WORKSHOP ON A RESEARCH ROADMAP FOR OFFSHORE AND MARINE RENEWABLE ENERGY (WKOMRE)

VOLUME 5 | ISSUE 56

ICES SCIENTIFIC REPORTS

RAPPORTS
SCIENTIFIQUES DU CIEM

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

ISSN number: 2618-1371

ICES Scientific Reports

Volume 5 | Issue 56

WORKSHOP ON A RESEARCH ROADMAP FOR OFFSHORE AND MARINE RENEWABLE ENERGY (WKOMRE)

Recommended format for purpose of citation:

ICES. 2023. Workshop on a Research Roadmap for Offshore and Marine Renewable Energy (WKOMRE). ICES Scientific Reports. 5:56. 32 pp. https://doi.org/10.17895/ices.pub.23097404

Editors

Jonathan A. Hare • Andrew B. Gill • Andrew Lipsky

Authors

Alan Haynie • Andrea E. Copping • Andreas Kannen • Andrew B. Gill • Andrew Kenny • Andrew Lipsky • Angela Muench • Antje Gimpel • Antonio Aguera Garcia • Bill Karp • Camille Vogel • Celine Frank • Corinna Schrum • Daniel Oesterwind • Daniel Wood • Edward Willsteed • Inês Machado • Jan Vanaverbeke • Jared Wilson • Jonathan A. Hare • Joop Coolen • Jörn Schmidt • Lisa Pfeiffer • Marion Cuif • Pedro Vinagre • Stefanie Haase • Steven Degraer • Ute Daewel • Vanessa Stelzenmüller • Wojciech Wawrzynski

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

Contents

i Executive summary

The Workshop on a Research Roadmap for Offshore and Marine Renewable Energy (WKOMRE) examined the ICES role in providing science, data, and advice in the context of offshore and marine renewable energy development. For 120 years, ICES has led an international marine science collaboration to support the sustainable use of the ocean. Much of the focus, which is based on historical ocean use, has been on transboundary fisheries science and scientific advice, and more recently on the development of ecosystem approaches to fisheries and marine environmental management. ICES has also made a concerted effort to develop aquaculture science and advice with the goal of informing sustainable ocean-based food production. Climate change and energy security have created an urgent global effort to develop renewable energy in ocean ecosystems. Offshore wind energy and other coastal and marine renewable energy technologies provide countries with the ability to generate renewable electricity within their borders. As a result, rapid and large-scale offshore and marine renewable energy (OMRE) development is now underway. As a science organisation that has worked at the human-ocean interface for many decades, ICES is well-prepared to take a leading role in this topic: providing science, data, and advice to decision-makers to inform on the changes to marine ecosystems resulting from human uses based on principles of ecosystem-based management. The goal for ICES would be to enable society to make scientific-based decisions that balance fisheries, aquaculture, renewable energy, conservation, and other human uses, while at the same time maintaining healthy, productive, and resilient marine ecosystems. ICES proven ability to work at the ecosystem-level and across national boundaries is needed to address the effects of offshore and marine renewable energy on marine resources and ecosystems. To be successful, ICES should act quickly by providing the best scientific information available now and work over the long-term to fill knowledge gaps, develop and use best practices, synthesise information, collaborate with partners and stakeholders, and improve data and advice outputs and outcomes. This WKOMRE report is intended to serve as a precursor to draft roadmap for ICES to pursue development of science, data, and advice on offshore and marine renewable energy in the context of ecosystem-based management.

ii Expert group information

Expert group name	Workshop on a Research Roadmap for Offshore and Marine Renewable Energy (WKMORE)
Expert group cycle	workshop
Year	2023
Chairs	Jon Hare, USA
	Andrew Gill, UK
Meeting venue and dates	ICES HQ, Copenhagen, Denmark; 7-9 March 2023 (33 participants)

1 The challenge before us

Climate change and energy security have created an urgent need for governments to initiate policy changes to rapidly transition from fossil fuel-based energy sources to renewable energy. To meet this need, the development of offshore and marine renewable energy is occurring at a rapid pace across national waters and regional seas. Offshore wind development is currently leading the way and other offshore and marine renewable energy technologies are being developed and deployed (e.g., tidal, wave, photovoltaics, hydrogen generation and storage, power islands). This energy development will transform our oceans, with the installation of thousands of fixed and floating structures, and tens of thousands of km of submarine power cables, along with the accompanying port development, increase in ship traffic, and increase in land-based electricity transmission lines. The expansion of the energy sector can lead to increasing conflict with several other human uses of the ocean (e.g., fishing, conservation) and there are uncertain consequences. For example, fishing effort may be displaced, resulting in *de facto* areas protected from physical disturbance. Commercial fisheries species also may aggregate on and around renewable energy infrastructure as a result of artificial reef effects. At the same time, climate-related changes in marine ecosystems are becoming increasingly evident, and human pressures on these ecosystems that are not directly related to offshore and marine renewable energy are growing (e.g. shipping, aquaculture, carbon sequestration). It is time for ICES to set out a roadmap of strategic action with the goal of furthering its role as a trusted international marine science organisation that provides science, data, and advice to inform decision making for the benefit of its member states and the international community more broadly.

Offshore and marine renewable energy generation is not new. The first offshore wind turbines were installed in Denmark in 1991 with a generation capacity of 4.95 MW. What is new, is the pace and magnitude of proposed development over the next 5–10 years, especially in the Atlantic, Pacific, North Sea, Baltic Sea, and Mediterranean Sea. At the end of 2021, there was 51 GW of generation capacity deployed globally. By 2027, 177 GW are expected to be deployed [1] – a 3.5-fold increase in 5 years (Figure 1.1). In addition, offshore wind development is moving into deeper waters (depths of 50–60 m to over 1000 m). The expected growth of floating offshore wind from 2021 to 2027 is from 123 MW to 8362 MW – a 68-fold increase (Figure 1.2). This shift into deeper waters potentially opens vast areas of the ocean to offshore wind and associated marine renewable energy development.

[1] https://www.energy.gov/sites/default/files/2022-09/offshore-wind-market-report-2022-v2.pdf

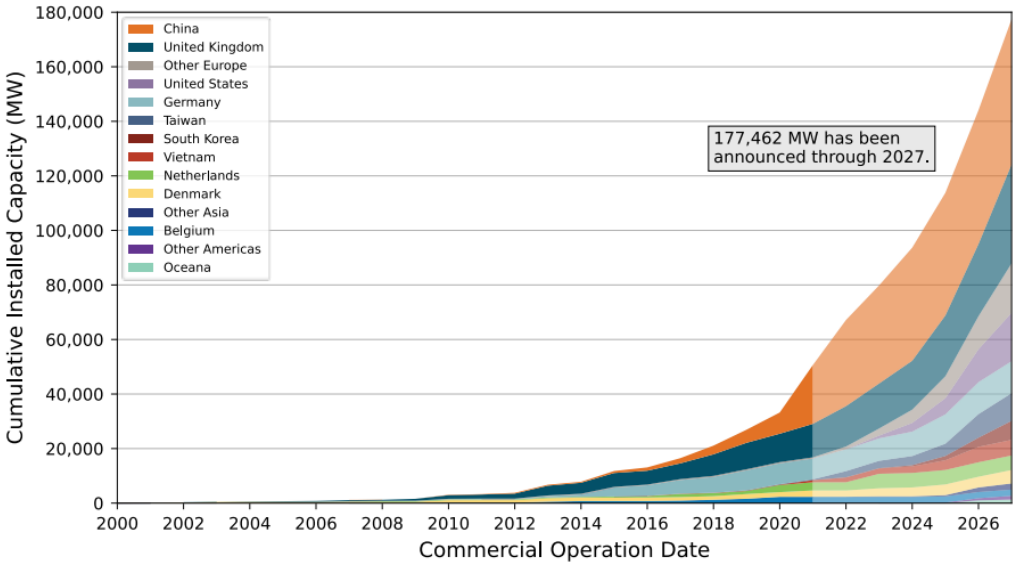


Figure 1.1. Estimated cumulative offshore fixed-turbine wind capacity by country based on developer-announced Commercial Operation Date. Source: Offshore Wind Market Report: 2022 Edition. U.S. Department of Energy [1]

