

MARINE ENVIRONMENT

Resources and natural environment

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REGIONAL WORKSHOP

Human impacts on Mediterranean marine ecosystems and the economy

The Mediterranean Sea is an important hotspot of biodiversity and climate change impacts. It is now facing both chronic and acute social, economic and ecological changes and challenges. Many anthropogenic impacts have been identified in marine and coastal zones of the Mediterranean that are amplified by current and emerging climate change effects. The magnitude of impact differs between countries due to differences in geographic and demographic characteristics such as the size of the country or the profile of the coastal population (including population density), and by different levels of economic development, marine and coastal activities, and economic, consumption, production and energy models.

Context

The semi-enclosed Mediterranean Sea is shared by more than 20 countries spread across three continents, which have important cultural, physical and economic differences. The economic development of this sea is based on two main sectors: fisheries and tourism. Commercial fisheries play a vital role in human society, particularly in the Southern shores where alternative sources of income are scarce. In addition, Mediterranean countries attract more than 30% of the tourism trade globally, due to their attractive landscapes, culture, climate and biodiversity. The development of the tourism sector has provided economic gains, especially for countries on the north coast of the Mediterranean Sea, but this has been at the detriment of environmental and social equity. The region is an important hotspot of marine biodiversity, hosting 7 to 10% of the world's known species in less than 0.5% of the ocean's volume.

The variety of climatic conditions allows the co-occurrence of cold water, temperate and sub-tropical marine biota. This biodiversity is threatened by global, regional, and local changes, including pollution, sea level rise, ocean warming and acidification, overexploitation of resources and invasions of alien species. Unsustainable forms of tourism also harm the environment. Overall, the Mediterranean is a hotspot of climate change and marine invasions, it is subject to major anthropogenic changes with plenty of scope for a more sustainable management of its rich environmental resources.

This document was drafted following a workshop co-organised by the Centre Scientifique de Monaco and Plan Bleu (supported by the Prince's Government, the Prince Albert II Foundation and the UN Environment/Mediterranean Action Plan of the Barcelona Convention), held in Monaco in October 2017 where 45 experts from 17 countries and from various fields of expertise, social sciences and natural sciences, participated.

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This workshop allowed participants to discuss and identify the threats of human origin and their long-term impacts on marine ecosystem services and the political and scientific responses that could be put in place to reduce the impacts of these threats and their causes. Taking into account existing regional frameworks (such as the Regional Framework for Adaptation to Climate Change) and the theme chosen, expert discussions helped to define recommendations, governance actions and best practices to implement at the local and regional levels to mitigate these impacts and adapt.

The groups were formed in three parts of the Mediterranean: North, East and South to compare threats and impacts in order to propose more pragmatic solutions.

This document analyses the main threats, vulnerability and ecological and human impacts. On the consensus of a wide range of specialists in different disciplines then some responses and policy options as well as main knowledge gaps and needs are proposed as conclusions for Mediterranean decision makers.



Participants of the regional Workshop on "Human impacts on Mediterranean marine ecosystems and the economy", Musée océanographique de Monaco, 17-18 October 2017

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Southern Mediterranean countries

The five countries considered (Morocco, Algeria, Tunisia, Libya, Egypt) differ in terms of: i) importance of marine and coastal economy, ii) coastal vulnerability, type of anthropogenic stressors and threats to the coastal and marine environments, iii) human resources and technical capacities, wealth, stage of development, level of knowledge, monitoring capacity, and political context and stability.

Main threats in the region

The four main anthropogenic stressors which are negatively affecting marine and coastal ecosystems on the Southern side of the Mediterranean basin are:

- i. overfishing and illegal fishing. For example, Algeria and Tunisia overexploit commercial fish, which alters species communities. Bottom trawls also cause habitat damage and lead to bycatch of vulnerable species
- ii. urbanisation and coastal development
- iii. marine pollution
- iv. seawater eutrophication.

All of these threats lead to habitat loss, fragmentation and degradation, causing lower species richness. For example, in shallow coastal habitats, urbanization and pollution are the main causes of the degradation of seagrass meadows and coralligenous communities, that supply nurseries for numerous fish and mollusc species. Future threats include seawater warming and heat waves, invasive species, storms and extreme events.

