

SCIENCE PLAN

ICES
International Council for the Exploration of the Sea
CIEM
Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark

Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purpose of citation:
ICES. 2019. Science Plan. http://doi.org/10.17895/ices.pub.5469

Unless otherwise stated, the copyright for the content of ICES Science plan is vested in the publisher. Material herein may not be reproduced without written permission from the copyright owners.

© 2019 International Council for the Exploration of the Sea

SCIENCE PLAN

INTRODUCTION 4

SCIENCE PRIORITIES 6

WHAT WE WILL DO AND HOW WE WILL WORK 8

ECOSYSTEM SCIENCE 12

IMPACTS OF HUMAN ACTIVITIES 14

OBSERVATION AND EXPLORATION 16

EMERGING TECHNIQUES AND TECHNOLOGIES 18

SEAFOOD PRODUCTION 22

CONSERVATION AND MANAGEMENT SCIENCE 24

SEA AND SOCIETY 26

Science plan of the International Council for the Exploration of the Sea

Marine ecosystem and sustainability science for the 2020s and beyond

Our science plan "Marine ecosystem and sustainability science for the 2020s and beyond" describes ICES scientific priorities and objectives and a pathway to achieve them. By successfully implementing our science plan we will generate ecosystem and sustainability science that has a high and beneficial impact on society. Our science will advance and shape understanding of marine ecosystems, improve assessments of the effects of human activities, improve observations of the seas and oceans, and provide evidence and solutions to support conservation and management. Supporting tasks will increase the visibility and impact of this science, provide a rewarding and efficient working environment, engage new scientists, increase training and networking opportunities, and strengthen collaboration with regional and global partners. By achieving our scientific objectives and completing the supporting tasks we will create a world-leading marine science organization and network, effectively meeting societal needs for impartial evidence on the state and sustainable use of our seas and oceans.

Our science plan was developed through an inclusive and consultative process. This drew on expertise throughout the ICES network and constituent bodies, a review of scientific priorities of member countries, and a review of national and international policy drivers and science opportunities for ICES. The intended audience for our plan is the marine science community, in ICES countries and beyond. Many people in the audience helped to create the plan! We hope the plan will also resonate with, and support, managers, industry, funding agencies, governments, and inter-governmental and non-governmental organizations committed to advancing marine science, conservation, and management.

Who we are

The International Council for the Exploration of the Sea (ICES) is an intergovernmental organization dedicated to advancing and sharing marine science to support conservation and sustainable use of our seas and oceans. Our international network comprises more than 5,000 scientists from over 700 marine institutes and organizations in 20 member countries and beyond.

ICES Vision

To be a world-leading marine science organization, meeting societal needs for impartial evidence on the state and sustainable use of our seas and oceans.

ICES Mission

To advance and share scientific understanding of marine ecosystems and the services they provide and to use this knowledge to generate state-of-the-art advice for meeting conservation, management, and sustainability goals.



Science priorities

To deliver "Marine ecosystem and sustainability science for the 2020s and beyond", our network will address seven interrelated scientific priorities, each with an objective and purpose.



Ecosystem science

Advance and shape understanding of the structure, function, and dynamics of marine ecosystems – to develop and vitalize marine science and underpin its applications



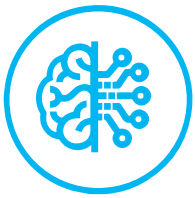
Impacts of human activities

Measure and project the effects of human activities on ecosystems and ecosystem services – to elucidate present and future states of natural and social systems



Observation and exploration

Monitor and explore the seas and oceans – to track changes in the environment and ecosystems and to identify resources for sustainable use and protection



Emerging techniques and technologies

Develop, evaluate, and harness new techniques and technologies – to advance knowledge of marine systems, inform management, and increase the scope and efficiency of monitoring



Seafood production

Generate evidence and advice for management of wild-capture fisheries and aquaculture – to help sustain safe and sufficient seafood supplies



Conservation and management science

Develop tools, knowledge, and evidence for conservation and management – to provide more and better options to help managers set and meet objectives



Sea and society

Evaluate contributions of the sea to livelihoods, cultural identities, and recreation – to inform ecosystem status assessments, policy development, and management

The collective and collaborative efforts of our science network to address the seven interrelated priorities will generate ecosystem and sustainability science that advances and shapes understanding of marine ecosystems and their interactions with society and climate. Such understanding, and the data and evidence streams that enrich it, will advance ICES capacity to provide authoritative and impartial insight and advice into the state and sustainable use of our seas and oceans.

What we will do and how we will work

Across all areas of our science we will increase the visibility of, and access to, our science, data, and advice and recognize, promote, and use our science outputs. ICES values the disciplines, perspectives and expertise brought to our network by member country institutions, partners, clients, and stakeholders. We will regularly and actively solicit their inputs to the development of our science at the Annual Science Conference, through other sponsored conferences, and discipline- and topic-specific workshops and meetings.