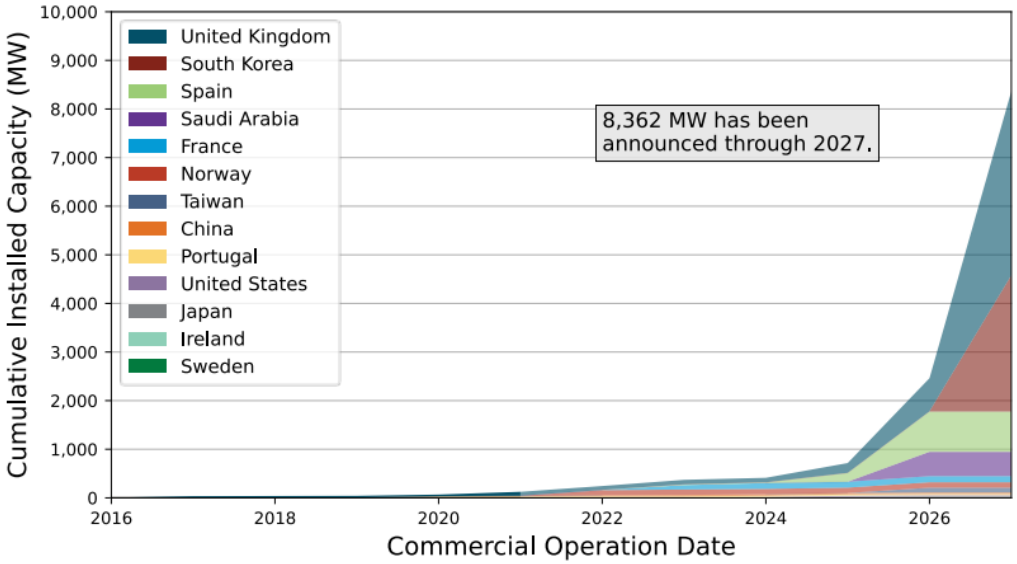


Figure 1.2. Cumulative floating offshore wind capacity by country based on announced Commercial Operation Date through 2027 as of 2022. Source: Offshore Wind Market Report: 2022 Edition. U.S. Department of Energy [1]

The scale of this new human activity will dramatically change and effectively industrialise large areas of ocean ecosystems, as well as interact with other human uses of these ecosystems. Fundamentally, this development will directly affect components of the ecosystem and cause indirect effects resulting in changes to ecosystem processes, structure, and function, as well as affect fishery and wildlife species that inhabit these ecosystems, and the humans that use and rely on these ecosystems. The services that the ecosystems and species provide include food provision, biological conservation, regulation of climate and biogeochemical processes, recreational opportunities, mineral production, and coastal protection. At the same time, other uses and priorities are also growing: transportation and national security. All these uses are interacting (both

positively and negatively) and as these uses continue to increase, their interactions will increase. To manage multiple human uses, it is necessary to identify, understand, and ideally quantify tradeoffs among the different uses. For example, what is the value of national energy production versus national food production? Are these two services competing or can they be complementary? What is the value of conserving natural habitats versus constructing artificial habitats? Can these be complementary? To support this evaluation of tradeoffs, the valuation of ecosystem services (qualitative or quantitative as appropriate) is required relative to the three pillars of sustainability: economic, environmental, and social values.

Offshore and marine renewable energy development will also profoundly challenge ICES and its member states through the impact on fisheries science and scientific advice. Fisheries management is based on a set of science operations that have been improved over the 120 years of ICES existence. ICES has overseen the coordination and synthesis of these operations to develop advice for fisheries management. The fundamental design and methods for executing these science operations will need to change to account for the effects of offshore and marine renewable energy development. There is a need to understand how changes manifest themselves in data collection, modelling, and advice and consider how to mitigate the effect of these changes, which will require modifications to ICES science, data, and advice processes. The development of new survey designs and approaches, assessment methods, and modelling approaches will be needed to account for increased spatial heterogeneity in habitats and biological and physical processes. These changes will also require a new way of providing advice to inform the quickly evolving interactions among fisheries, energy development, and conservation.

The increased demand on ocean ecosystems from offshore and marine renewable energy development creates a further urgent need for ecosystem-based management. This is defined as decision-making based on an integrated approach that incorporates the multiple user sectors and the entire ecosystem, including humans, and that is guided by an adaptive management approach.[2] Increased human activity at an industrial scale within the ocean is also going to reshape fisheries, disrupting the fishing activity itself and the science-management system developed to ensure that fisheries are sustainable. The increased human activity is similarly going to reshape wildlife and habitat conservation affecting the distribution and quality of habitat and affecting human interactions with these habitats and species. Some example questions are: does a wind energy development that restricts or excludes fishing function in part as a marine protected area? What impact does the addition of wind energy turbines have on species abundance and distribution and more broadly on biodiversity? What impacts do wind energy developments have on broader-scale atmospheric, oceanographic, and biogeochemical processes? The scale of offshore and marine renewable energy development makes these questions relevant at the regional and perhaps global scale in addition to the project scale. To meet the urgent societal and management needs, science, data, and advice must be coherently developed to inform sustainable marine energy development, to avoid and minimise conflicts with fishing and conservation, to develop, where possible, complementary approaches to ocean use, and to ensure the sustainability and resilience of associated marine ecosystems. To this end, the tools and approaches that aid in the implementation of ecosystem-based management have been advancing for decades. These approaches include: evaluating trade-offs, risks, and opportunities, understanding the cumulative effects of developments on species, habitats, ecosystems (processes, structure, and function), and humans, marine spatial planning to minimise conflicts and impacts, evaluation and necessary innovation of the fisheries data-science-management process, development and evaluation of management approaches which will ensure sustainability, promote coexistence, and enable adaptation.

[2] https://www.integratedecosystemassessment.noaa.gov/about-iea/ecosystem-based-management

To address these high-level requirements, advances are needed in three key areas: science, data, and advice. From a **science** perspective, three overriding challenges are identified:

1. Understand the effect of offshore and marine renewable energy development on the structure and function of marine ecosystems.
2. Understand the effect of offshore and marine renewable energy development on current and future human uses.
3. Understand and address the effect of offshore and marine renewable energy development on scientific data collections to support sustainable management of marine resources.

These science challenges include the need to ensure the right measurements, analyses, and assessments of the effects and impacts of offshore and marine renewables occur now and in the future. There is also the requirement to adapt and improve our measurement, analysis, and assessment approaches iteratively through time as offshore and marine renewables increase and human use of the ocean continues to change, at times quite rapidly.

From **a data** perspective, there are three overriding challenges:

1. Identify, standardise, collect, integrate, and provide the data necessary to inform the best approach for offshore and marine renewable energy development considering diverse management objectives.
2. Adapt current data systems to changes in data collection resulting from offshore and marine renewable energy development.
3. Maintain and adapt as necessary the data collection, management and dissemination systems necessary for ongoing sustainable management of fishery resources and conservation of biodiversity (including threatened and endangered species).

From **the advice** perspective, there are three overriding challenges:

1. Modify current advice process to include quickly evolving scientific information of relevance to offshore and marine renewable development.
2. Develop new advice to meet the needs of current and new advice requestors.
3. Improve and develop tools to inform offshore and marine renewable energy development in the context of ecosystem-based management and using adaptive management and assessment approaches.

Over the last several decades much progress has been made in all three key areas as marine ecosystem management and fisheries science, and management systems have begun to incorporate ecosystem-based management principles. The challenge is to accelerate this process and provide advice now to support the sustainable development of offshore and marine renewable energy, while continuing to make advances in the science, data, and advice in support of the ICES future role in supporting ecosystem-based management. Given the rapid pace of development, scientific information will need to be organised very efficiently and quickly to provide decision-makers with advice that includes up-to-date scientific information. To be clear, these changes in the use of ocean ecosystems do not require a change in the ICES strategic direction, rather an expansion from a focus on fisheries management to a focus on ecosystem-based management.

2 Unique capabilities of ICES for addressing the challenges

ICES vision is to be a world-leading marine science organisation, meeting societal needs for impartial evidence on the state and sustainable use of our seas and oceans[3]. ICES is an organisation that includes 6000 scientists, from over 700 marine institutes in the 20 member-countries and beyond. The expertise of these scientists spans multiple disciplines and represents numerous marine ecosystems. Therefore, ICES is in a unique position to face the challenges presented by offshore and marine renewable development.

