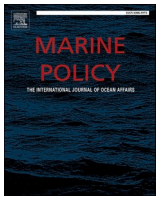
Marine Policy 148 (2023) 105469

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol



Roles for advisory science in the International Council for the Exploration of the Sea (ICES)

Sebastian Linke [a,*,1], Kåre Nolde Nielsen [b,2], Paulina Ramírez-Monsalve [c,d,3]

[a] School of Global Studies, University of Gothenburg, Sweden
[b] The Norwegian College of Fishery Science, UiT - the Arctic University of Norway, Norway
[c] World Maritime University, Malmö, Sweden
[d] NIVA Denmark Water Research, 2300 Copenhagen S, Denmark

ARTICLE INFO

Keywords:
Advisory science
Roles of science
Science-policy interactions
ICES
Advisory practices

ABSTRACT

What role should science take when providing advice in support of policy and politics? Should a provider of science-based advice have its own position on the issues it provides advise on? Or should it be as impartial as possible from the value and policy context of the advice? This theme, long debated, gained new attention in fisheries and marine governance. Starting from theoretical concepts and stylised models, this study attends to a theory-practice gap by investigating concrete advisory practices. We analyse roles that the *International Council for the Exploration of the Sea* (ICES) takes when producing and delivering science-based advice. ICES is an interesting case because its long history as advice provider offered it unique opportunities to consolidate and refine its advisory role. Published by the Advisory Committee in ICES, the 2021 "Guide to ICES advisory framework and principles" describes the overarching framework to ICES advice and the principles it builds on. Based on this guide, we analyse the forms of science-policy interactions and roles that ICES takes as advisor, how these roles are enabled, and the challenges they involve. We find that ICES takes different roles vis-à-vis policy and society for different contexts in which it provides advice. Our analysis of ICES' advice portfolio provides lessons on how different advice products can be developed through structured processes in a way that helps to bridge the boundary between science and policy and support the enactment of what ICES sees as appropriate advisory roles.

1. Introduction

How can science-based advice best inform policy and decision-making for environmental governance? This question has received increasing attention, not least in relation to climate and biodiversity governance [4,17,30], but also in other areas like soil and land degradation [16] or forestry [56]. Despite attempts to clarify roles for advisory science and a constant search for general principles, guidelines, or lessons for good policy advice, a well-developed and broadly accepted theory for scientific policy advice has not yet emerged (see Section 2). The research on roles and practices of science advice also sparked new interest in relation to the management of marine resources and ecosystems [15,21,27,54,46,71]. One important aspect of this concerns the division of tasks and roles for science and policy to enable the best use of science advice in supporting sustainable management of marine resources. In fisheries management the topic gains new relevance with commitments to move from a single species focus to an Ecosystem Approach to Fisheries Management (EAFM, see [3,61]) as well as with increasing demands for stakeholder participation and knowledge inclusion [2,53,40,51]. Furthermore, the role of scientists in practices of collaborative and transdisciplinary research in marine and fisheries governance emerged as an important topic [15,27,54,62,71]. Theoretical and practice-oriented social science research emphasises a plurality of roles that science and scientists take vis-a-vis policymaking bodies and other societal actors [60,74,77]. In applying these insights to marine and fisheries governance, Macher et al. [54] and Dankel et al. [15] point

* Correspondence to: School of Global Studies, University of Gothenburg, Box 115, SE 405 30 Göteborg, Sweden.
E-mail address: sebastian.linke@gu.se (S. Linke).
[1] https://orcid.org/0000-0003-0758-3715.
[2] https://orcid.org/0000-0003-4335-870X.
[3] https://orcid.org/0000-0001-5853-1830.

https://doi.org/10.1016/j.marpol.2022.105469
Received 1 April 2022; Received in revised form 21 December 2022; Accepted 21 December 2022
Available online 12 January 2023

out that the diversity of roles required from scientists creates confusion and misunderstandings. Consequently, perceived roles can be associated with frustration, calling for an articulation of concerns. For instance, scientists expressed discomfort of being enroled in a governance system that expects certainty of scientific outputs, which cannot be delivered, noting that science is used as an "alibi" in policy making ([48], 119; for a general discussion of this issue see Turnhout et al. [20]).

Our paper responds to Macher et al.'s ([54], 15) expectation that "[a] clarification of the roles of each partner using an appropriate typology and joint reflection … will assist improving efficiency of partnership platforms and prevent misunderstandings". Referring to Dankel et al. [15], Macher et al. [54] argue the need for empirical studies on roles of scientists in decision processes subjected to the increasing complexities of an ecosystem approach to management. In line with Macher et al. [54] and Dankel et al. [15], the aim of our paper is to stimulate further reflections on roles of science and scientists in policy and decision making. We pursue this aim with a study on the provision of advice by the *International Council for the Exploration of the Sea*, ICES.[4] ICES is selected as a case for three main reasons. First, ICES is arguably one of the oldest scientific advisory organisations. This long history provided ICES with unique opportunities to consolidate and refine its role as an advice provider in the complex, uncertain and often politicised contexts of fisheries and marine governance. Second, ICES is a network of nearly 6000 scientists from over 700 marine institutes in 20 member countries [39] and as such, a place that comprises a variety of perceptions on what the role of science in policy should be. Thirdly, in recent decades, and partly in response to a movement towards an ecosystem approach, ICES has significantly expanded its advisory portfolio, which accentuates the need to reflect on advisory roles in relation to different advisory products.

ICES is established and works as an independent scientific organisation fulfilling various tasks and functions from basic research collaboration to the provision of advice as defined in agreements with ICES' clients such as the Commission of the European Union (EU) [3]. In contrast to marine advisory science in the United States [58], Canada [68], Australia [12] and New Zealand [55], ICES provides its advice as an independent organisation and not as an "in-house" service [1]. ICES is a network organisation that to a large extent depends on scientists from various disciplines to carry out ICES' work. The scientists comprising the ICES community reflect diversity in terms of interests, agendas, expectations, and levels of engagement. Throughout its history, ICES has served to fulfil a double function, that implies, as historian of science Helen Rozwadowski [63] puts it, "a tension between the pursuit of new scientific knowledge and the societal uses intended for that knowledge". ICES is a highly organic and adaptive intergovernmental organisation, which is going through successive reform steps [70,75], and which, due to changes in the policy and governance context that it supports with advice, is experiencing "creative tensions" that provide space for ongoing reflection ([76], 259). Consequently, the ICES secretariat and ICES community constantly adapt ICES' services to enable the best use of science in a changing socio-political and socio-ecological environment [52], which increasingly also includes social science [49].

Drawing on theoretical conceptualisations of advisory science, we categorise the advisory roles associated with ICES' advice products. We thereby respond to a research gap between stylised theoretical models on roles of scientific advisors and actual advisory practices [47]. Specifically, we investigate the diversity of roles within the advisory practices of ICES, as framed in the most recent "Guide to ICES advisory framework and principles" ([35], henceforth referred to as "the Guide"). Published by ICES' Advisory Committee, the Guide describes the overarching framework of ICES advice and the principles it builds upon. As such, the Guide serves as a representation of ICES' roles as an advisor and explains how and why these roles are justified. Internally, the Guide, together with a range of specific guidelines (cf. [35], 3), serves as a primary reference for ICES practitioners involved in advisory processes. Externally, the Guide communicates the established practices and principles of the advisory process to the recipients of ICES advice.

Our study addresses two interrelated research questions: 1) What kinds of interactions between science and policy exist in the development of ICES' advisory products? 2) Which roles does ICES take when developing the advisory products? We address these questions based on an analysis of the Guide [10,8] where we relate our empirical observations to existing theoretical conceptualisations of advisory science. Thereupon we analyse and discuss which challenges these roles involve. Section 2 presents a theoretical background on advisory science. Section 3 describes the four ICES advisory products and presents our approach to analyse the information included in the Guide. Section 4 documents, based on our analysis, the answers to our two research questions. Section 5 discusses our findings considering how ICES' advisory roles are enabled and challenged while Section 6 presents concluding remarks.