For all people engaging with ICES science we will seek to provide an efficient, collaborative, respectful, and rewarding working environment. We will provide the resources and infrastructure needed by ICES groups to develop and share knowledge and expertise. We will ensure that expert groups, as the core contributors to ICES science, have flexibility to innovate and explore new topics. We will encourage and support cross-cutting science activity. To secure our future as a world-class marine science organization and network we will provide more and better networking and training opportunities and encourage engagement of a new and emerging generation of scientists with expert groups.

We will work closely with regional and global partners. Relationships with partners extends the reach of our science into the Mediterranean, Black Sea, Arctic, North Pacific Ocean and globally. Partnerships bring mutual benefits, by strengthening the contribution of regional expertise to larger-scale and global processes and contributing to shaping and delivering marine science and advice beyond the ICES region. We will exchange knowledge and expertise with regional and global partners through collaborative projects, networks and training: to shape and advance marine science and advice. We will also engage with partners to meet joint scientific goals; by developing joint expert groups, co-sponsoring conferences and conference sessions, and contributing to overviews and assessments of the state and uses of the marine environment.

The scientific objectives and tasks in this science plan are to be accomplished in the period 2019–2024. These accomplishments will also prepare us to address the scientific challenges that emerge in the late 2020s and beyond. Implementation of the plan will be assessed by measuring and reviewing outcomes. These include the impacts of our science and advice on conservation, management,

and sustainability goals, the extent of engagement with ICES and the uses of our science, data, and advice.

Responsibilities and actions to implement this science plan are described in an associated implementation plan. The intended audience for this plan includes the people and groups in ICES who are involved in implementing, monitoring, and reporting on delivery of the science plan. Progress with implementation will be reported to, and reviewed by, our governing body, ICES Council. Information gleaned from their reviews will be used to shape our future marine science objectives and tasks and to ensure we are contributing effectively to ICES vision and mission.