Main ecological and human impacts

The threats listed above are directly responsible for the loss of ecosystem function and biodiversity as well as the decline in fish stocks. Therefore, abundance and diversity of important commercial and non-commercial species in littoral and sublittoral habitats are decreasing. The recovery of damaged ecosystems is hindered by other threats, such as seawater warming as well as the occurrence of invasive species.

Regarding socio-economic impacts, seven major ecosystem services related to sea and coastal areas have been identified for the Southern Mediterranean. These are tourism and leisure/recreation, fisheries, aquaculture, land and marine transportation, oil, gas and mining exploration and exploitation, desalination and natural capital conservation.

Overfishing and pollution risk to induce a loss of income and employment for fisheries, aquaculture and tourism sectors. Small-scale fishing communities and aquaculture companies would be especially affected. A loss of cultural heritage, especially in terms of artisanal fisheries and recreational activities, is also a high risk. Moreover, the depletion of fish stocks might contribute to socio-political conflicts in the context of a higher competition for fish resources. All these socio-economic impacts may contribute to a rise of inequality and loss of socio-economic welfare. In addition, pollution and seawater eutrophication impact public health, e.g. episodes of shellfish poisoning. Other threats related to climate change, such as the increase of frequency of heavy storms, flooding and extreme events may impact coastal infrastructures, as well as future oil, gas and mining exploitations in the deep sea.

Eastern Mediterranean countries

There are several drivers of change and opportunities to limit environmental degradation and improve the status of the Levantine Sea in the Eastern Mediterranean region. This basin is bordered by Turkey in the North, Syria, Lebanon, Israel and the Gaza strip in the East, with Cyprus in the Centre.

Main threats in the region

Main global threats affecting the Eastern Mediterranean region are global warming, ocean acidification, salinization, sea level rise, and loss of biodiversity. Main regional threats are social unrest, war, and displacement of people. There has been a marked decrease in fish stocks, and an increase in invasive species, summer heat waves, oil and gas exploration and heavy maritime traffic. Local socio-economic and environmental threats in the Eastern Mediterranean region include ongoing armed conflicts, coastal urbanization, marine and coastal pollution, harmful algae blooms, drought and related forest fires, coastal erosion and habitat destruction, decrease in fish stocks, oil and gas exploration, and invasive species.

Main ecological and human impacts

An important ecological impact affecting the Eastern Mediterranean region is the expansion of invasive species (such as rabbitfish *Siganus luridus* and *S. rivulatus*) due to the recent widening and deepening of the Suez Canal and high levels of maritime traffic with insufficient biosecurity controls. Secondly, marine biodiversity is threatened due to habitat destruction and pollution which leads to loss of important species in littoral and sublittoral habitats such as coralligene, seagrass beds (e.g. *Posidonia oceanica*), coral gardens and vermetid reefs. Moreover, overfishing has already generated important fish stock problems that has resulted in loss of fisheries income.

Pollution-related problems include i) noise and light pollution that harm turtles in breeding areas and impact the habitats of monk seals and dolphins, ii) air contamination that affect humans in marine and coastal areas, and iii) an increase in plastics, pharmaceuticals, organic wastes, toxic metals, PCBs, pesticides, antibiotics as well as in oil spills and pollution, sometimes related to the destruction of infrastructure caused by war.



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The main social and socio-environmental impacts observed are:

- the loss of livelihood and cultural identity;
- detrimental effects to public health as a result of air contamination, poor water quality, emerging noise pollution;
- loss of recreational area and limited access to common marine and coastal areas affecting social cohesion, development and empowerment, and welfare of all social groups which may promote tensions and conflicts between different countries leading to negative ecological and social impacts, and limits possibilities of joint investigations.

Main socio-economic adverse impacts are the loss of employment, especially in rural area, as well as the changes in employment opportunities with the decline of some sectors (e.g., small scale fisheries, artisanal crafts, and small scale agricultural production) and emerging seasonal service sectors (e.g., beauty and entertainment related seasonal work during the tourism season) that usually generate more precarious and exploited working conditions. These include the loss of subsistence economy of small-scale fisher communities which in some instances lead to migration to urban areas or shifting to tourism sector. Furthermore, the loss of access to marine resources and a declining quantity and quality of the provision of resources and services reduce revenues and have the potential to displace people, meaning significant costs and burdens to the society. Moreover, rapid and poorly planned urbanization together with ongoing armed conflicts and political tension leads to a reduced access to coastline as well as to fewer possibilities of developing sustainable tourism and recreational activities. All these socio-economic impacts usually contribute to a rise of inequality and loss of socio-economic welfare.