2. Theory and concepts

Considerable scholarly attention has been devoted to how appropriate science-policy interactions can be enabled [28,29,42,64,50]. However, theoretical advancements have not provided straightforward answers to what constitutes 'good' advisory practice, nor to how this practice is best supported through institutional arrangements. Cash et al. [9] argue that boundary organisations, situated at the interface between science and policy, are likely to be effective when they provide for salience, credibility, and legitimacy, but also observe that these virtues can be achieved in many ways (cf. [76,21]). Lentsch and Weingart's claim ([50], 5) that "up to the present there is no well-developed theory of scientific policy advice available" still holds true a decade later, when no generally accepted theory of science advice exists. Yet increasing insights into the context-dependency of different forms of advisory practices as well as differences in cultural preferences for science-based advice have been presented. Different advisory contexts, be it earthquake prediction [18]; pandemic risks [65] or natural resource management set different needs and constraints for advisory processes. International organisations like the EU Commission or the Organisation for Economic Co-operation and Development (OECD) encourage the development of improved scientific advisory practices and institutions [57,66]. While answers for good policy advice depend on the specific contexts, Lentsch and Weingart [50], based on an international comparison, aimed to identify "universal guidelines" and "lessons", which they summarised in four "general principles" for securing the quality of advice: 1. distance and independence between advisers and end-users; 2. plurality of forms of advice (different disciplines); 3. transparency of advice and decision-making processes; and 4. publicity and openness ([50], 15–16).

Apart from such broad recommendations, few answers to the questions about the appropriate institutional design of advisory science have received broad recognition. For instance, a high-profile report on Science Advice for Policy by European Academies ([66], 16) stated that "there is no universally applicable model for structuring scientific advice". The report also noted that „…the type or nature of available expertise and the type of advice needed should determine the procedure, structure and composition of the advising process" ([66]). This suggests that science-based advice should result from the "coproduction of science and policy" [43], by which advisory practices depend on, and co-evolve with their social, political, and institutional context, and the respective demands for advice. Hence, science-policy interfaces are adapted to different advisory contexts, with implications for how science and policy cooperate on institutional as well as on practical levels [21].

[4] https://www.ices.dk/about-ICES/who-we-are/Pages/Who-we-are.aspx (last visited 25.03.22)

Theoretical role descriptions for science advice, as proposed for example by Hoppe [28], Pielke [60] or Turnhout et al. [73] are often theoretically stylised, but diverse and "likely to be blurred in reality" (Sarkki [67], 169; see e.g., [69]). Pielke [60] portrayed four stylistic roles of science advice vis-a-vis policy and politics (see Table 1). *Pure science* is detached from policy, not considering any use of research for society. *Science arbiters* answer specific questions to decision-makers but try to avoid considering normative aspects (i.e., what *should* be done). *Issue advocates* engage actively in decision contexts arguing to use their specialised expertise for a specific cause or policy direction. Finally, *Honest brokers* try to clarify and expand on possible actions by placing scientific expertise to decision makers like a "smorgasbord of policy options" ([60], 17). Pielke's model received both appreciative and critical responses [44,7]. While acknowledging the critique, we side with scholars accentuating the value of this stylistic approach because it creates "a clear way of talking about science in policy and policy for science" that "helps encourage our thinking" ([11], 96/98). Turnhout et al. [73] developed Pielke's framework by adding "participatory experts" as additional advisory role, which engage more collaboratively across science-policy boundaries (see Table 1). This role of science, aiming to integrate knowledge production and use, assumes that boundaries are "not necessarily bridged but are blurred" ([73], 362). Accepting such blurred boundaries as well as the practical need for divisions of tasks and roles, Weingart [74] introduced a "recursive model" for science policy interactions following four consecutive steps: 1) problem perception (either from science or politics); 2) a political process of defining the political criteria of relevance; 3) a political programme of research funding – giving the task (back) to science; 4) research that continuously informs policy and refining of original problem perceptions. While Pielke's model is developed to characterise the roles of scientists as individuals, scholars like Weingart are concerned with the institutional design required for providing quality in the provision of science-based advice. Highlighting different ideas on what "new roles of science should entail", and how these should be organised and institutionalised, also Turnhout et al. [73] underscore "the importance of existing *institutional norms* in shaping these roles in practice" ([73], 335, our emphasis), and recognise a need to look beyond ideal roles of science. This implies that research needs to extend beyond individual reflection and behaviours and take the strongly institutionalised norms and ethics of advisory organisations into account. Our study applies the roles described by Pielke, Turnhout and others to the organisational level and investigates how such roles are interpreted, performed, and practiced in the context of ICES advice for fisheries and marine governance.

Table 1
Overview of roles for advisory science described in literature (adapted from [28,29,54,60,62,67,69,73]). The first column presents the science-society relations of these roles, the second column presents the resulting interactions and the according roles for science.

	View of science-society relation	Science-policy interactions and the role of science
Pure scientist	Science is not concerned with its use/usefulness for society	One-directional (linear model): Science places knowledge in a reservoir that policy and society can draw from
Science arbiter	Science serves as resource for society but not taking a normative position	Science provides advice on 'answerable questions' posed by policy and society; avoiding normative position
Issue advocate	Science focuses on implications of advice for society; accepts normative positioning	Science provides normative answers to policy problems; advocates specific solutions to societal challenges; thereby reducing the scope of policy choices
Honest broker	Science accepts direct engagement with society but trying to avoid normative positioning of the advice	Science provides different scenarios or options for policy- and decision-makers to choose from; thereby broadening scope of policy choices
Participatory experts	Fluid science-policy boundary; knowledge producers accept to work in blurred boundary contexts between knowledge production and its societal use	Dialogue between science and policy; role of science/ scientists: facilitator, mediator, translator

Pielke's typology abstracts from the issue of whether and how different actors view the different roles of advisory science as salient, credible, and legitimate in practice. In turn, the concept of boundary organisations has been used to understand the practical constrains of organisations operating at science-policy interfaces, which implies dealing with divergent, at times conflicting, perspectives and interests [24]. ICES has been described as a "unique case study for research into boundary organisations" because of its virtue, mission and reputation as a science advisor ([13], 3). According to Guston [25], boundary organisations avoid the politicisation of science or the scientisation of politics by the "coproduction of mutual interests" (2001, 405), an idea questioned by other scholars ([23,74], see Section 5). Previous research on ICES as a boundary organisation found that successful science-policy interactions take many forms and impact of research occurs on different scales (organisations and people), for which trust is a major component [13,14].

3. Material and methods

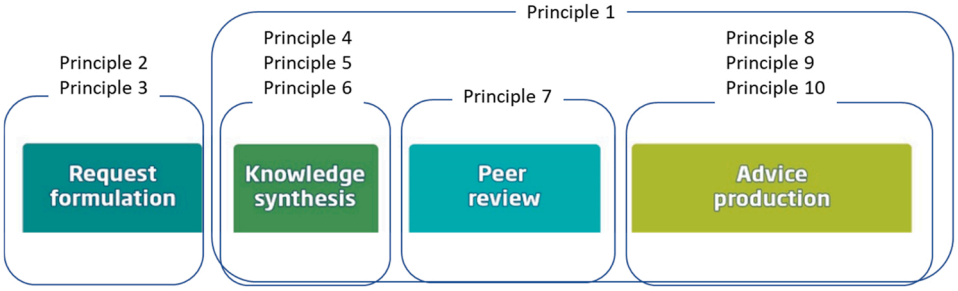
This section presents the four advisory products of ICES and the approach followed to analyse the information included in the Guide.