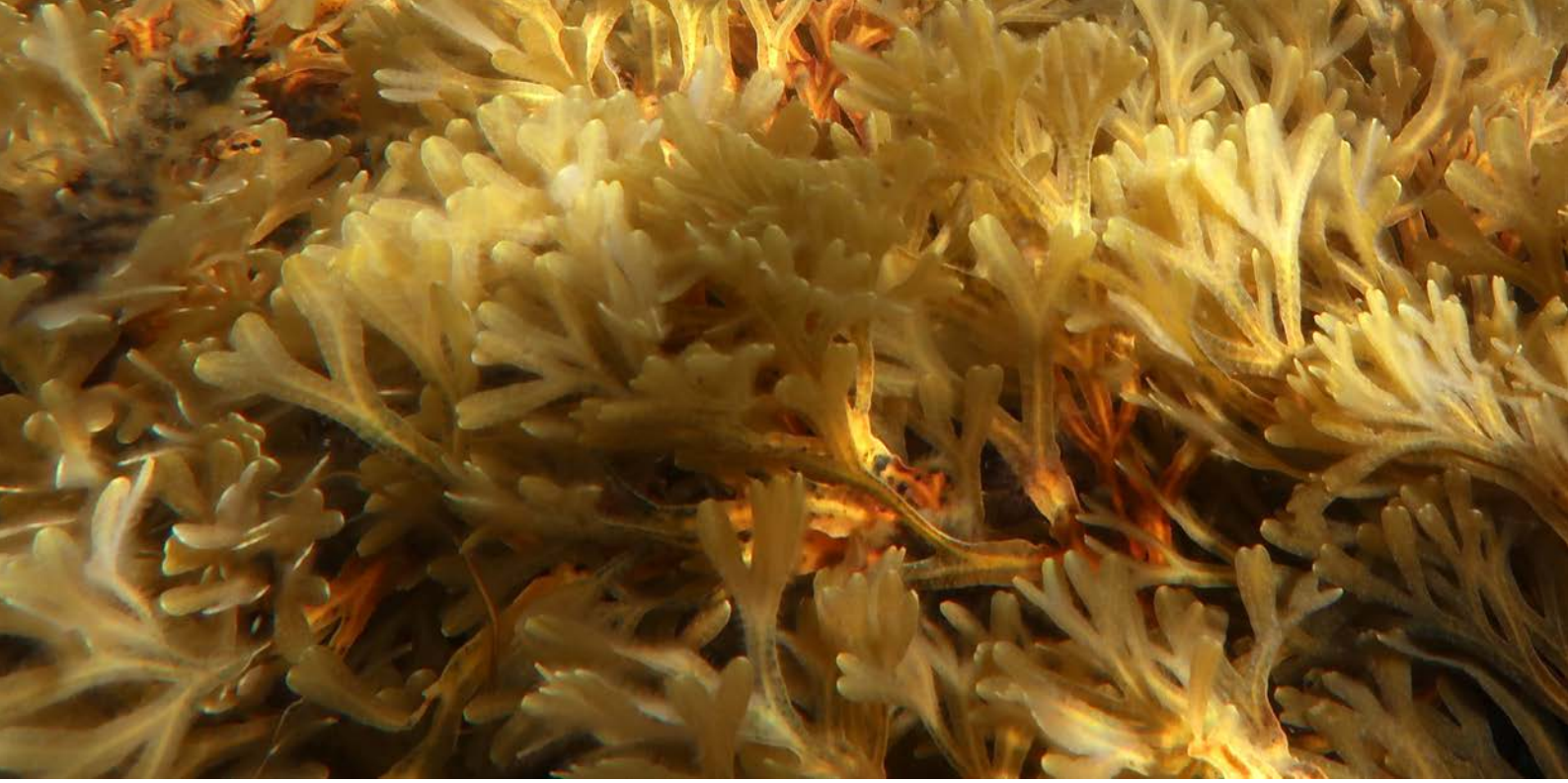
Science Plan outcomes

- Marine science with a high and beneficial impact on society
- Engaged and productive scientists from the natural and social sciences
- Increased visibility of, and access to, our science, data, and advice
- Stronger and more dynamic links between science and advice
- A secure position as a world-class marine science organisation

Image: nielshintzen.nl







Ecosystem science

Advance and shape understanding of the structure, function and dynamics of marine ecosystems – to develop and vitalize marine science and underpin its applications

Sustainability science and ecosystem-based management are predicated on an underlying understanding of the structure, function, and dynamics of marine ecosystems and their interactions with the physical and chemical environment. As this understanding advances and evolves, so does our capacity to report and advise on the status of the marine environment and to measure, describe, and manage human interactions with the sea.

Tasks

- Assess and report on trends in ocean climate.
- Improve understanding of the oceanography of semi-enclosed and shelf seas and the wider North Atlantic Ocean.
- Describe links between the physical and biological environment and their influence on production, biogeochemical cycles, and other ecosystem functions, and consequences for the stability and resilience of ecosystems and the services they provide.
- Describe connectivity within and among ecosystems, of many species and life stages at a range of spatial scales, and assess the ecological consequences.
- Develop methods to map and predict the distribution of seabed and pelagic habitats and biodiversity and their sensitivity to environmental variation and change.
- Develop and apply molecular, morphological, and other taxonomic methods to describe and identify species.
- Describe life histories, their links to the environment and responses to environmental change, including phenotypic and genetic adaptation.
- Build on, and challenge, existing assumptions about population and community structures and interactions by searching for new insights using molecular methods, physiology, and behavioural science.
- Conduct comparative analyses of the structure, function, and dynamics of ecosystems in ICES regions and beyond.



Impacts of human activities

Measure and project the effects of human activities on ecosystems and ecosystem services – to elucidate present and future states of natural and social systems

The seas provide many benefits for people but human activities pose risks as well as providing opportunities. Pressures from contaminants and pollutants, eutrophication, invasive species, litter, shipping, noise, oil and gas extraction, mining, construction, renewable energy, aquaculture, fishing, climate change, acidification and habitat loss affect ecosystems and the environment. Understanding these pressures and their impacts will provide evidence to advise on trade-offs between benefits and risks.

Tasks

- Describe the distribution and intensity of pressures that result from contaminants and pollutants, eutrophication, invasive species, litter, shipping, noise, oil and gas extraction, mining, construction, renewable energy, aquaculture, fishing, climate change, acidification and habitat loss.

- Explore how pressures on the marine environment act, independently and collectively, to modify the variety, quantity and distribution of marine life and the structure, function and dynamics of food webs and marine ecosystems (including cumulative pressures and their cumulative impacts).

- Develop methods to better characterise and map the sensitivity and role of seabed and pelagic habitats, from close to the coasts to the deep sea.

- Describe the exposure of habitats to pressures, their vulnerability and resilience, and develop and test indicators of pressure, state and function.

- Develop methods and models for assessing and projecting ecological impacts of diffuse pressures (climate change, pollution, litter and acidification) spanning different levels of biological organisation and at a range of time and space scales.

- Model the transport of pollutants, including litter, to link sources to areas of impact, especially when these span long distances (e.g. Arctic and deep sea) or many trophic levels (e.g. impacts on predatory fishes, birds and mammals).

- Assess and project implications of human activities for management systems and marine industries and advise on options for mitigation and adaption.



