EMB POLICY BRIEF

N°6 October 2019

Navigating the Future V

Recommendations for the Ocean Decade

United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

European MARINE BOARD

Advancing Seas & Ocean Science

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European Marine Board

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European Marine Board Member Organizations

This policy brief is based on the European Marine Board Position Paper 24 'Navigating the Future V' (NFV)[1].

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[1] European Marine Board (2019) Navigating the Future V: Marine Science for a Sustainable Future. Position Paper 24 of the European Marine Board, Ostend, Belgium. ISBN: 9789492043757. ISSN: 0167-9309. DOI: 10.5281/zenodo.2809392.S

Ocean Science for the 2030 Agenda for Sustainable Development

The United Nations General Assembly, representing 193 countries, has proclaimed 2021-2030 a Decade of Ocean Science for Sustainable Development. The Decade aims to ensure that ocean science supports and guides the 2030 Agenda for Sustainable Development, including its 17 Sustainable Development Goals (SDGs) and in particular SGD 14, Life Below Water. All United Nations member states adopted the SDGs in 2015 and their implementation is one of the main aims of Horizon Europe, the EU's upcoming Framework Programme for Research and Innovation (2021–2027).

The Decade is an opportunity to ensure that we continue to benefit from the ocean while improving its ecological health. Six societal goals have been outlined for the Decade: A Clean Ocean, A Sustainably Harvested Ocean, A Safe Ocean, A Healthy Ocean, A Predicted Ocean, and A Transparent Ocean. These six societal goals are comprehensively addressed by the recommendations from the European Marine Board's flagship publication: Navigating the Future V (NFV). NFV provides a holistic vision of marine science and recommends new research agendas to be developed with all stakeholders and with sustainable governance at their core. It recommends a solutions-oriented, transdisciplinary research agenda for the next decade. This policy brief highlights the close alignment and overlap between the societal outcomes of the Decade and the five substantive science chapters of NFV, highlighting the interdisciplinary and connected nature of the global sustainability challenges we are facing (Figure 1).