3.1. ICES' four advisory products

As presented in the Guide, ICES's advisory products are grouped into four categories: 1) Recurrent requests, 2) Special Requests, 3) Ecosystem, Fisheries and Aquaculture Overviews and 4) Viewpoints [35].[5] Each advisory product goes through a framework for provision of advice comprised of four key steps: *Request formulation*; *Knowledge synthesis*; *Peer review*; and *Advice production* (Fig. 1). Ten principles are applied consecutively during the four steps of the framework (see Fig. 1) and operationalised specifically to each advice product [35]. It is the description of the operationalization of the principles, in each of the advice products, which we analysed following a content analysis approach.

Recurrent requests build on a refined science and management framework ([35], 3), in which the procedures for knowledge production, including data handling and the use of models, are clearly structured and formalised. The advice on these requests regards primarily annual recommended levels of Total Allowable Catches (TACs) as they relate to specific predefined stock reference points, such as fishing mortality levels associated with Maximum Sustainable Yield (MSY) and minimum threshold levels of spawning stock biomass for the fish stocks in question. The knowledge basis for these advice products is synthesised in ICES' expert groups (EGs), compiling data and assessing the states of fish stocks. The process of conducing stock assessments to formulate this advice is highly formalised and presented as structured responses to the requests for annual advice on fishing opportunities (TACs). These responses can also entail information on the consequences and risks of certain management strategies, for example for mixed fisheries. Advice in response to recurrent requests represents the main annual advisory

[5] The "Requests for services" in the Guide are specific responses on requested information but „not considered ICES advice" [35]) and therefore excluded from our analysis.



Principle 1. The guidelines and procedures to produce ICES advice are documented, openly accessible, and up-to-date.

Principle 2. Final request formulation is agreed through dialogue to clarify the requester's needs and expectations, the ICES process, likely resource implications, timelines, format of advice, and roles and responsibilities of the engaged parties

Principle 3. Where possible, existing policy goals, objectives, and the level of acceptable risk relevant to the advice request are identified. Where these objectives and descriptions of risk are unclear, ICES will identify these in the advice, and, where possible, provide options for management action and the consequences of the options and their trade-offs.

Principle 4. The deliberations of all relevant expert groups are published by the time the associated advice is published

Principle 5. The best-available science and quality-assured data are used. ICES selects and applies relevant methods for any analysis, including the development of new methods. The methods are peer reviewed by independent experts and clearly and openly documented.

Principle 6. Data are findable, attributable, researchable, reusable, and conform to ICES data policy. Data flows are documented.

Principle 7. To ensure that the best available, credible science has been used and to confirm that the analysis provides a sound basis for advice, all analyses and methods are peer reviewed by at least two independent reviewers. For recurrent advice, the review is conducted through a benchmark process; for special requests through one-off reviews.

Principle 8. Advice is comprehensive, unambiguous, and consistent with the synthesized knowledge, while taking the peer review into account. All advice follows existing advice frameworks and any deviation from the frameworks or related, previous advice is identified and justified

Principle 9. All ICES advice is adopted by the ICES Advisory Committee (ACOM), through consensus, prior to being made available to the requester and simultaneously published on ICES website.

Principle 10. ICES provides advice as an impartial response to a request, and does not lobby the requester or any other party to implement its advice.

Fig. 1. Framework for provision of ICES advice, and area of applicability of the ten principles. Underlined is the text within the principles, which helps understand the placement of the principle in the corresponding step of the framework.
(Adapted from [35]).

work of ICES.

The second advisory product, *Special requests*, are "more ad hoc, complex, or ambiguous" and pose "unforeseen challenges and uncertainties" for the advice generation ([35], 3). They are responded to under an "absence of well-established science and management frameworks; a lack of documented and peer-reviewed knowledge and data; and vague or complex management objectives" ([35], 3). A recent example of a special request is EU's request for ICES to provide a compilation of "assessment methods and indicators that can be used to assess seabed habitats" [33]. This is a request for products that are not provided by ICES on a routine bases, and that therefore needs to be met on an ad hoc basis.

At first, ICES 'Advisory Committee (ACOM) evaluates whether to accept a special request, based on specific criteria (competence, best available knowledge, resources, data), and considers the urgency of the advice for the requester as well as its potential impact on management decisions ([35], 3). Then, a knowledge synthesis step is applied using the EG network or special workshops with terms of references set by ACOM, followed by a review of methods, results, and processes whereupon an Advice Drafting Group (ADG) will formulate the advice for subsequent scrutiny and approval by ACOM (see Fig. 1).

The third product, *Ecosystem, Fisheries and Aquaculture Overviews*, are complements to the two Request products, aiming to "increase the capacity to provide integrated ecosystem advice" ([35], 4). As "synthesised regional advice products" they are included in most grant agreements and memorandums ([35], 4), for which scoping exercises with managers and clients take place to develop the Overviews ([35]). The knowledge for these products is generally collected and synthesised by ICES EGs or in workshops, compiled by ACOM and draws on both qualitative and quantitative data including human pressures, spatial fishing, and ecological data. Where possible, they also provide socio-economic information and cross-sectorial interactions and trade-offs as part of a transition to a management that follows an ecosystem approach ([35], 5). At the time of revising this article (second half of 2022), a total of 24 Overviews had been produced [32,34,31].

The fourth advice product of ICES, *Viewpoints*, are recent and rather different from the other products. Viewpoints are "one-off advisory products", prepared "in response to a selection of societal-related questions" ([35], 4). Viewpoints are not requested by clients but "proactively identified" through ICES' EGs, their scope and nature then internally decided, before "their production as advice is agreed by ACOM" ([35], 4). They are intended to "stimulate … environmental policy and management practices" ([35]). These products are hence not advice on management requests but self-reliant statements from a scientific community. They emerge from agreements among scientists that available knowledge on specific issues should be used, also in absence of management requests (interview previous ICES ACOM member). All ICES Viewpoints state that they "provide impartial evidence-based analyses of marine science topics of potentially high importance to managers and society" and "allow ICES to highlight, in a balanced, timely, and impartial way, the potential management and societal implications of maturing science in its network" ([37], 1; [38], 1; [36], 1). Hitherto three Viewpoints have been published by ICES, respectively addressing vessel biofouling [37], discharge water from ships [38], and biological effects of chemical pollution [36].

3.2. Methods used to analyse the guide

A qualitative mixed methods approach was used to carry out this study. As mentioned, it is the description of the operationalization of the principles in each of the advice products, as described in the Guide, which we analysed following a content analysis approach [8]. We were looking for content manifested in terms of pre-determined categories (those of Table 1), which is the evidence that allowed the classification of ICES' advisory products into one of the five stylistic roles of advisory science. To do so, a coding scheme was designed (see Appendix 1), which helped us to explore the text of the Guide in a systematic and transparent manner [8]. We understand the Guide as a document that explains, justifies and foretells actions, on record with an embedded meaning, and as such, an object that can be subjected to analytic scrutiny [10]. Also, when we reviewed the Guide, we took the view of the document being a representation of the reality of the organisation, rather than seeing the Guide as a distinct object of reality in its own [8]. The analysis was also complemented with other sources of data from various ICES documents, studies made about ICES (e.g. [3,52,53,2]) and empirical material collected by the authors of this publication from participatory observations in ICES events (e.g. MIACO meetings from 2010 to 2022, the 2018 "Science2advice" workshop, and the benchmark meetings of the Baltic Fisheries Assessment Working Group (WGBFAS) between 2013 and 2019, as well as from participatory action research in various ICES expert group meetings (e.g. WGSOCIAL, WGBESEO, WGMARS)). Other sources of data refer to material collected in 2021 as part of a parallel project run by the two first authors of this publication which also had ICES as study focus: three focus group interviews with a total of 13 scientists working in an ICES Assessment Working group; one focus group with a total of four participants who at the time were involved in ACOM leadership; and five interviews with former ACOM chairs. All three sets of events centred on the topic of scientific assessments and advisory practices.