Image: © Ifremer

Observation and exploration

Monitor and explore the seas and oceans – to track changes in the environment and ecosystems and to identify resources for sustainable use and protection

Science and advice rely on observations of physical, chemical, and biological properties of the environment and ecosystems. Monitoring provides essential inputs to status assessments, including fisheries and ecosystem overviews, as well as feedback on the effects of conservation and management measures. Since large areas of the marine environment have not been observed, exploration provides essential information on the distribution of biological resources for sustainable use and protection.

Tasks

- Develop and coordinate, integrated, quality assured, and cost-effective monitoring programmes.
- Evaluate and optimize survey design, connectivity of observation systems, and survey data handling, access, and analysis – to meet existing demands for data and to meet emerging data, science, and advisory needs; with a focus on supporting fisheries assessment, integrated ecosystem assessment and ecosystem-based management.
- Conduct analyses and testing of techniques, sensors, and the logistical and statistical aspects of survey design to increase the efficiency, scope and accuracy of monitoring and the relevance of monitoring programmes to science and advisory needs.
- Conduct an ambitious co-ordinated programme to further explore and report the ecological characteristics of the ICES region, with a focus on the distribution of habitats.
- Develop more effective mechanisms to ensure that monitoring and surveillance data (e.g. VMS, AIS) can be reused or reprocessed to support ICES scientific and advisory needs.
- Identify, design, and make use of opportunities for public participation in observation and exploration through citizen-science; and identify and make use of opportunities for marine industries and other stakeholders to contribute to research design, data gathering, and interpretation.