For more than 120 years, ICES has led the international marine science community in the development and application of understanding and advice on the sustainable use of the ocean. For much of this time, fishing was the dominant human use of the ocean and ICES has developed a multinational science, data, and advice system to collect, analyse, and communicate information on the status of North Atlantic fisheries. Over these decades, ICES has also advanced the science, data, and advice to support ecosystem-based management[4]. ICES is now positioning itself to lead the development of scientific evidence and advice in support of multi-sectoral ecosystem-based management in the ocean. Arguably, the advent of offshore and marine renewables will affect most activities and science topics already established and underway within the ICES community. ICES now has the opportunity to organise and accelerate these activities with the express goal of meeting societal needs for regionally-based, impartial evidence and advice relating to the largest change in human use of the ocean in many decades.

ICES is driven by bottom-up participation of scientists from across nations, organised within a structure that fosters collaboration and focuses on the provision of science to inform decisions. This structure allows ICES to rapidly address emerging issues at the appropriate scale to address the challenges presented by almost any issue. ICES convening the WKOMRE is but one example. ICES also has a long history of providing advice for fisheries management and marine conservation, and impacts of human activities on marine ecosystems. As a result, it is a trusted knowledge broker and advisor to governments and international organisations. To meet these advice needs, ICES coordinates data collection by multiple countries, integrates, manages, and synthesises the data, performs assessments using the latest scientific approaches, and provides assessments as advice to various countries and international organisations. To support this work, ICES has a modern data management and dissemination system and robust and transparent data policies[5]that comply with international standards, including those necessary to manage confidential data that is entrusted to ICES by member countries.

ICES has also been instrumental in the development of ecosystem-based management in marine systems for much of its history. The ICES science network includes all aspects of marine ecosystems from physics to people. Recent emphasis has been on the development of Integrated Ecosystem Assessments[6] which demonstrate greater recognition of the importance of the human dimension and related scientific research and development in ICES work[7]. Working groups in ICES are currently developing science related to offshore wind and other marine renewable energy. ICES also produces Ecosystem Overviews which advance Integrated Ecosystem

[3] ICES Strategic Plan

[4] ICES and Ecosystem-Based Management

[5] ICES Data Policy

[6] ICES Integrated Ecosystem Assessments Steering Group

[7] ICES Human Activities, Pressures and Impacts Steering Group

Assessment through ecosystem-based management in regional marine ecosystems across the North Atlantic. It is now essential to put ecosystem-based management into practice to build on these efforts and develop robust science, data, and advice products to inform the development, operation, and future decommissioning of offshore and marine renewable energy developments, with offshore wind being the initial focus.

ICES has also been a leader in valuing the people who work in science with an ongoing strategic investment in early career scientists, which includes co-hosting four early career scientist symposia since 2007 and dedicated programmes for early career scientists at the ICES Annual Science Conference. ICES has adopted a Code of Ethics and Professional Conduct[8], which applies to anyone participating in ICES activities—including staff, officials, members, participants, speakers, volunteers, and exhibitors. ICES also understands the importance of engaging with stakeholders within and across nations throughout the process of developing science and advice - this is described in the ICES Stakeholder Engagement Strategy[9]. These people and stakeholder focused strategies contribute to the standing of ICES as a leading scientific organization and embrace the need to bring multiple perspectives to bear when addressing the challenges of ecosystem-based management.

[8] https://www.ices.dk/about-ICES/how-we-work/Pages/Code-of-conduct.aspx

[9] https://ices-library.figshare.com/articles/report/ICES_Stakeholder_Engagement_Strategy/21815106

3 Draft Roadmap for the implementation of ecosystem-based management in an era of offshore and marine renewable energy development

Here we lay out short, medium, and long-term actions, objectives, and goals for a strategic approach for ICES to address the challenges presented by offshore and marine renewable energy development. The intent is to position ICES, through building on current strengths, to become the leading international science organisation to provide science, data, and advice in support of ecosystem-based management. The immediate issue is offshore wind energy development, but ICES must also work to address offshore and marine renewable energy development more broadly, as well as to refine an ecosystem-based management framework to include other emerging and future human uses of the ocean. Addressing these issues will enable ICES to demonstrate the value of ecosystem-based management while improving science, data, and advice and using adaptive management approaches.

In the short-term, this work is focused on offshore wind energy developments (from the siting and installation of fixed and floating turbines, operation, cabling, and vessel traffic, through to decommissioning); in the medium and long-term, the goal is full implementation of ecosystem-based management related to the range of human uses of the ocean, including offshore and marine renewable energy development. Short-term actions are defined over the next year (2023–2024). Medium-term objectives are defined for the next two to five years, and long-term goals are defined for the next five to ten years (noting that there is a need to look even further ahead). To ensure the ICES response keeps up with the pace of offshore and marine renewable energy development across the ICES region, a roadmap should be revisited at least every two to three years. During each iteration, long-term goals, and medium-term objectives should be reviewed and adjusted as necessary. Short-term actions and work completed should be reviewed and communicated. Then the goals, objectives, and actions updated. In short, ICES should employ an adaptive approach.

1. Short-term actions (2023)

a) ICES experts continue proactive engagement with the ICES Network

1. WKOMRE participant make a presentation to SCICOM on the outcome of WKOMRE.
2. WKOMRE participants complete the report by 5 May 2023.
3. WKOMRE prepare a Quo Vadimus article and submit it to ICES Journal of Marine Science.
4. WKOMRE prepares a presentation for the 2023 ASC describing the workshop and presenting the report - September 2023.
5. The ICES General Secretary lead a discussion with ACOM Chair and SCICOM Chair to discuss the outcomes of WKOMRE - September 2023.
6. The ICES President presents preliminary results of WKOMRE to Bureau and subsequently to ICES Council - October 2023.
7. Chairs of HAPISG, WGOWDF, WGMBRED, and WGORE continue to meet every two months to coordinate ICES activities relative to offshore wind and other offshore and marine renewable energy technologies. Chairs and members continue to discuss the

issue within these Expert Groups and with other Expert Groups (see Annex 7) – Quarterly.

8. Chair of HAPISG completes assessment of current ICES activities and relevant Expert Groups related to offshore wind and other offshore and marine energy developments - September 2023.
9. WKOMRE Chairs work with SCICOM Chair to send WKOMRE report to all Chairs and encourage them to develop new or modify current ToRs to address issues related to their WG expertise and the challenges and opportunities presented here (also send guideline for modifying ToRs) - May 2023 - SCICOM SG Chairs Meeting.

b) ICES establish a Strategic Initiative on Offshore and Marine Renewable Energy (SIOMRE) (or a similar organisational structure)[10]

10. ICES President convene meetings with SCICOM Chair, ACOM Chair, General Secretary and Bureau to review and comment on draft SIOMRE Objectives (Annex 3).
11. WKOMRE Chairs work to identify Chairs for SIOMRE:
    a. WKOMRE participants provide recommendations to WKOMRE Chairs
    b. Three chairs, each from a different country
    c. At least one chair early or mid-career

    OR

    d. An ICES professional staff member to lead the SI, with support of a steering/advisory group made up of chairs from relevant groups.
12. WKOMRE Chairs address comments on objectives and draft ToRs and submit to SCICOM for review and approval.
13. ICES forms SIOMRE or some other equivalent organization structure within ICES.
14. General Secretary develops resourcing plan for the SIOMRE in consultation with SIOMRE Chairs.
15. SIOMRE convenes a directed workshop to undertake a more formal gap analysis of ICES current activities related to offshore wind and offshore and marine renewable energy, including determining where ICES should have specific focus in relation to other science organisational activities. Based on trade-off and gap analysis and defined needs:
    a. Ask Expert Groups to modify or add ToRs
    b. Facilitate the formation of new Expert Groups to address gaps
    c. Recruit new members, with the required offshore and marine renewable-related skills, to the ICES Network

c) ICES identify opportunities for advice in the areas of ecosystem-based management, offshore wind, and offshore and marine renewables

16. ACOM Chair and General Secretary discuss opportunities with current advice requesters.
17. ACOM provide available information in current fisheries advice relating to future challenges presented by offshore wind and other offshore and marine renewables. Examples include:

[10] The participants of WKOMRE identified ICES Strategic Initiatives as a way to advance the necessary development of science, data, and advice. However, ICES has indicated that there may be other structures within ICES that can meet the same intent. Thus, this report refers to a Strategic Initiative not prescriptively, rather to illustrate the need for a cross-ICES organisational structure to advance these ideas.

a. The amount of offshore and marine renewable energy infrastructure in the stock area
b. A short summary of information available regarding the interaction of the species with offshore and marine renewable energy infrastructure
c. The potential impact of offshore and marine renewable energy infrastructure on fishing activities and scientific data collection

18. Ecosystem Overviews Drafting Team to draft state of offshore and marine renewable development within specific ecosystems and update overviews accordingly. Examples include:
    a. The amount of offshore and marine renewable energy infrastructure in the ecosystem
    b. The spatial distribution of offshore and spatial renewable energy relative to other ocean uses

d) Adapt roadmap based on lessons learned and current situation

19. SIOMRE - Organise a workshop in the autumn of 2024 with the goal of reviewing and revising this roadmap.

e) Develop Communication and Engagement Plan around SIOMRE

20. ICES Secretariat lead the development of a communication plan. Purpose is to communicate the establishment and goals of the SIOMRE both internally and externally. Offshore wind should be presented as the immediate challenge that is part of the larger offshore and marine renewable development in the ocean. The collection of activities should be presented as an opportunity to apply ecosystem-based management to urgent challenges marine ecosystems face. The communications should describe what ICES is going to do and not going to do. The unique capabilities of ICES to be an international leader should be highlighted. The intended audiences for the plan are both internal to ICES (WGs, SGs, other SIs, Council, Bureau) and external (policy makers, advice requestors, stakeholders of current ICES advice, and the scientific community). A diverse set of communication tools should be used to reach a broad audience (videos, interviews, science highlights, and different activities and products should be highlighted (WG activities, WK outcomes, ASC presentations, relevant publications, relevant advice).