Dedicated calls among the three authors of this publication took place to discuss the coding of the content of the Guide following the coding scheme and the analysis it supported. During the calls, discrepancies were discussed, being related for example to the lack of knowledge about a specific advisory product (for which further secondary information was collected) or on the interpretation of the cell content (for which we followed an iterative deductive and an inductive approach as a way to refine the coding scheme). The final agreed consensus table can be seen in Appendix 1. Overall, it cannot be said that either of the ICES advisory products fall into a specific stylistic role of advisory science, but rather display a tendency of two or three of them. For example, *Recurrent requests* display characteristics of the roles of Pure scientists and Science arbiters; *Special requests* also display characteristics of the Science arbiter and Pure scientist roles but also additional elements of Honest brokers and Participatory experts. The Honest broker element is more prominent in the *Overviews,* where Pure scientists and Science arbiters are also present. Finally, *Viewpoints* are characterised by the Issue advocate element, which stands out in comparison to the Pure scientist and Science arbiter elements. The implications of these mixture of roles are elaborated in the following sections.

Table 2
Advisory products, science-policy interactions and roles for science as analysed in the text. The first line is a summary of information on the advisory products (see Section 3). The second and third line respond to the two research questions of this study (elaborated in Sections 4.1 and 4.2 respectively).

	1.Recurrent requests	2. Special requests	3. Overviews	4. Viewpoints
ICES Advisory Products What knowledge product is delivered?	- Clear knowledge objects - Standardized procedures - Primarily advice on fishing opportunities (TACs)	- Response to specific requests (from ICES clients) - Guidelines and codes for producing knowledge to avoid normative advice	- Syntheses and evidence reporting on trends in ICES' ecoregions, - Part of transition to an ecosystem approach advice	- Summary of available knowledge on issues deemed to be of societal relevance
Science-Policy Interactions What interplay exists between advisors and clients, and how is this organized?	- Highly structured through a well-established science-policy framework - Clear policy objectives (MSY & PA) to which ICES' advice responds	- More dynamic due to less well-established science-policy framework complex or vague objectives - Increased need for dialogue between ICES and clients	- Scoping exercises laying foundations for developing overviews - Need for dynamic process & increased dialogue to settle tasks for science and policy	- Identified proactively by ICES' community - No direct science-policy interactions involved
Roles for science *What role does ICES take?*	**Science Arbitering** - Clear division of roles for science & policy - Clear description of tasks for science advice	**Complex Arbitering & Participatory experts** - Iterative request formulation - Dialogue and subsequent response by ICES	**Knowledge brokering and Participatory experts** - Broad knowledge provision - Complements to requests - Unclear role-divisions	**Advocacy role** ICES scientists decide on societal relevance

4. Results

We analysed, based on the collected evidence, the type of science-policy interactions involved in the generation of the advice products (Section 4.1) and subsequently, we interpreted the type of roles that ICES as a scientific organisation takes, when developing the advisory products (Section 4.2). These two subsections respond, respectively, to the two research questions of our study. The outputs are summarised in Table 2.

4.1. Science-policy interactions of ICES' advisory products

The science-policy interactions for *Recurrent requests* are organised according to established processes, as part of a formalised management framework. The framework defines the processes of knowledge production and advice formulation. ICES' task here is confined to provide advice following clearly formulated management objectives such as the Precautionary Approach and the MSY concepts, laid down in international agreements (see [35], 8). The framework hence gives a clear task for ICES' advice by establishing a division of work between science and policy through defining a boundary between the two. The respective EGs responsible for specific fish stocks compile and synthesise necessary data and carry out scientific stock assessments and forecasts. The EG reports provide the basis for formulating advice in ADGs, which is then finally revisited and approved by ACOM (see Fig. 1). Peer review for Recurrent requests takes place during benchmark processes conducted every 3–5 years, within which main aspects of the assessment model, including data series and model parametrization, are defined and assessed by independent reviewers. To sum up, this most structured and formalised advice product of *Recurrent requests* follows standardised procedures for scientific policy advice, which is provided through ICES' annual advice on fishing opportunities.

The science-policy interactions of *Special requests* entail less formalised stages of request formulation, knowledge synthesis and advice formulation. Due to their ad-hoc nature and complex or vague objectives, Special requests require more dialogue between ICES and the requesters for ensuring that the requested issues can be addressed scientifically by ICES, and that the envisaged advisory product fulfils the client's expectations. The process of clarifying requests typically happens through direct communications between ACOM and ICES clients, but it may involve stakeholders, scoping for management objectives and explorations of new methods and ways to communicate the results ([35], 4). Clarity and shared understanding are seen as important, and the potential normative character of these requests is stressed as "challenges for quantitative analysis and the production of evidence-based scientific advice" ([35], 3). The Guide emphasises that it is necessary "to the extent possible" to clarify normative objectives and strategies already at the "request formulation stage" to "not compromise the independence of the advice or advisory process" ([35], 3). These reconciling interactions serve to "ensure the independence of the advisory process from inappropriate influence by requesters and stakeholders". Overall, we find that ICES is investing more efforts into "spanning the boundary" between science and policy [5] regarding specific request than regarding the Recurrent requests.

The science-policy interactions involved with producing *Ecosystem, Fisheries and Aquaculture Overviews* comprise ever more open-ended processes resembling the evolving developments of an ecosystem approach advice. The exact use of this information in decision-making is not clarified and a well-defined framework for advice provision on ecosystem aspects is still missing ([3], 525). The science-policy interactions are hence still part of iterative processes of developing feasible interactions between science and policymaking to harmonise the expectations of what policy wants/needs and what science can deliver. ICES tries to help answering some of these questions including "for whom" these advisory products should be generated and "for what purposes" ([3], 527). However, ambiguities reside regarding the different actors' agency and responsibility, i.e., the science-policy system's reliance on "pulling mechanisms" for an ecosystem approach advice from the policy side and/or the (in-)effectiveness of "pushing strategies" of actors like scientists or stakeholders [61].

The *Viewpoints* do not involve established science-policy interactions like the other advice products because they are not produced upon requests from policy, hence only involving the agency of science. As standalone advisory products internally decided by ICES (involving a compilation of societally relevant issues by ACOM and ICES' Science Committee, SCICOM), they resemble a fundamentally different form of "advice": an academic perspective suggesting useful knowledge on societal issues, not directly linked to ongoing political decision-making processes or stated policy preferences (interview previous ICES ACOM member).

4.2. Roles taken by ICES when developing the advisory products

The advice on *Recurrent requests* presents a response to straightforward questions like "what is the maximum sustainable fishing mortality for a specific fish stock". This advice product is part of an established framework enabled by the specific framing of such questions, for instance by setting reference points for MSY and the Precautionary Approach, and procedures for advice formulation. This institutional design of the advisory process assigns a clear role for science in form of stock assessment for scientists in the EGs and advice formulation in the ADGs and ACOM. The framework establishes a sharp boundary between science and policy that gives a clear and well-designed "scientific" task to ICES, thereby ensuring its independence from obvious political influence. The role that ICES fulfils in these contexts represents what Pielke [60] calls "*science arbitering*": science responding to scientifically answerable questions of interest to the advisee, which is enabled through substantial work invested in setting up this framework (see Section 5).

The role of ICES in the case of *Special requests* is similar in so far as it also entails some form of question-answer procedures. The difference from Special requests is that there is no well-established management framework for posing and responding to requests. The process for Special requests is therefore more open and involves interactive stages of request formulation and responses to arrive at formulating a question that is possible for ICES to address, and that seeks to prevent ICES taking a normative position on policy relevant issues when providing advice. ICES hence invests efforts to clarify the advisory process and to constrain it to fulfilling a non-political advisory function. While this role, of an objective, non-political knowledge provider, is a strong commitment for ICES, enabling it entails practical challenges and substantial efforts to 'purify' the scientific advisory process from inappropriate policy influence. The role for science involved here entails more "*complex arbitering*" because enabling science-based advice to Special requests requires more engagement with policymaking behind the formal advisory interface, thus also resembling the role of "participatory experts" that work across the science-policy boundary ([73], see Section 2).