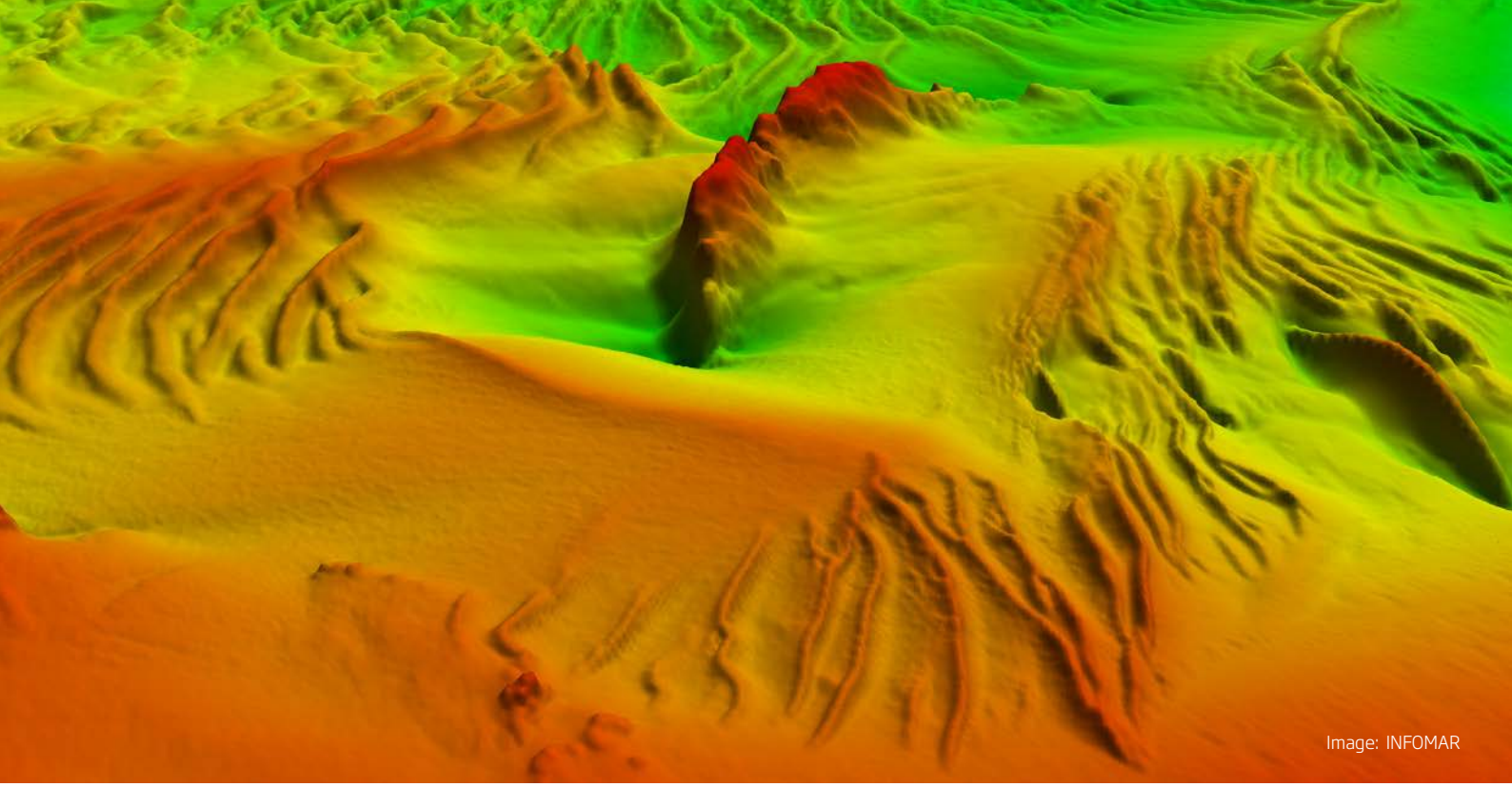


Image: INFOMAR

Emerging techniques and technologies

Develop, evaluate, and harness new techniques and technologies – to advance knowledge of marine systems, inform management, and increase the scope and efficiency of monitoring

New techniques and technologies continue to transform our capacity to understand and monitor biota, marine ecosystems, human activities and pressures, to analyse data and to conduct assessments. Some emerging technologies are so disruptive they fundamentally challenge the accuracy and cost-effectiveness of existing approaches. It is essential to develop, identify, and test emerging techniques and technologies, and to support uptake when they are shown to advance our capacity to generate data, science, and advice.

Tasks

- Horizon scan, test, develop and where appropriate harness new and emerging techniques and technologies that have potential to progress the ICES vision and mission; with an emphasis on data gathering, processing and interpretation.
- Develop more efficient ways of analysing, sharing and presenting big data from observation and monitoring; especially using data from remote sensing of the seas and monitoring of human activities.
- Develop and apply a wide range of analytical and statistical tools, such as machine learning, to describe the state and dynamics of the marine environment and the distribution and dynamics of human activities, and assess their strengths and weaknesses.
- Investigate the benefits and costs of techniques that may supplement or replace existing approaches to biological 'sampling', including the applications of acoustics, image analysis, molecular methods, (e.g. eDNA, genetic barcoding and genetic close-kin mark-recapture methods) as well as sensors for chemical and physical sampling.
- Track the emergence of new technologies in marine industries and assess how these technologies affect the interactions between those industries and the marine environment.



