

WORKING GROUP ON MARITIME SYSTEMS (WGMARS)

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i Executive summary

The Working Group on Maritime Systems (WGMARS) is a forum for interdisciplinary perspectives on ecosystem science, advice, and governance that engages with maritime stakeholders across the North Atlantic to take into consideration and better understand their perspectives.

During 2020–2022, WGMARS focused on methodological, operational, contextual, and science management aspects of ecosystem-based maritime management/governance. Topics addressed here include: 1) how behavioural economics (BE) can inform and enhance fisheries management; 2) the development and use of Integrated Ecosystem Assessments (IEA) in ICES; 3) the types and extent of connectivity among ICES expert groups based on Social Network Analysis (SNA); 4) the ways in which Ecosystem Based Management (EBM) is implemented via IEA and Marine Spatial Planning (MSP) in European Union (EU) member states, other member states of ICES and by the EU itself; and 5) the use of common conceptual modelling mechanisms for understanding ecosystems.

The working group developed and published a systematic review protocol identifying how BE can help marine managers understand and shape fisher behaviour.

The SNA group designed a database of attendees at all ICES expert group meetings from 2015–2019 to map and quantify the strengths and types of connections among the ICES network. This work finds that connectivity is increasing over time and suggests the importance of ICES workshops in this development.

The study on the implementation of IEA in ICES IEA Working Groups (WG) was based on interviews with chairs of 9 of the 11 IEA WGs, the academic literature, and ICES documents. As described in the group's recent paper (Clay *et al.*, submitted) implementation is mixed, complicated, and slow but shows general progress toward full IEA implementation. This work also identifies barriers to further progress, points to recent steps by ICES to foster improvement, and suggests ways to move forward.

WGMARS is extending and deepening its work on institutional barriers and enablers to integrated marine management.

ii Expert group information

Expert group name	Working Group on Marine Systems (WGMARS)
Expert group cycle	Multi-annual fixed term
Year cycle started	2020
Reporting year in cycle	3/3
Chairs	Patricia M. Clay, USA
	Leyre Goti, Germany
	Jennifer L. Bailey, Norway
Meeting venues and dates	20–24 April 2020 (virtual, 18 participants)
	3–4 May 2021 (virtual, 22 participants)
	23–27 May 2022 (virtual, 21 participants)

1 Terms of Reference Defined

Table 1.1 Terms of Reference for WGMARS 2020–2022, as defined in WGMARS Resolution 2019/FT/IEASG02

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
A	Analyse how inter- and transdisciplinary science can improve management and advice	ICES has prioritized the investigation of sustainability dimensions with a view to maritime uses and responses and the integration of different types of knowledge and evidence. One approach to do so are IEAs which are based on a premise of EBM. IEAs and EBM require both social and natural sciences as well as engagement with stakeholders.	3.6, 6.6, 7.4	3 years	Peer-reviewed papers, ICES reports, workshops
B	Analyse how the use of behavioural economics can support IEA/EBM implementation	Policy evaluation in IEA requires insight into human behaviour in order to (1) predict how users respond to policy interventions, and (2) how stakeholders judge trade-offs between conflicting objectives.	6.3, 7.4, 7.5	Years 1,2,3	Peer-reviewed paper on behavioural economics for policy evaluation
C	Review and provide guidelines for conceptual modelling to assist Regional Seas WGs	Conceptual modelling, including through the use of, for instance, Mental Modeler or Bow-Tie Analysis, can aid scientists from different fields, as well as scientists and stakeholders, to facilitate improvements to their IEA activities.	5.3, 6.2, 7.5	Year 1, 2, or 3	At least one workshop with one or more ICES Regional Seas or other IEA- related WGs
D	Evaluate the current development and use of ICES IEAs in support of management and advice	ICES has prioritized the development and use of IEAs, e.g. in the Regional Seas WGs, as a tool for understanding trade-offs in fisheries and maritime policies.	1.9, 3.2, 6.1	Years 1,2	Peer-reviewed paper on the current status of IEAs in the regional seas WGs
E	Apply Social Network Analysis (SNA) as a tool to assess ICES network connectivity and preparedness to address IEAs and the ICES Science Plan	ICES is dedicated to supporting EBM in fisheries and maritime governance. The SNA will analyse interactions of ICES EGs and the extent to which the organizational set up is a good “fit” for facilitating science for EBM.	6.3, 7.4, 7.5	Years 1,2,3	Peer-reviewed paper on the SNA of ICES

F	Analyse and compare the implementation and linkages of IEA/EBM/MSP and fisheries in the EU, individual European member states, and the US	ICES supports the use of EBM and IEAs, while many EU states support MSP. There is a need to connect science done for both purposes and IEA (supported by ICES) is a tool that could be used with either EBM or MSP.	7.4, 6.1, 6.6	Years 1,2	ICES Report
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2 List of Outcomes and Achievements of the WG in 2020–2022

ToR A Analyse how inter- and transdisciplinary science can improve management and advice

This ToR was constructed as a “meta” ToR, setting the broad direction of WGMARS in the three-year period. The analysis of “how inter- and transdisciplinary science can improve management and advice” has been implemented through Tors B–F. Outcomes and achievements for each of these ToRs is presented below.