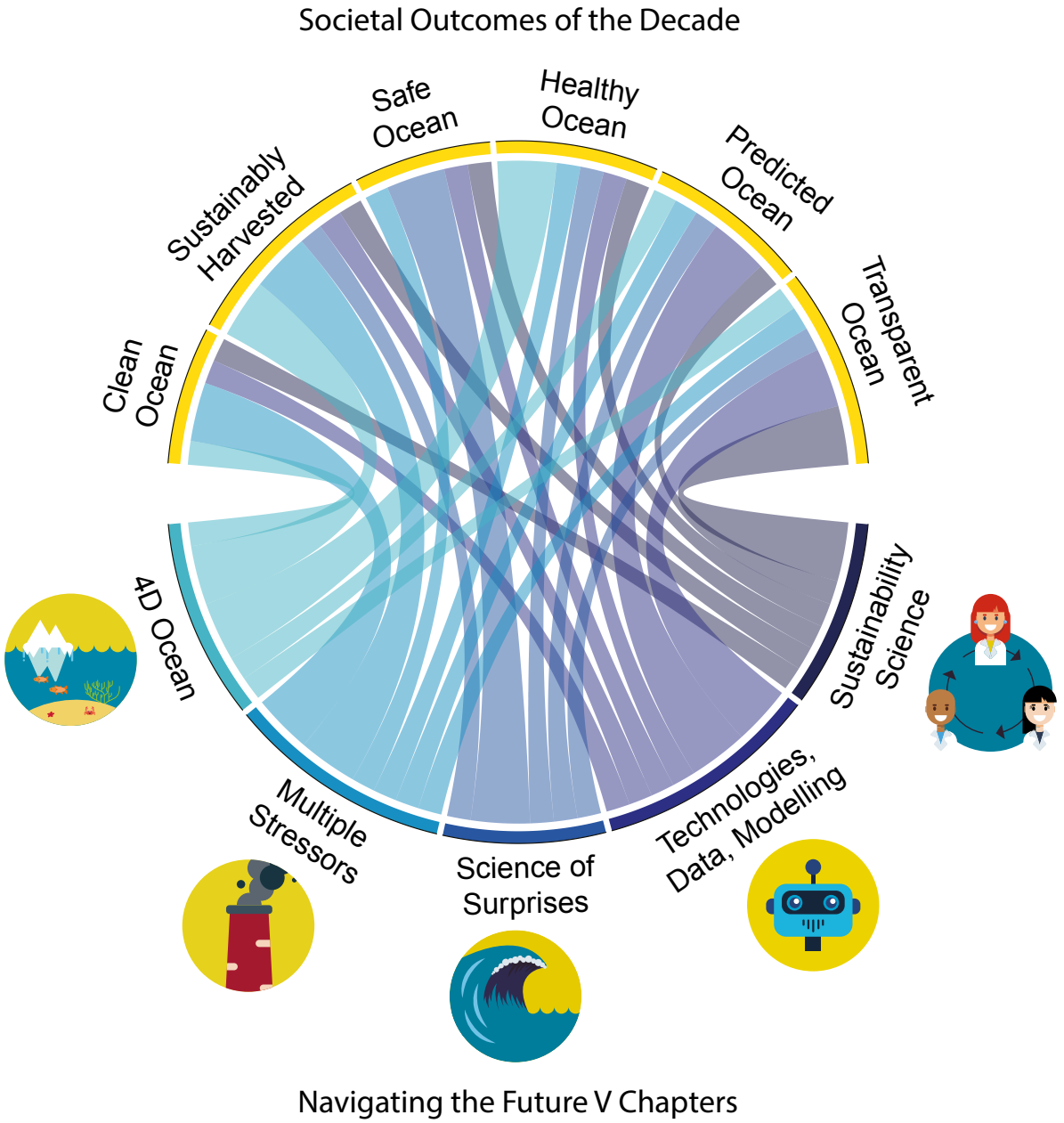


Figure 1. Links between the six societal outcomes of the UN Decade of Ocean Science and the five science chapters of Navigating the Future V. The width of each connection indicates the strength of the link. Graph created in R using circlize package.[2]

[2] Gu, Z. (2014). Circlize implements and enhances circular visualization in R. Bioinformatics 30 (19): 2811-2. Doi: 10/1093/bioinformatics/btu393.

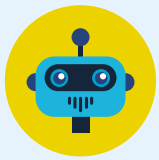
A Clean Ocean

The human population is predicted to grow to almost 10 billion by 2050, and together with the growth in consumerism and international trade, implies more pollution. Ocean pollutants include atmospheric CO_2, leading to ocean warming, ocean acidification and sea-level rise, each with their own knock-on effects. Agricultural run-off causes eutrophication (increased primary production), and subsequent ocean deoxygenation. Many toxic chemicals enter the ocean through untreated wastewater, and invasive marine species and plastic pollution are widespread. All marine pollutants, their synergies and the risks they bring need to be quantified and minimized.

NFV RECOMMENDATIONS:

- Evaluate the impacts of pollutants using an ecosystem approach within the context of the four-dimensional ocean, i.e. a three-dimensional, interconnected system changing over time.

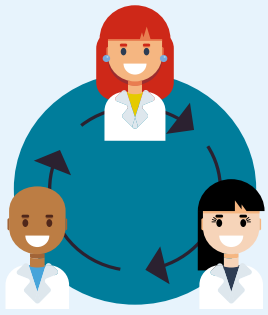
- Determine cumulative effects and interactions of multiple pollutants and other stressors (e.g. over-exploitation of fish stocks and habitat loss) using a unified framework.
- Evaluate the impact of stressors on the interaction between species and their evolutionary responses to determine impacts on ecosystem health.



- Develop novel technologies to measure new pollutants.
- Develop new data products to identify trends in ocean pollution over time.
- Combine multi-stressor experiments and sustained observations with multi-stressor models to develop early-warning indicators for ecological tipping points, and implement these indicators where they are already available. Going beyond tipping points means that large-scale ecological changes will occur that limit optimal ecosystem functioning and ecosystem services.

- Adopt transdisciplinary sustainability science to enable a clear dialogue between all stakeholders and to understand the socio-economic drivers behind human activities leading to pollution. This should generate management actions to promote recycling, improve waste and wastewater management and to encourage more sustainable production and consumption patterns.

BOX 1. WHAT IS SUSTAINABILITY SCIENCE AND HOW CAN WE ACHIEVE IT?