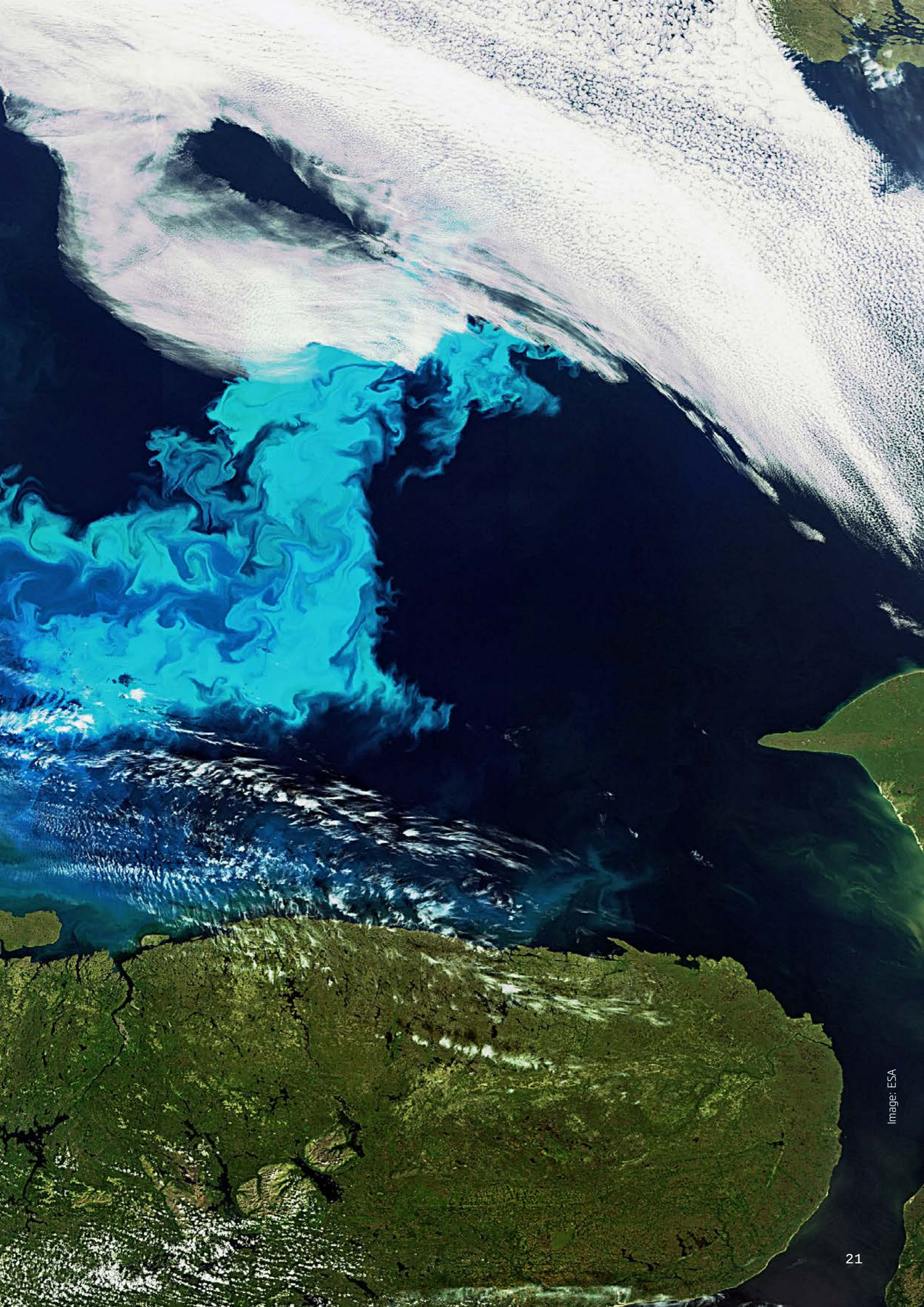
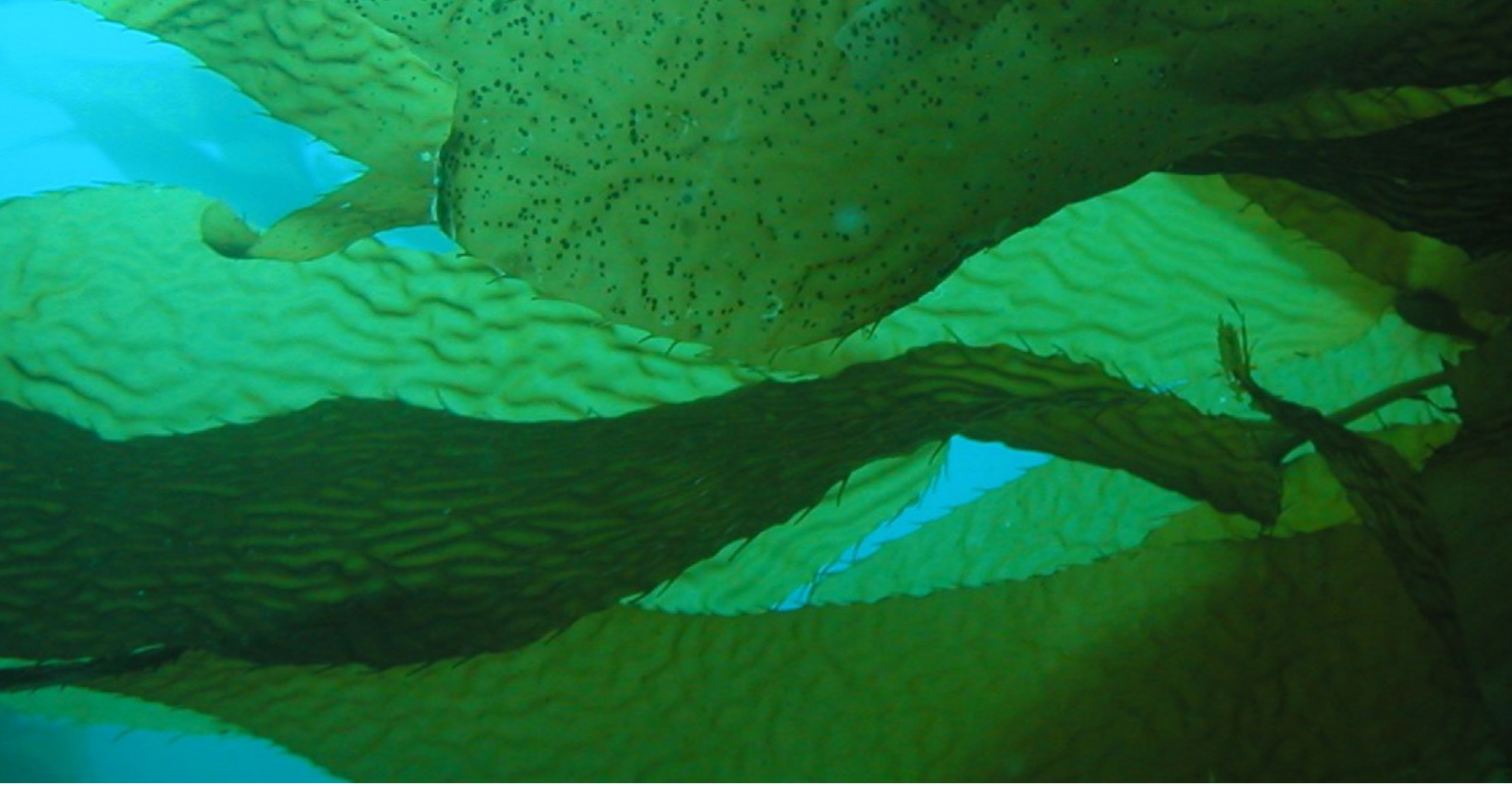