ToR B Analyse how the use of behavioural economics can support IEA/EBM implementation

In November 2020 the behavioural-economics (BE) group of WGMARS recruited three early career scientists (Alina Wieczorek, Amanda Schadeberg and Julie Krogh Hallin) as new WGMARS members who have been leading a stakeholder-driven systematic review on behavioural economics in fisheries. Several meetings and workshops were held between this lead team (Alina Wieczorek, Amanda Schadeberg, and Julie Krogh Hallin), other members of the BE group, and the wider WGMARS group to identify the scope of the review. Looking back, the BE group has benefitted greatly from the incorporation to the team, at different stages of the work, of early career scientists (ECS) Alina Wieczorek, Amanda Schadeberg, Mary MacKay, Noa Steiner and Julie Krogh Hallin (the latter active 2020–2021). They formed a core group to the project, rather than functioning as interns as initially planned. The entire group deeply felt the passing of Sarah Kraak in 2022, initiator of the BE work in ICES and one of the senior leaders of the study. Other members of WGMARS with different degrees of important involvement in the project include Ingrid van Putten, Andries Richter, Dorothy Dankel, Katell Hamon, Debbi Pedreschi and Marloes Kraan.

The lead team brought the initiative to split the behavioural economics study into three products in order to improve its quality and dissemination opportunities. These three products are a pre-registration at a public database, a peer reviewed review protocol paper, and a systematic review paper. The first two were required under this ToR. The third is required under the 2023–2025 ToRs period.

Key meetings included an initial scoping meeting between the lead group and the whole BE group on 15 October 2020 during which the niche of the study, the target group, the desired results, considerations on scale, effectiveness and ethics as well as the composition of the review stakeholder group were discussed. The lead team then developed a first draft protocol for the systematic review, which they presented to the entire WGMARS group in a webinar on the 25 November 2020. This was followed by a questionnaire that asked participants (i.e. stakeholders of the systematic review) for input on the primary and secondary research questions, behavioural economics mechanisms, keywords, suitable databases, eligibility criteria, and information synthesis. The second draft of the systematic review protocol was presented to the BE task group on the 4 December 2020, during which participants were able to give feedback during an open discussion.

A registered review protocol for the systematic review was submitted to the journal PLoS One in March 2021 and accepted in July (see Wiczorek *et al.* 2021). Once the protocol was accepted the next activities included the extraction of papers using search terms from EconLit, ProQuest and Web of Science (n=1185), the screening for eligibility based on title and abstract, and the reading and extracting of data from eligible studies (n=301).

The workplan proposed by the core team included the production of an internal survey tool, the organization of calibration exercises and, in a more practical way, the setup of virtual reading rooms¹ and a motivational leadership panel.² The reading rooms and leadership panel were found particularly useful given that the work was done remotely and across three continents. To make the reading rooms more accessible there were three sets of each reading room, each timed to accommodate those in one of three disparate time zones.

The user-friendly survey tool developed by the core team allowed anyone from WGMARS to participate in the review process. It also standardized reading and data extraction and finally it stored data in structured way so that it is more easily analysed at the end of the process.

Overall, more than 300 articles were processed by the review team using an online survey tool. The team aims to compile the findings and produce a peer-reviewed paper for submission to a scientific journal by the end of 2022, as part of the WGMARS 2023–2025 ToRs.

This work has also been presented at multiple conferences. At the 2021 ASC WGMARS members Sarah Kraak and Mary Mackay convened Theme session L on “Linking fisher attitudes, behaviours and beliefs to compliance in fisheries management”, where Ingrid van Putten, also a WGMARS member, presented the Keynote talk. The original lead team compiled a poster and video presentation for the ICES ASC 2021 (6–10 September 2021, virtual conference). The poster, titled “Behavioural economics in marine fisheries” won the People’s Choice Award for Alina Wiczorek. An accompanying video (both informative and comic) starred Amanda Schadeberg, Julie Krogh Hallin and Alina Wiczorek. Additionally, an on-demand oral presentation of the first findings was given during the 2021 World Fisheries Congress (20–24 September, Adelaide Australia, hybrid event).³ Work emerging from the BE efforts and based on Bisack and Clay (2021) was also presented at the International Institute for Fisheries Economics and Trade (IIFET) in Galicia, Spain, 18–22 July 2022.⁴ Finally, an oral presentation by Mary MacKay on the final results of the systematic review process⁵ is planned for the ASC 2022 in Dublin, in a session which will be dedicated to Sarah Kraak.