Sustainability science is an emerging academic discipline that operates at the interface of STEM (Science, Technology, Engineering, and Mathematics), social sciences and humanities. It is transdisciplinary, going beyond an integrated interdisciplinary approach by including different stakeholders as co-designers, knowledge producers and users.

Sustainability science underpins the achievement of all of the societal outcomes of the Decade. NFV recommends training a new generation of sustainability scientists to focus on a holistic vision of the marine ecosystem and who can work in parallel with scientists trained in traditional disciplines. It also recommends establishing a sustainability forum within Europe to bring together scientists and stakeholders including industry and civil society.

Credit: Viuz

A Sustainably Harvested Ocean

Marine resources are harvested for food and other industries including biotechnology and energy. The current 2% of protein we obtain from the ocean is likely to more than double to 4–5% by 2030, putting more pressure on the marine environment.

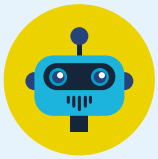
To implement a truly sustainable ocean economy, policy-makers and stakeholders need to know safe and sustainable thresholds within which ocean industries can operate.

NFV RECOMMENDATIONS:

- Improve knowledge on the interactions, dependencies and connectivity between environmental processes in space and time within the four-dimensional ocean.
- Adopt an ecosystem-based management framework that includes coherent spatial units of biodiversity distribution and ecosystem function (e.g. areas where species spawn, larvae drift or where their main food sources live) within management practices such as marine protected areas.

- Investigate the cumulative impacts of multiple stressors on fisheries and aquaculture including impacts of climate change (warming, acidification, sea-level rise), eutrophication, deoxygenation, energy generation, mineral extraction and tourism.
- Improve understanding of the environmental and economic consequences of harvesting marine resources from an ecosystem perspective and within the context of other stressors.

- Improve understanding and prediction of extreme events such as heat waves and harsh winters that impact the physiology and movement of commercially important species.



- Enhance monitoring and management tools to evaluate the costs and benefits of harvesting marine resources.
- Identify ecological tipping points using sustained observations and multi-stressor models in a transdisciplinary approach.

- Underpin management objectives and performance measures with clear dialogue between stakeholders to advance sustainable blue growth agendas while also prioritizing ecosystem protection.
- Integrate the scientific assessment of resilience strategies, associated trade-offs and underlying ethical concepts for the ocean into decision support frameworks.

Credit: iStock

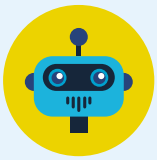
A Safe Ocean

Coastal communities are growing exponentially and becoming increasingly vulnerable to natural oceanic disasters such as storm surges, marine heat waves, harmful algal blooms, meteotsunamis, and marine geohazards including submarine earthquakes, landslides, volcanic eruptions and their associated tsunamis. These can have devastating local and global consequences. Climate change will enhance ocean hazards and improving the ability to anticipate climate extremes will be critical to minimize their impacts.

NFV RECOMMENDATIONS:

- Research the triggers, characteristics, probability and local, regional and global impacts of marine geological hazards.
- Research meteotsunamis that occur frequently from changes in atmospheric pressure.
- Improve understanding of the impact of climate change and weather on ocean hazards, and distinguish between natural and man-made causes for their occurrence.
- Research the impacts of extreme events on ecosystem resilience, marine biodiversity, ecosystem services and their socio-economic impacts in order to build a safe operating space for the blue economy.

- Include multiple interacting stressors within impact analyses of ocean hazards to gain a holistic understanding.



- Develop an integrated multi-hazard early warning system. This requires enhanced long-term observations and monitoring of ocean hazards in space and time for better prediction.
- Develop advanced observing system simulation experiments to choose key areas of the ocean and coasts to monitor as well as the frequency of monitoring.
- Incorporate extreme events into models using statistical methods accounting for their low probability of occurrence.

- Adopt sustainability science in the design of adaptation and mitigation strategies such as coastal defenses, better urban planning, and more resilient construction.
- Develop better ocean literacy relating to forecasting of extreme events, which will contribute to community preparedness and awareness.

Credit: M. Mackey

A Healthy and Resilient Ocean

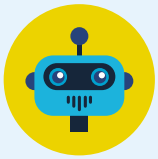
A healthy and resilient ocean requires that marine ecosystems are mapped and protected, marine biodiversity is maintained, and impacts from multiple stressors are measured and reduced. We need a more comprehensive overview of marine biodiversity functioning and its economic and societal value to enact better ecosystem-based management approaches, including marine spatial planning and marine protected areas.