Image: ESA



Seafood production

Generate evidence and advice for management of wild-capture fisheries and aquaculture – to help sustain safe and sufficient seafood supplies

Production of seafood and associated by-products supports livelihoods and businesses and makes an important contribution to human nutrition and health. Securing a sufficient and sustainable supply of safe seafood from wild-capture fisheries and aquaculture is an ongoing challenge for society and the effective development and management of these industries relies on scientific evidence.

Tasks

- Improve methods of single-species and multispecies stock assessment, including data-limited methods. Develop and conduct management strategy evaluations, address uncertainty, and improve the transparency, robustness, efficiency, and repeatability of stock assessment.

- Increase understanding of stock structures, migrations, life histories, natural mortality, climate, and food web impacts on marine and diadromous species, as well as multispecies interactions and the consequences of stock recovery; to strengthen the inputs and evidence base for assessment and advice.

- Further understanding and operationalization of ecosystem-based fishery management and MSY concepts and their application in mixed, multispecies, and emerging (e.g. mesopelagic) fisheries.

- Examine fisheries spatial dynamics, performance and impact of gear, links between catch and effort, mixed fishery interactions, role and impacts of recreational and small-scale fisheries, and the consequences of responses to management measures.

- Assess aquaculture production potential and carrying capacity, development scenarios, and methods of risk and benefits assessment; for rearing or full production systems including low trophic level and seaweed aquaculture, integrated multi-trophic aquaculture, and offshore production facilities.

- Assess interactions between aquaculture and the environment including the risks posed by diseases and pathogens and their mitigation, harmful algal blooms, and the effects of escapees and nutrient and organic loads.

- Develop aquaculture overviews to describe the distribution, ecosystem interactions, benefits and impacts of aquaculture production.

- Assess the wider role of seafood production in society, including resilience of the food system, interactions between food systems in the sea and on land, and the effects of the changing expectations of seafood consumers on practices in aquaculture and fishing.

