WORKING GROUP ON ECONOMICS (WGECON; outputs from 2020 meeting)

VOLUME 3 | ISSUE 4

ICES SCIENTIFIC REPORTS

RAPPORTS
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ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

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ISSN number: 2618-1371

ICES Scientific Reports

Volume 3 | Issue 4

WORKING GROUP ON ECONOMICS (WGECON; outputs from 2020 meeting)

Recommended format for purpose of citation:

ICES. 2021. Working Group on Economics (WGECON; outputs from 2020 meeting).
ICES Scientific Reports. 3:4. 54 pp. https://doi.org/10.17895/ices.pub.7652

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Contents

i Executive summary

The ICES Working Group on Economics (WGECON) was established to address the challenge of bringing fisheries economics into ICES science and advice, with the growing recognition that this can assist process understanding of uses of marine ecosystems, their drivers and responses to changes, and assessment and communication of trade-offs that include economic, social and ecological dimensions. The group has progressed in two complementary directions: (i) drafting a scientific manuscript reviewing current research and future needs for economic science and advice in ICES; (ii) discussing the information flow needed to provide trade-off analysis. In particular, the group agrees that a clear distinction needs to be established in such analyses between economic impacts and welfare changes. A review of available economic data showed that a significant body of information exists in Europe and in the US to describe the economic status of commercial fisheries in different regions. A survey of the fisheries economics profession showed that more than 80% of the respondents would be interested in contributing to Integrated Ecosystem Assessments on a regional basis. WGECON has also actively sought to develop links with other ICES working groups and initiatives, and to the organisation of international conferences and meetings.

Future WGECON work will continue to enhance the economic dimension to be an integral part of marine science and scientific advice regarding the use and conservation of marine resources. This is based on the still increasing demand for science and advice to address economic considerations, and the observation that ICES does only to very limited extent engage economists and address economic issues in many member countries in its existing work. WGECON members have agreed on the importance of integrating economics in ICES science generally, but have highlighted the importance of identifying and reviewing the specific problems that can be addressed, as this leads to a more concrete discussion on the applied contributions of economic research. Also, the group has emphasized the use of demonstrators of the ways in which such problem identification and analysis of relevant economic research, methods, tools and data can be implemented to meet the problems. On this basis the group has pointed to the following future needs and ToRs for the continued WGECON: i) Build additional capacity for economic science in ICES, giving consideration to research and institutional needs in all ICES member countries, as well as useful connections to international marine/ fisheries economics organisations such as International Institute of Fisheries Economics and Trade (IIFET), North American Association of Fisheries Economists (NAAFE) and European Association of Fisheries Economists (EAFE); ii) Identify and report on economic data-related needs and priorities for short and longer-term economic data collection, access and analysis; and where possible propose systems to collect missing data; iii) Demonstrate the approaches, methods, tools and information flow needed to provide analysis of trade-offs relating to ecosystem-based management of fishing (EBFM); iv) Assess and report on economic aspects of commercial fishing and its management for selected regions in the ICES area; and v) Coordinate the provision of economic indicators and analysis as part of integrated socio-ecological evaluations in support of EBFM.

ii Expert group information

Expert group name	Working Group on Economics (WGECON)
Expert group cycle	Multiannual
Year cycle started	2018
Reporting year in cycle	3/3
Chair(s)	Hazel Curtis (2018, 2019), UK; Arina Motova (2020), UK
	J. Rasmus Nielsen, Denmark
	Olivier Thébaud, France
Meeting venue(s) and dates	11-15 June 2018, Copenhagen, Denmark, 18 participants
	11-14 June 2019, Paris, France, 26 participants
	15-19 June 2020, online Meeting, 33 participants

1 Background and scoping of the group's work

As background to the establishment of the Working Group on Economics (WGECON) of the International Council for the Exploration of the Sea (ICES), the resolution noted that nations are concerned about fish stocks and marine ecosystems not least because they can contribute to human wellbeing, and these natural resources have an economic value. The economic dimension should thus be an integral part of marine science and scientific advice regarding the use and conservation of marine resources.

Demand for science and advice to address economic considerations is increasing, but at the initiation of WGECON, ICES did not engage many economists or address economic issues in many member countries in its existing work. The efforts of the Strategic Initiative on the Human Dimension (SIHD) with ICES had served to raise the profile of economics in the last few years, but, with a few exceptions, SIHD efforts were not comprehensively supported and informed by the work of the ICES expert groups (EGs). Further, none of the existing EGs that addressed economic issues were focusing on the development of economic metrics and core economic analyses that are demanded in parts of the ICES network (e.g. further development of ecosystem overviews) and, in some cases, by clients for ICES advice.

The need to expand the engagement of ICES in economics was also reflected in the outcomes of many meetings, especially the "Understanding marine socioecological systems" (MSEAS) Conference which ICES co-sponsored in Brest in 2016. Also, other ICES working groups had pointed at this need such as the ICES WGIMM (Working Group on Integrated Management Modelling) and ICES WGIPEM (Working Group on Integrated, Physical-biological and Ecosystem Modelling). Other drivers included high level aspirations for Blue Growth in European countries and globally, the interest in managing fisheries for Maximum Economic Yield and a desire to understand economic consequences of human-induced changes in the sea (WGHIST – Working Group on the History of Fish and Fisheries). There was also recognition in ICES, and from its clients, that it would be desirable to add economic metrics to ICES ecosystem overviews and better recognise people and their livelihoods as part of the ecosystem and ecosystem drivers. Further, in the longer term, ICES growing engagement in aquaculture science is likely lead to inclusion of aquaculture activities as part of ecosystem overviews that will also require economic inputs.

WGECON was established in 2018, and tasked with the four following terms of reference (ToRs):

a) To map the current work and identify future needs for economic science in ICES, giving consideration to useful connections to international marine/ fisheries economics organisations such as the International Institute for Fisheries Economics and Trade (IIFET), the North American Association for Fisheries Economics (NAAFE) and the European Association of Fisheries Economists (EAFE);
b) To identify and report on economic data gaps that point to priorities for longer-term data collection, research, institutional needs, and researcher training in all ICES member countries; and where possible propose systems to collect missing data;
c) To define and report on the information flow needed to provide economic analysis of trade-offs relating to ecosystem-based management of fishing;
d) To assess and report on the economic significance of commercial fishing for selected coastal regions in the ICES area.

Given the novelty of the group and of these topics within ICES, as well as the breadth of these terms of reference, the group initiated its work with a scoping discussion focused especially on ToRs a) and b), with the aim to define these in more detail and identify achievable objectives

over the three years. The group also identified a work plan, which would help progress towards achieving these objectives.

This scoping discussion was initiated by reviewing the background for establishing the Working Group (WG), its overall aims and the expertise it brought together to address these. This involved reviewing working group members' background and relevant experience, perspectives and expected contributions to the different ToRs. The plenary discussion also focused on capacity for involvement in intersessional work. Sub-groups were also identified to further address the ToRs.

Initial scoping

The initial scoping discussion allowed the WG to agree on the following points:

1. Broadly speaking, economic science as applied to marine systems can provide insights regarding: (i) the ways in which maritime activities develop, evolve and respond to ecological, economic and institutional changes, given individual and collective decision-making processes; (ii) the assessment of economic trade-offs for society associated to alternative states of these systems; and (iii) the development of integrated ecological-economic scenario analyses in particular regarding alternative management options.
2. WGECON members agreed on the importance of integrating economics in ICES science generally, but highlighted the importance of identifying the specific problems that can be addressed, as this leads to more concrete discussions on the applied contributions of economic research. Given that marine resource economics is largely focused on issues relating to the management of activities harvesting these resources, the discipline finds itself largely engaged in the analysis of maritime policies and their implementation and thus end up producing information that may be directly relevant for management advice.
3. Beyond reviewing the actual and potential contribution of economic research to different management issues, the group suggested selecting specific problems that would motivate economic analysis, and that could be used as demonstrators of the ways in which such analysis could be carried out. Such demonstrators can also serve as a guide to the issues that need to be addressed with respect to methods, tools and data needs.
4. While the integration of economic information and analyses in advice is not explicitly mentioned in the description of the group's ToRs, it was specifically referred to in the background provided to ToRs b), c) and d). Hence while the primary focus of the group was on the actual and potential contributions of economic research to ICES science, the group also considered how this might also contribute to management advice.
5. The geographical scope of the WG potentially spans across the entire ICES area, so includes a diversity of contexts for the generation and use of economic information and analyses, including but not limited to the EU. The group recognized the value of maintaining this diversity in its work. Experience from other regions of the world, such as Australia, could also be considered, when relevant and feasible.
6. The questions addressed by the WG also potentially span across a wide range of maritime activities and ecosystem services. The group however considered that its primary focus should be on commercial marine fisheries, while also acknowledging the direct and indirect interactions between these and other sectors. From a methodological perspective, links can also be established with other working groups focusing on other sectors, in particular aquaculture.
7. The focus of the group is clearly on economic research, methods, tools and data. But the questions relating to integration with the other disciplines, in informing on

the status of marine socio-ecological systems, should also be considered. This is for example the case with respect to integrated ecosystem assessments, or with the development of integrated bio-economic models. Such analyses must consider trade-offs between biological sustainability indicators and economic (and social) outcomes.

Based on this initial scoping discussion, the WG agreed to the following approach to address its ToRs:

- Work from identified problems and the associated needs identified in management or policy and driving research, to map current work and identify future needs, as well as current data resources and gaps, needs for additional data collection, as well as institutional development and training needs;
- Provide a clear description of the economic perspective on trade-off analysis;
- Identify and start developing demonstrators illustrating the contribution that can be made to the ICES science and advice;
- Identify and strengthen the links with key networks in marine resource economics.

This approach led to the following work being undertaken in the course of the group's three annual meetings. First, the WG agreed to a list of 11 key management issues with economic implications that are relevant to ICES, and reviewed current work and future needs in relation to these key issues. This review was undertaken by the entire WG, using a combination of moderators, sub-group work and plenary discussions, in session and intersessionally, including an internal peer review and commenting process organized by the co-chairs. Second, in order to gain insights beyond membership of the group, a survey of the profession was carried out, based on the list of issues identified by the WG. Third, the group also discussed the nature of trade-off analyses which could be carried out in relation to the selected issues relevant to ICES, and developed a description of the accepted economic approach to this type of analysis. Fourth, the WG identified two types of case studies that could be used as demonstrators, with the aim to identify the methods, data, tools and information flow needed to apply such evaluations on a standardized and continuous basis. These case studies included: (i) evaluation of the implementation of a fisheries-management policy relating to one of the key issues identified in the review; and (ii) expansion of Integrated Ecosystem Assessments to include economic dimensions.

This report presents the main results of this work. Section 2 presents the results of the review of the 11 key management issues with respect to current research and future needs, including data availability and data gaps, as well as institutional and training needs. Section 3 presents the standard framework for trade-off analysis. Section 4 presents the initial steps taken to develop demonstrators of economic analyses using case studies.

Given the WG's acknowledgement of the importance of integrating across disciplines to successfully address the issues relating to the status of marine socio-ecological systems, the group endeavoured to establish links with other ICES working groups and initiatives. In particular, discussions were regularly held with the Working Group on Social Indicators (WGSOCIAL), a WG established at the same time as WGECON, with very similar terms of reference relating to social dimensions. This led to the organisation of a joint meeting in the third year of the two groups, where joint work on defining trade-off analyses, and approaching the two types of case studies, was initiated. Section 5 describes this, and the other collaboration and outreach activities undertaken by the group in the first three years of its existence.

Finally, section 6 presents suggested areas for future work, which were developed into a new set of terms of reference for WGECON, for the period 2021–2023.

2 Review of current research and key future developments

2.1 Introduction

In recent years, ICES has actively sought to expand the scope of its scientific expertise to incorporate contributions from the social sciences. According to its recently adopted Strategic Plan[1], the vision of ICES is "to be a world-leading marine science organization, meeting societal needs for impartial evidence on the state and sustainable use of our seas and oceans" (page 4). Based on this vision, ICES defines its mission as advancing and sharing scientific understanding of marine ecosystems and the services they provide, and using this knowledge to generate state-of-the-art advice for meeting conservation, management, and sustainability goals.

This has led ICES to broaden its scientific priorities. Indeed these now include: the understanding of the effects of human activities on ecosystems and ecosystem services "to elucidate present and future states of natural and social systems"; generating evidence and advice "to help sustain safe and sufficient seafood supplies"; developing tools, knowledge, and evidence "to provide more and better options to help managers set and meet objectives"; and last but not least, "evaluating contributions of the sea to livelihoods, cultural identities, and recreation" in support of policy and management (ICES 2019 Strategic Plan, p18-19).

These are strong directions towards integration of social sciences (broadly speaking) in the science-base of ICES, and a move from the conventional information basis provided by ICES to support policy decisions, still largely centred on biological / ecological information, towards more explicit integration of social and economic trade-offs associated with policy development and management choices. This shift to a marine socio-ecological system perspective (Link *et al.* 2017) has led to new initiatives within ICES, including the Strategic Initiative on Human Dimensions (SIHD), and the initiation of new working groups, including the Working Group on Economics (WGECON) focused on progressing the integration of economics into marine science and advice, established in 2018. As its initial focus, the group reviewed the current work and key future needs relating to economic research on marine capture fisheries within ICES.

Here, we present the results of this review, and address the question of how contributions from economic research can be incorporated in the science of ICES, eventually contributing to informing policy development and management decision-making for sustainable uses of the ocean. Indeed, given its strong emphasis the analysis of maritime policies and their implementation, fisheries economics research provides information of direct relevance to management decision-support. Examining a selection of key issues of current relevance to fisheries science and policy, we show that by providing improved understanding of the ways in which fisheries develop, evolve and respond to change, as well as of the trade-offs associated with alternative scenarios and management strategies, economic analyses and their integration in multi-disciplinary approaches can play an important role in the strategy of ICES.

[1] https://doi.org/10.17895/ices.pub.5470

2.2 Methodology

We identified eleven key contemporaneous fishery management issues on which economic research has developed in recent years, and on which a review of current and future research priorities can be carried out, classifying these into two broad categories relating to (i) standard fisheries economic research questions, and (ii) wider maritime issues. The issues identified were:

Standard fisheries economics issues

1. TAC setting in output-based management systems
2. Adjustment of capacity to resource potential
3. Fishing rights allocation
4. Mixed species fisheries management
5. Links between catch sector and markets for fish
6. Sustainability of Small scale fleets (SSF)
7. Data limited situations (fleets, fish stocks)
8. Diversification & commercial fishing-aquaculture connections

Wider marine and maritime economics issues

9. Shared stocks management
10. Evaluation of ecosystem services
11. Area-based and spatial management

For each issue, we considered:

- The research currently conducted and advice currently provided as part of ICES work and outside ICES. The review considered:
  - Dimensions and questions that economists can document;
  - Evaluation methods and tools available;
  - Data available and indicators used;
- Key future needs for research and integration into ICES science:
  - Dimensions and questions that could be documented;
  - Evaluation methods and tools that should be developed;
  - Data and indicators that need to be made available;
  - Information flow required to do so.

The information was compiled in bullet-point format based on the WG members' expert knowledge, complemented by a survey of the fisheries economists profession which was carried out in collaboration with the EAFE in 2019 and to which members of the NAAFE were also invited to respond, and on the literature in bullet point format. Based on the bullet point lists, subgroups consisting of typically 2 moderators and 2 reviewers for each issue (see Annex 3) developed summary sheets for each issue. As indicated, the summary sheets (and reports used as basis for those) produced by the moderators were systematically peer-reviewed internally by WGECON members, leading to revised versions of the summary sheets.

2.3 Results

This section provides a compilation of the summary sheets produced based on this review for each of the 11 key issues identified.

2.3.1 TAC setting in output-based management systems

Total allowable catches (TAC) is one of the main fisheries management instruments in the ICES area. They are fundamental to output-based management systems, including under frameworks such as the EU landing obligation. As a consequence, there is a lot of research and advice regarding the economic impacts of implemented measures. Those impacts cover especially the economic performances of the fishing fleets, distributional effects of TAC management (among fishing fleets, Member States…) or changes in economic indicators and dependency of the fleets on certain fish stocks/TAC. It also concerns assessment of the use of fishing possibilities existing under TAC regulation and the Landing Obligation (in terms of TAC utilisation and incentives to discard/to highgrade) and evaluation of the rent created under existing Maximum Sustainable Yield (MSY) approach in management compared to alternative based on Maximum Economic Yield (MEY) (i.e. measure of efficiency of management).