NFV RECOMMENDATIONS:

- Include the four-dimensional structure and function of the ocean in sustainable ocean management.
- Develop an interdisciplinary research program on ocean connectivity to understand links between the physical-, chemical-, biological-, and geological ocean and humanity.
- Study the impacts of climate change on the connected ocean over time (the highly relevant fourth dimension).

- Measure the impacts of multiple interacting and cumulative stressors on the structure and function of marine ecosystems, taking into account biological responses including changes to species interactions and adaptation to climate change.

- Research the effect of extreme events on marine biodiversity, ecosystem functioning, and ecosystem resilience in order to better predict and manage impacts.



- Upgrade observing systems with novel technologies to observe biodiversity and ecosystem function. This will lead to better models to improve prediction of future scenarios and to inform management decisions.
- Develop sustainable measurements for Essential Ocean Variables including physical, biogeochemical, biological and ecosystem variables.
- Assess the quality of biological data and enhance curricula in biodiversity.

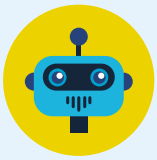
- Implement sustainability science to encourage more transdisciplinary interactions.
- Overcome barriers to collaboration and knowledge sharing.

Credit: Mert Gokalp

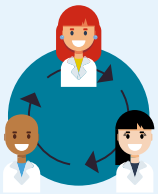
A Predicted Ocean

An accurately mapped, well-observed and better predicted ocean is needed to improve climate forecasting, mitigate impacts from storms, marine hazards and flooding, sustain healthy fisheries, protect marine ecosystems, and enhance decisions on efficient shipping routes. Improved prediction requires scenario building based on accurate observations. Satellites, ships, buoys and robots measure and monitor physical, chemical and some biological ocean variables. Progress is needed particularly in mapping and observing the deep-sea, marine biodiversity, and studying ocean hazards and extreme events.

NFV RECOMMENDATIONS:



- Develop an ensemble of interdisciplinary models that can be used in early-warning systems for multiple stressors, approaching tipping points and extreme events. These models should include ocean physics, biology, geology, biogeochemistry, and socio-economics as well as changes over time, and uncertainties and unknowns that lead to surprise events.
- Improve data and infrastructure support to share standard computer code and develop high-performance computing clusters.
- Parameterize models through a better network of global observations. This requires ongoing development of next-generation multi-sensor observation technologies including automation, robotics, miniaturization, local data processing and DNA sequencing.
- Integrate new technologies into a network of *Ocean Internet of Things* where data is made available and processed in real-time using machine learning, artificial intelligence and cloud-computing. This should include adaptive sampling, in which the location and frequency of sampling could be altered based on real-time information.
- Develop a business model to ensure sustainable ocean observations to provide long-term ocean data, which should be considered a public good and a utility necessary to keep us safe. This will improve assessments for the four-dimensional ocean, multiple stressors and ocean hazards:



- Use sustainability science to better integrate sustained ocean observations, data collection and forecasting into evidence based policy-making and ecosystem-based management.

Credit: Sam Jones

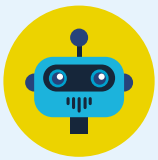
Modelled marine species' migration in response to changes in sea surface temperature.[3]

[3] Molinos *et al.* 2016. Climate velocity and future global redistribution of marine biodiversity. Nature Climate Change, 6, 83-88.

A Transparent and Accessible Ocean

New technologies and the digital revolution will make the ocean more accessible and will transform ocean science. There is an enormous need to deliver ocean data and information to all ocean stakeholders to transform their scientific and technical capacity enabling informed decisions and improved ocean engagement.

NFV RECOMMENDATIONS:



- Establish a data value chain from sensors and platforms to end-users.
- Integrate data collected from different sources into common platforms where data is findable, accessible, interoperable and re-usable (FAIR).
- Develop multi-stakeholder partnerships for ocean data acquisition, storage and sharing.
- Develop a common virtual reality interface where data can be uploaded, allowing the public to explore and see all information about the ocean in real-time.
- Provide information policy-makers need to implement decisions on the four-dimensional ocean, multiple stressors and ocean hazards:

- Implement sustainability science to increase engagement among stakeholders in sharing and visualizing ocean information.
- Accelerate technology transfer through establishment of a sustainability science forum.