Northern Mediterranean countries

Main threats in the region

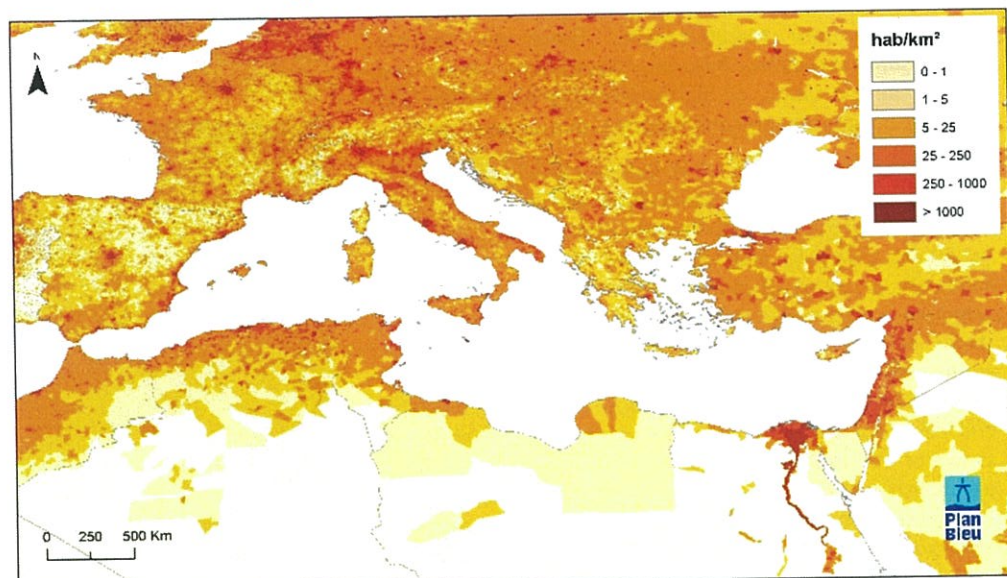
Warming (and heat waves): In the Northwestern Mediterranean Sea, seawater has warmed by 0.7 °C in the Bay of Villefranche over the last decade, a rate much higher than that observed for the global ocean. This warming is variable in time and not only due to climate change but also to oscillations in the Atlantic Multidecadal Oscillation during this period. An increase of about 2.6 °C is projected for 2100 following RCP 8.5, with the largest seasonal increase in summer and an intensification of heat waves with potential deleterious impacts on marine communities.

(Over-) Fishing: Total landings in the region increased irregularly from the 70's until mid-90's but show a significant decreasing trend since then. The vast majority of stocks are fished outside biologically sustainable limits. Fishing can also affect marine communities through undesired catch of untargeted species (bycatch) and habitat destruction, through the use of bottom trawls for instance.

Habitat loss: The loss, fragmentation or degradation of habitats is the main threat to Mediterranean species and ecosystems, leading to lower abundances and richness of species and often allowing opportunistic species to prosper. Changes in land-use patterns are the main causes of this degradation. Amongst the most threatened areas, seagrass meadows and coralligenous communities are highly biodiverse and productive ecosystems that supply food resources and nurseries for species of commercial interest.

Invasive and dangerous species: The introduction of invasive alien species can be deliberate, to satisfy human needs (food, pest control), or accidental (increased globalization of transport). Marine invasive species, which number doubles in the Mediterranean Sea every 20 years, are regarded as one of the main causes of biodiversity loss. There are some reports of toxic species appearances, for instance, of both planktonic (e.g. *Alexandrium*) and benthic dinoflagellates (e.g. *Ostreopsis*).

Figure 1: Adjusted Population Density, 2015



Source: UN, GRUMP V4 Project

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Pollution (e.g. eutrophication, endocrine disruptors, litters, noise): Most of the northern coastal areas receive excessive loads of nutrients from sewage effluents, river fluxes, aquaculture farms, fertilizers, and industrial facilities, showing intense eutrophic phenomena with many adverse effects for marine ecosystems and humans (e.g. toxic species, mass mortality due to oxygen deficiency). Additionally, chemical hazardous substances originating from industrial and urban emissions reach the sea through direct discharge, or through rivers and run-off from soil or atmospheric deposition. Finally, the Mediterranean Sea has recently been identified as a great accumulation zone of plastic debris.