2. Medium-term objectives (2024–2026)

Science

21. Establish a framework for identifying and prioritizing emerging issues; for issues identified as high priority, start engagement across the ICES network (e.g., marine carbon capture).
22. Develop series of Best Practice Guides:
    a. Monitoring impacts objectively to determine, positive, negative or neutral outcomes of offshore wind development on project and regional ecosystem scale, including standardization and integration of sampling approaches and data
    b. Assessing cumulative impacts from offshore wind and offshore and marine renewable development projects at the species, sector, and regional ecosystem scale

c. Methods for scaling from individual turbine, to project, to regional ecosystems using case studies (e.g., artificial reefs, biogeochemical properties, fish behaviour, atmospheric and ocean dynamics, aquaculture)
d. Assess development and use of spatial tools to support transboundary and transnational planning at regional/ecosystem scales.
e. Using indicators to track impacts of offshore wind development on species, sectors, and regions/ecosystems
f. Mitigating impacts of offshore wind to ICES Surveys and Data Collection (building on work of WGOWDF, WKUSER, WGISDAA)
g. Approaches for determining the effects on fisheries for negative impacts, such as lost revenue and displacement, and potential new fishing opportunities in the future
h. Use of offshore and marine renewable energy infrastructure as scientific platforms for ocean observations
i. Approaches for impacts and opportunities on aquaculture impacts

23. Evaluate the effects of offshore and marine renewable development on the fisheries data collections, including fisheries surveys; stock assessment and stock management process and make recommendations as to how to address these issues.
24. Evaluate the social, economic and ecological effects of offshore and marine renewable development on fishers and fishing communities and make recommendations as to how to assist in adaptation.
25. Set out criteria for upscaling local to regional scale assessments of coexistence outcomes and opportunities with other marine users at regional scales, including co-existence.
26. As part of the SCICOM research recommendation process, include review and prioritization of research related to offshore and marine renewable energy development. Match these research recommendations to funding opportunities.
27. Conduct future OMRE scenario assessments of ecosystem change in light of climate change predictions using IPCC scenarios, to identify and evaluate potential future actions to be taken by ICES.
28. Initiate efforts to inform future IPCC scenarios with regards to ocean use, food production, and energy production.
29. Engage in the IPCC process to include information about local, regional and global tradeoffs in the development of future scenarios.
30. Evaluate the effect of offshore renewable energy development on ecosystem structure and function, including cumulative effects and potential ecosystem-scale impacts.

Data

31. Identify, collate, and develop spatial data at the appropriate scale to provide a better understanding of spatial use of marine ecosystems, where offshore and marine renewable deployment will have an effect at the ecosystem scale.
32. Identify, develop, institute, and evaluate science and industry partnerships to enhance data collection activities; including data management, sharing, and dissemination.

Advice

33. Include information regarding offshore and marine renewable energy development in ecosystem overviews and in fisheries advice. Initially this information will likely be qualitative and descriptive.

34. Conduct an analysis of tradeoffs associated with offshore wind, fishing, marine conservations; develop a framework that allows analysis to be updated periodically and improved.
35. Conduct an ecosystem services valuation exercise including natural capital; develop a framework that allows analysis to be repeated and improved.
36. Develop strategies and best practice guides to address the challenges and opportunities of applying new survey and assessment approaches in response to the interactions of offshore wind development on the monitoring and assessment enterprise of ICES. These approaches should be designed so that they can be applied to new forms of renewable technologies as they are developed and deployed.

3. Longer-terms goals (2027 and beyond)

These goals are generic on purpose as they will depend on the outcome and activities in the short and medium-term goals. They also will need to be adapted as knowledge advances and science evidence requirements change.

37. Implement an ecosystem-based management approach to support ICES advice on fisheries, conservation, offshore and marine energy development and other human uses.
38. Increase understanding of ecosystem-scale impacts (both negative and positive) from human activities with the goal to maintain healthy, productive, and resilient ecosystems.
39. Transform the ICES science, data, advice model related to offshore and marine renewable and fisheries interaction to continue to provide contemporary science evidence and advice.
40. Develop an integrated understanding of the combined effect of climate change and offshore and marine renewable energy development on marine ecosystems.
41. Develop an understanding of the effect of changing human uses of marine ecosystems with respect to climate change effects.
42. Set out an approach to understand the interconnections and dependencies between terrestrial, coastal and marine ecosystems and how offshore and marine renewable energy will affect these.
43. Implement an adaptive and iterative approach to developing advice with a formal evaluation of previous advice relative to expected changes as a result of offshore and marine renewable.
44. Support multidisciplinary and interdisciplinary science, data, and advice.
45. Prepare early career and next generation of scientists in the context of ecosystem-based management approaches and changing human influence on ecosystem components that we depend on.
46. Maintain leadership in the provision of marine and coastal ecosystem data.
47. Enable international science to address issues of regional and global effect and importance.

4 The need to be adaptive

The pace and scale of offshore wind and other offshore and marine renewable energy development is rapid and there are large gaps in science and data needed to inform scientific based advice. This requires immediate action, and ICES is well positioned to meet this need and to start providing advice to countries and organizations based on the best available science and data. ICES must also work rapidly to assess science and data needs in the context of offshore and marine renewable development to improve and expand future advice. The challenge calls for a regional ecosystem-focused adaptive approach to implement a roadmap. This process would be similar to the adaptive approach taken by ICES in implementing its Strategic Plan. A SIOMRE or some other organizational structure should review this roadmap annually and then, with guidance from SCICOM, ACOM, Bureau, and Council, develop a detailed plan for the forthcoming year, e.g., identify short-term actions for 2024, medium term actions for 2025 to 2027, and long-term actions for 2028 and beyond. Performance metrics should be agreed-upon for the short, medium, and long-term actions and evaluation of these performance metrics should take place when revising the roadmap.

5 Conclusion

Offshore and marine renewable energy development will impact marine ecosystems for decades to come. The scale is expected to be at least comparable to fishing activities. Over its first century of existence, ICES focused primarily on fisheries as this was the human use with greatest effect on marine and coastal ecosystems. In recent decades, ICES has increasingly focused on the ecosystem components of fisheries science and management (habitat, multispecies management) and has increased focus on climate change effects on marine ecosystems. Looking forward at the pace and scale of offshore and marine renewable energy development, it is imperative that ICES address this issue now. This imperative comes from the 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.