¹ Virtual reading rooms were online meetings where members of the team in a common (or proximate) time zone worked together, solved shared doubts and established joint criteria.

² A leadership panel was a graph showing how many papers each member of the group had achieved to review, to foster motivation through healthy competition. It was complemented by a graph showing how many papers had been completed by the team, to keep the focus on the final objective.

³ Hallin, Julie Krogh Alina M. Wiczorek, Amanda Schadeberg, Sarah B. M. Kraak, Andries Richter, Leyre Goti Aralucea, Debbi Pedreschi, Ingrid van Putten, Patricia M. Clay, Rolf Groeneveld, Dorothy Dankel, Mary Mackay, Katell Hamon. A systematic review of behavioural economics mechanisms in a fisheries context: Lessons for Management. Presented by Julie Krogh Hallin at the World Fisheries Congress. 2021 in Adelaide, Australia.

⁴ Bisack, Kathryn and Patricia M. Clay. Behavioral Responses to Competing Incentives and Disincentives: Compliance with Marine Mammal Protection. Presented by Bisack at the IIFET (International Institute for Fisheries Economics and Trade) annual meeting in Galicia, Spain, 18–22 July 2022.

⁵ Wiczorak Alina; Amanda Schadeburg, Julie Krogh-Hallin, Mary Mackay, Noa Steiner, Ingrid van Putten, Katell G. Hamon, Andries Richter, Patricia M. Clay, Leyre Goti Aralucea, Debbi Pedreschi, Dorothy J. Dankel, Mimi Lam, Marloes Kraan, Nathalie Steins, Xane Verschurr, and Sarah M. Kraak. Applications of Behavioural Economics in Fisheries. To be presented in person by Mackay at the ICES Annual Science Conference 19–22 September 2022 Dublin, Ireland.

Finally, the work on BE has brought to the working group a new form of working with ECS and highlighted the importance of their role, often doing invisible tasks. Some of these tasks have been: designing an accessible method for data collection, managing reading rooms and calibration meetings, allocating papers and preparing conference presentations. A discussion on initial expectations vs. the realities of the workload for ECS that took place during the 2022 WG annual meeting was highly valued by the members, with actions initiated by the senior members to adjust the mismatch. This discussion, which links the work of WGMARS with that of the recently created Strategic Initiative on Integration of Early Career Scientists (SIECS), was led by Amanda Schadenberg and Alina Wieczorek, members of WGMARS and also chairs of SIECS.

ToR C Review and provide guidelines for conceptual modelling to assist Regional Seas⁶ WGs

In pursuance of ToR C, WGMARS arranged to submit a grant request to EuroMarine to organize a workshop on conceptual modelling for ICES IEA WG chairs and other participants. Because only those affiliated with a EuroMarine institution can submit such a grant, then WGMARS co-chairs Patricia M. Clay and Johanna Ferretti worked with WGMARS member Debbi Pedreschi, whose Institute is affiliated with EuroMarine, and a colleague of hers from another such institution – Marcos Llope, to write and edit the grant proposal. The grant was received for an in-person workshop in autumn 2020. This was later rescheduled as in-person for autumn 2021, but again delayed due to the ongoing pandemic. The workshop, the Joint ICES/EUROMARINE Workshop on Common Conceptual Mapping Methodologies (WKCCMM), ultimately took place on 1–4 November 2021 as a virtual gathering. Debbi Pedreschi (Ireland) and Marcos Llope (Spain) chaired the meeting, with additional WGMARS members Patricia M. Clay and Sean Lucey (also a Working Group on the Northwest Atlantic Regional Sea (WGNARS) chair), and Jamie Tan (WGNARS chair) leading specific days of the workshop.

ToR D Evaluate the current development and use of ICES IEAs in support of management and advice

The expected deliverable for ToR C was a “Peer-reviewed paper on the current status of IEAs (Integrated Ecosystem Assessments) in the regional seas WGs”. Work commenced on this ToR in 2018 when the foundation for the literature review work was laid and much relevant literature was identified. The formal literature review was initiated by WGMARS member Ana Fraga, who established the first set of articles and ICES documents for review along with a draft table for important characteristics. The WGMARS chairs at that time, did some reworking of the table and added additional literature. The literature review led to the joint creation by IEA subgroup members of a preliminary framework for the article, a work plan, and a questionnaire for interviewing IEA group chairs. As work progressed, additional articles and documents were added to the review.

