dynamic nature of the ocean is amplified by climate change, which, in our view, is the most serious of all pressures the ocean is currently facing[11,71]. Many regions already suffer from the effects of climate change, especially the least-developed countries and small island states where coastal communities and even whole countries are threatened[72]. These challenges are further exacerbated when ocean management systems are not holistic and adaptable[73]. We argue that forward-looking, adaptive solutions where risk is explicitly considered will become an even more important element of IOM.

Climate change is manifesting itself in tropical, temperate and polar marine environments[71]. Sea level rise, ocean warming and deoxygenation, ocean acidification, changing storm intensities, and melting sea ice, as well as migrating species, are examples of consequences of climate change already representing major challenges to ocean management[11]. Current climate projections indicate that societies must prepare for an even more disturbing situation in the future[71]. In this respect, IOM represents an important tool for addressing multiple uses while considering the impacts of climate change and improving the resilience of marine ecosystems.

With increasing uses of and pressures on the ocean, concerns regarding the cumulative impacts on marine ecosystems have grown[74,75]. UNCLOS recognizes these concerns on a general basis, while some national governance plans address them specifically and take the approach that cumulative impacts need to be an integrated part of IOM[76]. On this basis, we recommend that IOM is used as a way to capture the dynamic nature of marine ecosystems as well as the connectivity and differences between land and ocean in an integrated, adaptive and forward-looking manner[64]. Thus, we suggest that ocean governance considers expected future changes in the ocean environment by using the best available scientific knowledge on climate change[77,78]. For example, due to climate change, a static approach to establishing MPAs may lose its effect over time in preserving the ecosystem values it was originally established to preserve[79].

Conclusions

We argue that there is a pressing need to take an integrated approach to ocean management, and identify several central components for successful IOM. Achieving a healthy, productive and resilient ocean requires taking a holistic perspective on ocean use and management, and effectively implementing relevant national and international management measures. Given the current levels of pressures on many marine regions in our ocean[74], few human activities can be viewed in isolation. To preserve ocean health and fully capitalize on the economic potential of the ocean in a sustainable way, we must consider the cumulative impact of all human activities in the ocean, as well as how those activities affect each other and other issues[13]. The need for an integrated, ecosystem-based and knowledge-based approach to ocean governance is more pressing than ever.

It is, however, also critically important to further develop and maintain effective sector-based management. Effective regulation of, for example, shipping, petroleum-related activities, or pollution can be achieved only by implementing dedicated and precise regulatory measures and assigning competent agencies to implement them.

The statuses of marine ecosystems and their properties and characteristics vary considerably[80]. IOM enables an understanding of the totality of ocean uses and pressures and provides guidance for how to prioritize among these various uses. Governance solutions need to be tailored to the characteristics and problems of the different marine regions—one size does not fit all. Understanding context is essential.

Governments, in partnership with ocean industries, need to ensure that industries do not degrade the environment they and others depend on. It is critical that short-sighted solutions with negative environmental impacts are replaced with long-term solutions. To this end, important knowledge often exists but is not used in decision-making for several reasons, including a lack of efficient science–policy interfaces[4]. The precautionary principle should be applied where knowledge is insufficient and where there are threats of serious or irreversible damage. Also, effective ocean governance must consider advancements in technology, the impacts of climate change, and the dynamic nature of the ocean and seas, as well as the interactions and synergies between land, ocean and people[19].

Furthermore, the need for enhanced regional collaboration is critical. Ecosystems and economic activities often occur in several jurisdictions and across national boundaries. Also, activities in the marine realm can have widespread, cross-border impacts[3]. In the case of such transboundary situations—for example, in fisheries management[7] or in the prevention of marine pollution—regional cooperation is necessary to address the problems at an appropriate geographical scale. At the local level, connectivity among people and institutions plays a vital role in ensuring sustainable ocean governance.

Finally, climate change represents a challenge vastly larger than anything we have faced before. The ocean is intimately connected to climate and vice versa[71]. Perhaps the most important issue in the future is therefore our ability to efficiently take action on climate change[8]. Questions of adaptation and risk management loom large in this respect and are critical dimensions of all opportunities for action discussed in this Perspective.

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Author contributions

J.-G.W., M.D., T.R., A.H.H., Y.L., A.T., K.M., M.A.J.-M., L.F., S.U., F.R.S., P.H. and S.W. designed the study and carried out analyses. J.-G.W., M.D., T.R. and A.H.H. wrote the paper. J.-G.W., M.D., T.R., A.H.H., Y.L., A.T., K.M., M.A.J.-M., L.F., S.U., F.R.S., P.H. and S.W. provided comments on the text and figures that helped to develop the paper.

Competing interests

The authors declare no competing interests.

Additional information

Correspondence should be addressed to J.-G.W.