The *Ecosystem, Fisheries and Aquaculture Overviews* entail even more open processes of providing knowledge to less specified policy-requests. Since there is still no clear uptake mechanism from the policy side, the tasks for science are less well defined. Hence, what the Overviews, as part of an ecosystem approach advice trajectory, can and should deliver is less clear. As complements to the Requests ([35], 3), Overviews are part of an evolving management agenda, which opens new and challenging questions for the role of science. It is partly unclear how and by whom the process should be initiated to push new developments forward [3,61]. The Overviews hence imply an advisory role for ICES as broad knowledge provider for a knowledge that is on an early path of being of used for management. This resembles what Pielke [60] described as "knowledge brokering", but also requires scientists to take the role of "participatory experts" working "within the blurred boundaries between knowledge production and use" ([73], 356). However,

from the Overviews descriptions in the Guide we can also identify the aspiration to move towards an arbitering role, because science is concerned with its societal use, by "addressing issues relevant to regional managers" ([35], 4), which involves aspects of pure science (see Appendix 1).

The role for science in *Viewpoints* appears clearer than in the previous case. With Viewpoints ICES takes a strong and engaged role in choosing what is important and relevant for society and management. According to the typology in Table 1, ICES' role here resembles that of an *issue advocate* [60]. In this role, ICES takes on a role of a whistle blower for environmental problems, but also in recommending actions to be taken by policy or other actors. However, it is at present unclear how the knowledge provided by ICES through Viewpoints is, or can be used by policy- and decision-makers. This is the case as Viewpoint are not developed in response to requests by ICES in support of ongoing policy processes. According to an interview with a previous ACOM member, the inspiration for developing Viewpoints was that much relevant science produced in ICES is unused, and that it should be. This suggests some adherence to a linear model perspective of producing science for a "knowledge reservoir", from which society and managers can select relevant elements suggesting a role of pure science. In this view, ICES maintains independence as a neutral, unpolitical knowledge provider that is not accountable for its use. As the previous ICES ACOM member we interviewed put it, while ICES serves as an ideal actor to present such relevant knowledge, "it is not science's fault if it is not used". Some of the recommendations stated in the viewpoints are formulated in a quite strong way in the sense of prescribing a preferred course of action for the authorities in charge. For instance, the Viewpoint on scrubber discharge water from ships recommends that: "Until scrubber water discharge can be avoided: a) discharges in specific areas […] should be banned; b) stringent limits for contaminants in discharge water should be set and enforced, and c) further development of standards and protocols for measuring, monitoring, and reporting on scrubber discharge water for contaminants and other parameters should be ensured" [38].

5. Discussion

We have characterised a diversity of roles that ICES takes on in relation to its four distinct advisory products. Each role is associated with strengths and weaknesses, and its suitability depends on the specific advisory context. We can concur with earlier studies [50,60] that there is no panacea for how science advice can best inform policy and decision-making. Nevertheless, we find that ICES is striving to realise the principles of Lentsch and Weingart [50], aiming to achieve distance and independence, plurality, transparency and openness of the advice (see Section 2). The framing of the first three advice products can be understood historically in terms of how the advice and resulting science-policy interactions were established and consolidated through repeated interplays of request and advice.

The basic characteristics of the *Recurrent requests* emerged from negotiations between scientists and managers in the international fisheries commissions during the 1960s and 1970s [22,46]. The resulting institutional framework became the default system for fisheries management in the Northeast Atlantic under ICES [59,26]. Roles for science and policy became defined clearly in the respective and interlinked frameworks for fisheries advice and fisheries management. This included a division of tasks and responsibilities for science and policy respectively that enabled a formalised and high-throughput process for ICES to produce and deliver advice in response to recurrent requests for annual advice. The *arbitering* function enabled for science here is based on the historical development of the interface between the provision of fisheries advice and its use in management [59]. Substantial efforts were invested in the development of this framework for ICES fisheries advice, notably through a series of dialogue meetings between ICES and its clients (see [45]). This "co-production of science and policy" [43] resulted in what practitioners in fisheries science and management in the Northeast Atlantic generally recognise as a workable interplay between science (producing knowledge for TAC advice) and policy (using this advice for TAC decisions). The standard procedures of this arbitering framework serve to shelter the science process from political influence but necessitate continued work to establish and adjust ICES' advisory procedures, as laid down in grant agreements, internal guidelines for assessment and the introduction to ICES advice.

To arrive at such an arbitering role for ICES's advice is more challenging with *Special requests*. Here, the lack of a well-established science-management framework ([35], 3) requires exchanges across the science-policy boundary to enable scientific responses, as described with Turnhout et al.'s [73] role of "participatory experts" (Section 2). This is realised through increased dialogue between ICES and its clients to work out how to deal with normative issues, avoiding the politicisation of science and ensuring the independence of the advisory process. In contrast to the dialogues between ICES and its clients that contributed to the historical development of its framework for providing advice on Recurrent requests, the dialogues leading to Special requests happen on a case-by-case basis. Following Bowker and Star [6], these dialogue efforts are needed for "sorting things out" by attributing roles and functions, rights, and obligations to enable specific roles for science and policy respectively. They reveal how the formalised interactions between science and policy are rendered possible through establishing procedures for how different actors should interact. Such procedures may provide for an independent role for science. It is obvious from the analysis of the Guide, other ICES documents, and our fieldwork observations and interviews, that ICES clearly strives to attain the role of an independent advisor through defining a clear-cut boundary between science and policy (some ICES scientists prefer to say "evidence" instead of "advice" to underscore this position). A question emerging from this is how much the credibility of ICES' advice is dependent on this strict boundary definition for maintaining a non-political and objective role or whether accepting to be part of and steered by a political regime may impede on it (see below).

The *Overviews* are an interesting object for our study because they are associated with a comparatively unspecified role for science and science-based advice. This suggests a need for more extensive collaborations between scientists, policymakers, and stakeholders to clarify expectations, roles/tasks, and responsibilities relating to this product. The process of building a new science-policy interface for a management agenda following an ecosystem approach is still under development and "continuously evolving" ([35], 4). Therefore, the questions what science can deliver and what policy wants, or needs, remain partly unresolved [3,61]. While ICES has taken a proactive role to gradually include new knowledge for this agenda [3], uncertainties remain on how the advancing knowledge on ecosystem perspectives can be tailored to decision-making contexts, i.e., be transformed from 'useful' to 'useable' knowledge, which is regarded as "key in overcoming the barriers to usability" ([72], 455). This poses new questions about the normative role of science in society regarding for whom this type of knowledge is generated and for what purposes. As Ballesteros et al. ([3], 527) argue, the proactive role taken by ICES to generate an ecosystem approach advice has "raised unreasonable expectations of what it could and should deliver" and „increased the responsibilities placed on scientists". While ICES appears as a well-suited organisation to facilitate progress, initiate and maintain dialogue, not only between science and policy but also between various scientific disciplines and stakeholders to reduce the knowledge-action gap regarding an ecosystem approach to management, it seems "unrealistic to expect ICES also to produce all the answers" ([3], 527).

Further progress towards policy relevant Overview products will require continuous dialogue between science and policy to clarify what the actual policy objectives are and which normative or objective role science can and should legitimately play as an entrusted provider of knowledge in support of an ecosystem approach. This role for ICES as a science advisory body resembles an intense, at times unclear or diffuse

type of "knowledge brokering", which Turnhout et al. [73] define as "linking knowledge supply and demand by serving as intermediary" ([73], 357). They define different "repertoires" for knowledge brokering, of which "facilitating", requiring the role of "participatory experts" ([73], 362), matches the role of science needed for an ecosystem approach. However, this role of science not only implies to accept working *across* imagined boundaries, but also to engage collaboratively in *blurred* boundary contexts. According to our analysis of ICES' advisory products, corroborated by our fieldwork observations and interviews, ICES as an organisation does not aspire to operate in such blurred science-policy contexts but instead engages in separating the two realms of science and policy to the extent possible. Separation is regarded by ICES as a main source of credibility and legitimacy. Accordlingly, ICES invests heavily in boundary setting through ordering devices in its advisory framework, including the advice products and their adapted processes defined in the Guide [35]. While it might be questioned to what extent such a strategy to strongly separate science and policy is a viable option in a highly politicised, uncertain, and dynamic policy environment like fisheries and marine governance, our analysis shows how ICES has developed strategies for separation adapted to different advisory products in order to safeguard its operation as an advisory organisation. This strong separation of science and policy is a unique feature of ICES compared to other international advisory organisations, e.g., in climate or biodiversity governance [17], where the political dimensions of science-policy interactions pose more obvious challenges [23,30].