In the EU, the advisory work is split between ICES and Scientific Technical Economic Committee for Fisheries (STECF) with ICES especially looking at biological impacts and to a limited extent impacts on the fleets (e.g. mixed fisheries advice) while STECF especially requested to address the social and economic impacts of long-term management plans.

External research to ICES: For the assessment of the impacts, the economic data collected under the EU Data Collection Framework (DCF) is essential. Those data is used in specific bio-economic models developed in most cases within large European Research Projects (e.g. VECTORS, CERES, SOCIOEC) for certain fisheries, areas and management measures.

Within the European Union the Data Collection Framework provides funds to Member States to collect biological, economic and social data (JRC/STECF databases for economic, Fisheries Dependent Information (FDI), social and dependency data) for the assessment of Common Fisheries Policy (CFP). Other European institutions databases can also be used (FIDES, EUROSTAT, etc.). NOAA is collecting data in the US.

Future integration into ICES: Within the ICES framework there is a specific need to address the socio-economic effects of TAC settings including the analysis of trade-offs between different TACs and alternative options to adjust to TAC constraints (including possible adjustments of fishing strategies and capacities at producer levels, at producer organization levels or at Member States levels). Such an impact assessment could also address effects on markets (e.g. price development) and uncertainties in the management system (e.g. precautionary buffer). Fleets typically operate in a mixed fisheries environment catching several species together, however the economic analysis of single species TACs taking into account issues of top-ups and compliance are critical to understanding the impact of TACs on fleets and stocks. Further, the optimisation of mixed fisheries systems can provide a longer term view that is essential to understanding the short term costs of specific single species TAC reductions against longer term benefits.

2.3.2 Adjustment of capacity to resource potential

Knowing the level of catching capacity in a specific fishery (or country) and how this relates to the resources they target (current and potential levels) are fundamental pieces of information for management. In addition, managers need a clear understanding of the appropriate policy tools for adjusting capacity, how they can be effectively implemented, and the multiple (long- and short-term) trade-offs and risks associated with alternative choices (welfare implications, spillover or reentry of effort). Combined, this information provides fishery managers with the knowledge required to make well-informed strategic decisions for improving fishery conditions (welfare, sustainability etc.) and meeting management objectives.

Internal research in ICES: At present, ICES routinely undertakes stock specific assessments to determine reference points and advise on the levels of fishing mortality appropriate for achieving long term management targets, such as MSY. Capacity in the fleets associated with these stocks and how that might best be adjusted to achieve these management targets is currently not incorporated in either the assessment process or the advice ICES provides.

External research to ICES: Fleet capacity related research has long been undertaken both within the ICES area and more broadly. In addition to defining the concept of capacity, questions economists have been working on, and can contribute to a better understanding of, predominantly fall into the areas of: assessing capacity in relation to the resource, methods for adjusting capacity (to match the resource), and identifying and incorporating the implications of factors (e.g. policies) that may be influencing capacity.

Most work has been focused on the assessment of fishing capacity (static or dynamic); (e.g. Pascoe *et al.* 2003; Pascoe and Gréboval 2003) and how that compares with associated fishing opportunities (e.g. of national fleets in EU Member States, see STECF national evaluations of balance). Capacity adjustment, through regulatory or market-based approaches to achieve management objectives (e.g. MSY, MEY) is another area where substantial work has been undertaken. This includes the implementation of Individual Transferable Quota (ITQ) or other transferable fishing rights systems along with their potential benefits and limitations (e.g. Yandle and Dewees 2008; Brinson and Thunberg 2016; Pascoe *et al.* 2019), an area covered in greater detail in issue 3, and the design of buyback programmes (e.g. Campbell 1989; Holland *et al.* 1999, 2017; OECD 2009, Blomquist and Waldo, 2018). Factors influencing capacity, as observed in capital (including rights) dynamics / ownership, entry / exit dynamics of fishing capacity, technical progress in fisheries (e.g. Palomares and Pauly 2019), have also been extensively considered. This includes research into the specific implications of governmental support policies to the fishing sector (including subsidies) on capacity, fish stocks and fisher welfare (e.g. Clarke *et al.* 2005; World Bank Sunken Billions; OECD FishPEM), where data limitations remain an issue.

A range of established methodological approaches exist and include the EU oriented balance indicator guidelines (STECF), mathematical programming (data envelopment analysis for capacity and utilisation) and statistical approaches (stochastic production frontiers for capacity and utilisation, regressions for fishing power, random utility maximization (RUM) models for entry / exit). Bio-economic modelling (e.g. Fishrent, FLBEIA, FishPEM) and approaches such as co-viability analyses (e.g. Gourguet *et al.* 2013) have also been widely applied to the topic of capacity. There is also a growing body of work detailing and retrospectively analysing experiences and lessons learnt from policies aimed at reducing capacity (e.g. entry / exit scheme analysis) and advising on evidence-based policy approaches for achieving sustainable fisheries (e.g. OECD 2000a, 2000b, 2006; 2007).

Future integration into ICES: Having clearly-stated long-term objectives that include the optimal fleet capacity are a necessary, if not essential, requirement for setting management measures to achieve sustainable fisheries in the long-term. While this is evidently a national issue, for example in the EU the CFP aims to make fisheries environmentally, economically and socially sustainable, there is a clear role for ICES to carry out analysis with a commonly developed approach/methodology and provide guidelines to inform and support managing authorities.

Aspects of this could include looking at balance indicators in the EU, these have been the same for a long time and it would be advisable to evaluate whether they are still fit for future purpose in EU and other ICES member states. Current short-term assessment should be complemented with long-term analysis to set the long-term objectives for fleet structure, this would presently be the most applicable to EU Member States but could and should be extended to include an assessment of balance in all ICES countries fleets, over both the short- and long- term.

Further advice could be provided through overviews of how capacity is influenced in each country (e.g. through subsidies, Gross tonnage caps/limits, market measures, or other factors), comparisons of national action plans for fleet capacity adjustments (in relation to fishing rights systems), the provision of viable strategies for inducing and facilitating the adoption of individual property rights (for countries with an interest), and co-viability (balancing long- term objectives) assessments of alternative capacity adjustment approaches. Last, a clear potential role exists in determining how to deal with and effectively communicate uncertainty and stochasticity in assessments and advice, as adequate approaches for clearly distinguishing between epistemic and natural uncertainty are lacking at present.

2.3.3 Fishing rights allocation

Fishing rights, in particular quota, allocation is a key foundation of many fisheries and their management in ICES member countries. In many ways it represents the interplay between traditional ICES biological advice, centred on identifying target and limit fishing mortality levels, and the policy practicalities of how management bodies actually implement that advice. This interplay runs both ways, with biological advice affecting the TAC to be allocated, with ensuing social and economic implications at multiple scales, while the ways in which fishing rights are allocated and used also has feedback loops to the science. Economics can play a key role in helping understand this interplay, especially in relation to the political economy of converting science advice into fishing opportunities.

Internal research in ICES: Currently, questions relating to the allocation of quota or fishing rights are not included in the research undertaken by ICES or the advice it produces.

External research to ICES: However, currently strong scientific expertise exists and an active research effort is being undertaken in ICES countries on the economic analysis of this issue, including by research groups and organizations that are also strongly involved in ICES (e.g. Ifremer, individual Fishery Administrations or responsible bodies). Examples include: research by NOAA on best practice allocation of quota and what to consider; the SECFISH project on valuation of fishing rights; the SIMFISH model on the effects of quota trading; Shotton (2001) looking at fishing right allocation case studies; Pascoe *et al.* (2019) on an evaluation of rights allocation in Australia; and, OECD (2006) presenting the case for market mechanisms in rights allocation.

In particular, there has been a growing number of studies that specifically investigate the differences between individual (tradeable/non-tradeable) and collective (quota pools, cooperatives, etc.) allocation mechanisms. The core questions considered in these analyses relate to the description of how quota is currently allocated, and the analysis of impacts that changes could have on overall economic efficiency (e.g. evaluation of potential rents under alternative scenarios using bio-economic modeling), social impacts and distributional aspects, including issues relating to rent capture.

With the improved data sets now available – such as individual quota holdings databases, applications of economic theory aim to quantify existing rents and how they have or could be captured by different parties to the fisheries is feasible. There is some information on the trade value of quotas, but data required to estimate rents associated with fishing rights are now fairly widely available.

Future integration into ICES: Involving ICES in the coordination of research efforts across ICES countries to improve our understanding of this core issue for the development of fisheries according to various management and sustainability objectives would seem particularly relevant. While it seems unlikely that ICES would be directly consulted for advice on allocation questions, this coordinated research effort would be able to provide independent guidelines on how these

questions can be addressed, that could be made available to a broad range of stakeholders within ICES countries. These guidelines could include: (i) structured approaches to the key economic questions to consider; (ii) empirically tested methodologies and tools, and (iii) key data sets and indicators required for the analyses of alternative designs of the allocation of fishing possibilities. Applications of such analyses could also inform the ecosystem and/or fisheries overviews while a review of national administrative databases holding either quota, fishing rights, swaps, or actual fishing activity data to help build up an evidence base of how rights are distributed could also be undertaken.

An example of the type of information that WGECON could provide can be seen by the ToR D case study on Rights Based Management in section 4.2. This involves a review of the catch share experience in North America, with specific reference to what is being monitored and measured, and initial lessons learnt. It is envisioned that this case study will broaden and deepen in scope in future in order to bring out transferable lessons for application in other contexts and locations.

Finally, it should be noted that undertaking further research within an ICES setting on this issue, and developing advisory products, likely falls under several ICES WG's, including WGECON, WGHIST, WGMARS (Working Group on Maritime Systems), and WGSOCIAL, as well as the Integrated Ecosystem Assessment (IEA) groups. Building links with these other groups will be crucial to adequately address this issue.

2.3.4 Mixed species fisheries management

Mixed fisheries issues result from technical interactions and fishing behaviors driven by economic incentives. Integrating economic information, evaluation and considerations in the ICES mixed fisheries advice is therefore a major issue to account for ecological, social and economic trade-offs existing when managing mixed fisheries and to identify potential room of maneuver when setting TACs and trying to reconcile fishing possibilities.

Three kinds of approaches can contribute to economic analyses of mixed fisheries issues: (i) the assessment of the economic consequences of current management options and policies to highlight trade-offs on both the short and long-term, (ii) the design of economically informed mixed fishery policies, comparing it with more standard/current management options and (iii) the identification of viable solutions satisfying a set of ecological, social and economic constraints.

Data and robust methods/models are locally available and implemented to conduct all three types of evaluations. However, further development, standardization and application of the evaluation methods/tools are still necessary to support mixed fisheries management advice. Data is a fundamental issue. Work is still required on standardization of data sampling design, protocols, sources and compatibility for both transversal and economic data, dimensions (units) such as fleet/fishery/vessel units, spatial/ temporal/selectivity resolution, and robust parameters, indicators and certainty levels. Furthermore, more research is needed to capture economic driven fisheries behavior in choices of gear, effort levels, allocation of effort between areas and seasons, discarding, as well as fleet/fishery/vessel adaptations and efficiency changes, to meet the challenges of mixed fisheries management options according to the three pillars of sustainability.

The use of economic methods would allow for the study of critical issues in mixed fisheries:

1. Evaluate the effects of different management options according to biological sustainability indicators such as single stock MSY targets and associated ranges, multi-species MSY, economic sustainability indicators such as single- and multi-fleet MEY and/or economic and social sustainability in terms of, e.g. revenue, profit/gross value-added and/or employment. Also, the evaluation could consider

scenarios including the current management principles according to the Precautionary Approach (PA) and single stock MSY quota settings and other management options addressing, for example, changes to the EU CFP Relative Stability distributing quotas among countries.

2. Evaluate the consequences and inform the design of TAC quota policies. TAC quota distribution and allocation is a very important factor determining the mixed fisheries behavior, targeting and the fishery adaptations. Thus, it is necessary to obtain adequate information and study the economics behind the dynamics in this allocation and distribution (including risk pools/quota swaps/trading). This is to evaluate the consequences of management options according to available fishing possibilities and distributional effects given management and available fishing capacity. This is both on national, regional, harbor, fleet, fishery, producer organization/company and vessel level. Some information and models on this are already available, but, again, more standardized information and methods/models for tracking and evaluating these dynamics according to different management options is needed. In general, it should be emphasized that in a mixed fisheries context, information on an individual vessel basis is preferable in all contexts as it is possible from this level to make any other aggregation and categorization needed. This data is however, seldom available for confidentiality reasons.
3. Evaluate the effects resulting from mixed catch composition. Technical interactions in mixed fisheries relate to the fact that several fleets and fisheries are exploiting the same stock, and at the same time are exploiting different other stocks. The importance of the interactions can be measured through the economic dependency of a fleet to a stock and through the fishing mortality a fleet contributes to a given stock. Current stock-fleet segment interactions have already been identified, but more standardized data and information on vessel basis is needed.

A row of robust methods and models integrating biological and economic information is available. However, these needs to be further developed to further support mixed fisheries management advice, including a diversity of approved integrated models designed for scenario simulation and multi-criteria assessment, for optimization or co-viability approach. Ex-post evaluation of management measures need to be further implemented to complement ex-ante approaches by highlighting the observed behaviors and strategies adopted in e.g. choke effects contexts and their economic consequences. This should for example elaborate on scenario evaluation of long term management plans across stocks, setting multi-year TACs for individual stocks and allowing industry to distribute quota across years, elasticities of output substitution such as catches composition and price effects, and evaluating costs associated with mixed catch handling under alternative regulatory obligations (such as the Landing Obligation in the EU) and observed responses to changes in these obligations.

2.3.5 Links between catch sector and markets for fish

Internal research in ICES: At this time, it looks like there is no research conducted on this topic by ICES.

External research to ICES: Relevant approaches & science are currently practiced external to ICES and mostly consists in description of market of fishery products and supply chains. In some countries (e.g. US) effect of commercial fishing management systems on welfare and wider economy are investigated (Costello, C., *et al.* 2019). In the last twenty years and regarding the failures of traditional fisheries management systems, studies started to look at the effect of eco-labelling and fisheries certification on production systems and/or fishers' behaviour (Roheim, C. A., *et al.* 2018; Gutierrez, N. L., *et al.* 2016) and lean on seafood consumer behaviour, trying to understand

its expectations and preferences or assess its willingness to pay for "eco-friendly" seafood (Zander, K. and Y. Feucht 2017, Ankamah-Yeboah, I. *et al.* 2020).

Methods and tools used for these current analyses are proven and refer to impact analysis, input/output analysis for measuring management effects on wider economy. For fish market and demand, traditional quantitative tools like supply/demand curve estimation, inverse demand models, co-integration as well as hedonic price models are used. Qualitative tools like focus groups are also often used for consumer perception analysis. Data and parameters easily available for fish market studies (e.g. DCF, EUMOFA) are first sales (ex-vessel) data (at least at EU level) but often not enough detailed for a large range of market analysis (missing a lot of fish attributes). Value chain analysis are generally based on national data but their consistency and coverage at international level are still in progress (see for EU, STECF EWG on Processing Industry). Generally speaking, it is still difficult to relate effects of management measures on markets. Regarding consumer and demand analysis, it requires implementation of ad hoc data collection at national level with the risk of non-consistencies between studies and most of all, their disappearance and outdating.

Key future needs for research and integration into ICES science: Fishing activity is not only catching fish but also selling it, process it, create additional value on a territory and/or along a supply chain, and at the latest, generate welfare and wealth in the society. Managing fisheries/ecosystems needs to keep in mind this broad picture (so called the blue economy) as it could have an impact on or could be influenced by. Research on implications of different fisheries management options on value chain structure as well as understanding wider market issues and forces must continue. Some ICES countries currently put a monetary value on advice and agreed quotas once announced, a process that WGECON could advise on as well by highlighting price effects, supply chain tipping points, and their feedback loops with fish mortality that could benefit both member countries and ICES when considering the impact of their advice. Consumer behaviour and effects of ecolabelling is still an open research question for fishery science as there is a need to look at all externalities that it could generate (overfishing for instance). Above all, because management could be a driving force for fish prices or market outlets, this linkage should be better documented by fishery science and consider when defining management scenarios. Micro-economists and marketing experts could also be helpful in joining fishery science.