Annex 1: List of participants

Name	Institute	Country (of institute)	Email
Alan Haynie	ICES		alan.haynie@ices.dk
Andrea E. Copping	Pacific Northwest National Laboratory	United States	andrea.copping@pnnl.gov
Andreas Kannen	Helmholtz-Zentrum Heroen Institute of Coastal Research	Germany	andreas.kannen@hereon.de
Andrew B. Gill (chair)	CEFAS	United Kingdom	andrew.gill@cefas.gov.uk
Andrew Kenny	CEFAS	United Kingdom	andrew.kenny@cefas.gov.uk
Andrew Lipsky	Northeast Fisheries Science Center, NOAA	United States	andrew.lipsky@noaa.gov
Angela Muench	Cefas Lowestoft Laboratory	United Kingdom	angela.muench@cefas.gov.uk
Antje Gimpel	Federal Maritime and Hydrographic Agency	Germany	antje.gimpel@bsh.de
Antonio Aguera Garcia	Institute of Marine Research	Norway	Antonio.aguera@hi.no
Bill Karp	ICES		bill.karp@ices.dk
Camille Vogel	IFREMER	France	Camille.Vogel@ifremer.fr
Celine Frank	European Commission		Celine.FRANK@ec.europa.eu
Corinna Schrum	Helmholtz-Zentrum Heroen Institute of Coastal Research	Germany	corinna.schrum@hereon.de
Daniel Oesterwind	Thünen Institute	Germany	daniel.oesterwind@thuenen.de
Daniel Wood	CEFAS	United Kingdom	Daniel.Wood@cefas.gov.uk
Edward Willsteed	Howell Marine Consulting	United Kingdom	ed@howellmarine.co.uk
Inês Machado	Wave Energy Centre - Centro de Energia das Ondas	Portugal	ines.machado@wavec.org
Jan Vanaverbeke	Royal Belgian Institute of Natural Sciences	Belgium	jvanaverbeke@naturalsciences.be
Jared Wilson	Marine Scotland Science	United Kingdom	jared.wilson@gov.scot

Jonathan A. Hare (chair)	Northeast Fisheries Science Center, NOAA	United States	jon.hare@noaa.gov
Joop Coolen	Wageningen University & Research	Netherlands	joop.coolen@wur.nl
Jörn Schmidt	ICES		joern.schmidt@ices.dk
Lisa Pfeiffer	Northwest Fisheries Science Center, NOAA	United States	lisa.pfeiffer@noaa.gov
Marion Cuif	IFREMER	France	Marion.Cuif@ifremer.fr
Pedro Vinagre	Wave Energy Centre - Centro de Energia das Ondas	Portugal	pedro.vinagre@wavec.org
Stefanie Haase	Thünen Institute	Germany	stefanie.haase@thuenen.de
Steven Degraer	Royal Belgian Institute of Natural Sciences	Belgium	steven.degraer@naturalsciences.be
Ute Daewel	Helmholtz-Zentrum Heroen Institute of Coastal Research	Germany	ute.daewel@hereon.de
Vanessa Stelzenmüller	Thünen Institute	Germany	vanessa.stelzenmueller@thuenen.de
Wojciech Wawrzynski	ICES		wojciech@ices.dk

Annex 2: WKOMRE resolution

A **Workshop on a Research Roadmap for Offshore and Marine Renewable Energy** (WKOMRE), chaired by Jon Hare, USA; and Andrew Gill, UK; will be established and will meet at ICES HQ, Copenhagen, Denmark, 7–9 March 2023 to:

a) Identify the main challenges and opportunities regarding ecosystems associated with offshore and marine renewable energy developments and scope their characteristics, policy drivers and evidence requirements across ICES member states (Science Plan codes: 2.2, 2.7);
b) Review ongoing work on offshore and marine renewable energy development in ICES to identify synergies and knowledge gaps (Science Plan codes: 6.1);
c) Develop a roadmap for the integration, coordination and delivery of science on offshore renewable energy developments (Science Plan codes: 4.5).

WKOMRE will report by 30 April (via HAPISG) for the attention of ACOM and SCICOM.

Supporting information

Priority	Offshore renewable energy developments, and in particular offshore wind, are priority policy objectives in most ICES member countries and beyond. Advisory needs will develop quickly. The activities of this workshop will lead ICES into better coordination of science on offshore renewable energy development, identify scientific capabilities and services and role that ICES can provide to meet transboundary science needs. and prepare for advisory requests. Consequently, these activities are considered to have a very high priority.
Scientific justification	Term of Reference a) Several expert groups in ICES are focussed on work in relation to offshore renewable energy development and its interactions with other human activities, scientific operations, as well as its impact on marine habitats. An increasing number of other expert groups have recently started working on specific aspects related to offshore renewable energy development. It is therefore important, through a review process, to identify potential synergies and knowledge gaps to guide ICES work so that effective integration and scientific advice can provided. Term of Reference b) To develop a roadmap for the integration and coordination of ICES Activities with respect to understanding the effects of marine renewable energy developments on the marine environment and society.
Resource requirements	Many research programmes are underway or have been carried out. The breadth of the work in ICES and the need for coordination might require additional resources in the ICES Secretariat.
Participants	The workshop is targeted towards the chairs and members of existing relevant groups and additional experts. In person/hybrid participation to be encouraged to effectively brainstorm, scope and plan the work required to address the issues.

Secretariat facilities	Meeting room and technical support for hybrid meeting.
Financial	No direct financial implications for the workshop, however, see above "resource requirements"
Linkages to advisory committees	ACOM
Linkages to other committees or groups	There is a very close working relationship with all the groups working on offshore renewable energy development, ecosystem observations/monitoring, and marine spatial planning, WGOWDF, WGORE, WGMBRED, WGMPCZM, WGSOCIAL, WGECON, WGCEAM, EOSG
Linkages to other organisations	OSPAR, HELCOM, EU-MSFD, renewable energy industry

Annex 3: Draft objectives for the Strategic Initiative on Offshore and Marine Renewable Energy

The participants of WKOMRE identified ICES Strategic Initiatives as a way to advance the necessary development of science, data, and advice. However, ICES has indicated that there may be other structures within ICES that can meet the same intent. Thus, this report refers to a Strategic Initiative not prescriptively, rather to illustrate the need for a cross-ICES organisational structure to advance these ideas.

1. To advance the scientific capacity on understanding the interactions among offshore and marine renewable energy development and marine ecosystems by engaging the ICES scientific community in focused workshops, theme/topic sessions and symposia that target key issues, studies on the impacts on marine ecosystems explicitly including humans, and efforts to advance ecosystem-based management related to multiple human uses.
2. To advance development and application of models supporting the analysis of impacts from offshore and marine renewable energy development at regional and ecosystem scales and at subseasonal to decadal scales.
3. To effectively communicate this capacity to clients, Member Countries, stakeholders and the broader scientific community.
4. To facilitate an international effort to design data collection networks at the spatial and temporal scales needed to monitor, assess and predict offshore and marine renewable energy development impacts on marine ecosystems.

To facilitate international collaboration to design and implement comparative analysis of marine ecosystem responses to offshore and marine renewable energy development at regional and ecosystem scales and subseasonal to decadal scales through modelling and coordinated process studies and long-term observations.

Annex 4: Challenges exercise

During the workshop, all participants were asked to identify challenges presented by offshore wind and other offshore and marine renewable energy development. These challenges were framed as challenges to ICES and challenges in the context of implementing fisheries management and ecosystem-based management. These challenges were then discussed by the participants and steps to address the challenges were identified. These steps were then used in the development of the roadmap.

Challenges	**Action, Objective, Goal that Addresses Challenges**
How does ICES work across a distributed network to enable efficient use of ICES working groups and support the creation of advice products to inform offshore and marine renewable development?	1-18, 33
How does ICES create a strategic direction to implement ecosystem-based management in the current context of offshore and marine renewable development and connect across the ICES network facilitate contribution to the strategic direction?	1-18, 33
How to develop and communicate a shared unified vision of what ICES wants to achieve to help member countries and international organization make decisions?	10-15, 23
How to measure ecosystem impacts and cumulative effects of offshore and marine renewables?	25a, 25b, 25c
How to standardize and integrate offshore and marine renewable project-scale monitoring data (cross-border, integrate different gear, methods, and data)?	25a
How to accommodate differences in the national and regional pace and scale of offshore wind and offshore and marine renewable development?	25a
How to assess impacts of offshore wind development at the turbine, project, and regional ecosystem scale?	25b, 25c
How to validate and improve modelling tools to evaluate impacts of offshore and marine renewable development?	25b, 25c
How to address the complexity of modelling and decision support tools to inform offshore and marine renewable development?	25b, 25c
How to link scales from turbines to projects to regional ecosystems?	25c
How to use offshore and marine renewable infrastructure as observation platforms?	26h
How does offshore and marine renewable development affect fisheries data, assessment, and management?	26
How to identify, develop, and share technologies that provide for the coexistence of fishing and offshore and marine renewable development?	27

How does ICES set science priorities and match to national and international funding opportunities?	28
How to measure and assess cumulative effects of offshore and marine renewable development on ecosystem function including the potential for tipping points?	31
How to identify and quantify trade-offs of human uses to inform ecosystem-based management?	33
How to develop advice to support ecosystem-based management in the context of offshore and marine renewable development; how to identify advice recipients; how to develop standards for advice?	33
How to synthesize knowledge to provide advice and to identify key science questions appropriate to the regional ecosystem scale?	34, 35
How to implement ecosystem-based management in the context of fishing and offshore and marine renewable development?	36
How to ensure ICES is perceived as a leader in providing science to inform ecosystem-based management including but not limited to the fisheries and offshore and marine renewable energy sectors?	36

Annex 5: Opportunities exercise

During the workshop, all participants were asked to identify opportunities presented by offshore wind and other offshore and marine renewable energy developments. These opportunities were framed as opportunities for ICES and opportunities in the context of implementing fisheries management and ecosystem-based management. These opportunities were then discussed by the participants and steps to realise these opportunities were identified. Some opportunities were combined during and after the workshop if they were equivalent. For many of the opportunities, specific outcomes or products were defined. These steps and outcomes were then used to inform the unique capabilities of ICES and the roadmap.