BOX 2. OCEAN LITERACY AND CITIZEN SCIENCE

Ocean literacy proposes a research-based framework at the core of basic educational programs and involves understanding the ocean's influence on our society and how we influence the ocean. Ocean literacy helps to deliver ocean information to citizens and stakeholders so they can behave more responsibly. Marine citizen science programs, whereby citizens and scientists collaborate to collect data from the ocean, can increase ocean literacy to address all the societal outcomes of the Decade.

Credit: Mert Gokalp

Credit: European Marine Board

NAVIGATING THE FUTURE V

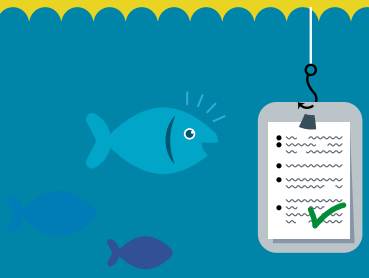
RECOMMENDATIONS FOR THE UN DECADE OF OCEAN SCIENCE FOR SUSTAINABILITY

A CLEAN OCEAN

- Develop a unified framework for understanding cumulative effects and interactions between multiple stressors.
- Develop technologies to measure new pollutants and multi-stressor models to identify tipping points.
- Adopt transdisciplinary sustainability science to enable clear dialogue between stakeholders.

A SUSTAINABLY HARVESTED OCEAN

- Investigate the cumulative impacts of multiple stressors on fisheries and aquaculture.
- Identify ecological tipping points using sustained observations and multi-stressor models.
- Improve knowledge of ocean connectivity and integrate the structure and function of marine ecosystems into management practices.

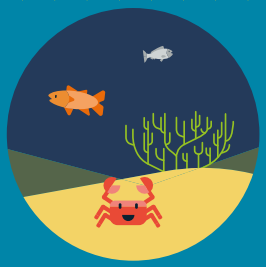


A SAFE OCEAN

- Research meteotsunamis and marine geohazards including the influence of climate change and impacts on biodiversity.
- Develop enhanced early-warning systems based on observations, modelling and forecasting.
- Adopt sustainability science in the design of adaptation and mitigation measures.

A HEALTHY AND RESILIENT OCEAN

- Develop an interdisciplinary research program on ocean connectivity.
- Update observing systems for biodiversity.
- Adopt an ecosystem-based management framework that includes spatial units of ecosystem function.



A PREDICTED OCEAN

- Integrate next-generation multi-sensor observation technologies into the *Ocean Internet of Things*.
- Feed data into interdisciplinary models used in early-warning systems for multiple stressors, tipping points and extreme events.
- Develop a business model to ensure the sustainability of ocean observations.

A TRANSPARENT AND ACCESSIBLE OCEAN

- Integrate data into common platforms and ensure it is findable, accessible, interoperable and re-usable (FAIR).
- Develop a virtual reality ocean platform where data is available and processed in real-time.
- Adopt sustainability science to increase data sharing among stakeholders and accelerate technology transfer.

Suggested reference

European Marine Board (2019). Navigating the Future V: Recommendations for the Ocean Decade. EMB Policy Brief N°. 6, September 2019. ISSN: 0778-3590. ISBN: 978-94-92043-77-1. DOI: 10.5281/zenodo.3465570.

Further reading

European Marine Board. 2019. Navigating the Future V: Marine Science for a Sustainable Future. Position Paper 24 of the European Marine Board, Ostend, Belgium. ISBN: 9789492043757. ISSN: 0167-9309. doi: 10.5281/zenodo.2809392