Eight teams of WGMARS researchers conducted interviews with one or more chairs of 9 of the 11 IEA working groups, usually by video. In 2018, we interviewed chairs of the eight existing ICES IEA WGs: Working Group on Integrated Assessments of the North Sea (WGINOSE), Working Group on the Integrated Assessments of the Barents Sea (WGIBAR), Working Group on the

⁶ Now known as IEA Working Groups

Integrated Assessments of the Norwegian Sea (WGINOR), Working Group on Comparative Ecosystem-based Analyses of Atlantic and Mediterranean marine systems (WGCOMEDA), Working Group on Ecosystem Assessment of Western European Shelf Seas (WGEAWESS), Joint ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea (WGIAB), WGNARS, and ICES/PICES/PAME Working Group on Integrated Ecosystem Assessment (IEA) for the Central Arctic Ocean (WGICA). Three new IEA WGs (Working Group on Integrated Assessment of the Azores (WGIAZOR), Joint ICES/PICES Working Group on Integrated Ecosystem Assessment of the Northern Bering Sea-Chukchi Sea (WGIEANBS-CS), and Working Group on Integrated Ecosystem Assessment of the Greenland Sea (WGIEAGS)) were created in 2019. Chairs of WGIAZOR and WGIEAGS were interviewed in 2020. However, WGIEAGS had only been in existence for such a short period that they were still setting up the WG, so that interview was not analysed. The chairs of WGIEANBS-CS were not interviewed due to timing issues. The interviews were recorded and then transcribed via software packages such as Trint[®]. The interviews were coded with MaxQDA[®] by one person for consistency. A second person read all the interviews to assure that the MaxQDA[®] segments captured the proper context. Finally, multiple researchers individually or in pairs read all text with a specific code to better synthesize the results. A joint coding session was held in March 2020. In the April 2020 annual meeting, a second round of joint coding was completed, and analysis of the results began. Because of some transitions in the WGMARS leadership, work on the project languished for a short period but resumed in later 2020. An advanced draft of the paper was completed in early 2022 and submitted to the required NOAA technical and policy review, required because chair Patricia M. Clay is a NOAA employee. (No changes were required.) Additional review was sought from ICES (Debbi Pedreshi, Jörn Schmidt, and Mark Dicky-Collas). That process completed, minor adjustments to the text were made.

Preliminary findings of the paper were presented at the ICES Annual Science Conference in 2018 and 2019 (prior to the current ToRs period), and reported in ICES (2019). The final version will be presented at ASC in Dublin in September 2022⁷. The paper itself⁸ is to be submitted to ICES JMS by mid-September.

ToR E Apply Social Network Analysis (SNA) as a tool to assess ICES network connectivity and preparedness to address IEAs and the ICES Science Plan

In January 2019, a subgroup of WGMARS met for a 3-day workshop at the Stockholm Resilience Centre to re-join Örjan Bodin, with whom they had worked previously (see ICES (2019)), to design a reliable database with updated data from the ICES Secretariat. Follow-up Webex meetings were held on 2 March 2020 and 22 April 2020. Preliminary results were then presented in April 2020 during the WGMARS annual meeting and published as Annex 3 to the WGMARS 2020

⁷ Clay, Patricia M., Johanna Ferretti, Jennifer L. Bailey, Leyre Goti, Dorothy J. Dankel, Marina Saturtún, Jessica Fuller, Sebastian Linke, Jörn Schmidt, Kåre Nolde Nielsen, David Goldsborough, Rolf Groeneveld, Ana Rita Fraga, Isa El-egbede, & Christine Röckmann. Implementation of Integrated Ecosystem Assessments in the International Council for the Exploration of the Sea – Conceptualisations, Practice and Progress. To be presented virtually by Clay at the ICES Annual Science Conference September 19–22, 2022 Dublin, Ireland.

⁸ Clay, Patricia M., Johanna Ferretti, Jennifer L. Bailey, Leyre Goti, Dorothy J. Dankel, Marina Saturtún, Jessica Fuller, Sebastian Linke, Jörn Schmidt, Kåre Nolde Nielsen, David Goldsborough, Rolf Groeneveld, Ana Rita Fraga, Isa El-egbede, and Christine Röckmann. *In prep.* Implementation of Integrated Ecosystem Assessments in the International Council for the Exploration of the Sea – Conceptualizations, Practice and Progress.