No more specific methods or tools as those described above are suggested but a strong need among researchers and experts from several groups (ICES, STECF, NOAA…) to share their methods and experiences. Regarding the data collected for market and demand analysis, which is the very important point, they have to meet several objectives and purposes which are often far removed from those of fisheries science. Our suggestion for ICES future research is to focus on the linkage between ecosystem/fisheries management and markets/value chain and, via a strong interaction with DCF, FAO, EUROSTAT experts, design a format of data demand (ex-vessel, processing…) which allows this kind of analysis.

2.3.6 Sustainability of small scale fleets

Currently, few research or advice with regards to Small Scale Fleets (SSF) are conducted and mostly external to the ICES context. In the past, this fleet segment was considered as economically and ecologically not relevant, therefore data is often not available or very limited (see also issue 7: data-limited stock). Lately, with growing research on the economic and ecological impacts of the SSF, the quantity and quality of available data is improving. Besides standardized data collections on national and international level, surveys, focus group interviews or innovative/experimental methods are applied to complement existing data. This is often done in the context of local coastal dependency on fisheries and their adaptation to changing markets, environments and institution/management approach (see also WGSOCIAL), assessing the efficiency

of public funding (e.g. European Maritime and Fisheries Fund) as well as evaluating the cultural ecosystem services (i.e. heritage, tradition) provided by SSF to the coastal region (e.g. Interreg project Cabfishman). SSF tend to harvest in areas also in high demand for other sectors (e.g. recreational activities, aquaculture, renewable energy) which often leads to spatial conflicts. Additionally, some of the fish stocks exploited by SSF are also in high demand by the recreational sector. Driven by these conflicts and the resulting need for management (e.g. marine spatial planning, management evaluations, and/or quota allocation), there is on-going discussion on the definition of SSF, in particular compared to recreational fisheries (see also issue 8: diversification).

Key future needs for research (and integration into ICES science): To be able to assess the ecological impact and the economic importance (including cultural values) of the SSF, a harmonization of the definition for SSF would be helpful. While this definition would optimally allow for a variety of potential research questions (Smith, H. and X. Basurto, 2019), it needs to consider that it might be subject to be used for special financial considerations (e.g. European Maritime and Fisheries Fund) and should help to distinguish between recreational and SSF.

Establishing a commonly accepted definition on SSF would allow to support fisheries management (e.g. quota allocation) more efficiently, for example, with regards to trade-off analysis on large scale fleets, small scale fleets and/or recreational fishing sharing the same stocks (see also issue 3: Rights allocation), but also trade-off on SSF ecosystem services. It would further allow to study the structure and economic behaviour of the SSF and therewith to assess the economic impact of fisheries management on the SSF, and their potential adaptation. Having a better understanding of the structure of the SSF, their income dependency on fishing and their interactions with other sources of income would allow to a more comprehensive assessment on the economic impact of fisheries management on the respective coastal community (see also WGSOCIAL).

Studying the synergies/competition within the supply chain of SSF and large-scale fishing would allow further to link fisheries management to markets and welfare effects (see also issue 5: linking catch sector with markets) and therewith allow a holistic assessment of fisheries management.

Currently existing tools to provide the assessment of fisheries management with regards to SSF need to be further developed as well as data gaps closed. These gaps were identified in the ICES WGECON 2018 report section describing EU data. In particular, the accuracy of data collected by national and international data collection programs needs to be improved to reflect the distribution of activities within fishing community (skipper-owner, crew, etc.), ownership of fishing rights and quota trade (see Issue 3 – Rights allocation), income from fishing and other businesses (see Issue 8 : diversification). A higher resolution on spatial data regarding SSF is needed to allow also more robust spatial planning through the economic assessment of the SSF fishing grounds.

2.3.7 Data Limited Situations (fleets, fish stocks)

Currently, ICES conducts assessment and management advice for many Data Limited Stocks (DLS) according to the Precautionary Approach (PA) and the MSY management indicators and reference levels. This is done under a range of ICES assessment working groups and also involves development of new assessment methods, e.g. under ICES WKLIFE (Workshop on the development of quantitative assessment methodologies for stocks categorized as data-limited). Evaluation of harvest rules and methodology behind those, with regards to DLS is also conducted by ICES for a very high number of data poor stock assessments.

Economic evaluation and optimization of quota use according to DLS should be addressed following the MSY approach, and other policies such as the EU CFP Relative Stability. Under this baseline framework policy important issues in ICES management advice need to be addressed

from a socio-economic perspective. This is especially important with respect to economic impact assessment of data poor choke species management options. It is especially relevant for certain fleets that might be highly constrained by those choke species which will highly impact the economic performance indicators of the fishery.

Data poor situations are also emerging, for instance in a context of development by the EU Member States the Marine Strategy Framework Directive (MSFD) and Maritime Spatial Planning (MSP), due to the lack of spatial and temporal resolution and disaggregation in data. SSF is a key example of this with growing interest to be included in ICES advice. In some data poor systems there may be lack of basic data on stocks but there may be some economic information available (for example, key business indicators as revenues, added values or profits) useful to provide advice using the economic importance (spatial and temporal) in management context. In a similar way, some employment dimensions as socio-demographic data can be considered specially for small scale and recreational fisheries.

In relation to management advice, the economic perspective will have policy relevance and consequences given that the money is the common denominator for evaluating importance of different management related to choke species, or to the uses of the marine space across marine sectors. Small scale and recreational fisheries may in several cases have significant economic importance.

For example, the Bayesian approaches utilizes probability distributions which describe the quality of the knowledge, and the data poor stocks have simply wider probability distributions for the parameters than the well-known stocks. A Robin Hood approach can show how the parameters of a data rich stock can be used to improve the knowledge for poor data stocks. Key policy relevance in current management advice is also the data poor situations evolving from Illegal, Unreported and Unregulated (IUU) fishing (OCDE).

It is crucial to set harvest control rules for data-poor stocks that takes account of economic and social aspects. Trade-offs are to be considered when assessing the data poor situations (i.e. choke species) including the economic and social performance. Also, consideration of illegal fishing (IUU) levels and fines, values of detected illegal fishing, and estimates of undetected illegal fishing are needed according to economic impact assessment. In data poor contexts, the fraction of the revenue of fleets which is derived from species/stocks that are data poor is quite large. In addition, some of the species may become core species for the fleets, if circumstances change their relative economic attractiveness. It seems unrealistic to expect that the data rich approach of developing full-blown population dynamics models for these numerous species can be done in all cases. So, there is a need to invest new approaches that can both capture the total economic activity of the fleets, and link this to some understanding of the biological status of the stocks from which the landings are taken.

In many fisheries' management cases, there is a need for management decision under all circumstances, without waiting for improved knowledge. In such cases, the best available knowledge must be collected with suitable methods. For example, in Bayesian decision analysis, a utility function and optimization techniques are used to rank decision options under uncertainty. It offers the possibility to carry out value-of-information analysis, which identifies which parameters/variables have a capacity to re-rank the decision options. Those variables which can do this are important to be estimated more precisely in a data poor case where there are no economic possibilities to study all parameters. Sensitivity analysis does not do this. In all data limited fisheries analyses, a good practice would be to carry out, as a first step, meta-analysis, i.e. integrate the knowledge from existing papers and such data sets, which are somehow related and have a capacity to decrease uncertainty according to raising from limited data. This knowledge can be used as a prior in Bayesian data analysis, leading to learning chains in science, between the analysis.

2.3.8 Diversification and commercial fishing-aquaculture connections

Diversification and fisheries management: One of the fundamental features of diversification for companies is the reduction of risk. This is a well-established research field in economics that applies to fisheries as it does to other sectors of the economy (Kaspersky and Holland, 2013). In fisheries, diversification can take several forms; one is diversification from fisheries to other sectors in the economy, which reduces the fishers' risk exposure to general changes in fishing opportunities and market conditions. This is especially important in regions where fisheries are constrained to few species or few alternative fishing practices. Fishers that have diversified to other sectors are expected to be less economically vulnerable for reduced fishing opportunities. It is also possible for fishers to diversify *within* fisheries. This could take the form of using multiple gears, fish for multiple species, or fish in multiple areas. Fishers that are diversified within fisheries are less vulnerable to management measures affecting one of their activities since they can redistribute fishing effort to other fisheries. Redistributing effort might on the other hand cause biological effects that was not intended by the managing authorities. Such dynamic effects of management is a topic for bio-economic modelling.

Key future needs for research and integration into ICES science: While many bio-economic analyses focus on specific eco-systems, economics can also contribute to analyses where companies are diversified to fish in multiple eco-systems. Diversification to sectors outside fisheries are less well integrated in bio-economic models, although example exists of models with multiple sectors and/or fish value chains (Nielsen *et al.* 2018). Analyzing effects outside the fishing sector will need the addition of new data such as employment in other sectors (STECF report on the EU fish-processing sector; national labor market statistics). However, data already available at the ICES such as catch compositions of existing fleets, which shows within fisheries diversification, will contribute to the analysis. The fleets that are most affected by e.g. a fishing moratorium might not be the ones with highest catches of the species. The economic effect will depend on the impact on the species managed, alternative fishing opportunities, and alternative employment opportunities (Hammarlund *et al.*, 2018). Within the ICES framework, both bio-economic models and descriptive data on fishers' diversification would contribute to the knowledge of how fisheries and fishing communities are affected by management measures.

Commercial fishing-aquaculture connections: There is currently an ICES working group on Social and Economic Dimensions of Aquaculture (WGSEDA), also under the SIHD, but no working group analyses specifically the interactions between fisheries and aquaculture.

Fisheries and aquaculture have a wide array of interactions beyond the usual biological interactions of e.g. genetic, restocking and disease, which are currently tackled by ICES biological working groups (e.g. Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM)). Economists can identify interactions throughout the value chain and beyond, and WGECON can contribute by structuring interaction of the two sectors based on their production systems, geographic location and socio economic interaction. Examples of these are, starting from the beginning of the production process, where fishing and aquaculture compete for space, which occurs in the EU and North America among others, and is sometimes dealt with through marine spatial planning (Outeiro *et al.* 2020, Lester *et al.* 2018). Regarding raw materials fishing activity is also used to provide aquaculture with feed, seed, fry or fingerlings, for example for mussels (Kamermans and Capelle 2019) and European Eel. Larger fish are caught for capture-based aquaculture (CBA), for example tuna and cod (Sønvisen Standalb 2019). Aquaculture and fisheries can be alternative sources of employment for the same coastal communities. Importantly, market interactions between wild and farmed species require further research since they can influence fish prices and, consequently, fishers and farmers incentives and strategies.

At a broader level, fisheries firms can learn from the efficiency gains in the aquaculture sectors, regarding product forms and markets. Finally, aquaculture and Fisheries could also be complementary sources of food for world population. In the context of SGDs, ICES could participate in the elaboration of scenarios for fisheries and aquaculture to achieve the most obvious SDG 14 (Ocean) but also SGD 12 (Sustainable consumption and production) and SGD 3 (Good health) as seafood is a major source of valuable nutriments for people.

The study of these interactions would require geographically disaggregated economic data on fisheries and aquaculture (e.g. the Annual Economic Report or the Economic Report of the EU Aquaculture sector, though only at country and year level) as well as geographically disaggregated social data on employment in both sectors. Methodologically, an assessment of the competition and effects within the value chain as a whole (for single species or in a broader context) integrating socioeconomic, environmental managerial issues and effects has been identified as a possible way forward.

There is work ahead of cooperation between WGECON and WGSEDA to incorporate these interactions that affect EBM and should be taken into account for the production of ICES advice.

2.3.9 Shared stocks management

Managing the exploitation of shared fish stocks to ensure biological sustainability as well as utilisation in a way that provides greatest societal benefit, remains a significant and in many cases elusive challenge. Determining and advising on the biologically appropriate total level of catch (i.e. TAC) for a shared stock generally requires much the same information and methods of assessment as stocks that are not shared. However, economic analysis can play a key role in identifying and assessing the factors influencing how a TAC is ultimately set and distributed, the outcomes of this allocation in terms of actual fishing mortality and associated economic and social impacts, and possible alternative scenarios (Bailey *et al.* 2013; Lazkano *et al.*, 2012). Country level factors, including strategic and political aspects, as well as industry level factors mean mismatches can occur, resulting in significant differences in incentives for cooperation and uptake of management decisions in the fisheries, potentially reducing the stability of any agreements. These are issues that have become further complicated and strained by the geographical boundaries of some shared stocks moving over time, due e.g. to climate-related change in ecosystems (Hannesson, 2013; Bjorndal *et al.*, 2004; Kaiser *et al.* 2018).

At present, ICES routinely undertakes assessments to determine reference points and advise on the setting of TACs for shared stocks from the biological perspective (e.g. NE Atlantic mackerel), but the international component of this, how this influences the TAC that is actually implemented, and the subsequent need to allocate quotas (which can feed back to the TAC setting process) is not explicitly accounted for in ICES analysis or advice at present.

Issues associated with shared stock management have been the focus of substantial economic work in research groups and organizations that are heavily involved in ICES and elsewhere. These efforts have mostly been devoted to understanding outcomes from the fishery perspective in a single-stock, TAC based, setting. Extensive modelling work has been undertaken on the subject of quota allocation, following a TAC being set, and the implications of different regimes. Standardised methodologies exist to analyse the impacts and trade-offs of different management options, and when sufficient data is available multiple objectives can be considered, utilising approaches such as goal programming and game theory to consider strategic behaviour (Hannesson, 2011). Integrated scenario analyses, models for the explorative forward-looking simulation of various scenarios, over both the short and long-term, also exist and can be used to also explore normative scenarios (MSY, MEY, co-viability targets such as in Curtin *et al.*, 2013). Research from a less fishery-centric perspective has also been undertaken but these analyses are

more limited in number at present, such as those focusing on bycatch, discards, the objectives of contracting parties, industry stakeholders, fishing communities (e.g. Lane, 2008), and environmental NGOs. For example, incorporating bycatch and discards in internationally managed stocks relies on accounting for the incentives fishers face and using those to adjust behaviour (e.g. Lent & Squires, 2017).

By accounting for the broader set of factors at play, economics has a key role in better defining and understanding the bigger picture of shared stock management, considering the likely outcomes and trade-offs of different management approaches, thus informing management on how overall outcomes may be improved. In addition to improved understanding and integration of the above fundamental questions relating to shared stock TAC allocation, key areas where important questions remain include the TAC setting process itself, and broader ecosystem concerns including bycatch and discards, and issues arising from shifting stock boundaries.

The TAC (or other gear & spatial stock conservation measure) is a critical component of the management system, where multiple competing interests can intersect, yet research into the political economy of this process remains limited. In the same context more could also be learnt with respect to allocation of fishing possibilities, considering multiple decision levels[2] (individual companies, POs, regional authorities, nations), and non-fishing related interests (e.g. processing, fishing right holders, broader community interests, other industry interests). This includes research in political science, political economics, applications of public choice theory, as well as MSE approaches. The role of additional factors influencing incentives for cooperative management and compliance with management regulations such as financial support policies to the fisheries sector should also be taken into account in these analyses.

Including ecological processes in the assessment of alternative harvest strategies also offers promising developments, particularly as regards current and future shifts in stock distributions and the ensuing need to adapting methods used to allocate quotas (e.g. historic catch shares vs zonal attachment). From the trade perspective, issues such as bycatch and discards are increasingly becoming potential barriers to market, requiring these impacts to be better understood and integrated into scenario analyses. More generally, integrated scenario analysis that accounts for benefits (or costs) beyond catches, directly linking allocations with their outcomes for associated communities as a whole, would allow the broader welfare implications of given allocations to be considered.