Opportunity	**Potential Product / Outcome**	**Action, Objective, Goal that Addresses Opportunity**
ICES is uniquely situated to provide science advice for fisheries management and ecosystem-based management and to understand, measure, and assess human impacts on marine ecosystems	Describe unique capabilities of ICES in the Roadmap	done
Use existing WG's and expertise within the network and grow the network to be more inclusive of the expertise needed	Describe the strategic direction and then work with Committees, Steering Groups, and Working Groups to provide their expertise	15
	Describe unique capabilities of ICES in the Roadmap and the need for an adaptive approach informing ecosystem-based management	done
Further enable ICES to advise on human uses of marine ecosystems - broaden ability to address questions from an ecosystem perspective	Conduct "Horizon Scanning" efforts at a regular interval; develop a structure to identify future human uses (e.g., review national strategy documents)	21
	Link ICES activities more explicitly to IPCC scenarios. Conduct scenario planning for ICES and link future offshore and marine renewable scenarios to IPCC scenarios	27-29
	Develop and improve tools to advise on future use of marine space; describe processes and products to incorporate changing and new human uses.	22d

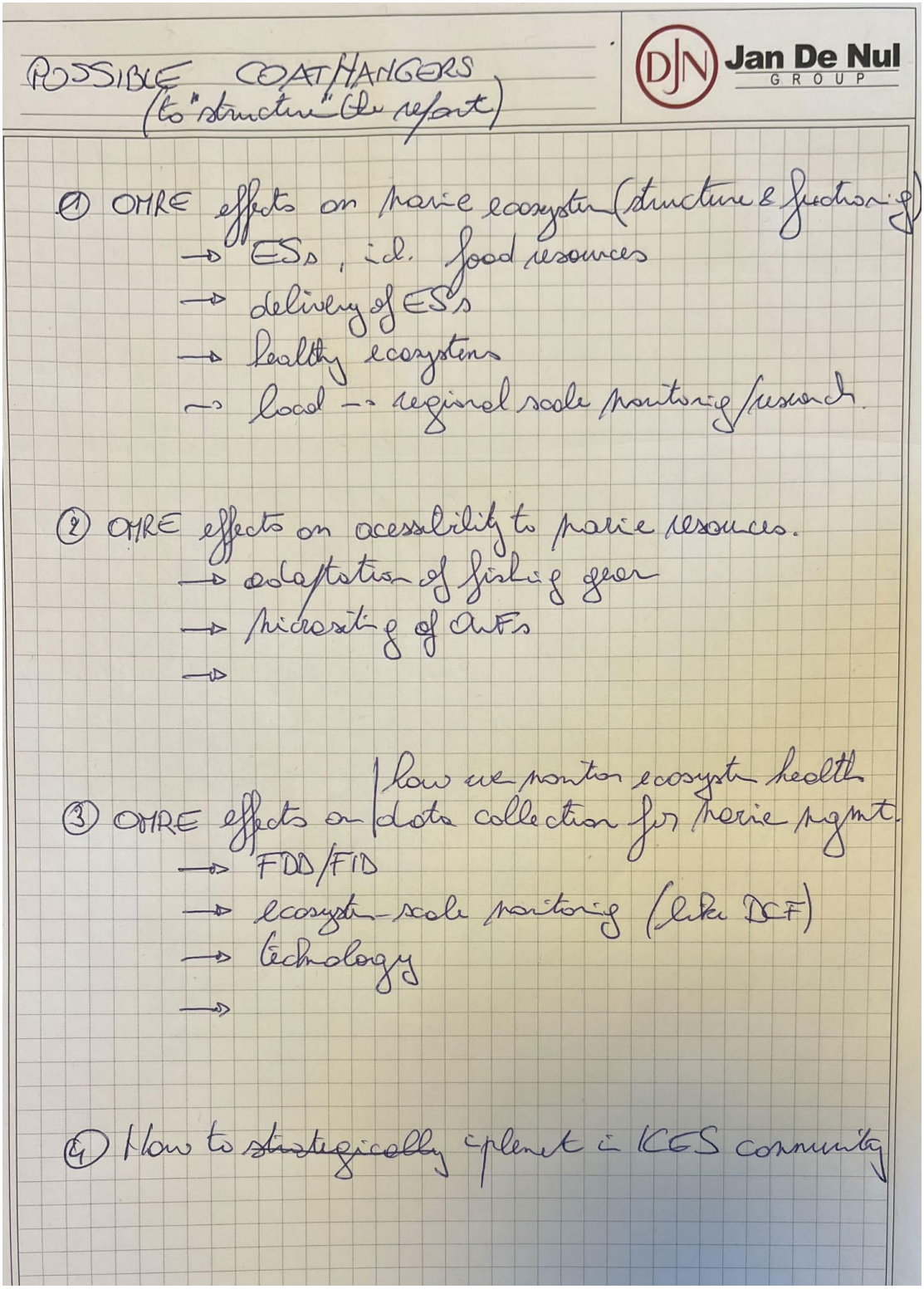
	Identify best practices for Marine Spatial Planning	
	Regularly update data on spatial and magnitude of human uses in marine ecosystems	18
Develop a Marine Ecosystem Valuation Framework	Development, use, and improve a valuation framework (natural capital, ecosystem good and services)	30, 34, 35
	Use ecosystem overviews; make ecosystem assessment more inclusive of valuation and tradeoffs	18, 33
Support cross-disciplinary & interdisciplinary science	Continued recruitment of scientists and disciplines into the ICES network (early career SI)	15b, 15c
	More integrative and better use of existing expertise	15b, 15c
Demonstrate and improve the application of ecosystem-based management approaches to informing decisions around human use of the ocean	Development of products for advice requestors and building of clientele	33
	Improve literacy of ecosystem-based management approaches among decision makers (infographics; science communication, knowledge transfer) - ICES is a trusted source	20
Prioritize research recommendations with a focus on the identifying broad areas of need	Iterative prioritization of research recommendations (and funding needs) - link to Science Plan 3-year cycle	21,26
Stimulate hypothesis driven research that allows predictive capacity and scenario development	Develop hypotheses and test, then iterate	26
Support decision making at the regional ecosystem scale	Develop regional advice and provide to decision makers - ecosystem overviews	18
Analyze available data now and identify and collect data needed to improve analyses in the future	Use data to address research questions and support advice needs; develop and apply new approaches to data integration, synthesis (e.g. AI)	31

	Explore value of data in a workshop to analyze existing and identify future data needs - OSSE - applied to specific questions	25
	Further use ICES data systems to make data more available, useful, and understand	31
Identify and use modelling tools that are available now and develop and improve modelling tools to improve future applications	Develop modelling guidelines and identify models fit to purpose and then iteratively improve	22d
Develop tools to evaluate trade-off among multiple ocean uses	Develop framework for identifying and evaluating tradeoffs, and iteratively improve	15, 34
Produce guidelines for project-level and regional ecosystem system level monitoring of the impacts of offshore and marine renewable development	Develop guidelines for monitoring impacts on the ecosystems, on data collection, and on fisheries assessments (bringing fisheries along and adapting fisheries assessments) - develop renewable assessments at the ecosystem scale	22a
Evaluate and mitigate the effects of offshore and marine renewable development on fisheries data collection including both fisheries independent and fishery dependent methods		23
Evaluate the potential for offshore and marine renewable infrastructure to be used for ocean observations	Identify current and future use of infrastructure for contributing to ecosystem and fisheries observations	22h, 32
Provide spatial maps of fishing effort and fishing value both in terms of project location and port locations	Develop and provide spatial information on fisheries: species, gear, country, home port, port of landing	31
Develop spatial maps of trade-offs and valuation to examine the impacts at different scales	Develop map of distribution and magnitude of pressures and tradeoffs	31
Build cooperative and collaborative research networks around offshore and marine renewable and other marine uses	Implement roadmap	13