Science Report (ICES 2020). In 2021, data analysis continued, methodological protocols were refined, and final results were generated. A full draft of the paper was available by the end of 2021. The beginning of 2022 saw progress on the workshop analysis part of the study, and all results were presented to the WGMARS annual meeting in May 2022 via Webex.

The latest draft of the paper is being finalized and will be submitted to a journal for consideration by end-September 2022.

ToR F Analyse and compare the implementation and linkages of IEA/EBM/MSP and fisheries in the EU, individual European member states, and the US

The WGMARS ToR on the implementation of EBM via IEAs and MSPs has suffered from turnover in the participants and the leadership of WGMARS, as well as from the illness of individual researchers who had committed to contributions. Preliminary studies have been made of several countries (Germany, Norway, the Netherlands, and the US) and members from Sweden and Spain have agreed to contribute reports as well. A new author has been secured for the overview of the EU. In addition, WGMARS has recognized the need for additional information with respect to the reports already done, per a recommendation from ICES. This work will carry over into the new ToR period as ToR E and result in an ICES Cooperative Research Report.

3 Progress Toward Completion of Each ToR

ToR A

This ToR was constructed as a “meta” ToR, setting the broad direction of WGMARS in the three-year period. The analysis of “how inter- and transdisciplinary science can improve management and advice” has been implemented through Tors B–F. Progress toward each of these ToRs is presented below.

ToR B

The BE group has benefited greatly from the incorporation to the team, at different stages of the work, of early career scientists (ECS) Alina Wieczorek, Amanda Schadenberg, Mary MacKay, Noa Steiner and Julie Krogh Hallin (the latter active 2020–2021). They formed a core group to the project, instead of the initially planned interns. The group deeply felt the passing of Sarah Kraak in 2022, initiator of the BE work in ICES and one of the senior leaders of the study. Other members of WGMARS with different degrees of important involvement in the project include Ingrid van Putten, Andries Richter, Dorothy Dankel, Katell Hamon, Debbi Pedreschi and Marloes Kraan.

The lead team (ECS from 2020 onwards) opted to develop a systematic registered review protocol, which is a method that aims to make the selection and evaluation of insights from a large body of literature transparent, objective and reproducible (Haddaway *et al.*, 2015).

The lead team also brought the initiative to split the behavioural economics study into three products in order to improve its quality and dissemination opportunities. These three products are a preregistration at a public database, a peer reviewed review protocol paper and a systematic review paper. The preregistration and production of a protocol paper had the following advantages:

- Make the work transparent and reproducible
- Minimize bias
- Have the methods peer-reviewed before starting to read
- Help a large team produce consistent work
- Make the work more relevant to policy

A registered review protocol for the systematic review was submitted to the journal PLoS One in March 2021 and accepted in July (see Wieczorek *et al.* 2021). The registered review protocol focuses on the primary question of: “Which behavioural-economics mechanisms influence fisher behaviour?” and aims to provide a comprehensive overview of the various mechanisms which have been applied or observed in studies relating to fisher behaviour at sea.

Once the protocol was accepted the next activities included the extraction of papers using search terms from EconLit, ProQuest and Web of Science (n=1185), the screening for eligibility based on title and abstract, and the reading and extracting of data from eligible studies (n=301).

Overall, more than 300 articles were processed by the review team using an online survey tool. The team aims to compile the findings and produce a peer-reviewed paper for submission to a scientific journal by the end of 2022. As of now, the foreseen structure of the paper will include its motivation (that is, why human behaviour is important for fisheries management), a synthesis

of the BE mechanisms and examples in the literature, a discussion of ethics in BE research, and discussion of possible future applications of BE insights in fisheries.

ToR C

The goal of the workshop was “to advance approaches to support inter- and transdisciplinary science via qualitative conceptual models to inform Integrated Ecosystem Assessment (IEA) throughout European seas and beyond.” Day 1 began by describing what conceptual modelling consists of and introducing the Mental Modeler™ tool. This was followed by small group exercises in which each of four subgroups chose what system they wanted to model and what the key components were, without any guidance from the facilitator. The models produced by the four breakout groups were very different, varying in focus and degree of detail. Group 1 focused on climate change and the resulting expected increase in shipping in the Central Arctic Ocean. Group 2 chose cod as a central species and then included socio-economic benefits of this fishery to countries in northern Europe (producers) and southern Europe (traditional consumers). Group 3 chose a more generic issue of invasive species in marine ecosystems (including near-shore) and resultant environmental, social, and economic consequences. Group 4 focused their model on the interactions among fisheries, Marine Protected Areas and biodiversity, including major socio-economic concerns. Seeing this variety helped participants to understand the importance of talking through ideas in advance about what they wanted the model to capture and at what level of detail, as well as showing the variety of approaches and interests that are possible to examine with this tool. Days 2 and 3 involved presentations of a wide variety of conceptual modelling tools and different visualization options already in use in ICES Working Groups and Workshops, as well as discussions of the pros and cons of different options. Day 4 focused on the potential uses of conceptual models specifically in ICES contexts, such as Ecosystem Overviews (e.g. via foodweb and/or socio-ecological system modelling), Integrated Ecosystem Assessment, and to inform/underpin wider trade-off analyses relevant to ICES and the wider scientific community. Finally, though stakeholders other than ICES Working Group members could not be accommodated in this workshop, the challenges of and good practices for including stakeholders were addressed throughout the workshop. For more complete information on WKCCMM, see ICES (2022a).