The more engaged and pro-active stance that ICES takes with the *Viewpoints* could be understood to be in tension with its aspiration to deliver non-political advice through a clear separation of science and policy. ICES nonetheless highlights the impartiality of the Viewpoints and guarantees the same level of quality control and balanced presentation as in the other advice products. However, with the Viewpoints, ICES steps out of a strict arbitering role by taking a standpoint on societal problems. Despite this, the processes of synthesising the relevant knowledge are referred as unbiased, implying a role of producing pure science independent from policy influence.

The tension revealed for Viewpoints between the roles of pure knowledge provision and advocacy tendencies bears similarity to an ambiguity addressed to the IPCC's credo of being "policy relevant but not policy prescriptive" [41]. Grundmann and Rödder [23], 3887) argue that the IPCC is, due to the mutual influences between science and policy in such a boundary organisation "more political (or policy-prescriptive) and less policy-relevant". This stands in contrast to ICES, which as an institution aims to uphold the separation of science and policy as a key source for its credibility - even more strongly than the IPCC does ([17]; cf. [46]). While this might not be problematic for a boundary organisation described by Guston [25] that escapes both a politicisation of science and a scientisation of politics "by the coproduction of mutual interests", authors like Grundmann and Rödder [23] find the entanglement of science and policy in boundary organisations like the IPCC more problematic, because that risks a simultaneous depoliticisation of politics and politicisation of science, resulting in lack of progress when science takes centre stage while being unable to offer political solutions. ICES, as a similar type of boundary organisation, has found ways to escape this apparent dilemma through the adaptable framework of different advisory roles in the framework of the Guide analysed here. This way of establishing and maintaining science-policy boundaries resembles the "recursive model" from Weingart [74] suggested above. It provides better guidance because it defines tasks and responsibilities for science and scientists, hence enabling both domains to work as undisturbed as possible from each other. We find Weingart's model particularly helpful to conceptualise ICES' boundary work because it accepts a blurred boundary context while concurrently enabling a practical separation between science and policy through four consecutive steps of a recursive process (see Section 2). While the two Request advisory products and the Viewpoints have sorted out these roles for science and policy, the Overviews reveal how this process still unfolds. Hence, the Overviews advice products, as part of the evolving ecosystem approach, pose challenging questions about sorting out the role of science in practice. While science is part of dynamic and interactive developments to provide integrated ecosystem advice ([35], 4), exactly how, i.e., in which capacity, function and responsibility, ICES should contribute here is not yet resolved [3,61]. As Dickey-Collas [19] argues, this requires an advisory approach with cycles of participatory scoping and rescoping of the problem contexts, *assisted by* science. It implies that ICES, both as an institution and as individual scientists, neeed to engage in increased dialogue with society to facilitate new forms of knowledge products that can meaningfully feed into policy and decision processes. The novelty with the Overviews and the ecosystem approach is that this happens in transparent and participatory fora and not 'behind the scenes' in closed circles like the 1960s/70s fisheries commissions setting up the science-policy framework for fisheries management under ICES [22].

5.1. Limitations and further work

Based on the Guide, we have analysed the roles that ICES takes as an advisor, how these roles are enabled, and some of the challenges they involve. The empirical focus on the Guide represents a strength as well as a weakness for our study. The strength is that the focus on the Guide supports an analysis of the roles that ICES commits itself to take on for different advisory products. The Guide hence serves a dual purpose: internally it informs practitioners in the advisory process about the principles and the characteristics of each advice product. Externally the Guide communicates these aspects to ICES' advice clients and other recipients of ICES' advice. Accordingly, the Guide both serves to instruct advisory practices and to communicate externally the values and norms that these practices build on. The main weakness of our study is that we have not explored in detail how the principles and ideals expressed in the Guide are met in real life practice. The latter would require additional empirical analyses and was considered beyond the scope of this study. We would encourage further detailed work on this latter aspect, together with more comparative studies on the separation and formalisation of advisory practices that our case study revealed.

6. Conclusion

This study investigated the roles that ICES takes as an advisor to policy- and decision-making. Our results show that ICES' four advisory products involve different roles for ICES as an advisor. This finding aligns with earlier studies suggesting that there is no panacea for how science-based advice can best inform policy and decision-making. Our analysis reveals how ICES as an organisation manages to navigate between different roles through assigning specific procedures to different advisory products in the Guide [35]. The study shows how ICES invests substantial efforts to develop this advisory framework and has historically managed to find new and innovative ways to navigate between different roles for science advice through assigning specific procedures to different advisory products. Moving beyond our study to broader challenges of science-society relations in environmental governance, we find questions lingering about the accountability and responsibility of science vis-a-vis policy or other societal actors. These questions emerge when developing new interfaces between available knowledge, advice, and policy-uptake, for instance in the context of developing advice in support of an ecosystem approach. More research is needed to understand in detail how the roles of science and policy can be sorted out in such practical contexts, and which challenges and opportunities these processes entail.

CRediT authorship contribution statement

Conception and design: SL, KNN, PRM. Data acquisition, analysis and interpretation: SL, KNN, PRM, Drafting of manuscript, SL. Input,

comments, revisions and final approval of manuscript: SL, KNN, PRM.

Declaration of interest

The authors declare that there are no conflicts of interest.

Data availability

Data will be made available on request.

Acknowledgements

The research for this study has been funded by the Swedish funder "Riksbankens Jubileumsfond", as part of the project "Science for environmental governance: dilemmas in advisory processes" (project no. P16-0362:1). We acknowledge Petter Holm and two anonymous reviewers for providning valuable suggestions and constructive feedback on earlier versions of this article.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2022.105469.