Implement an adaptive approach to science, data, and advice	Define and use adaptive management processes	43
Demonstrate the advantages of taking an ecosystem approach vs the current model of focussing on species with greatest conservation protection	Describe results as an example of implementing ecosystem-based management, showing how conservation species are part of the wider ecosystem and can be integrated without losing the critical ecosystem focus	37
Co-develop adaptation approaches for fisheries in response to offshore wind and offshore and marine renewable	Develop fishing technologies that work within offshore and marine renewable development	24
	Compensation review and guidelines	22g, 34
	Examination of community-scale effects of offshore and marine renewable development (economy, identify, social, cultural)	24
	Develop and implement adaptation strategies	24
Develop approaches for scaling science, data, and advice across the turbine-project-regional ecosystem continuum	Workshop on Artificial reef - to upscale - fish, organic matter - BGC effects, fishery behaviour effects - identify research needs (WGOMG/ WGIPEM)	22c
	Workshop on oceanographic and atmospheric effects - BGC - identify data needs	22b, 22c
	Workshop to connect regional efforts, disciplines, and determine what data/monitoring is still needed	22
Practically apply ecosystem-based management approaches to support multiple human uses of marine ecosystems; use concepts of ecosystem-based management and complex socio-ecological systems	Definition of ecosystem-based management applied to renewable energy (conceptual to applied) Within Marine spatial planning ecological processes with Stock assessment	37

Continue to develop and apply social science and economic expertise to support multiple human uses of marine ecosystems		24
Continue to support ICES data systems		31, 32
Apply new approaches to data analysis including artificial intelligent and the use of digital twins		32
Make recommendations as to the design of offshore wind and offshore and marine renewable developments to minimize negative impacts and maximize positive impacts		22b,22c

Annex 6: Science questions developed during WKOMRE


POSSIBLE COATHANGERS
(to "structure" the report)

Jan De Nul GROUP

① OMRE effects on marine ecosystem (structure & function)
- → ESs, i.d. food resources
- → delivery of ESs
- → healthy ecosystems
- → local -- regional scale monitoring/research

② OMRE effects on accessibility to marine resources.
- → adaptation of fishing gear
- → hindering of AWFs
- →

③ OMRE effects on | how we monitor ecosyst. health
| data collection for marine mgmt.
- → FDD/FID
- → ecosyst.-scale monitoring (like DCF)
- → technology
- →

④ How to strategically implement in ICES community

Annex 7: Partial list of ICES Experts Working on Offshore and Marine Renewable Energy

Explicit Offshore and Marine Renewable Energy Terms of Reference

Working Group on Fisheries Acoustics, Science and Technology (WGFAST)
OSPAR-HELCOM-ICES Joint Working Group on Marine Birds (JWGBIRD)
Working Group on Marine Planning and Coastal Zone Management (WGMPCZM)
Working Group on the Effects of Extraction of Marine Sediments on the Ecosystem (WGEXT)
Marine Chemistry Working Group (MCWG)
Working Group on Marine Protected Areas and other Spatial Conservation Measures (WGMPAS)
Workshop on Climate Change Considerations in Marine Spatial Planning (WKCCCMSP)
Working Group on Offshore Wind Development and Fisheries (WGOWDF)
Working Group on Marine Benthal and Renewable Energy Developments (WGMBRED)
Working Group on Offshore Renewable Energy (WGORE)
Workshop on Socio-economic Implications of Offshore Wind on Fishing Communities (WKSEIOWFC)

Other Experts Groups working on Offshore and Marine Renewable Energy identified during WKOMRE
Working Group on Social Indicators (WGSOCIAL)
Working Group on Economics (WGECON)
Working Group on Spatial Fisheries Data (WGSFD)
Working Group on Cumulative Effects Assessment Approaches in Management (WGCEAM)
Working Group on Introductions and Transfers of Marine Organisms (WGITMO)
Working Group on Marine Protected Areas and other Spatial Conservation Measures (WGMPAS)
Working Group on Integrative, Physical-biological and Ecosystem Modelling (WGIPEM)
Baltic International Fish Survey Working Group (WGBIFS)
Working Group on Balancing Economic, Social and Ecological Objectives (WGBESIO)
Working Group on Ecological Carrying Capacity in Aquaculture (WGECCA)

Annex 8: Partial list of national and regional activities related to Marine Ecosystems and Offshore and Marine Renewable Energy

Research Programs - National Opportunities Related to Offshore and Marine Renewable Energy Development (contributed by WKOMRE participants during the workshop)

Germany: BSH/Hereon: OffChEm – Chemical Emissions from Offshore Wind Farms - https://www.bsh.de/EN/TOPICS/Research_and_development/Current_projects/OffChEm

Germany: OffChEm II - Chemical emissions from offshore wind farms – Potential impacts on the marine environment and their evaluation - https://www.hereon.de/institutes/coastal_en

Germany: Climate, Climatic Change, and Society (CLICCS) - Sustainable adaptation scenarios for coastal systems - https://www.cliccs.uni-hamburg.de/

Germany: BMBF: MOHN – Masterplan Offshore Hydrogen North Sea - https://www.cruh21.com/en/107.html

Germany: SeaUseTip - Spatio-temporal analysis of tipping points in the socio-ecological system of the North Sea) - https://www.seausetip.de/en/

Germany: The German Project CoastalFutures (part of the DAM Research Mission sustainMare Future Scenarios) - https://www.coastalfutures.de/index.php.en

Germany: H2Mare Offshore Technologies - using renewable electricity offshore to produce hydrogen and its secondary products. - https://www.wasserstoff-leitprojekte.de/projects/h2mare

Germany: Expansion of offshore wind energy in Germany: effects on seabirds in the North Sea and Baltic Sea (OWF-seabirds), https://www.ftz.uni-kiel.de/en/

Germany: Bird migration across North Sea and Baltic Sea: Migratory patterns and possible impacts of offshore windfarms (TRACKBIRD) - https://www.ftz.uni-kiel.de/en/research-divisions/ecolab-marine-animal-ecology/current-projects/xxx-trackbird

Germany: sustainMare - https://www.sustainmare.de/index.php.de

Germany: MUSSEL on cumulative effects (incl. wind farms) on the Southern North Sea - https://mussel-project.de/portal/apps/sites/#/mussel/

Germany: Sound Refine - Investigation and modelling of cumulative effects from the construction of offshore wind farms on harbour porpoise populations - https://www.tiho-hannover.de/en/clinics-institutes/institutes/institute-for-terrestrial-and-aquatic-wildlife-research-itaw/research/projects-aquatic/ongoing-projects-aquatic/sound-refine-investigation-and-modelling-of-cumulative-effects-from-the-construction-of-offshore-wind-farms-on-harbour-porpoise-populations

United Kingdom: Offshore Wind Evidence and Change Programme - https://www.thecrownestate.co.uk/en-gb/what-we-do/on-the-seabed/offshore-wind-evidence-and-change-programme/

United Kingdom: ORJIP - Offshore Renewables Joint Industry Programme - http://www.orjip.org.uk/

United Kingdom: Ecostar - Ecosystem level importance of Structures as Artificial Reefs - http://www.smru.st-andrews.ac.uk/ecostar/

United Kingdom: OWEER - Offshore Wind Environmental Evidence Register - https://www.marineda-taexchange.co.uk/details/3480/2021-jncc-offshore-wind-evidence-and-change-programme-offshore-wind-environmental-evidence-register-/summary

United Kingdom: ScotMer - Scottish Marine Energy Research Programme - https://www.gov.scot/policies/marine-renewable-energy/science-and-research/

United Kingdom: Strategic Resource Areas Programme - https://www.gov.wales/development-strategic-resource-areas

United Kingdom: COWRIE - Collaborative Offshore Wind Research Into The Environment - https://www.offshorewindfarms.co.uk/pages/cowrie/cowrie_explained/

United Kingdom: EcoWind - Ecological consequences of offshore wind - https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/ecological-consequences-of-offshore-wind-ecowind/

Netherlands: Offshore Wind Ecological Program - WOZEP - https://wozep.nl/

Netherlands: Acoustic ecology of PELAgic FIsh COmmunities: A study into the effects of construction and operations of wind farms - APELAFICO - (https://mareco-odnature-naturalsciences.be/project/apelafico/)