ToR D

This study has as its vantage point the need for integrated management of marine spaces because of the increasing activity of multiple sectors therein (Dankel *et al.* 2012; Jouffray *et al.* 2021). The increasing and multi-sided pressures on marine socio-ecological systems mean that more holistic approaches are required for management. To meet this need, ICES has promoted EBM since first ICES Strategic Plan in 2001 (Stange *et al.*, 2012; Wenzel, 2016) and has long specifically endorsed the application of IEAs (ICES, 2013; Walther & Möllman 2013). ICES include EBM and IEAs in its Science Priorities and the IEA WGs are tasked with carrying out regional seas IEAs. But to what degree does this IEA WG work accord with prescribed IEA practice in ICES reports and the scientific literature?

We used internal ICES documents and a literature review to determine how IEAs are understood in the ICES context as well as in the professional literature. The study indicated that the prevalent understanding of the ideal IEA within both draws heavily upon work by Levin, e.g. in Levin *et al.* (2009; 2014). Both papers describe five iterative steps of an IEA process: scoping, indicator development, risk analysis, management strategy evaluation and monitoring and evaluation.

The paper used these five steps as the framework within which to assess the degree to which ICES IEA working groups have been able to implement an IEA. In addition, six key elements of IEA were derived from our literature search:

1. Provides a framework for exploring potentially conflicting objectives and trade-offs;
2. Provides a broad assessment of dynamics and relationships, not just status and trends of individual components;
3. Must include social, economic, and ecological elements;
4. Needs to consider humans as both impacting and being impacted;
5. Must be iterative and adaptive for management; and
6. Must involve stakeholder input.

These are not a contrast to the Levin cycle steps, but rather serve to further elucidate the activities within each step.

All groups acknowledge the holistic goals of IEA, and many use the IEA model as laid out by Levin *et al.* (2009; 2014). However, we found significant variation in the degree to which the IEA groups have been applying IEAs and in their level of integration. We identified two primary areas where WGs did not fully implement IEA: 1) integration of social and economic issues and 2) involvement of stakeholders. We also identified some potential barriers to the full implementation of IEAs. WGs vary in their composition but often lack the required diversity of expertise; the lack of social science expertise was particularly striking. They frequently lack the resources required for acquiring needed expertise, although some do reach out to other ICES WGs or draw upon additional personnel from their home institutions. In addition, the groups vary in the degree to which and how they envision incorporating social and economic data, or they lack familiarity with the data that is available. WGs diverged along North American-European lines and reflected differing historical development.

We offer examples of how WGs have been making progress toward full IEAs. We also take note of ICES ongoing efforts to promote and support the IEA approach (such as, recently, through updates to the Ecosystem Overviews), but suggest additional steps that might be taken. In particular, some chairs have called for greater involvement by ICES in the clarification of procedures and in how to implement the work. One handicap identified is that the role of the IEA WGs in the ICES system is not clear; though efforts are moving forward to include more input from IEA WGs in Ecosystem Overviews, little of the current officially requested ICES advice relates specifically to IEA work.

ToR E

Work is close to being finished on applying social network analysis (SNA) as a tool to assess ICES network connectivity and preparedness to address IEAs and the ICES Science Plan. SNA allows for a statistical analysis of how people are connected, and this study looked at how connected the ICES WGs are to each other, through shared participation of individuals in working groups and workshops. The underlying theory is that individuals who attend Working Groups share expertise and information with each other, thus expanding the topical “reach” of specific subjects and potentially improving knowledge and activities throughout the ICES scientific network.