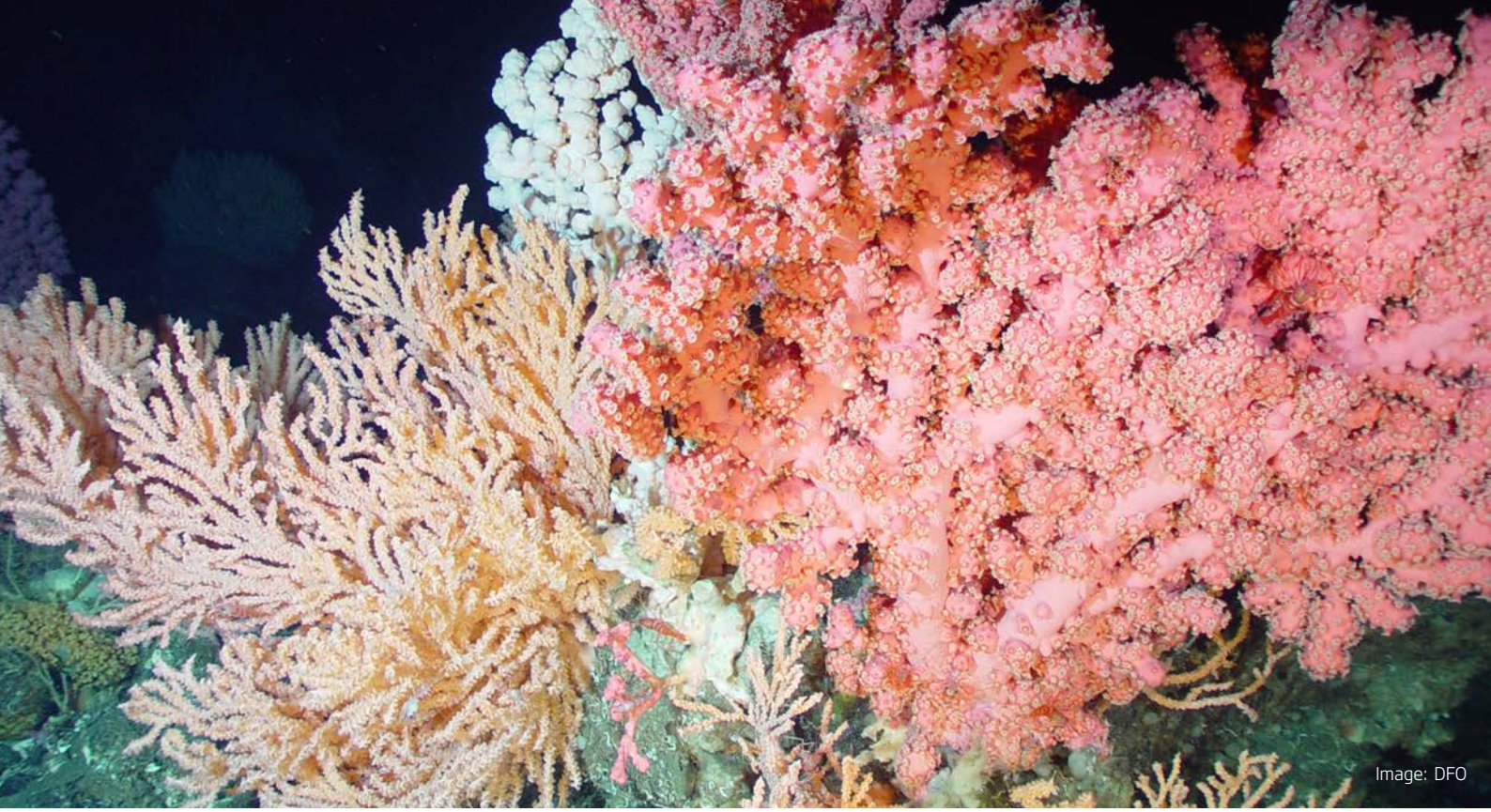


Image: DFO

Conservation and management science

Develop tools, knowledge, and evidence for conservation and management – to provide more and better options to help managers set and meet objectives

Conservation and management measures are taken to meet the objectives of those management bodies that are tasked to balance demands for use and protection of the sea. To guide and support effective conservation and management these bodies require evidence and advice based on current policies and management regimes, but also seek inputs on the performance of management, the status of the managed environment and information to develop future approaches and policies.

Tasks

- Develop an evidence base and assessment tools to support existing and potential demands for advice on conservation and management. To cover activities and pressures including fisheries and aquaculture, contaminants and pollutants, eutrophication, invasive species, litter, shipping, noise, oil and gas extraction, construction, renewable energy, climate change, acidification, and habitat loss.

- Develop methods to support implementation and evaluation of the suitability and effectiveness of national and international commitments and governance relating to marine spatial planning; coastal zone management; protection of species, habitats and marine ecosystems; mitigation; restoration; and the delineation, management and monitoring of marine protected areas.

- Develop methods to support implementation of marine policies and commitments applying to ICES member countries. To include the UN Sustainable Development Goals, the Common Fisheries Policy, the Marine Strategy Framework Directive, and other national or international policies and commitments.

- Provide evidence to inform policy developers as they seek to set objectives and to address and reconcile use and conservation of the sea.

- Develop and publish integrated ecosystem assessments and ecosystem overviews to describe and report on regional status and use of the sea, and associated challenges and risks.

- Further develop ICES capacity to provide ecosystem-based advice by adding quantitative analyses of more activities, pressures and impacts, as well as social, cultural and economic information, to fisheries and ecosystem overviews; and by developing and integrating aquaculture overviews.



Sea and society

Evaluate contributions of the sea to livelihoods, cultural identities, and recreation – to inform ecosystem status assessments, policy development, and management

People and their communities, societies, and cultures benefit directly from seas and oceans because people engage in aquaculture, fishing, shipping, and other marine industries, or use the sea for recreation. All other humans benefit indirectly from services provided by the seas and oceans, given their role in global biogeochemical cycles and the climate system. We seek to achieve a step change in understanding and reporting of human interactions with the sea, to inform policy development, conservation, and management.

Tasks

- Develop, test, and apply methods and indicators to assess the social and economic status and dependence of coastal communities on aquaculture, commercial and recreational fishing, tourism, and other marine industries.

- Trial and improve social and economic indicators for use in fisheries and ecosystem overviews and the emerging aquaculture overviews.

- Investigate the social and economic risks and opportunities provided by alternate uses of the sea.

- Investigate the social and economic consequences of human responses to management actions and the role of spatial planning in resolving conflicts and supporting co-existence of human activities and livelihoods.

- Assess the effects of alternate models of engagement on the success of participatory processes and the perceived salience, credibility, and legitimacy of outcomes that result, as well as the practicality and performance of resulting conservation and management options.

- Describe alternate futures and management options for marine socio-ecological systems and assess the vulnerability and resilience of marine industries and society to climate change.

- Develop understanding of how traditional and historical knowledge can inform conservation and management and how this understanding influences the effectiveness of contemporary conservation and management.



ICES
International Council for the Exploration of the Sea

CIEM
Conseil International pour l'Exploration de la Mer