Despite data availability having improved in many countries, a lack of standardisation, compatibility, and sometimes comparability in the types of data collected results in integration issues and remains an impediment to better analysis[3]. Assessing potential obstacles for negotiators and the industry in making economic information available when initiating negotiations on conservation objectives and/or access right allocations between parties, and the potential for long term-harvest strategies to minimize such incentives, also is key to support shared stocks management advice.

As is the case for quota or access allocations at the national level (please see issue 3), the sensitive nature of shared stock allocation questions means ICES being consulted for direct economic advice seems unlikely. ICES could however coordinate research efforts across its members to improve the general level of understanding of shared stock management issues, to inform policy and support the development of relevant advice in relation to changing established allocation

[2] The data used should reflect the level at which decisions are being made.

[3] These issues include limited levels of standardization of formats and aggregation levels of data between legal unities and international database platforms, and a large diversity of setups for accessing transversal and economic data, including information on government support. They also include limited understanding of the value chain (due to vertical integration) or the processes/interactions leading to TAC determination.

approaches. Applications of such analyses can also inform the ecosystem or fisheries overviews. Further key areas where ICES work is already developing, include the evaluation of community benefits of different quota allocations (e.g. WGSOCIAL), the clarification of management objectives (e.g. WGBESEO - Working Group on Balancing Economic, Social and Ecological Objectives) and evaluating the quota allocations, drivers and benefits to marine biodiversity from shared stocks. The drivers and benefits include "telecoupling" effects, which refer to socioeconomic and environmental interactions between distant coupled human and natural systems (e.g. WGRMES - Working Group on Resilience and Marine Ecosystem Services).

2.3.10 Ecosystem Services Evaluation

Internal research in ICES: There are currently several ICES WG involved in ecosystem services (ES) at variable extents, more directly as the WGRMES and the WGMPCZM (Working Group for Marine Planning and Coastal Zone Management) or to a lesser extent the WGSEDA or the WGBIODIV (Working Group on Biodiversity Science). The ICES WGRMES is currently developing quantitative and qualitative methods to map, assess and evaluate the contribution of marine ecosystem services to human well-being in European ecoregions, in collaboration with the Ecosystem Services Partnership. WGMPCZM developed the concept of culturally significant areas, and also some pilot applications, WGRMES already provided a global data repository on existing marine and coastal cultural ES.

External research to ICES: Current research external to ICES focuses on the link of marine ES to human wellbeing of the coastal community. This includes the importance and limitations of scale and transferability when looking at specific ES studies in assessing and monetising ES as well as integrating these approaches into environmental impact assessments and multi-criteria analysis. Key aspects are likely around understanding human impacts on ES to help foster behavioural changes. This research underpins, for example, policies on spatial planning (e.g. Welsh National Marine Plan), the Natural Capital approach (e.g. UK's 25 years Environmental Plan, UN's SEEA) or Blue Growth policies (e.g. OECD's Ocean Economy 2030). Thereby, special consideration is given to the trade-offs between different ES within or across different systems and their relation to various objectives.

To achieve this, there is an extensive range of methods and tools that are typically used when examining the different ES provided by marine ecosystems and competing activities involved in their exploitation in the context of an ecosystem-based approach to fisheries management (EBFM) approach that requires Marine Spatial Planning (MSP). Typically a holistic view is needed for robust policy making, which in economics is conceptualised through the Total Economic Value approach. Various methods are used within this framework and can ultimately be integrated in to environmental accounting – including systematic approaches to the treatment of depletion. Moreover, the need of MSP in the context of EBFM also requires the implementation of different tools and methods for spatial analysis including GIS, spatial statistics or network analysis. Finally, multi-criteria analysis exercises are often required where there are multiple objectives and less comparable data in order to effectively explore trade-offs.

Underlying these methods are several widely-accepted ES classification systems in existence now. These could provide a framework for ICES to work upon. A range of data are now available on ES; from standardised carbon accounting datasets at a national level to point estimates of ES in particular locations. However, wide-ranging internationaly comparable datasets of the monetary or non-monetary value of ES across countries do not currently exist. There are some exceptions in particular in relation to several provisioning and some cultural ES, where national accounts provide information.

Future integration into ICES: Given the importance of EBFM, which requires ES economic assessments to be fully effective, which requires ICES to incorporate this in future. Other aspects may include: potential impacts of ICES TAC-advice on ES, the definition of the optimal TAC advice including tipping points or thresholds of ES and their relation to ICES advice, trade-off analysis including marine spatial planification, and ES economic assessments can help highlight conflicts and support policy making with respect to social welfare.

In response to these needs, WGECON can contribute economic expertise to existing groups on ES as well as a link to the integrated ecosystem assessment work in ICES for sound policy advice. Particular attention should be paid to move from the ES assessment to the environmental-economic accounting. The future needs of data for integrating economics analysis in ICES advice are mainly related to the availability of different economic variables with the highest level of spatial precision disaggregation (per decision making unit) and frequency of different economics activities that exploit different ES and operate in the market. It is also important to link all this economic data needed with environmental, biological, oceanographic, ecological, etc. data.

Difficulties to serve the demand of economic data are much higher if we go through non-use values or non-marketed ecosystem goods and services. The collection of data needed to approach their analysis requires most of the case of specific surveys. There is a need for standardization of different techniques available to systematize the process of collecting the data needed.

2.3.11 Area-based and spatial management

Along with numerous Working Groups (WG), ICES is providing support with biological and ecosystem-related data that can support the evaluation of spatial management options and performance. Among them, WGFBIT (Working Group on Fisheries Benthic Impact and Trade-offs) is a working group focusing on the fishing impacts on the seafloor integrity in a spatial way, with support from WGSFD (Working Group on Spatial Fisheries Data), the ICES WG collecting and analyzing spatial fisheries data. Such WGs can help documenting the best place and timing for fishing gear restrictions as spatial management mitigation tools, e.g. for fishing closure or conservation areas for ecosystem component of particular interest (e.g. essential fish habitat, sensitive habitats such as habitat-forming animals, risk areas for unwanted catches, etc.). Another complementary example is WKBEDPRESS (Workshop on scoping for benthic pressure layers) that has been carried out to document the interaction with other occupying space marine sectors and spatial reservation for other industries (aquaculture, energy, transport, mineral extraction, military, marine recreation), in the Marine Spatial Planning realm.

It appears that very few initiatives in ICES have been evaluating what could be the performance of spatial management on the biological side. Hence, the evaluation of economic impacts of such spatial management options is even more lacking given collecting and using economic and social data was not the focus of ICES up to WGECON and WGSOCIAL. Recent ad hoc initiatives have taken the step to balance the environmental issues with the fisheries economics, also spatially, that for example related to the risk for habitat degradation (e.g. WKTRADE - Workshop to evaluate tradeoffs between the impact on seafloor habitats and provisions of catch/value, 2017-2019, and WKREG - Workshop to disseminate the ICES deep-sea access regulation technical service, and scope the required steps for regulatory purposes, 2019). However, beside initiatives from individual scientists bringing the information to ICES WGs, there were not implemented to any integrative advice so far. Besides, an initiative for running bioeconomic modelling and management started by STECF was recognized as need (e.g., STECF 17-05) but was still not routinely installed, and only few bioeconomic models are spatial.

Incorporating the human dimension in analysis of spatial management allows us to identify the impacted fishing stakeholders to be involved at the vessel, fleet and community levels, to quantify the importance of areas in terms of catch and revenue, and based on change in behavior scenarios (including reallocation of effort in space, time and to metiers), to estimate the economic consequences of spatial restrictions to fishing. In short it provides economic and social information needed for a trade-off analysis. What should be incorporated to ICES is existing models that could assess the past performance of spatial management, the likely impacted fleet by a proposal, and the projection of possible paths in alternative futures. This would make the impact assessment of the fishing pressure on the biological and ecosystem components with effects that could propagate to the fisheries economics. Even if ICES is hosting many data that could help to condition the impact assessment, the major obstacle would still be the limited data collection or data resolution of the data collected that currently does not fit the spatial and time resolution that matters to stakeholders and policymakers.

Besides providing an ecological-economic integrated assessment, such evaluation could complement the ICES ecosystem overviews. This complement will ideally take the form of a i) hindcasting of spatial plans past performance, ii) a static evaluation of the present situation about what fishing fleets could be impacted the most by the spatial plans, and iii) a forecast of the effects on a few years, including with transitional costs, crowding effects, and possible change in resource availability. The integrated management could support the policymakers' decision with new knowledge on hotly debated topics. For example, this may include case studies documenting the possible effort displacement in response to the implementation of conservation areas (in EU, Natura 2000 designated areas) that could require a costly adaptation on the short run, at least for fishers that were fishing there, a loss balanced with possible long term benefits. Another example could be the "Brexit" where implementing one-side so-called zonal attachment in the UK would lead to excluding the EU fleet from the UK Economic Exclusive Zone, a fundamental spatial issue. Case studies will be the basis for scaling-up local knowledge and process with a bio-economic modelling approach to applying at MS or regional level with scenario analysis, to illustrate what the natural fish stock resources could contribute to society in various spatial plans and across different management context. Such integrative support tool, knowledge and advice will be an entry point to engaging stakeholders for assessing all impacts of fishing sustainably, including stakeholder participation and qualitative information in the impact assessment process.

2.4 Survey of the fisheries economists profession

This section summarizes the main results from the survey of the economists profession carried out in 2019. The aim of the survey was to map existing work and future needs for economic science in ICES and access participation in ICES work by fisheries economics community. The survey was conducted through an online form that had been circulated to EAFE and NAAFE mailing lists. To increase a response rate and discuss some preliminary results a specific session was organized during 2019 EAFE Conference in Santiago de Compostela. In addition, a presentation of WGECON and the survey was given at the NAAFE Conference in Halifax, that same year. Additional paper responses were also collected during the Conference. There were 36 responses collected through fisheries economics networks.

The survey form was organized in 2 main sections:

1. Key issues for economic science in ICES (current and future work);
2. Connections to ICES (by respondents)

Responses to the first set of questions are presented in this section, while second set of questions is analyzed in section 5.3.

Analyzing issues of current and future work relevant to ICES, respondents were asked to identify issues of the most importance for ICES from the list of 8 main issues and rank them from 1 to 9 where 9 is the highest importance rank.

2.4.1 Issues of interest for current/ existing economic work

Survey respondents ranked mixed fisheries and small scale fisheries management, fishing rights allocation and other issues as the most important on average. However opinions were very diverse and median scores of responses also showed an importance granted to the development of TAC and output based management systems as well as analysis and research of links between catching sector and markets (see Figure 1). Among other issues of particular importance climate change and its impact on communities and fishing fleets was mentioned most often.

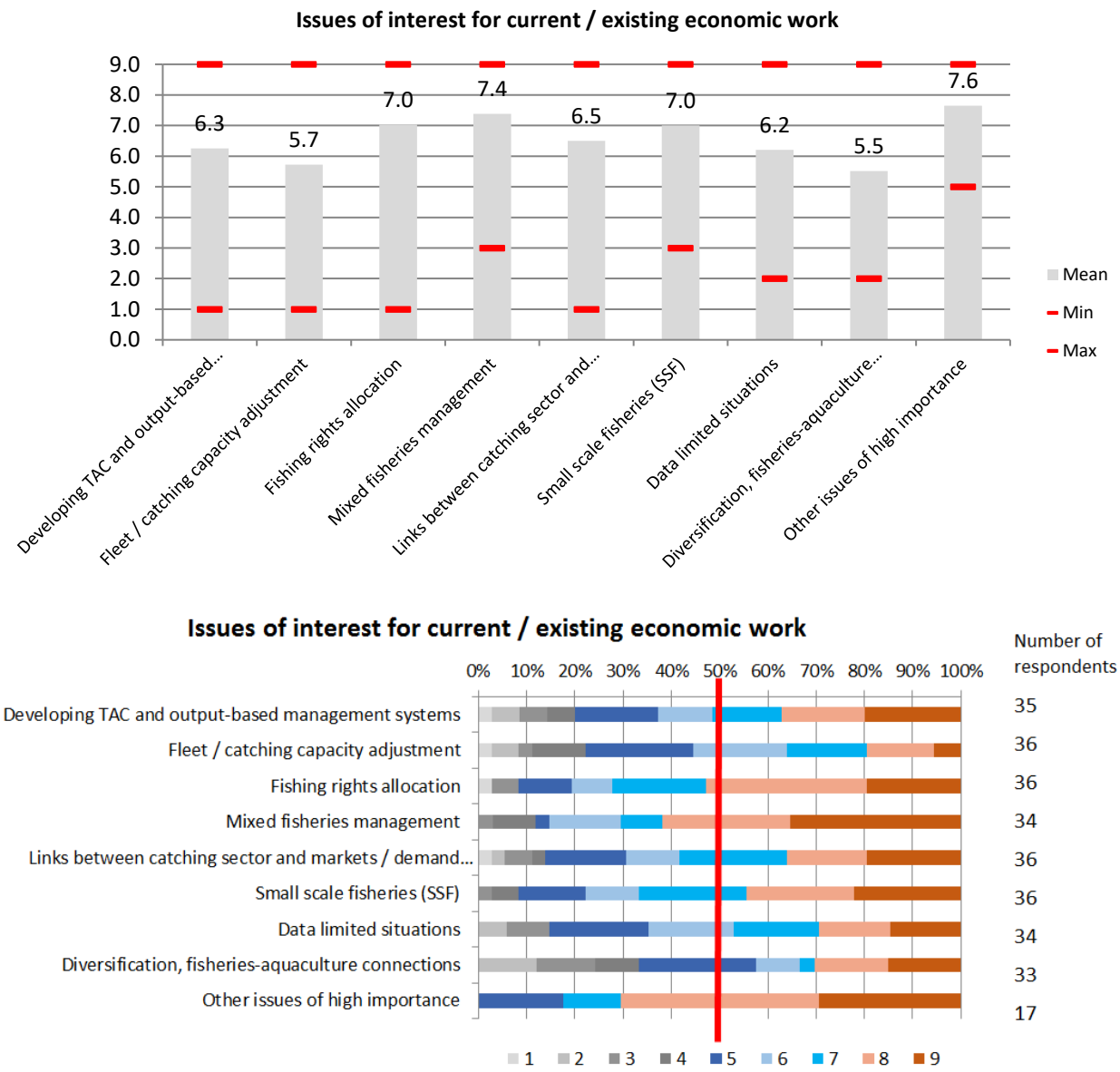


Figure 1. Issues of interest for current/existing economic work (mean and median results of survey).

2.4.2 Issues of interest for future economic work

Main future priorities and interests were broadly in line with the current work, however some current work areas where ranked lower, likely due to having already attracted a significant amount of research by economists. Research on TAC and output based management, as well as on adjustment of capacity to resource potential were ranked lowest on average, i.e. respondents perceived these should be of lower priority in the future. Other emerging issues such as climate change, pollution, regionalization and coastal communities studies were mentioned as other issues of high importance for future work (see Figure 2).