References

[1] F. Alcock, The institutional dimensions of fisheries stock assessments, Int. Environ. Agreem. Polit. Law Econ. 4 (2004) 129–141.
[2] M. Ballesteros, M. Dickey-Collas, Managing participation across boundaries: a typology for stakeholder engagement in the International Council for the Exploration of the Sea, Mar. Policy 147 (2023), 105389, https://doi.org/10.1016/j.marpol.2022.105389.
[3] M. Ballesteros, R. Chapela, P. Ramírez-Monsalve, J. Raakjaer, T.J. Hegland, K. N. Nielsen, U. Laksa, P. Degnbol, Do not shoot the messenger: ICES advice for an ecosystem approach to fisheries management in the European Union, ICES J. Mar. Sci. 75 (2) (2018) 519–530.
[4] S. Beck, M. Borie, J. Chilvers, A. Esguerra, K. Heubach, M. Hulme, R. Lidskog, E. Lövbrand, E. Marquard, C. Miller, T. Nadim, Towards a reflexive turn in the governance of global environmental expertise. The cases of the IPCC and the IPBES, GAIA Ecol. Perspect. Sci. Soc. 23 (2) (2014) 80–87.
[5] A.T. Bednarek, C. Wyborn, C. Cvitanovic, R. Meyer, R.M. Colvin, P.F.E. Addison, S. L. Close, K. Curran, M. Farooque, E. Goldman, D. Hart, H. Mannix, B. McGreavy, A. Parris, S. Posner, C. Robinson, M. Ryan, P. Leith, Boundary spanning at the science–policy interface: the practitioners' perspectives, Sustain. Sci. 13 (2018) 1175–1183, https://doi.org/10.1007/s11625-018-0550-9.
[6] G.C. Bowker, S.L. Star, Sorting Things Out: Classification and Its Consequences, The MIT Press, Cambridge, 2000.
[7] M. Brown. Review of Roger S. Pielke, Jr., The Honest Broker, Minerva, 2008, pp. 485–489.
[8] A. Bryman. Social Research Methods, fifth ed., Oxford University Press, Oxford, United Kingdom, 2016.
[9] D.W. Cash, W.C. Clark, F. Alcock, N.M. Dickson, N. Eckley, D.H. Guston, J. Jäger, R.B. Mitchell, Knowledge systems for sustainable development, Proc. Natl. Acad. Sci. 100 (14) (2003) 8086–8091.
[10] K. Charmaz. Constructing Grounded Theory, second ed., Sage, Thousand Oaks, 2014.
[11] K. Currey, S.G. Clark, Roger A. Pielke, Jr., The honest broker: making sense of science in policy and politics, Policy Sci. 43 (2010) 95–98.
[12] C. Cvitanovic, A.J. Hobday, L. Kerkhoff, N.A. Marshall, Overcoming barriers to knowledge exchange for adaptive resource management; the perspectives of Australian marine scientists, Mar. Policy 52 (2015) 38–44.
[13] C. Cvitanovic, M. Mackay, R.J. Shellocka, E.I. van Putten, D.B. Karcher, M. Dickey-Collas, Understanding and evidencing a broader range of 'successes' that can occur at the interface of marine science and policy, Mar. Policy (2021) 134, https://doi.org/10.1016/j.marpol.2021.104802.
[14] C. Cvitanovic, R.J. Shellock, M. Mackay, E.I. van Putten, D.B. Karcher, M. Dickey-Collas, M. Ballesteros, Strategies for building and managing 'trust' to enable knowledge exchange at the interface of environmental science and policy, Environ. Sci. Policy 123 (2021) 179–189.
[15] D.J. Dankel, K. Stange, K.N. Nielsen, What hat are you wearing? On the multiple roles of fishery scientists in the ICES community, ICES J. Mar. Sci. 73 (2016) 209–216.
[16] M. De Donà, Matching institutionalized expertise with global needs: boundary organizations and hybrid management at the science-policy interfaces of soil and land governance, Environ. Sci. Policy 123 (2021) 82–90.
[17] M. De Donà, S. Linke, 'Close but not too close' – experiences of science-policy bridging in three international advisory organizations, Crit. Policy Stud. (2022) 1–19, https://doi.org/10.1080/19460171.2022.2028173.
[18] D. DeVasto, Being expert - L'Aquila and issues of inclusion in science-policy decision making, Soc. Epistemol. 30 (4) (2016) 372–397, https://doi.org/10.1080/02691728.2015.1065928.
[19] M. Dickey-Collas, Why the complex nature of integrated ecosystem assessments requires a flexible and adaptive approach, ICES J. Mar. Sci. 71 (2014) 1174–1182.
[20] E. Turnhout, W. Halffman, W. Tuinstra (Eds.), Environmental Expertise: Connecting Science, Policy and Society, Cambridge University Press, Cambridge, 2019.
[21] K. Fawkes, S. Ferse, A. Scheffers, V. Cummins, Learning from experience: what the emerging global marine assessment community can learn from the social processes of other global environmental assessments, Anthr. Coasts 4 (2021) 87–114, https://doi.org/10.1139/anc-2020-0018.
[22] S. Gezelius, The problem of implementing policies for sustainable fishing, in: S. Gezelius, J. Raakjær (Eds.), Making Fisheries Management Work, Springer, London, 2008, pp. 1–25.
[23] R. Grundmann, S. Rödder, Sociological perspectives on earth system modeling, J. Adv. Model. Earth Syst. 11 (12) (2019) 3878–3892, doi:10.1029/2019MS001687.
[24] K.M. Gustafsson, R. Lidskog, Boundary organizations and environmental governance: performance, institutional design, and conceptual development, Clim. Risk Manag. 19 (2018) 1–11.
[25] D. Guston, Boundary organizations in environmental policy and science: an introduction, Sci. Technol. Hum. Values 16 (2001) 399–408.
[26] H. Rozwadowski, The Sea Knows No Boundaries: A Century of Marine Science under ICES, University of Washington Press, Seattle and London, 2002.
[27] P. Holm, M. Hadjimichael, S. Linke, S. Mackinson (Eds.), Collaborative Research in Fisheries: Co-creating Knowledge for Fisheries Governance in Europe, Springer, Dordrecht, 2020.
[28] R. Hoppe, Rethinking the science–policy nexus: from knowledge utilization and science technology studies to types of boundary arrangements, Poiesis Prax. 3 (2005) 199–215.
[29] R. Hoppe, Scientific advice and public policy: expert advisers' and policymakers' discourses on boundary work, Poiesis Prax. 6 (3/4) (2009) 235–263.
[30] C. Ibarra, G. Jiménez, R. O'Ryan, G. Blanco, L. Cordero, X. Insunzaa, P. Moraga, M. Rojas, R. Sapiains, Scientists and climate governance: a view from the South, Environ. Sci. Policy 137 (2022) 396–405.
[31] ICES, Aquaculture Overviews, n.d. ⟨https://www.ices.dk/advice/aquaculture_overviews/Pages/default.aspx⟩.
[32] ICES, Ecosystem Overviews, n.d. ⟨https://www.ices.dk/advice/ESD/Pages/Ecosystem-overviews.aspx⟩.
[33] ICES, EU Request for a Technical Service to produce a compilation of assessment methods and indicators that can be used to assess seabed habitats under D6/D1 for the MSFD, Report of the ICES Advisory Committee, ICES Advice 2022, sr. 2022.11, 2022. ⟨https://doi.org/10.17895/ices.advice.21070975⟩.
[34] ICES, Fisheries Overviews, n.d. ⟨https://www.ices.dk/advice/Fisheries-overviews/Pages/fisheries-overviews.aspx⟩.
[35] ICES, Guide to ICES advisory framework and principles. Report of the ICES Advisory Committee, Version 2, 21 January 2021, Section 1.1, 2021. ⟨https://doi.org/10.17895/ices.advice.7648⟩.
[36] ICES, ICES VIEWPOINT: Assessment of the Biological Effects of Chemical Pollution for Better Management of the Marine Environment, 2021. ⟨https://www.ices.dk/news-and-events/news-archive/news/Pages/ViewpointCP.aspx⟩.
[37] ICES, ICES VIEWPOINT: Biofouling on Vessels – What Is the Risk, and What Might Be Done about It?, 2019. ⟨https://www.ices.dk/news-and-events/news-archive/news/Pages/ICES-Viewpoints-biofouling.aspx⟩.
[38] ICES, ICES VIEWPOINT: Scrubber discharge water from ships – risks to the marine environment and recommendations to reduce impacts, Report of the ICES Advisory Committee, ICES Advice 2020, vp.2020.01, 2020. ⟨https://doi.org/10.17895/ices.advice.7486⟩.
[39] ICES, Who We Are, n.d. ⟨https://www.ices.dk/about-ICES/who-we-are/Pages/Who-we-are.aspx⟩.
[40] ICES, Workshop on Stakeholder Engagement Strategy (WKSHOES), ICES Scientific Reports, 3(75), 2021, p. 9. ⟨https://doi.org/10.17895/ices.pub.8233⟩.
[41] IPCC Secretariat, Statement on IPCC Principles and Procedures, Geneva, 2010. ⟨https://www.ipcc.ch/site/assets/uploads/2018/04/ipcc-statement-principles-procedures-02-2010.pdf⟩.
[42] S. Jasanoff, The Fifth Branch: Science Advisers as Policymakers, Harvard University Press, Cambridge, MA, 1990.
[43] S. Jasanoff (Ed.), States of Knowledge: The Co-Production of Science and Social Order, Routledge, London, 2004.
[44] S. Jasanoff, Speaking honestly to power, Am. Sci. 96 (3) (2008) 240–243.
[45] K. Hoydal (Ed.), History of the ICES Advisory Committee on Fishery Management, 1978–2007, ICES Cooperative Research Report No. 322, 2014.
[46] K.N. Nielsen, Science|Politics: Boundary Construction in Mandated Science – The Case of ICES' Advice on Fisheries Management (Ph.D. Dissertation), University of Tromsø, 2008.
[47] L. van Kerkhoff, V. Pilbeam, Understanding socio-cultural dimensions of environmental decision-making: a knowledge governance approach, Environ. Sci. Policy 73 (2017) 29–37.
[48] S. Kraak, C. Kelly, E. Codling, E. Rogan, On scientists' discomfort in fisheries advisory science: the example of simulation-based fisheries management-strategy evaluations, Fish Fish. 11 (2010) 119–132.
[49] M. Kraan, S. Linke, Commentary 2 to the manifesto for the marine social sciences: applied social science, Marit. Stud. 19 (2020) 129–130.
[50] J. Lentsch, P. Weingart, The Politics of Scientific Advice: Institutional Design for Quality Assurance, Cambridge University Press, Cambridge, UK, 2011.