Main ecological and human impacts

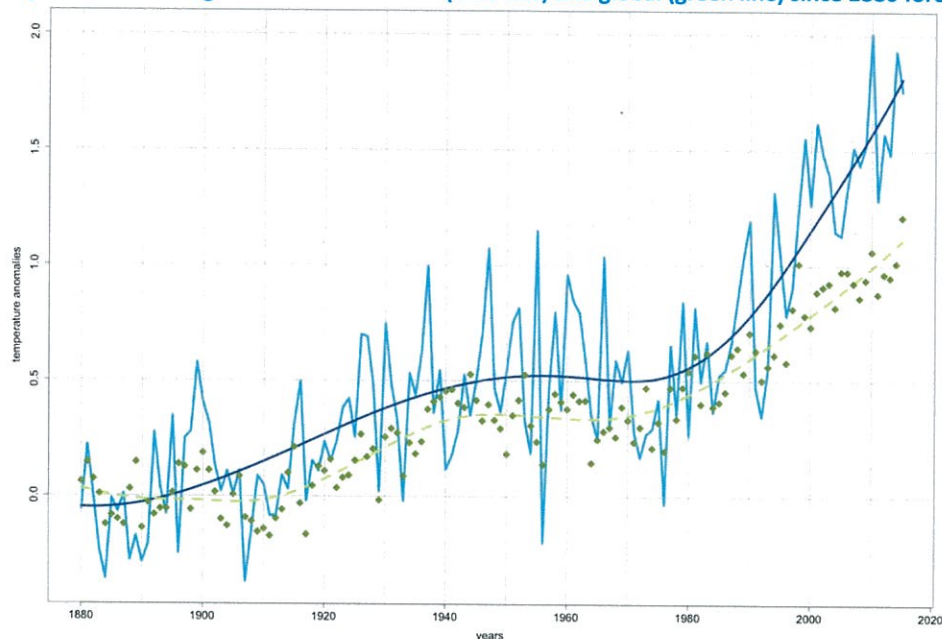
Main ecological impacts associated with the previously identified threats include biodiversity loss, potentially involving unique and iconic species (e.g. *Posidonia oceanica*, red coral *Corallium rubrum*, marine mammals and sea turtles); the degradation of idiomatic benthic ecosystems (such as *Posidonia oceanica* meadows, coralligenous, and vermetid reefs); geographical shifts of certain species; alteration of local community equilibrium; and several physiological impacts (e.g. effects on reproduction and growth of species).

Regarding socio-economic impacts, the loss of income and employment represent potential significant effects for fisheries, aquaculture and tourism sectors. A negative effect on cultural heritage might be associated with the fisheries sector, notably in terms of the loss of traditional knowledge and artisanal practices associated with the subsistence and commercial exploitation of certain species. As for the tourism sector, the associated effect translates into loss of cultural heritage value of particular vulnerable coastal and marine ecosystems and species. Moreover, the depletion of fish stocks might contribute to socio-political conflicts in the context of a higher competition for fish resources.

Regarding aquaculture, certain areas might become less suitable or even inadequate for aquaculture production, forcing farm relocation to other areas that might be vulnerable. Moreover, negative implications of human health might occur due to episodes of shellfish poisoning. The potential disruption of the carbon sequestration service could represent a positive retroaction on climate, which may contribute to an increase in mitigation and adaptation costs. In addition, the lower capacity of particular habitats to support coastal protection might influence the need for the adoption of alternative coastal protection measures, which could mean significant investments in coastal infrastructure. Finally, the degradation of the previously mentioned services might lead to indirect effects on fisheries, tourism, and aquaculture.