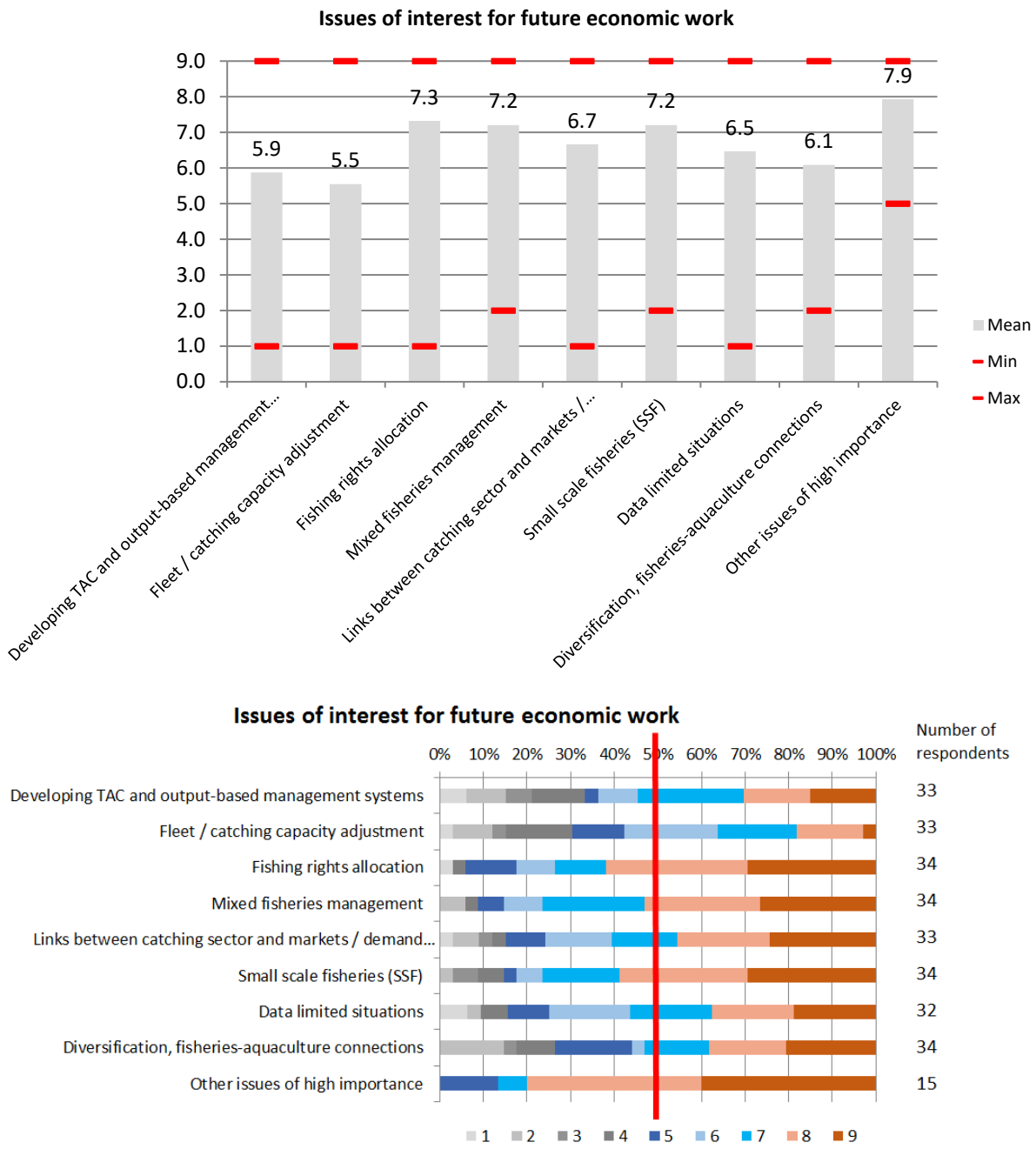


Figure 2. Issues of interest for future economic work (mean and median results of the survey).

Respondents were also requested to provide three keywords best describing issues of interest for the future economic work they ranked as most important. "SSF" and "fisheries management" issues were mentioned most often (see Figure 3). "Change", "Resilience", "Rights", "Social" and "Data" were also more frequently mentioned.

Figure 3. Word cloud of keywords best describing issues of interest for future economic work.

While the comparative analysis of current and future economic work issues shows quite a similar average priorities ranking, some priorities and issues of current work are seen to be reducing in the future, while the importance of others is expected to increase. Issues related to fishing rights allocation, small scale fisheries, links between catching sector and markets as well as data limited situations and diversification are issues the importance of which is expected to grow in the future (see Figure 4).

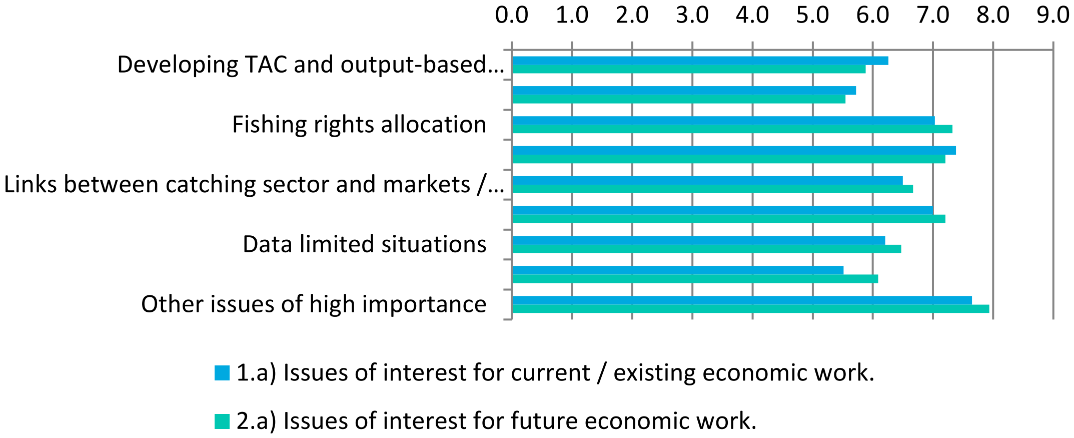


Figure 4. Comparison of priorities expressed for issues in current and future work.

3 Trade-off analysis

Term of reference c) of WGECON aimed to "Define and report on the information flow needed to provide economic analysis of trade-offs relating to ecosystem-based management of fishing."

3.1 Context and background, interpretation and focus

This section provides a brief introduction to trade-off analysis within the economics discipline. In economics, the term trade-off is typically expressed as an opportunity cost, which represents the value of the next best possible alternative. For example, for a recreational angler the (economic) trade-off is given by the time and money spent during the fishing trip, as compared to the alternative of spending the day gardening at home and saving the money and time spent travelling to the fishing site. This idea of trade-offs is consubstantial to economics as a discipline. Indeed, since economics deals with the efficient allocation of scarce resources, the idea of trade-off is embedded in the very concept of economic value, which is defined as agents' willingness-to-pay (i.e. willingness to give up something: time, money or other goods) to gain access to a good or service. In a nutshell, resources such as time and money are limited, and we must therefore decide how to best allocate them by making trade-offs. Economics places society's total valuation of differing outcomes at the centre of trade-off analysis.

What choices and decisions could be better informed by economic analysis of the trade-off to be made?

We illustrate this with an example the methods economics use to help inform policy making that involves trade-offs across multiple alternatives. Let's assume a fisheries management agency is considering two mutually exclusive policy alternatives X and Y. In other words, the manager can only implement one of the alternatives.

For the purposes of illustration, alternative X may allow the commercial fishing industry to harvest an annual quota of 1000 tons but have a detrimental impact on the population of a certain species of marine mammal due to bycatch mortality[4] . Concretely, assume this marine mammal population is expected to be reduced by 15% (equivalent to 100 individuals) due to bycatch in the target fishery. Alternatively, the manager may decide to implement policy Y (the status quo), which would keep the harvest unchanged with respect to the previous year and allow the industry to catch only 200 tons, but would have no anticipated impacts on the marine mammal population.

In this simple example, the trade-off is clear: the benefits associated with higher landings versus the costs associated with a reduction in the marine mammal population. However, as discussed next, even in this simplified world the determination of these benefits and costs can be challenging and will typically depend on the criteria adopted for the analysis. While this is a simple example, alternatives X and Y could, more generally, represent different sectors (not necessarily fishing management policies) and should ideally incorporate the dynamics of the system.

How can economics help inform the decision on what policy to adopt?

[4] This example extends to bycatch of any species, e.g. in the Portuguese long-line black scabbard fishery, the primary bycatch is leafscale gulper shark, *C. squamosus* (European Commission 2013).

3.2 Welfare analysis vs impact analysis

The first step is to decide which criterion to use to compare the two policy alternatives. Once that determination is made, the methods associated with each approach will determine the data necessary to conduct the analyses. Broadly speaking, there are two types of economic analyses that managers use to rank policy alternatives: *welfare* analysis and *impact* analysis. Only the former is suited for determination of the best alternative from an economic efficiency standpoint. Below, however, we describe both approaches since impact analysis is popular among managers as it looks at different trade-offs involved in policy making.

The standard economic approach (the gold standard) to deal with trade-offs is to estimate the monetary value, the so-called net-benefit or welfare, of alternatives X and Y. The recommendation from an economic efficiency standpoint is to then pick the alternative with the highest net-benefit. How would you proceed to come up with the monetary value for the net-benefits of the two policies in the example? For the fishing industry component of welfare, economists would typically calculate the "value for consumers and producers" of an increase in annual landings (the so-called consumer and producer surplus in economic jargon, or the difference between the total cost to produce a good and the total value society places on that good[5]). For the value associated with the marine mammal population, economists would conduct surveys in order to assess the economic value (willingness to pay) society attaches to preserving the species[6]. These surveys belong to what is known as stated preference studies, which are used to estimate the value of things such as conservation, recreation, culture, and a host of other important services which cannot be bought or sold directly in a market. While these non-market valuation methods present challenges and are not free from criticism, they allow the costs of losing part of the marine mammal population to be estimated in monetary-equivalence. The underlying assumption of these methods is that for something to have value, somebody must be willing to pay for it. Monetisation (i.e. expressing benefits and cots in the same unit[7]) allows economists to explicitly account for the trade-off involved in each policy when computing net-benefits since costs are directly subtracted from benefits (for further details on non-market valuation (see McConnell and Habb 2002).

To continue with the example above, denote the benefits and costs of each policy, respectively, by Bi and Ci where the sub-index refers to the policy, i=X, Y. Then, from an economic efficiency standpoint, policy X will be preferred to policy Y if and only if B_X-C_X>B_Y (since policy Y will not hurt the marine mammal population, it follows that its monetized costs are C_Y=0). Thus, policy X would combine a larger monetary value in the form of benefits for the fishing industry (and possible consumers) but it would incur a cost in terms of marine mammal population loss when compared to alternative Y. This cost C_X is directly subtracted from the benefits to arrive at the net-benefits of the policy, NB_X= B_X-C_X. Only if the net benefits of policy X exceed those of Y, would the former be preferred from an economic efficiency standpoint (see Pearce *et al.* 2006 for

[5] Economists believe that people's actions can be used to assess the implicit value, or utility, of goods and services they consume. By examining how people respond to price changes, in terms of what and how much they consume, economists estimate the monetary-equivalence of the utility generated. People's actual trade-offs are thus used to estimate the monetary-equivalence of the full value that they place on the goods and services used.

[6] Although revealed preference studies such as the travel cost method can be used to assess nonmarket values in certain contexts, we focus on stated preferences here as it can be used universally in estimating any nonmarket value.

[7] Given the near ubiquity of monetary transactions, and thus prices, using money as the numeraire is by far the simplest alternative. However, in reality any numeraire can be used as long as all goods can be estimated in equivalent terms. Note, however, that casting everything in terms of blue whale equivalence is likely to decrease the transparency of the trade-offs.

additional details on cost-benefit analysis). Importantly, note that if the monetised costs of reducing the marine mammal population was not specified, alternative X would always be preferred as $B_X > B_Y$ (as the higher the welfare from an alternative, the more efficient the use of scares inputs). As we discuss in section II, determining a credible monetised value to ecosystem and other non-market services can be difficult.

Alternatively, managers may be interested in a criterion different from welfare, e.g. number of jobs in the industry, value added, business output, taxes collected, etc. The focus on this approach –the so-called impact analysis– is on the impact of the different policies on the local economy under consideration. It captures the inter-industry transactions among businesses and between businesses and final consumers within this economy. *While not well-suited to rank alternatives from a net-benefits perspective, this approach looks at the distributional effects of policy within a given jurisdiction*. For example, managers may want compare the increase in jobs associated with a higher annual quota under alternative X, against alternative Y, which leaves both the number of jobs and the marine mammal population unchanged. How does the increase in fishing output under policy X is translated into additional jobs (or value-added or business output)? This is typically done by using input-output models for the regional economy, which capture the multiplier of ripple effect of an additional dollar spent in the region. For example, increasing annual harvest from 200 to 1000 tons may increase the number of full-time jobs from 1500 to 1900. Unlike welfare analysis, however, here the comparison between alternatives X and Y is less obvious since the 400 additional jobs must be weighed against 100 fewer marine mammals, without the help of a common metric (willingness-to-pay). Indeed, how does an additional job compare to one less marine mammal? This will depend on the subjective assessment of both variables by the parties making the decisions. In these circumstances, it is entirely possible, for example, that policy makers interested in employment in the region may adopt policy X even when the welfare analysis described previously suggests otherwise (i.e. $B_X - C_X < B_Y$).

Moreover, computation of regional economic impacts critically depends on the delimitation of the geographic region under consideration. Impact analyses critically lack behavioural responses to changes, which means that they overestimate the total changes to an economy which would be expected. Furthermore, as indicated earlier, economic impact analysis may lead to the adoption of inefficient policies from a welfare standpoint. Consider, for example, the extreme example of digging a ditch on the ground in order to fill it immediately after. Hiring labour for this activity would generate positive economic impacts for the region (i.e. increase in employment), but would be wasteful from a welfare standpoint, as the costs of digging the ditch fail to generate any social benefits. Thus the resources could be used more productively somewhere else in the economy. Another example is the case of open-access. While it is well-known that open-access is wasteful as it leads to overfishing and the dissipation of economic rents, it is characterized by overcapacity and higher levels of input used than a rationalized fishery. As such, it generates higher economic impacts than a rationalized fishery in the short-term.

3.3 Data requirements

Data requirements will depend on the criterion adopted to conduct the analysis.

As discussed earlier, welfare analysis relies on the quantification of both the benefits and the costs associated with each policy alternative. In the case of commercial fishing, net benefits associated with the commercialization of the target species entails estimating consumer and producer surpluses. Consumer surplus measures the difference between what consumers are willing to pay for the catch and what they actually must pay in the market. Producer surplus, on the other hand, measures the difference between what the markets pays for the catch and the costs of harvesting the market equilibrium level of output. Computation of the consumer surplus requires

estimation of the demand for the species of interest (or system of demands in a multispecies fishery). In turn, demand estimation requires data on quantities demanded at different prices. Calculation of producer surplus, on the other hand, relies on estimation of the market supply, which requires data on quantities supplied at different prices. Supply and demand functions are typically estimated jointly using market equilibrium data on prices and quantities, to ensure unbiased estimates of both functions.

When a fishery produces only a very small portion of the total global production of a good, the effect of policy changes on consumers are often so small that they can be ignored. In these scenarios, economists estimate (when the data is available) vessel-level profit functions, that is, the relationship between net revenues per trip (revenues minus trip costs) and prices of both inputs and outputs for each gear type in the fishery. This approach requires data on revenues, variable costs (ice, fuel, bait, quota rental costs, etc.), and prices of all species landed and of inputs used at the trip level for all participants in the fishery. When coupled with information on fixed costs (such as interest on loans, repair costs, insurance, etc.), these estimated profit functions allow the manager to compare participation and total net benefits (i.e. the aggregation of trip profits across trips and vessels) for each policy alternative under consideration.

Next, it is necessary to determine the economic benefits and costs associated with the non-market outcomes resulting from each policy. In the example above, this corresponds to the depletion of the marine mammal population under policy X. More broadly, especially in the context of ecosystem-based fisheries management, all the impacts of a policy on the complex of species and habitats in the ecosystem should (ideally) be identified and valued. This requires i) for the science on the ecosystem linkages to be in place in order to describe the anticipated changes associated from each policy, and ii) economic valuation of those identified changes. The latter, while difficult, is done using various techniques that fall into two categories: revealed preference approaches (that rely on actual agents' decisions and infer the non-market values implicit in those choices), and stated preference approaches (that rely on surveys and hypothetical choices). The main data required, particularly in design on valuation surveys, is a clear description of the changes induced by each policy, and demographic information for survey respondents (see, for example, Champ *et al.* 2017).

Unlike welfare analysis, economic impacts analyses are typically conducted with the help of so-called input-output models (I/O models) such as IMPLAN. These models attempt to describe the regional economy. To this end, they are populated with data on employment, employee compensation, industry expenditures, commodity demands, relationships between industries, and the share of each industry's purchases that are supplied by local firms. By relying on inter-industry data, I/O models help determine how changes in one industry will impact other sectors. Based on this data, multipliers are calculated and used to estimate economic impacts. Generally, I/O models are so complex and require so much data that they are bought from vendors such as IMPLAN (www.implan.com), rather than developed independently, and then customized to suit the questions at hand.