The results show that from 2015–2019, the ICES network of Expert Groups has been steadily growing, with an increasing number of individuals participating in meetings, and with the establishment of new WGs and Workshops each year. This points to the increasing relevancy and interest of the ICES work to the North Atlantic scientific community. Furthermore, the IEA-

focused Working Groups have also been growing in size, with new Working Groups established for more ecoregions. The SNA sociograms reveal that, over time, the ICES network grows denser and more clustered, which suggests an increasing number of shared participations between meetings (Working Groups and Workshops). A similar trend is seen for the social network of the IEA-focused groups. Finally, an analysis was done to understand how workshops function to improve network connectivity in the ICES network. A comparison of the full ICES network (Working Groups and Workshops) was made with an ICES network excluding workshops, and the results showed fewer overall connections and more isolates when workshops were removed (correcting for density calculations). A similar result was seen with a sub-network of the IEA-focused Working Groups and Workshops, where the removal of Workshops from the network meant one or more IEA Working Groups became isolated from each other. Thus, our results suggest that not only do Workshops hold significance for their topical relevance to WG TORs, but also serve to improve connectivity within the ICES network. This has implications for ICES management where resources can be strategically oriented to enhance inter-Group collaboration and networking. A paper⁹ will be submitted in a journal by end September.

ToR F

WGMARS has recognized the need for additional information with respect to the reports already done, per a recommendation from ICES. This work will carry over into the new ToR period and result in an ICES Cooperative Research Report.

⁹ Fuller, J. L., H.V., Strehlow, Schmidt, J.O., Bodin, Ö., Dankel, D.J. (In prep.). Tracking integrated ecosystem assessments in the ICES network: a social network analysis of the ICES expert groups.

4 Degree of success and future of the WG

All ToRs, with the exception of ToR F on EBM/IEA/MSP, were completed. ToR F has been slightly reformulated and added to the ToRs for the upcoming WGMARS Resolution for 2023–2025, with a clear plan for completion. Several completed ToRs were expanded to build upon existing work in the upcoming WGMARS period, 2022–2025, including ToR B on behavioural economics and ToR E on social network analysis of ICES Expert Groups. See our new resolution on the ICES website in late November 2022, for these and the other new ToRs.

4.1 Hosting a virtual meeting

All annual WGMARS meetings in this ToRs period were run as virtual meetings, usually using the Webex program. Hosting virtual meetings has been challenging, but also has had some advantages. Among the challenges is finding a time that works for as many WGMARS members as possible. This is challenging, since the WGMARS membership spans both the Atlantic the Pacific. The best solution to this problem has been to meet for only four hours in latter half of the European workday (a change from the daylong annual meetings that had been customary when all or the vast majority of participants were physically present. This was found, however, to have its benefits. Short meetings left the rest of the day for individual WGMARS work or for sub-groups to meet on their own. They also allowed the participation of members who might not have been able to spend the time to travel to a week-long meeting at some distance from home (leaving aside the health issues relating to the pandemic). Virtual meetings may also allow younger researchers to combine family responsibilities with meaningful, if possibly shorter, participation. It allowed for the effective participation of researchers who could only participate on selected days or in selected segments. Preparations for a digital meeting were similar to those for traditional meeting, not presenting particular problems or significant additional work. One issue that did emerge is the importance of choosing a meeting application that all participants can and are permitted to use. Webex worked well and proved acceptable to all. Because this is not the current meeting software supported by ICES, this did require outside technical assistance (usually courtesy of NOAA). It is advisable to sort this out before the meeting.

On the other hand, occasions for informal interaction were lacking at the annual meetings, despite attempts to introduce digital social events. WGMARS work has, in other circumstances, demonstrated that networking, both formal and informal, has a beneficial effect; WGMARS members have expressed the desire to meet in person when practicable. Meeting away also helps researchers focus on the issues at hand and diminishes distractions.

In the future, WGMARS plan a virtual autumn meeting and a shorter in-person meeting in the late winter or spring.

4.2 Future Plans

WGMARS will continue to function. Patricia M. Clay has agreed to serve an additional year as chair to facilitate the hand-off to two relatively new chairs (Jennifer Bailey, who has been chair for one year and Jessica Fuller, starting as chair in August 2022) and at a time when continuing chair Leyre Goti is scheduled to take parental leave. Our draft ToRs for the next three-year cycle are:

A. Paper on Behavioural Economics paper on its use in fisheries submitted to a peer-reviewed journal

- B. Finalize and submit to a peer-reviewed journal a paper on understanding of Social Network Analysis (SNA) as applied to ICES EGs as a tool to assess network connectivity and preparedness to address IEAs and the ICES Science Plan
- C. Investigate consideration of sex and gender in scientific work of ICES Expert Groups
- D. Analyse of Implementation and linkages of IEA/EBM/MSP and fisheries in individual European member states, non-member states and the EU
- E. Use organizational theory to understand mechanisms and barriers to implementation of IEA in ICES

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Annex 1: List of participants

Table A1.1 List of Participants 2022

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Annex 2: Resolution

2019/FT/IEASG02 **A Working Group on Maritime Systems (WGMARS)**, chaired by Patricia M. Clay, USA, Leyre Goti, Germany, and Jennifer Bailey, Norway, will work on ToRs and generate deliverables as listed in the Table below.