Figure 2: Air temperature warming in the Mediterranean (blue line) and global (green line) since 1880 forecasted until 2020



Source: Data from Berkeley Earth. Andrea Toretì, Joint Research Centre, Ispra, Italy

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Table 1: Main threats by region

Main threats	North Mediterranean countries	South Mediterranean countries	East Mediterranean countries
Urbanisation and coastal development	+	+++	+++
Eutrophication	+	++	++
Coastal erosion and coastal habitat destruction	+++	++	++
Sea level rise	+	++	+++
Oil and gas exploration	+	+	++
Harmful algae blooms	+	+	++
Marine pollution	++	++	++
Seawater eutrophication	+	+	+
Ocean warming	+++	++	+++
Ocean acidification	+	+	+
Salinization	+	+	+++
Loss of biodiversity	++	++	++
Invasive species	++	+	++
Overfishing and illegal fishing	+++	+++	+++

Note: This table summarizes 40 opinions of scientific experts who met at the Oceanographic Museum of Monaco on 18 and 19 October 2018. It comes from three working groups by region and therefore intended to be read in columns rather than lines. This initial analysis may be extended by future work and by those already carried out at the regional level within the frame of the QSR and EcAp initiative coordinated by MAP.

Challenges such as political instability, illegal migrations and war have not been considered but will influence environmental sustainability and climate resilience as they are threats to marine resources and ecosystem services.

General conclusions for the Mediterranean Sea

Responses and policy options

Several policy recommendations are considered for the entire Mediterranean area and beyond.

a) Citizen initiatives, participation and awareness-raising

Ocean literacy should be promoted, both to students in schools and to the general public and policy-makers. Such public education and awareness-raising campaigns can include environmental education for children. They could also be for a wider public (such as cleaning the beaches, and/or providing an interdisciplinary scientific approach of different sources of marine litter and its relation to production, consumption and recycling patterns) and for employees in the tourism and hospitality sectors. The implementation of wide platforms will allow sharing knowledge among NGOs, local communities, scientists, sector representatives and policy-makers. Promotion of citizen science initiatives, besides raising awareness of environmental issues, might be key to expand at large-scale and long-term the monitoring efforts on the effects climate change, invasive species dynamics, marine litter and losses in biodiversity and/or habitat.

b) Policies for fisheries

Promotion of sustainable seafood production will limit habitat damage and overfishing. In this regard, small-scale, artisanal fisheries, as well as local consumption of seafood should be encouraged while avoiding "Tragedy of the Commons". For this purpose, local markets, local storing and marketing opportunities for small-scale fisheries should be strengthened. As an important part of the problem, fuel subsidies to harmful industrial fisheries have to be phased out. The role of Regional Fisheries Management Organizations (RFMOs) like the General Fisheries Commission for the Mediterranean (GFCM) is crucial.

c) Coastline management

Implementation of a sustainable zoning plan of coastal construction will ensure social welfare and sustainability in coastal areas. Policies should promote public access to the coastline and sustainable eco-tourism. Such eco-tourism should not lead to exclusion or displacement of people living in the area, but rather should incorporate and strengthen their local livelihood, socio-economic and socio-environmental activities.

d) Joint research among countries in the Mediterranean region and networks of collaboration

Even though some efforts are currently made in the Mediterranean in applying the Aichi 10 target to develop a MPAs network (ecologically representative and efficiently managed), the promotion of joint research between different

countries and with different interdisciplinary experts, as well as strong and long-lasting networks of collaboration are lacking. Such an international research network, especially in the context of a politically unstable region like the Eastern Levantine, would help align common priorities and actions. They can increase the efficiency of policies, benefitting from existing knowledge from public and private actors on coastal governance. Some options are first related to the Eastern Mediterranean MPAs, whose network should be expanded with improved management. Second, further participative Integrated Coastal Zone Management should be implemented. An important way to promote such networks is through ensuring the implementation of the Convention on Biological Diversity (CBD) and the Barcelona Convention. Most of the Mediterranean countries are already part of these agreements, but the implementation has usually been problematic. The alignment with the European Marine Strategy Framework Directive and the Water Framework Directive in Eastern Mediterranean, which is currently promoted with the ecological approach, could benefit from bilateral agreements and cooperation, which can promote their implementation. Lastly, in the Southern and Eastern Mediterranean countries, the funding of marine research and marine centers will help the development of an integrated ocean observing system, which is a prerequisite for any science-based decision process. The inclusion of existing national databases into standardized international databases would help create or enhance research networks and collaboration among different public and research institutions of Mediterranean countries.