France: Follow Wind Turbines at Sea - EOLENMER - https://www.umr-amure.fr/projets-scientifiques/eolenmer/?lang=en

France: Development of an integrated acoustic observatory of the water column to assess the impact of marine renewable energy - ECHOSONDE - https://www.weamec.fr/projets/echosonde/

France: Role of offshore wind farms in preserving biodiversity and ecosystem services - WINDSERV - https://www.france-energies-marines.org/R-D/Projets-en-cours/WINDSERV

France: Develop and test a methodology to assess the risk to benthic habitats linked to the accumulation of discharges from anti-corrosion system - POLLUECUME - https://ccem.ifremer.fr/Risque-Chimique/PolluEcume-2022-2023

France: Socio-ecosystemic approach to wind farm impacts - NESTORE - https://www.france-energies-marines.org/wp-content/uploads/2022/12/221004-fiche-projet-NESTORE-EN.pdf

France: Prefiguration of an observatory of marine ecosystems in the Gulf of Lion - ECOSYSMEOF - https://umr-marbec.fr/les-projets/ecosysm-eof/

France: Analysis of Cathodic Protections to assess the chemical risk of elements released - ECOCAP - https://www.france-energies-marines.org/projets/ecocap/ECOtoxicology

France: Monitoring strategies to identify and assess the effects of offshore wind farms on fish populations - FISHOWF - https://www.france-energies-marines.org/projets/fishowf/

France: Real-time Ecosystem Monitoring Buoy for Offshore Wind - REMBOW - https://www.ifremer.fr/fr/innover-avec-l-ifremer/rembow

Belgium: Stakeholder view on OWF decommissioning - https://mareco-odnature-naturalsciences.be/project/vision-development-aquaculture-wind-farm-decommissioning/

Belgium: Floating solar at sea - MPVAQUAbis - https://mareco-odnature-naturalsciences.be/project/mpvaquabis/

Belgium: Eco-designing marine photovoltaic installations - EcoMPV - https://mareco-odnature-naturalsciences.be/project/ecompv/

Belgium: Offshore wind farm monitoring program: benthos, fish, noise, marine mammals, birds, and bats - WinMon.BE - https://odnature.naturalsciences.be/mumm/en/windfarms/#monit

Belgium: Building offshore wind farms in Natura2000 area - EDEN2000 - https://mareco-odnature-naturalsciences.be/project/on-the-compatibility-of-offshore-wind-farms-and-marine-protected-areas/

Belgium: Food-web modeling in the framework of offshore wind farms - METRIC - https://mareco-odnature-naturalsciences.be/project/rbins-embrc/

Belgium: Quantifying organic matter pools in OWF environments - OUTFLOW - https://mareco-odnature-naturalsciences.be/project/outflow/

United States: Offshore Wind in California - https://www.energy.ca.gov/programs-and-topics/topics/renewable-energy/offshore-renewable-energy

United States: Department of Energy - https://www.energy.gov/eere/wind/offshore-wind-research-and-development
https://www.energy.gov/eere/wind/wind-energy-technologies-office
https://www.pnnl.gov/wind-energy

United States: Oregon Territorial Sea Plan - https://www.oregonocean.info/index.php/tsp-home/123-territorial-sea-plan-part-5-marine-renewable-energy-development-2

United States: NOAA Fisheries Integrated Ecosystem Assessment Program - https://www.integratedecosystemassessment.noaa.gov/

United States: Synthesis of Environmental Effects Research - https://tethys.pnnl.gov/us-offshore-wind-synthesis-environmental-effects-research-seer

United States: Bureau of Ocean Energy Management, Environmental Studies Program - https://www.boem.gov/environmental-studies

Research Programs - Regional Opportunities and Organizations Related to Offshore and Marine Renewable Energy Development (contributed by WKOMRE participants during the workshop)

EU Horizon Projects (not a comprehensive list)

MUSES23 - https://muses-project.com/

ULTFARMS - https://mareco-odnature-naturalsciences.be/project/ultfarms/

MarinePlan - https://www.marineplan.eu/

GES4SEAs - https://www.ges4seas.eu/

MSP4Bio - https://msp4bio.eu/

MPAEurope - https://mpa-europe.eu/

SEAWise - https://seawiseproject.org/seawise-results/i

UNITED - https://www.h2020united.eu/about

OLAMUR - https://cordis.europa.eu/project/id/101094065

Europe: OSPAR Environmental Impacts of Human Activities Committee - EIHA - https://www.ospar.org/work-areas/eiha

Europe: OSPAR Offshore Renewable Energy Developments ICG-ORED - https://www.ospar.org/work-areas/eiha/offshore-renewables

Europe: European Maritime, Fisheries and Aquaculture Fund - https://cinea.ec.europa.eu/programmes/european-maritime-fisheries-and-aquaculture-fund_en

Europe: Sustainable Blue Economy Partnership - https://bluepartnership.eu/

Europe: European Fisheries and Aquaculture Research Organisations - https://efaro.eu/

Europe: Chemical emissions from offshore wind farms - ANEMOI - https://www.interreg-northsea.eu/anemoi

Europe: Scotland Marine renewable energy - https://www.gov.scot/policies/marine-renewable-energy/science-and-research/

Europe: Environmental Impacts of Noise, Vibrations and Electromagnetic Emissions from Marine Renewable Energy - MaRVEN - https://tethys.pnnl.gov/research-studies/marven-research-study-noise-vibrations-electromagnetic-emissions

United States: Responsible Offshore Science Alliance - ROSA - https://rodafisheries.org/portfolio/responsible-offshore-science-alliance/

United States: Regional Wildlife Science Entity - https://rwsc.org/

United States: Naitonal Offshore Wind Development Consortium - https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Research-and-Development

United States: Pacific Ocean Energy Trust https://pacificoceanenergy.org/

United States: Science Center for Marine Fisheries - SCEMFIS - https://scemfis.org/

United States: National Center for Coastal Ocean Science - Marine Spatial Planning - https://coastalscience.noaa.gov/research/marine-spatial-ecology/&sa=D&source=docs&ust=1678278002139656&usg=AOvVa

United States: Mid-Atlantic Fishery Management Council - https://www.mafmc.org/northeast-offshore-wind

United States: New Jersey Offshore Wind Program- https://njoffshorewind.com/

Guidance Documents and Collections of Available Data

France: Depository of Biodiversity Database - DEPOBIO - https://depot-legal-biodiversite.nature-france.fr/

France: Offshore Wind Observatory - https://www.eoliennesenmer.fr/observatoire/presentation

France: Système d'information sur le milieu marin - https://www.milieumarinfrance.fr/

France: Système d'information halieutique - https://sih.ifremer.fr/

France: France Energy Marines - https://www.france-energies-marines.org/nos-ressources/

Europe: European Marine Observation and Data Network - EMODnet - https://emodnet.ec.eu-ropa.eu/en/human-activities

Belgium: Belgian Marine Data Centre - www.bmdc.be

Germany: Biodiversity Information System of benthic species at ARtificial structures - BISAR - https://critterbase.awi.de/preview/#projects-bisar

United States: Tethys is a knowledge hub with information and resources on the environmental effects of wind and marine energy - https://tethys.pnnl.gov/tips-tethys

Europe: OSPAR Data & Information Management System - https://odims.ospar.org/en/

United Kingdom: Marine Data Exchange (Crown Estate) - https://www.marinedataexchange.co.uk/

United Kingdom: Crown Estate Scotland Spatial Data - https://crown-estate-scotland-spatial-hub-core-gis.hub.arcgis.com/

United Kingdom: Marine Scotland Interactive - https://marine.gov.scot/

United States: Minimum Recommendations for Use of Passive Acoustic Listening Systems in Offshore Wind Development - https://www.frontiersin.org/articles/10.3389/fmars.2021.760840/full

United States: Bureau of Ocean Energy Management - renewable energy guidance documents: https://www.boem.gov/about-boem/regulations-guidance/guidance-portal

United States: Marine Cadastre https://marinecadastre.gov/

United States: NOAA Fisheries and Bureau of Ocean Energy Management Survey Mitigation Strategy - Northeast Region https://repository.library.noaa.gov/view/noaa/47925

United States: Fisheries and Offshore Wind Interactions: Synthesis of Science - https://repository.li-brary.noaa.gov/view/noaa/49151

United States: Responsible Offshore Science Alliance - Fisheries Monitoring Guidance - https://te-thys.pnnl.gov/publications/rosa-offshore-wind-project-monitoring-framework-guidelines