What are the limitations of the welfare analysis approach adopted by economics to address trade-offs?

Economic efficiency need not be the only objective of policy makers. Indeed, more often than not, it is not the primary goal of policy makers. In these circumstances, when deciding how to weigh economic efficiency against other goals, managers need to look to other social sciences for advice. For example, while welfare analysis provides a sharp ranking between policies X and Y in terms of net benefits, it is of little help when it comes to the ranking of distributional outcomes. Concretely, policy X may generate higher net benefits than policy Y, but when there are different winners and losers under each policy, economics can only describe those distributional impacts. It lacks a framework for decision making in terms of equity/fairness similar to that of choice

based on efficiency. Moreover, as described earlier, economic valuation of non-market goods and services is far from trivial and is not always feasible. For example, how would you go about determining the existence value of an entire fishing community? Furthermore, some of the non-market benefits are likely to occur in the medium to long term and are therefore characterized by high degree of uncertainty. Guidance from other social sciences would be critical in this and similar cases.

4 Demonstrating integration of economic information and analyses

In cooperation with WGSOCIAL, case-specific studies involving trade-off-analyses were initiated in two complementary directions: (i) introducing economic dimensions in Integrated Ecosystem Assessments, with a focus on the Celtic Seas; end (ii) evaluation of a fishery management scheme, with the example of Rights Based Management Systems and their implementation in North America. This section summarizes the first steps taken to develop these two demonstrators.

4.1 Integrating economic analyses in Ecosystem Overviews (EOs)

Under its ToR D, WGECON should assess and report on the economic significance of commercial fishing for selected coastal regions in the ICES area and support potential advice requests and development of ICES ecosystem overviews. WGECON was approached several times in this working period with respect to developing an economic perspective in the ICES Ecosystem Overviews (EOs). Several members of the WG attended the workshop on Challenges, Opportunities, Needs and Successes for including human dimensions in IEAs (WKCONSERVE), held in Copenhagen in October 2019. The workshop had three primary goals: (i) Summarize social and economic data, indicators and relevant research done across ICES and other IEA regions; (ii) Identify goals for including social and economic data and analyses in IEAs; and (iii) Develop a roadmap for including social and economic data and analyses in each IEA.

Discussions at this workshop highlighted three questions which are key to the process of including an economic perspective in IEAs:

- **what is it that users of the IEAs care about?** This should drive the efforts devoted to identifying economic variables to consider in assessments (e.g. supply availability/provisioning services, other ecosystem services including cultural, livelihood security, economic efficiency, social acceptability, …);
- **what is our understanding of the linkages between ecological variables and economic variables of interest?** This will be central to our capacity of developing an integrated assessment drawing from an analytical understanding of interactions between ecological and economic processes;
- **what is the scale of the social system at which synthesis information is deemed relevant and useful?** An important issue to address is how to select the economic information, which is usually generated at national level, to use in assessments that relate to eco-regions, or areas within those. This will depend on responses to the first two questions, and may require dedicated efforts to develop a generic and flexible approach to the generation of indicators at multiple scales. For the European context, this should be pursued in collaboration with colleagues involved in the STECF work on economic data collection for European fleets.

The figure below illustrates the multiple scales at which fisheries socio-ecological systems may need to be considered in order to answer the questions which are being asked these systems as part of an EO.

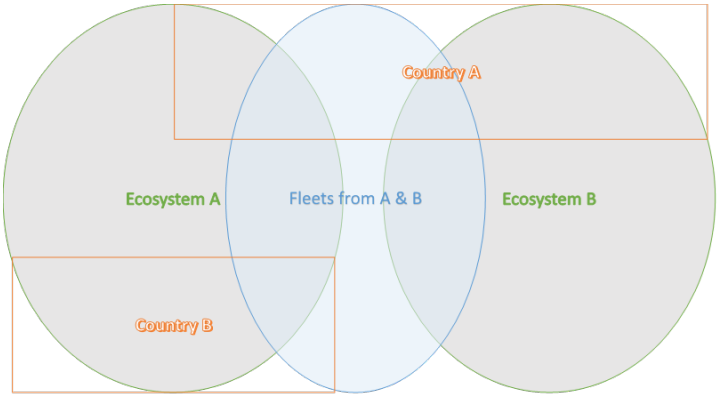


Figure 5. Multiple scales of socio-ecological system at which synthesis may be relevant and useful.

4.1.1 A case study

Current EOs provide a description of the ecosystems, identify the main human pressures, and explain how these affect key ecosystem components. The group reviewed economic data available across ICES, including the EU STECF work, NOAA's fisheries reporting systems and OECD's efforts to produce economic indicators in relation with a regional impacts assessment approach. This review of available economic data made by WGECON showed that a significant body of information exists in Europe and in the US to describe the economic status of commercial fisheries. However most data sets are providing economic performance data per fleet segments and fishing areas/regions, while there is limited information available related to coastal regions.

The Celtic Seas was identified as test case study to explore the ways in which economic dimensions could be incorporated in an EO contributing to IEA. The area had also been selected for the work of WGSOCIAL on including social dimensions, therefore strong relationships with WGSOCIAL were built within this case study.

The starting point of the work regarding the Celtic Seas case study was a region-specific analysis of data availability. In the Celtic Seas case study analyses of economic data available and possible methods to use fisheries specific data available in some ICES member states to produce region-specific analysis were carried out. The group agreed that a first step contributing to Ecosystem Overviews could be a data request from the Regional Database to identify coastal communities based on the analysis of ports of landings, thus enabling assessment of the economic significance of fishing in these communities, in the future. A summary of the data available and ways in which it could be used is presented below.

4.1.1.1 European data collection

DCF fisheries socio-economic data is collected by EU Member States (MS) through annual sampling programs which are outlined in National Work Plans[8]. Data is provided under the provisions of Regulation 2017/1004 in accordance with Commission Decision (EU) 2016/1251, a full list of data requirements can be found on the Data Collection website[9].

The socio-economic data is requested by STECF annually and provided by MS to the European Commission Joint Research Centre. The data is aggregated by fleet segment, based on vessel

[8] https://datacollection.jrc.ec.europa.eu/wp/2020

[9] https://datacollection.jrc.ec.europa.eu/dc/fleet/var#_48_INSTANCE_70x2z8ezEyUT_%3Dhttps%253A%252F%252Fdatacollection.jrc.ec.europa.eu%252Fdocuments%252F10213%252F1291400%252FEUMAP_data_requirements_2020.pdf

length and main gear used as defined in the DCF legislation. Along with the socio-economic data biological and transversal data (landings and effort variables) is also collected and provided to the STECF with reference to fishing area and species. The high level of aggregation for the economic and social data means that any analysis at a national administrative level is not possible. The analysis of economic fleet segments by ecoregions is also limited as those are defined at North Atlantic Ocean supra-region level.

All economic data collected and available from EU MS is disseminated through STECF data dissemination tools and available online[10].

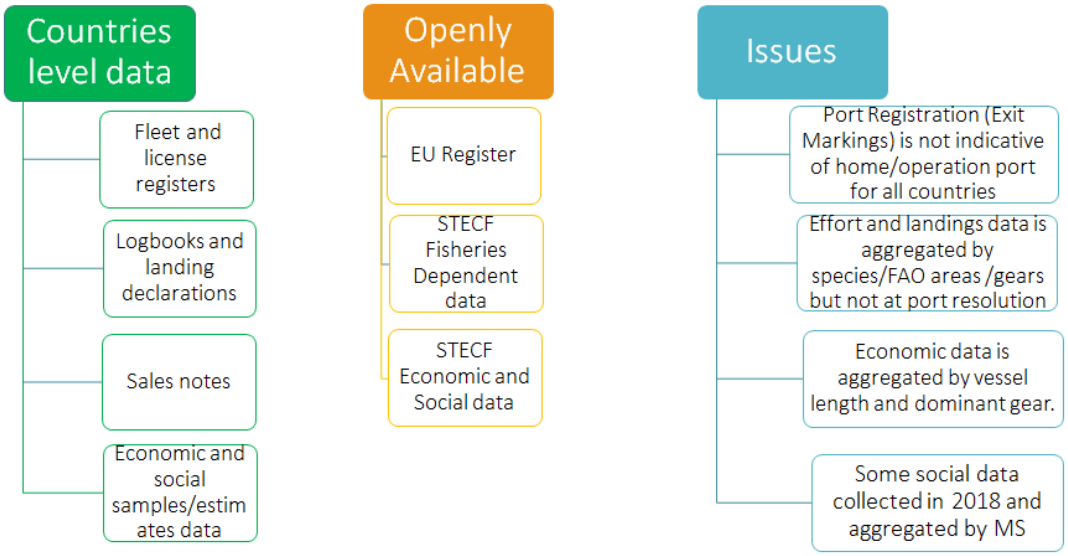


Figure 6. Data availability and issues related to open data sources.

When looking for a link between fleet operation at sea and onshore activities in harbours, the landings and effort data submitted under the DCF does not report the data by port, but is aggregated by species, FAO Area level 3-4 and DCF Fleet segments. Therefore, to assign landings weight and value to ports these must be requested from MS directly, or extracted/requested from the Regional Data Bases (RDBs).

Regional and other lower dimensions

There are several methods to disaggregate economic data to lower dimensions:

1. STECF AER approach: using effort and value of landings to allocate fleet segments costs and earnings parameters to different Sea Regions[11].
2. Some studies e.g. Natal *et al.*, (2013), are using ports from European Fleet Register that is available online to proportion socio-economic data. This method is dependent on the assumption that the port of registration corresponds to the main location of the vessel's economic activity. However this analysis is limited to ports of registry definition and might be biased for some countries (e.g. UK and Ireland).
3. Use of PGECON proposed common methodology on disaggregation of economic data (PGECON, 2019) allows to create a list of coefficients at individual country

[10] https://stecf.jrc.ec.europa.eu/data-dissemination#_48_INSTANCE_eG0Y_%3Dhttps%253A%252F%252Fstecf.jrc.ec.europa.eu%252Fdocuments%252F43805%252F1593959%252Ftableau-instructions.pdf%252F22cef4a4-7814-408d-aea3-cd9a0f69b801

[11] https://stecf.jrc.ec.europa.eu/documents/43805/2483556/STECF+19-06+-+AER+-+2019.pdf/db370547-4405-416d-b2e3-76f8276edae2?version=1.2&download=true

level data that could be shared afterwards to partition economic information provided to STECF during economic data call to the lower level of e.g. metier provided during fisheries dependent data call.

4. Individual vessel level data analysis and further stratification of local fleets (e.g. France, UK, Spain, etc.)
5. Economic dependency assumption introduced also in other studies e.g. Surís-Regueiro and Santiago, (2014) the level of fisheries dependence. The dependence level is estimated at municipality level according to the income and employment linked to fisheries. In addition, with a wide perspective of the macro-economic analysis, the input-output analysis also allows to identify the level of economic dependence to fisheries for a certain region/country (García-Negro (Dir.), 2003).

Use of different methods depend on the end user needs and access to primary data, e.g. in the 3rd and 4th disaggregation example there is a need to work at primary data level to achieve partitioning, while in the 1st and 2nd examples of methodology only publicly available data can be used, however results will be limited and less accurate.

There are already several countries that are partitioning economic data to national regions using national methodologies. Short description of those methodologies is explored below.

Sea basin approach

Currently Regional economic analyses are available in STECF AER[12]. The data there is interrogated to disaggregate economic information from supra-regional level to Sea Regions using 1st methodology mentioned above. Therefore Regional analyses from AER might be useful addition to Ecosystem Overviews and already provide some economic parameters, e.g. GVA, net profit, etc.

There are several regions analysed in AER related to North Atlantic Ocean (NAO):

- North Sea & Eastern Arctic
- NAFO
- Baltic Sea
- North western Waters (extended)
- Southern Western Waters

Even if some of the AER regions are defined differently, the methodology used by AER and data provided by EU Member states to AER economic data call and fisheries dependent information data call might provide an opportunity to partition economic data to ICES Ecosystems level.

AER methodology has its pros and cons. Allocation of costs to fishing regions using effort and revenues (value of landings) from different ICES areas might shift profit towards regions will lower effort and higher value of landings, while in reality the cost structure of fishing fleets in both regions is different. Therefore disaggregation of publicly available data sources might be less favourable than additional national data request e.g. in some countries fleets definition and stratification during the data collection might be at lower level than DCF fleet segment, or take into account sea basins (e.g. UK, else?) allowing to have a better regional economic estimates at national level.

[12] https://stecf.jrc.ec.europa.eu/reports/economic/-/asset_publisher/d7Ie/document/id/2571760?inheritRedirect=false&redirect=https%3A%2F%2Fstecf.jrc.ec.europa.eu%2Freports%2Feconomic%3Fp_p_id%3D101_INSTANCE_d7Ie%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26

Harbour approach

In 2019 ICES WGSOCIAL took a simplistic approach to identify coastal fishing communities through ports of landings. Identification of the ports of landings/first sales markets could also open another way to explore economy of fishing fleet though money flows to specific terrestrial regions within countries. That could also open an avenue for example to the analysis of different regions dependency on a specific management stocks, e.g. small communities fully dependent on small proportion of specific stock catch (e.g. hake in Celeiro or swordfish in A Guarda (Galicia, NW Spain). If this approach is further elaborated and RDBs data becomes available to ICES WGECON and WGSOCIAL work could be done to develop national methodologies (possibly similar to UK), or wider ICES methodologies (similar to STECF AER) that could be tested by ICES.

4.1.1.2 United Kingdom

Due to an increasing interest in regional analyses Seafish recently developed methodology that helps to allocate fishing activity to terrestrial regions using top port of landings[13]. The way UK data collected under EUMAP, stored and estimated allows grouping vessels and their economic performance estimates by different dimensions including ports of landings (see example of views developed based not this approaches in Figure 7).

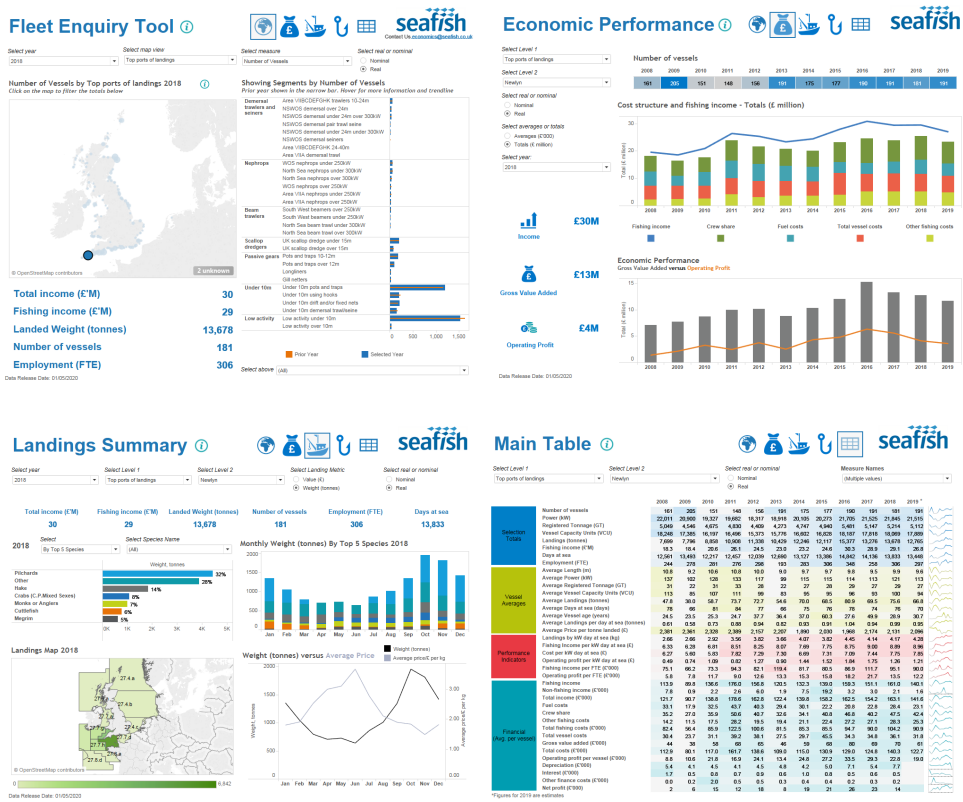


Figure 7. Example of ports level data analysis created by Seafish in Fleet Enquiry Tool[14].