	MEETING DATES	VENUE	REPORTING DETAILS	COMMENTS (CHANGE IN CHAIR, ETC.)
Year 2020	20-24 April	Online meeting	ICES Scientific report by 1 June 2020	Johanna Ferretti, Germany outgoing and Leyre Goti, Germany incoming
Year 2021	3-7 May	Online meeting	ICES Scientific report by 20 August	Jennifer Bailey incoming additional Chair
Year 2022	23-27 May	Online meeting	Final ICES Scientific report by 31 August	

ToR descriptors

ToR	DESCRIPTION	BACKGROUND	SCIENCE PLAN CODES	DURATION	EXPECTED DELIVERABLES
a	Analyse how inter- and transdisciplinary science can improve management and advice	ICES has prioritized the investigation of sustainability dimensions with a view to maritime uses and responses and the integration of different types of knowledge and evidence. One approach to do so are IEAs which are based on a premise of EBM. IEAs and EBM require both social and natural sciences as well as engagement with stakeholders.	3.6, 6.6, 7.4	3 years	Peer-reviewed papers, ICES reports, workshops
b	Analyse how the use of behavioural economics can support IEA/EBM implementation	Policy evaluation in IEA requires insight into human behaviour in order to (1) predict how users respond to policy interventions, and (2) how stakeholders judge trade-offs between conflicting objectives.	6.3, 7.4, 7.5	Years 1,2,3	Peer-reviewed paper on behavioural economics for policy evaluation

c	Review and provide guidelines for conceptual modelling to assist Regional Seas WGs	Conceptual modelling, including through the use of, for instance, Mental Modeler or Bow-Tie Analysis, can aid scientists from different fields, as well as scientists and stakeholders, to facilitate improvements to their IEA activities.	5.3, 6.2, 7.5	Year 1, 2, or 3	At least one workshop with one or more ICES Regional Seas or other IEA-related WGs
d	Evaluate the current use of ICES IEAs in support of management and advice	ICES has prioritized the use of IEAs, e.g. in the Regional Seas WGs, as a tool for understanding tradeoffs in fisheries policies.	1.9, 3.2, 6.1	Years 1,2	Peer-reviewed paper on the current status of IEAs in the regional seas WGs
e	Apply Social Network Analysis as a tool to assess ICES network connectivity and preparedness to address IEAs and the ICES Science Plan	Review of existing SNA paper drafts and relevant reports from previous WGMARS work; finish and submit the current SNA draft that was initiated with the ICES Science Fund; initiate updated analyses for ICES IEA EGs.	6.3, 7.4, 7.5	Years 1,2,3	Peer-reviewed paper on the SNA of ICES
f	Analyse and compare the implementation and linkages of IEA/EBM/MSP and fisheries in the EU, individual European member states, and the US	ICES supports the use of EBM and IEAs, while many EU states support MSP. There is a need to connect science done for both purposes and IEA (supported by ICES) is a tool that could be used with either EBM or MSP.	7.4, 6.1, 6.6	Years 1,2	ICES Report

Summary of the Work Plan

Year 1	MAP THE USE OF EBM, IEA, AND MSP IN A VARIETY OF CONTEXTS.
Year 2	Explore techniques for understanding stakeholder behaviour as well as facilitating stakeholder involvement.
Year 3	Explore uses of our work and how ICES stakeholders interact to support ICES advice.

Supporting information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem effects of fisheries and ecosystem-based maritime management, especially with regard to the integration of different sustainability dimensions in the consideration of human maritime activities. Consequently, these activities are considered to have a very high priority.
Resource requirements	Resource requirements are covered by WGMARS members, including through already funded projects and in some cases with institutional support.
Participants	The Group is normally attended by some 10-15 members and guests.

Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other committees or groups	There is a very close working relationship with the IEASG. WGMARS is also very closely connected to the Strategic Initiative on Human Dimensions and involved in its activities.
Linkages to other organizations	WGMARS is very relevant to the Regional Seas Working Groups, and involved in Workshops such as WKINWA, WKBESIO, WKCONSERVE, and others. WGMARS reaches out to various stakeholders and EBM professionals outside of ICES.