e) Ecological precautions and pollution prevention

Implementation of biosecurity measures in Suez Canal will help fight against invasive species, which threaten the Eastern Mediterranean. In addition, a waste management plan, as well as a coordinated monitoring of marine pollution and a better protection of groundwater supplies are necessary to fight against coastal and marine pollution, which is another existing, emergent and growing problem.

f) Limit the use of fossil fuels and climate change mitigation

All policy recommendations related to Mediterranean should address climate change issues. In this regard, harmful fuel subsidies and extraction of fossil fuels should obey common rules edited by one general authority. Several implementations could limit the risks such as: i) a dedicated coordination to limit the impact of offshore exploitation; ii) an immediate plan to encourage the transition to renewable energies (e.g. subsidies, tax breaks, investing in R&D on renewables); iii) the application of the “polluter-pays-principle” with limits on the maximum levels.

g) Participative mechanisms and inclusion of stakeholders in ports and harbor areas

Harbor areas are important aspects of life in Mediterranean, highly affecting the social, ecological and economic characteristics of the region. Implementation of “bay-contract” (or “maritime clusters” among stakeholders in harbor areas) including all stakeholders should ensure participative mechanisms for decisions on harbor development. Growing attention is given today to such an approach, as in the Mediterranean European countries and the Eastern Levantine region which could benefit by joining this movement. Furthermore, “booster” approaches promoted by technological clusters can be used for technological innovations in the important and relevant sectors (e.g. systematic use of in situ/spatial information to develop services, development of marine renewable, etc.), and to provide tools for environmental monitoring by different stakeholders; e.g. to reduce the impact of the shipping industry, burning oil etc.

h) Promoting NGOs and treaties would be helpful in making multilateral agreements that would help the region

A better monitoring of coastal and marine ecosystems, together with a better evaluation of the impacts of human activities on these ecosystems and a greater knowledge of the coastal vulnerability and risks is necessary.



Main knowledge gaps and needs

A number of gaps need to be addressed in the short term in order to enhance local, national, sub-regional and regional resilience of the Mediterranean ecosystems to face threats related to climate change and other environmental changes by future research projects and capacity building strategies:

- Building cross-sectional long-term large scale databases and supporting monitoring schemes will help knowledge gaps such as population biology of key/emblematic/habitat forming species, key habitats, coastal vulnerability, coastal risks, sedimentary dynamics, acoustic pollution, more general ecosystem functioning, coastal population characteristics, available stocks of fisheries, carrying capacities, ecosystem services, identification and evaluation of climate change impacts including losses in economic wellbeing (reduced catches and losses from flooding and loss of property), health impacts and loss of biodiversity.
- Assessment of stocks, carrying capacities and ecotourism potential, as well as mapping of key and sensitive coastal and marine habitats, are needed to provide more reliable evaluation of human activities' impacts and environmental and risk assessment at relevant spatial scales (from local to sub-regional level).
- Monitoring/science and management/decisions that are presently disconnected, data/outputs from monitoring/science that are inaccessible to managers, and in some cases research projects may produce outputs of no help to practitioners/managers/decision-makers. Support for the development of collaborative platforms devoted to the implementation of monitoring schemes on coastal habitats on core indicators using standardised protocols and data repositories.
- Prospective analysis and simulation of scenarios (coastal and marine sustainability, climate change effects, coastal and maritime activities such as fishing, aquaculture, shipping and traffic, oil & gas, desalinization, etc.), predicting extreme events, and projections and studies on main human and natural drivers.
- Waste management planning, aquaculture planning, and assessment of desalination impacts.
- Climate change interactions, coastal risks and hazards, and interactions between stressors, including climate changes and ecosystem services.
- Proficiency of technology (continuous ballast water, remediation tools, etc.).

- Feedback mechanisms and capacity building.
- MPA network (and no take zones).
- Legislative, regulatory, institutional and financial frameworks.
- Awareness on marine and coastal environmental issues.
- An agreement of acceptable thresholds for changes.
- Carrying capacities for sustainable marine and coastal activities.

In addition to the need to recognize lack of knowledge, other issues have been also highlighted, such as knowledge integration, spatial distribution of knowledge availability and the compromise between monitoring and obtaining new knowledge. These various issues need to be addressed in an appropriate manner at the relevant scale by using integrative tools. The responses have different nature and types, mainly legislative and institutional, financial, and technical.



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