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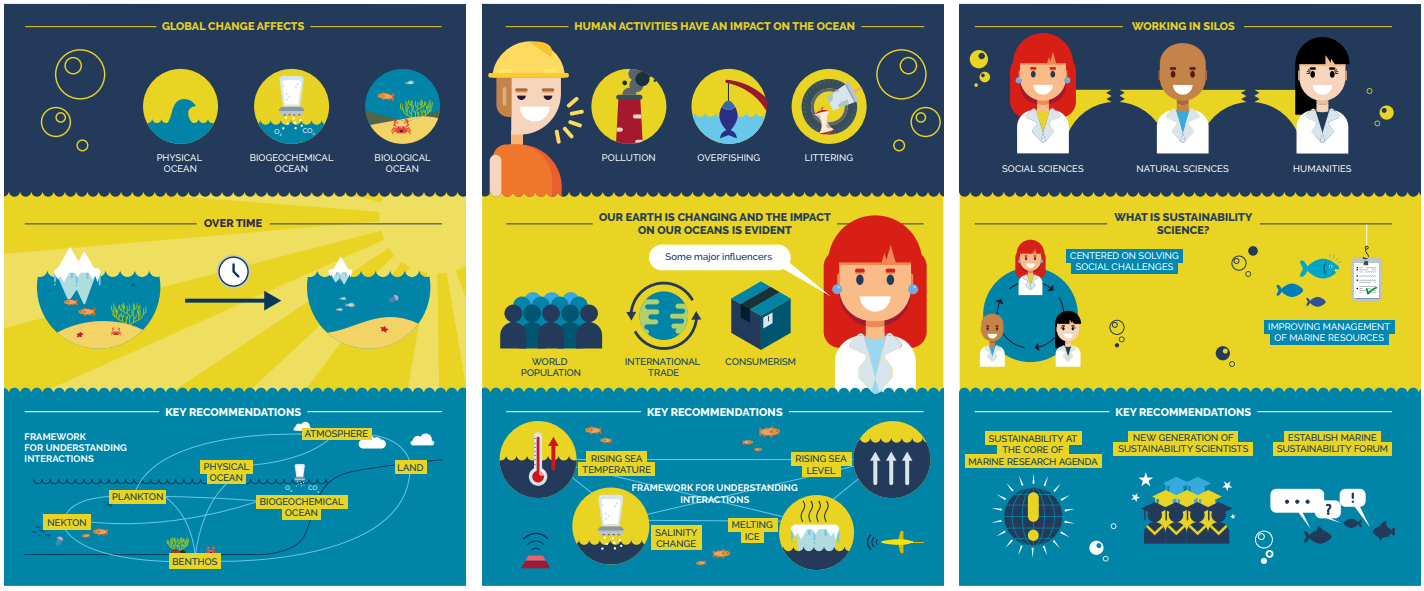
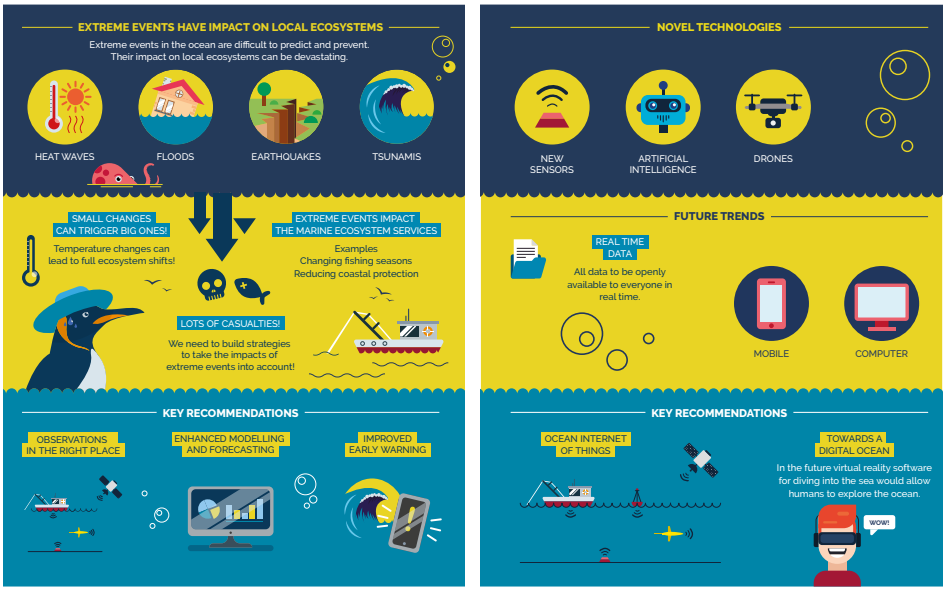
Navigating the Future V Infographics

The five science chapters of NFV are summarized in the following infographics.





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