[51] S. Linke, M. Hadjimichael, S. Mackinson, P. Holm, Knowledge for fisheries governance. Participation, integration and institutional reform, in: P. Holm, M. Hadjimichael, S. Linke, S. Mackinson (Eds.), Collaborative Research in Fisheries: Co-creating Knowledge for Fisheries Governance in Europe, Springer, Dordrecht, 2020, pp. 7–25.
[52] M. Dickey-Collas, M. Ballesteros, Swinging Back? Science Ethos and Stakeholders' Engagement in ICES Advisory Processes. (Fishing Industry as Authors of ICES Expert Group Reports), ICES News, 2019. ⟨https://www.ices.dk/news-and-events/news-archive/news/Pages/Science-ethos-and-stakeholders-engagement-in-ICES-advisory-processes.aspx⟩.
[53] M. Dickey-Collas, M. Ballesteros, The Process in ICES of Opening up to Increased Stakeholder Engagement (1980–2020), ICES Cooperative Research Report, 353, 2021, p. 26. ⟨10.17895/ices.pub.8516⟩.
[54] C. Macher, N.A. Steins, M. Ballesteros, M. Kraan, K. Frangoudes, D. Bailly, M. Bertignac, F. Colloca, M. Fitzpatrick, D. Garcia, R. Little, S. Mardle, A. Murillas, L. Pawlowski, M. Philippe, R. Prellezo, E. Sabatella, O. Thébaud, C. Ulrich, D. Dankel, Towards transdisciplinary decision-support processes in fisheries: experiences and recommendations from a multidisciplinary collective of researchers, Aquat. Living Resour. (2021) 34, https://doi.org/10.1051/alr/2021010.
[55] S. Mackinson, D.A.J. Middleton, Evolving the ecosystem approach in European fisheries: transferable lessons from New Zealand's experience in strengthening stakeholder involvement, Mar. Policy 90 (2018) 194–202, https://doi.org/10.1016/j.marpol.2017.12.001.
[56] K. Nagasaka, M. Böcher, M. Krott, Are forest researchers only scientists? Case studies on the roles of researchers in Japanese and Swedish forest policy processes, For. Policy Econ. 70 (2016) 147–154.
[57] OECD. Scientific Advice for Policy Making: The Role and Responsibility of Expert Bodies and Individual Scientists, OECD Science, Technology and Industry Policy Papers, No. 21, OECD Publishing, Paris, 2015, https://doi.org/10.1787/5js33l1jcpwb-en.
[58] J. Olson, P. Pinto da Silva, Taking stock of fisheries science through oral history: voices from NOAA's Fishery Science Centers, ICES J. Mar. Sci. 76 (2) (2019) 370–383, https://doi.org/10.1093/icesjms/fsy187.
[59] P. Holm, K.N. Nielsen, The TAC machine, Report of the Working Group on Fishery Systems, WGFS Annual Report, ICES, Copenhagen, 2004, pp. 40–51.
[60] R.A. Pielke, The Honest Broker: Making Sense of Science in Policy and Politics, Cambridge University Press, Cambridge, UK, 2007.
[61] P. Ramírez-Monsalve, K.N. Nielsen, M. Ballesteros, T.S. Kirkfeldt, M. Dickey-Collas, A. Delaney, T.J. Hegland, J. Raakjær, P. Degnbol, Pulling mechanisms and pushing strategies: how to improve ecosystem advice fisheries management advice within the European Union's Common Fisheries Policy, Fish. Res. 233 (2021), 105751, https://doi.org/10.1016/j.fishres.2020.105751.
[62] C. Röckmann, J. van Leeuwen, D. Goldsborough, M. Kraan, G. Piet, The interaction triangle as a tool for understanding stakeholder interactions in marine ecosystem based management, Mar. Policy 52 (2015), 155-62.
[63] H. Rozwadowski, Science, the sea, and marine resource management: researching the International Council for the Exploration of the Sea, Public Hist. 26 (2004) 41–64.
[64] S. Jasanoff, Science and democracy, in: U. Felt, R. Fouché, C.A. Miller, L. Smith-Doerr (Eds.), Handbook of Science and Technology Studies, MIT Press, Cambridge, MA, 2017.
[65] SAM, Statement on Scientific Advice to European Policy Makers During the COVID-19 Pandemic European Commission, 2020. ⟨https://ec.europa.eu/info/sites/info/files/research_and_innovation/groups/sam/sam_covid-19-statement-v5a.pdf⟩.
[66] SAPEA, Science Advice for Policy by European Academies, Making Sense of Science for Policy under Conditions of Complexity and Uncertainty, SAPEA, Berlin, 2019. ⟨https://doi.org/10.26356/MASOS⟩.
[67] S. Sarkki, H.I. Heikkinen, T. Komu, M. Partanen, K. Vanhanen, E. Lepy, How boundary objects help to perform roles of science arbiter, honest broker, and issue advocate, Sci. Public Policy 47 (2) (2020) 161–171.
[68] S. Soomai, The science-policy interface in fisheries management: insights about the influence of organizational structure and culture on information pathways, Mar. Policy 81 (2017) 53–63.
[69] P. Spruijt, A. Knol, E. Vasileiadou, J. Devilee, E. Lebret, A. Petersen, Roles of scientists as policy advisers on complex issues: a literature review, Environ. Sci. Policy 40 (2014) 16–25.
[70] K. Stange, P. Olsson, H. Österblom, Managing organizational change in an international scientific network: a study of ICES reform processes, Mar. Policy 36 (2012) 681–688.
[71] N. Steins, M.L. Kraan, K.J. van der Reijden, F.J. Quirijns, W. van Broekhoven, J. J. Poos, Integrating collaborative research in marine science: Recommendations from an evaluation of evolving science-industry partnerships in Dutch demersal fisheries, Fish Fish. 21 (2020) 146–161.
[72] G. Sundqvist, D. Gasper St, A.L. Clair, E.A.T. Hermansen, S. Yearley, I. Øvstebø Tvedten, B. Wynne, One world or two? Science-policy interactions in the climate field, Crit. Policy Stud. 12 (4) (2018) 448–468.
[73] Turnhout, M. Stuiver, Klostermann, J. Harms, B, C. Leeuwis, New roles of science in society: different repertoires of knowledge brokering, Sci. Public Policy 40 (2013) 354–365.
[74] P. Weingart, Scientific expertise and political accountability: paradoxes of science in politics, Sci. Public Policy 26 (3) (1999) 151–161.
[75] B. Wenzel, Organizing coordination for an ecosystem approach to marine research and management advice: the case of ICES, Mar. Policy 82 (2017) 138–146, https://doi.org/10.1016/j.marpol.2017.05.009.
[76] D.C. Wilson, The Paradoxes of Transparency – Science and the Ecosystem Approach to Fisheries Management in Europe, Amsterdam University Press, Amsterdam, 2009.