This method has its limitations, especially when analysing vessels with multiple activities and landings ports during the year, however it also opens an opportunity to add economic performance indicators (also collected under EUMAP and also defined in STECF AER) for fleets to

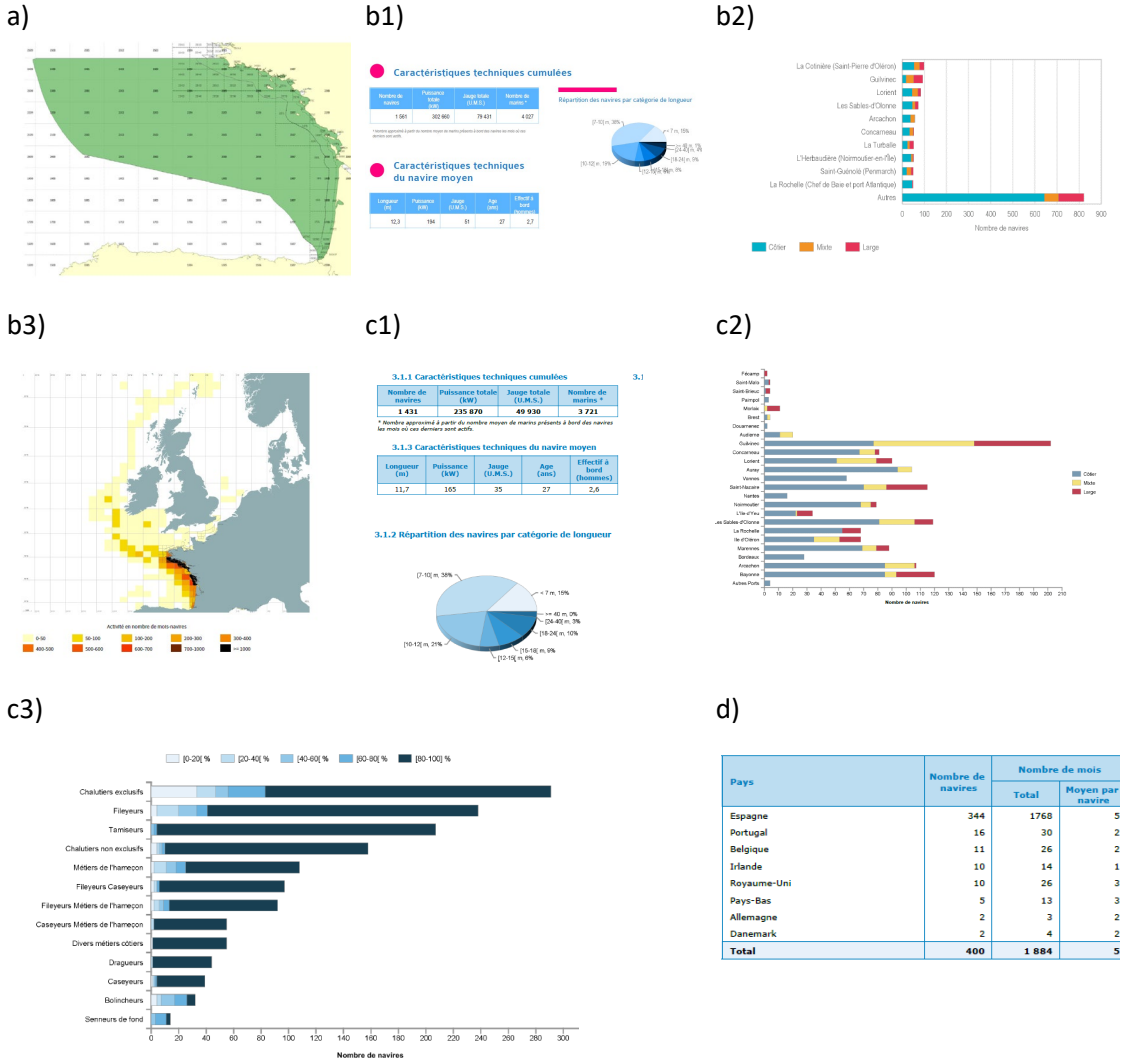
[13] UK Economic Fleet Estimates and Fleet Enquiry Tool - Methodology Report, Seafish, 2020.

[14] Available online: https://public.tableau.com/profile/seafish#!/vizhome/FleetEnquiryTool/1Overview

territorial regions within the country. Also link between vessels and their activity information as well as economic costs and earnings information allows us to analyse specific ports fleet activity in terms of effort and landings by ICES areas and/or potentially rectangles as well as e.g. group vessels by size category.

4.1.1.3 France

Based on a large set of vessel data (landings and effort, Register fleet, Sales notes, Annual fishing calendar per vessel…) made available by the Ministry of Agriculture and Fisheries and the Ifremer Observatory system (https://sih.ifremer.fr/), an approach combining for the same ecoregion, a "land-based" perspective and a "sea-based" perspective, has been developed by AMURE for the MSFD exercise. The results for the Bay of Biscay are provided here as an example of what could be done in other ecoregions.



Pays	Nombre de navires	Nombre de mois	
		Total	Moyen par navire
Espagne	344	1768	5
Portugal	16	30	2
Belgique	11	26	2
Irlande	10	14	1
Royaume-Uni	10	26	3
Pays-Bas	5	13	3
Allemagne	2	3	2
Danemark	2	4	2
Total	400	1 884	5

Figure 8. Summary of French data available: illustration with the Bay of Biscay.

a) The Bay of Biscay fishing area;

b) Land-based approach (French data for 2015):

- b1) Number of vessels registered in fishing harbours closed to the Bay of Biscay (general features);

- b2) Main fishing harbours closed to the Bay of Biscay according to number of fishing vessels;
- b3) Fishing areas visited by vessels (in terms of fishing effort) registered in harbours closed to the Bay of Biscay;

c) Sea-based approach (French data for 2015):

- c1) Number of French vessels fishing in the Bay of Biscay;
- c2) Registered harbours of vessels fishing in the Bay of Biscay (from North to South – France);
- c3) Fleet segmentation of vessels fishing in the Bay of Biscay and dependency level to the fishing area;

d) Sea-based approach (Foreign vessels): number of foreign vessels (per country) fishing in the Bay of Biscay and their fishing effort in the area (first assessment).

Socio-economic indicators (including landings per specie (stocks) per fishing harbour, crew data, fleet economic performance) can be easily added.

4.1.1.4 Spain

The official fishing segmentation, developed in the frame of the CFP (Reg. 1380/2013), includes 3 marine supra-regions: North Atlantic, Mediterranean and other fishing regions (long-distant fisheries). This segmentation relates the fishing area with the gear and the vessel dimensions. In particular, there are 34 fishing segments for the Atlantic sea basins, 20 for the Mediterranean and 6 for the long-distant areas (MAPAMA 2020). The socio-economic information for these segments is gathered in the frame of the DCF but these segments are not clustered with any geographical criteria.

However, specific studies have been developed at regional level in order to identify the socio-economic effects of the fisheries activity in those areas. From a wider perspective, the input-output tables developed in Galicia (NW Spain) allows to identify the relevance of the fisheries by taking into account the direct, indirect and induced effects of this activity (García-Negro, 2015). In addition, some advances focus on relating the socioeconomic consequences at regional and/or segment were carried out. For instance, the relation between the TAC allocation of certain stocks and the spatial distribution of the socioeconomic effects (Santiago *et al.*, 2018), the consequences of technical measures in a fishing segment (e.g. the landing obligation in Rodríguez-Rodríguez *et al.*, 2019) or the development of certain fishing area in a region (e.g. the Celtic Seas in Varela-Lafuente *et al.*, 2019) or in a coastal city (e.g. Vigo in Surís-Regueiro *et al.*, 2014). In all these cases the data is gathered from databases of the national a regional statistical institutes in combination to the active participation of stakeholders (mainly fishermen) and the input-output tables developed by the Regional Government. Being the availability of input-output tables, with specific information on fisheries sector, as the key to develop this type of socio-economic analyses at regional scale.

4.1.1.5 Future Directions

The following directions were identified for future work in this area, in the short term as well as in the longer term.

Short term

The group agreed to examine the AER regional analyses already carried out by STECF and their relevance for Ecosystem Overviews. It was also agreed that the availability of data outside the EU for similar undertakings should also be explored. In cooperation with WGSOCIAL, the group will request data on value by ports of landings from RDBs to improve understanding of fleets operations and spread of value between different regions (that should include countries which

fleets operate in the ecosystem, but landing ports are outside ecosystem defined, e.g. Belgium, Spanish, French fleets operating in Celtic Seas). This can be a first exploratory step of the analysis that will then need to be discussed by WGSOCIAL and WGECON experts to agree on a common ground for analysis.

Long term directions

The discussions of Celtic Seas case study by WGECON and WGSOCIAL were mainly focused on short term achievable objectives using mainly existing monitoring options and data to contribute to EOs. A broad range of bio-economic models might also be available for short term and long term forecasts as part of IEAs. These were not considered in this case study, but should explored in the future developing of IEAs when progress has been made with respect to data issues.

The Celtic Seas CS group was limited in number of contributors and time available for discussions; however some members considered that in the future, when data problems have been resolved and methodologies agreed to, the Ecosystem and Fisheries Overviews might include the following socio-economic dimensions, as part of the ecosystem and fisheries descriptions.

1. *Description of the basic economic indicators,* such as gross value of landings, total profit, total capital, number of people employed, mean income per fisher. This could be presented as a table with text or numbers, as well as figures of changes in key variables over time, using a standard presentation format for all fisheries. Another table could describe such information which is considered important from a decision making point of view, including indications of whether economic buffers or alternative fishing options exist for given fleets, and whether a given fleet or fishery may be perceived to be more or less resilient to management change or fluctuations due to natural variability.
2. *Scientific comments for strategic policy action*, on what should be done in the long run, if given policy aims are followed. In many cases, such aims exist in legislation and/or agreements relating to the management of a fishery, so that a direction for policy advice can be identified, and legitimately argued for in front of a broad audience. Such a section would need to be based on strong contributions regarding socio-economic dimensions. This could include knowledge of long term profits, required capital investments, likely socio-economic impacts of alternative policy options, including options not yet implemented.
3. *Comments on the latest couple of years regarding biological, tactical/operational advice*. This should include an assessment of medium-term economic impacts of fisheries advice, as these impacts are usually considered as part of the objectives with which TACs are being set, although TAC advice is usually given on yearly levels.

These three steps could be implemented in simple and easy to understand ways in a couple of example fisheries used as examples, on which feedback from the ICES community could be provided, in order to progress the contents of Fisheries and Ecosystem Overviews in the longer term.

4.2 Including economic dimensions in assessments of management regulations

Here we provide a brief synthesis of the work initiated by the group regarding lessons learned from the United-States catch-share review experience, including a progress report on a short-term review of selected fisheries, undertaken as a ToR D case study. Longer-term plans for carrying out a similar review effort on a broader scale will be reported in future WGECON reports.

A case study of North American catch share programs was selected to further examine important aspects of economic models, data collection, and analysis in the design of catch share programs. An initial draft of the case study (Section 4.2.1) was prepared and presented at a joint WGECON/WGSOCIAL virtual meeting held during 15 to19 June 2020. The joint deliberations led to consideration of a more expansive examination of catch share fishery design to consider social, economic, and governance aspects in both the EU and North America (Section 4.2.3) that may be further developed as a joint effort of WGECON and WGSOCIAL, under their ToRs for 2021.

For purposes of WGECON it was decided that the ToR D would go forward independently of a joint ToR with WGSOCIAL with the expectation that it would be completed before the end of 2020. Given the time frame the scope of the case study was narrowed to U.S. catch shares and was further narrowed to three catch share programs; New England Groundfish, Pacific Groundfish, and Alaska Amendment 80 Multispecies groundfish (Section 4.2.2). These programs were selected because they are all target demersal species using similar gear yet adopted different catch share systems. Progress on the case study has been delayed due to reassignment of the case study lead (Eric Thunberg) to social and economic assessment of the impacts of the COVID-19 pandemic on U.S. trade as well as impacts on seafood harvesters, dealers/distributors, and operators of recreational angler passenger services. For this reason completion of the U.S. Catch Shares case study has been deferred to 2021.

4.2.1 Catch Share Case Study Development

The discussion of the case study approach held during the June 2020 meeting of WGECON considered the following structure for analysing catch share programs.

Review the Literature of Catch Share Program Critiques:

- Cross-National and/or cross-program comparisons
- Common metrics
- Economic dimensions
- Social dimensions

Review catch share program objectives and design features:

- Response to lessons learned
- Monitoring data needs

Evaluation:

- US Catch share program reviews
- Lessons Learned

4.2.2 WGECON North American Catch Share Fishery Case Study

The group agreed to initiate the following short-term analysis of selected catch share programs, to illustrate the way in which such analysis could be conducted. The objective of this analysis is to describe the role of economic analysis and data used in the development of selected U.S. catch share programs, including:

a) Pacific groundfish
b) AK Amendment 80 Multispecies groundfish
c) New England groundfish

The following structure for this analysis was agreed to:

1) Role of economic analysis and input in initial catch share program implementation
    i) Program objectives – reasons for implementation
    ii) Type of economic analysis
    iii) Data used
    iv) Indicators of performance
2) Economic analysis and data collection post-implementation
    i) Economic models in plan amendments or adjustments
    ii) New data collection
3) 5-year Catch Share Program Reviews
    i) Program review economic objectives
    ii) Economic models used
    iii) Economic data used
4) Lessons learned
    i) Economic analysis needed
    ii) Data needed

4.2.3 Roadmap for a joint WGECON/WGSOCIAL case study

In a joint sub-group meeting of the two working groups during the June 2020 meeting, the following common analytical approach was agreed to for a future joint case study effort, to be pursued in 2021:

- Literature review of catch share program performance
    - Social
    - Economic
- Identify metrics/criteria for evaluation
    - Data needs
    - Available data
    - Gaps
- Review/Summarize catch share program objectives and design features (EU & N. American)
    - Changes over time
    - Proactive or reactive?
- Evaluate catch share programs relative to social and economic metrics
- Lessons learned & recommendations to ICES
    - Links to WGBSEOS
    - Links to the WGSOCIAL/WGECON Tradeoff ToRs

5 Collaborations and outreach

A key factor determining the capacity for economic research to increase its contribution to ICES work is the economic research capacity that can be attracted to participate in ICES activities. With this objective in mind, as well as the need to strengthen collaborations with other social sciences and the natural sciences within ICES, WGECON actively sought to develop collaborations with existing networks, throughout its first three years of existence.

5.1 Interactions with scientific networks

In particular, working group members presented WGECON and its objectives and results at dedicated sessions of the bi-annual conference of IIFET (Seattle, 2018), as well as of the EAFE conference (Santiago de Compostela, 2019) and the NAAFE conference (Halifax, 2019).

Members of the group also co-chaired several conference sessions focused on bringing economic and other social dimensions into integrated approaches to marine socio-ecological systems analyses, including:

- Organisation of a theme session entitled "Modelling social-ecological systems: methods and tools for scenario development and prediction" at the 2019 IMBeR Open Science Conference (Brest);
- Joint organisation with members of WGSOCIAL, the working group on marine systems (WGMARS) and the Strategic Initiative on Human Dimensions (SIHD) of a session entitled "Understanding humans within ecosystems: Innovative tools, strategies, and research", co-sponsored by PICES, at the 2019 ICES Annual Science Conference;
- Joint organisation with the Ocean University Initiative of the workshop on Global Ocean Social Science (WKGLOSS) as part of the UN decade on Ocean Science for Sustainable Development;
- Joint organisation with members of WGSOCIAL and the SIHD of a thematic session entitled "Connecting economic, social science, and interdisciplinary research and management advice" at the ICES ASC 2020 (now postponed to 2021).

In addition, several members of WGECON were strongly involved in the planning of the 2020 conference of the IIFET in Spain (now postponed to 2022), and in the planning of the ICES-PICES sponsored MSEAS 2020 symposium in Japan (now postponed to 2021).

These interactions with scientific networks have enabled increasing the knowledge of ICES in these networks, and spreading the word of the existence of ICES WGECON and its ToRs, with the aim to expand the network of colleagues who can contribute to economic science in ICES. A measurable impact of these efforts is the regular increase in the number of members of WGECON, who are now 50. These efforts should be pursued in the next three years, with a particular emphasis on identifying means to increase the participation of economists in ICES meetings, including workshops, working group meetings and annual science conference sessions.

The potential for developing a training program in economics for the ICES community was also discussed in 2020.

5.2 Interaction and cooperation with other ICES activities.

Throughout the three years, WGECON also established regular interactions with other activities in ICES, with in particular:

- Invited presentations at WGECON meetings of their activities and potential linkages by chairs of groups addressing closely related themes, including the Working Group on Resilience and Marine Ecosystem Services (WGRMES), the Working Group on Mixed Fisheries Advice, the Workshop to evaluate trade-offs between the impact on seafloor habitats and provisions of catch/value (WKTRADE), the Workshop on Balancing Economic, Social, and Institutional Objectives in Integrated Assessments (WKSIHD-BESIO);
- Participation in meetings organised by other activities, including the workshop on challenges, opportunities, needs and successes for including human dimensions in integrated ecosystems assessments (WKCONSERVE), the scoping workshop on next generation of mixed fisheries advice (WKMIXFISH), as well as the regular meetings organized by the SIHD at the ASC.

In addition, WGECON and WGSOCIAL have maintained regular contact in order to co-ordinate work and obtain synergies where possible to avoid overlap and enhance the usefulness of outputs. There is valuable overlap in membership in the two groups, with a few experts in both groups. The two groups managed to organise a full week joint meeting (15–19 June 2020) in virtual format with a combination of plenary sessions between the two working groups, plenary sessions for each group separately, and parallel sub-group meetings focused on case study work. This enabled initiating a number of case studies joint between WGECON and WGSOCIAL, which will be further developed in the next cycle of the two groups. A joint discussion with WGSOCIAL was also held on the coordinated development of terms of reference for the next cycle of the two groups.

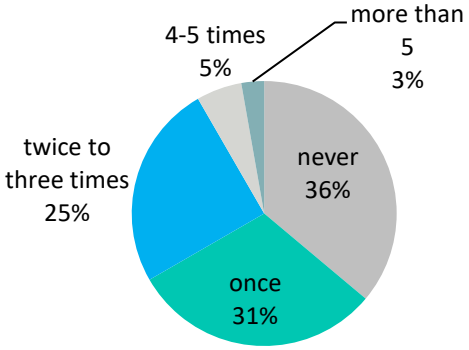
5.3 Participation of economists in ICES activities: survey results

Part of the survey of the profession already mentioned focused on the participation of economists in ICES activities. The results of this section of the survey are presented in the set of figures below.

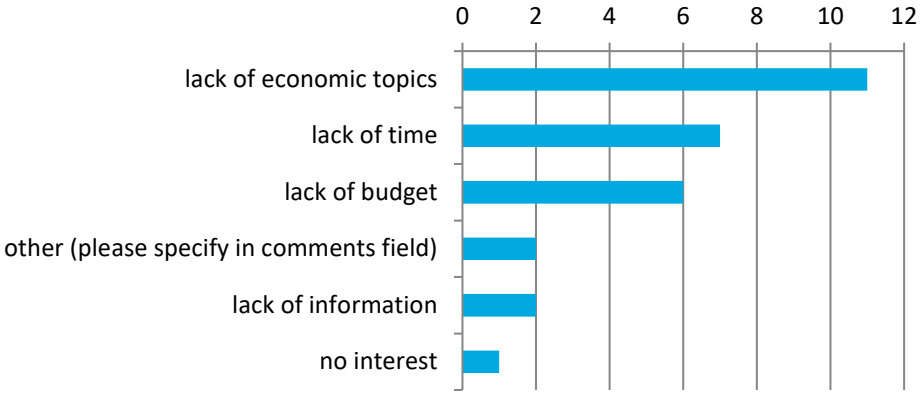
The survey showed that so far economists are not actively involved in ICES activities. One third of respondents did not participate in ICES conferences and/or symposia in the last five years, while another third participated only once. Lack of economic topics and time were mentioned as main factors affecting low participation levels, however almost half of respondents were involved in ICEC WGs work with most involved in WGECON work.

Many of the economists who contributed to the survey said they would increase their participation in ICES WGs if funding was available to support their participation and if topics of the meetings & conferences would be closer to interests. Three quarter of the respondents showed interest in participation in IEA groups work.

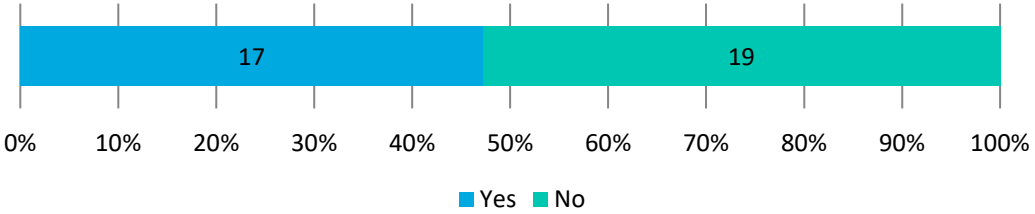
3.a) Participation in ICES conferences and/or symposia. How often have you participated in ICES conferences and/or symposia in the last 5 years



3.b) Barriers preventing you from attending ICES conferences and/or symposia. If you have responded once or less, what are the barriers preventing you from attending ICES conferences and/or symposia (please choose the most important)?

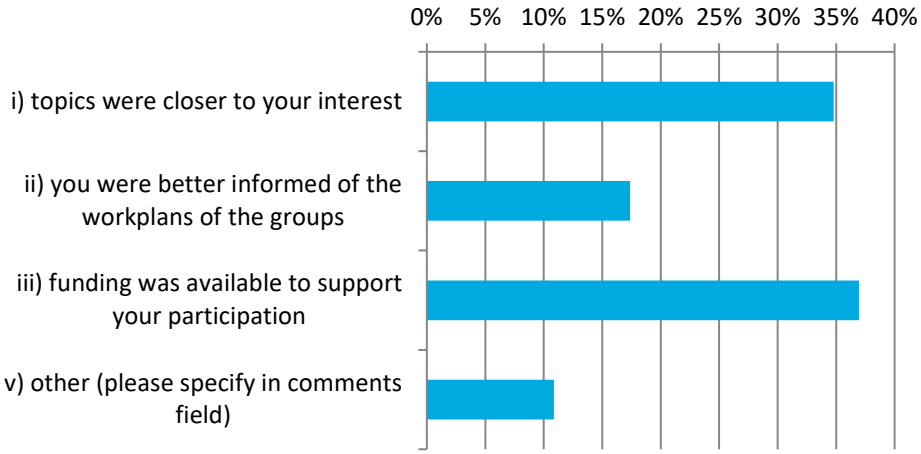


4. Participation in ICES Working Groups. Are you a member of an ICES working group (WG)?

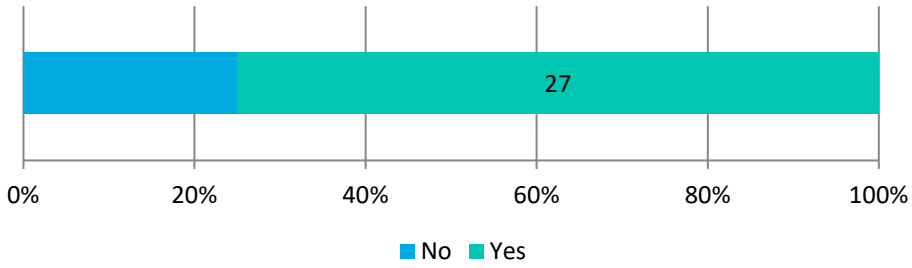


4.a) If yes, please specify: WG name and the number of meetings you attended in the last 5 years (both in-person and remotely) for each working group cited

4.b) Would your participation in ICES Working Groups increase if (please select the two most important):



4.c) Would you be interested in participating in an interdisciplinary integrated ecosystem assessment (IEA) group?



4.c.1) If yes, in which region?

4.d) Do you have any other recommendations for guiding the work of WGECON?

1. Ensuring practical and policy applications are carefully kept in mind
2. Focus on the primary challenges facing fisheries management and their sustainability (as opposed to secondary topics that are already being studied by fisheries economists).
3. I think the economists should be included to some actual advisory task of ICES.
4. "Question 4c is a good example of communicating the need for economics in ICES. How does economics fit into this and what added value does it provide against other economic work?
5. To work in close cooperation with existing bodies such as STECF or FAO
6. Try to establish a framework to estimate socioeconomic assessment beyond the (traditional) bioeconomic models and tailor it with regional adjustments
7. WGECON is doing well; please keep doing what you have been doing

6 Future work

Future ICES WGECON work will continue to enhance the economic dimension to be an integral part of marine science and scientific advice regarding the use and conservation of marine resources. This is based on the still increasing demand for science and advice to address economic considerations, and the observation that ICES does only to very limited extent engage economists and address economic issues in many member countries in its existing work. WGECON members have agreed on the importance of integrating economics in ICES science generally, but have highlighted the importance of identifying and reviewing the specific problems that can be addressed, as this leads to a more concrete discussion on the applied contributions of economic research. Also, the group has emphasized the use of demonstrators of the ways in which such problem identification and analysis of relevant economic research, methods, tools and data can be implemented to meet the problems.

WGECON will continue for a new 3-year term 2021–2023.

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WGECON 2020 meeting

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WGECON 2019 meeting

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WGECON 2018 meeting

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Annex 2: WGECON Resolution

The Working Group on Economics (WGECON), chaired by J. Rasmus Nielsen, Denmark; Olivier Thebaud, France, and Arina Motova, UK, will be established and will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2018	11–15 June	ICES HQ, Copenhagen, Denmark	Interim report by 25 August	
Year 2019	11–14 June	Paris, France		
Year 2020	15–19 June	by corresp/ webex	Final report by 20 August	- Change in Chair: Outgoing: Hazel Curtis, UK Incoming: Arina Motova, UK

ToR descriptors

ToR	Description	Background	Science Plan codes	Duration	Expected Deliverables
a	To map the current work and identify future needs for economic science in ICES, giving consideration to useful connections to international marine/ fisheries economics organisations such as IIFET, NAAFE and EAFE.	This is mostly scoping exercise within ICES, but also ensures coordination of activities with other international bodies and links to the wider scoping work in the Strategic Initiative for the Human Dimension (SIHD).	6.3; 6.4; 7.3	Years 1, 2	Annual reporting
b	To identify and report on economic data gaps that point to priorities for longer-term data collection, research, institutional needs, and researcher training in all ICES member countries; and where possible propose systems to collect missing data.	To aid prioritisation of data collection to enable quantitative analyses and estimates of economic issues for ecosystem overviews and future advice requests. The ToR also links to ICES Data Centre.	3.1; 3.2; 4.2	Years 1, 2	Annual reporting
c	To define and report on the information flow needed to provide economic analysis of trade-offs relating to ecosystem-based management of fishing.	To develop a system to support potential future advice requests and development of ecosystem overviews	5.3; 6.1; 7.6	Years 2, 3	Annual reporting
d	To assess and report on the economic significance of commercial fishing for	To support future potential advice requests and	6.6; 7.1; 7.2	Years 2, 3	Annual reporting, potentially also scientific manuscript

selected coastal regions in the ICES area	development of ecosystem overviews

Summary of the Work Plan

Year 1	Start mapping the current work and identify future needs for economic science in ICES (ToR a) and identifying economic data gaps (ToR b). Briefly brainstorm and discuss ideas on how to address and organise work under the remaining ToRs in year 2. Ensure establishing close connections with other relevant groups within and outside ICES. Producing Interim Report.
Year 2	Progress work towards completion of ToR a) and ToR b). Start work on defining the information flow needed to provide trade-off analysis (ToRc) and assessing the ecocomic significance of commercial fishing (ToR d). Producing Interim Report.
Year 3	Finalise ToR c and ToR d, incl. the manuscript. Discuss and plan strategies and concrete steps for future work. Produce Final Report.

Supporting information

Priority	Nations are concerned about fish stocks and marine ecosystems not least because they can contribute to human wellbeing; therefore, these natural resources have an economic value. The economic dimension should be an integral part of marine science and scientific advice regarding the use and conservation of marine resources. Demand for science and advice to address economic considerations is increasing, but ICES does not engage many economists or address economic issues in many member countries in its existing work. The efforts of the Strategic Initiative on the Human Dimension (SIHD) with ICES have served to raise the profile of economics in the last few years, but, with a few exceptions, SIHD efforts are not comprehensively supported and informed by the work of the ICES EG. Further, none of the existing EG that address economic issues are focusing on the development of economic metrics and core economic analyses that are demanded in parts of the ICES network (e.g. further development of ecosystem overviews) and, in some cases, by clients for ICES advice. The need to expand the engagement of ICES in economics was also reflected in the outcomes of many recent meetings, especially the "Understanding marine socio-ecological systems" (MSEAS) Conference which ICES co-sponsored in Brest in 2016. Others drivers include high level aspirations for Blue Growth in European countries and globally, the interest in managing fisheries for Maximum Economic Yield and a desire to understand economic consequences of human-induced changes in the sea (WGHIST). There is also recognition in ICES, and from our clients, that it would be desirable to add economic metrics to ICES ecosystem overviews and better recognise people and their livelihoods as part of the ecosystem. Further, in the longer term, ICES growing engagement in aquaculture science will likely lead to overviews of aquaculture activity that will also require economic inputs.
Resource requirements	The group will rely on ongoing international and national research projects with active involvement of WGECON members.
Participants	This is a new Group, expected to be attended by some 20–25 participants.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are currently no linkages with ACOM, but the EG will be ready to address advisory requests if these are forthcoming.

Linkages to other committees or groups	The subject area of this EG has close linkage with at least the following ICES groups: WGMIXFISH, WGSEDA,WGIMM, WGRMES, WGNARS, WGHIST and the Strategic Initiative SIHD.
Linkages to other organizations	International Institute of Fisheries Economics and Trade (IIFET), North American Association, of Fisheries Economists (NAAFE), European Association of Fisheries Economists (EAFE), EU Scientific, Technical and Economic Committee for Fisheries (STECF), Food and Agriculture Organisation of the United Nations (FAO)

Annex 3: Lead, co-lead and reviewers of issue reviews

Issue No.	Issue title	Lead	Co-lead	Reviewers
1	TAC setting in output-based management systems	Arina Motova	Jarno Virtanen	Claire Macher, J. Rasmus Nielsen, Raul Prellezo, Renato Rosa
2	Adjustment of capacity to resource potential	Jarno Virtanen	James Innes	Alan Haynie, Arina Motova, Raul Prellezo
3	Fishing rights allocation	Peter Greene	James Innes	Hazel Curtis, Jarno Virtanen, Olivier Thébaud
4	Mixed species fisheries management	J. Rasmus Nielsen	Renato Rosa	Angela Muench, Claire Macher, Katell Hamon
5	Links between catch sector and markets for fish	Fabienne Daurès	Gustav E. Blomqvist	José Luis Santiago Castro-Rial, Peter Greene, Rasmus Nielsen
6	Sustainability of Small Scale Fleets	Gustav E. Blomqvist	Fabienne Daurès	Angela Muench, Arantza Murillas, Staffan Waldo
7	Data Limited Situations – fleets, fish stocks	J. Rasmus Nielsen	Gustav E. Blomqvist	Ralf Doering, Sakari Kuikka
8	Diversification and commercial fishing-aquaculture connections	Staffan Waldo	Leyre Goti	Arina Motova, David Castilla Espino, Fabienne Daurès, Gustav E. Blomqvist
9	Shared stocks management	James Innes	Olivier Thébaud	Alan Haynie, Juan José Garcia del Hoyo
10	Ecosystem services evaluation	Leyre Goti	Peter Greene	Arantza Murillas, David Castilla Espino, Sebastian Villasante
11	Area-based and spatial management	François Bastardie	Renato Rosa	James Innes, Katell Hamon, Peter Greene