This project has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under grant agreement no. 773713

Deliverable No. D 4.1

Key management needs and scenarios

PAradigm for Novel Dynamic Oceanic Resource Assessments

Grant agreement No: **773713**
Project funded by the European Commission within the Horizon 2020 Programme

Start date of project: **1st May 2018**
Duration: **48 months**

Deliverable D 4.1

Key management needs and scenarios

Due date of deliverable: Project month 8, 31 Dec 2018

Actual submission date: 31 December 2018

Dissemination Level: CO[1]

Type of deliverable: Report, confidential

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[1] PU: Public, PP: Restricted to other programme participants (including the Commission Services), RE: Restricted to a group specified by the consortium (including the Commission Services), CO: Confidential, only for members of the consortium (including the Commission Services)

The PANDORA Project

The Blue Growth of European fisheries is at risk due to over-exploitation, unforeseen changes in stock productivity, loss of markets for capture fisheries due to aquaculture, future trade agreements opening European markets to external fleets, and fluctuations in the price of oil and other business costs. All of these risks need to be considered when providing advice needed to sustainably maximize profits for the diverse array of fisheries operating in European waters and to help safeguard the benefits this sector provides to the social coherence of local, coastal communities.

PANDORA aims to:

1. Create more realistic assessments and projections of changes in fisheries resources (30 stocks) by utilizing new biological knowledge (spatial patterns, environmental drivers, food-web interactions and density-dependence) including, for the first time, proprietary data sampled by pelagic fishers.
2. Advise on how to secure long-term sustainability of EU fish stocks (maximum sustainable /"pretty good" and economic yields) and elucidate tradeoffs between profitability and number of jobs in different fishering fleets. Provide recommendations on how to stabilize the long-term profitability of European fisheries.
3. Develop a public, internet-based resource tool box (PANDORAs Box of Tools), including assessment modelling and stock projections code, economic models, and region- and species-specific decision support tools; increase ownership and opportunities for the industry to contributute to the fish stock assessment process through involvement in data sampling and training in data collection, processing and ecosystem-based fisheries management.

The project will create new knowledge (via industry-led collection, laboratory and field work, and theoretical simulations), new collaborative networks (industry, scientists and advisory bodies) and new mechanisms (training courses and management tools) to ensure relevance, utility and impact.

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Deliverable data	
Project / Grant Agreement Number	773713
Project title and acronym	PAradigm for Novel Dynamic Oceanic Resource Assessments - PANDORA
Type of action:	RIA, Research and Innovation action
Call identifier:	H2020-SFS-2017-2
Topic:	SFS-21-2016-2017 Advancing basic biological knowledge and improving management tools for commercially important fish and other seafood species
Starting date:	01.05.2018
Duration:	48 months
Work Package(s) / Task(s):	WP 4 (Management Options)) / Tasks 4.1 (Definition of key management questions)
Lead beneficiary:	DPPO
Main author:	Claus Sparreohn (DPPO)
Co-authors:	Stefan Neuenfeldt (DTU Aqua), Vera Köpsel (UHAM), Pierre Failler (UoP)
Date of delivery:	31.12.2018
Deliverable type:	Strategy/plan
Date of internal approval (for the submission to EC)	
Approved by: (name)	
Keywords:	Ecology, Marine biology, Fishery, Ecosystem-based fisheries management, socio-economics, stakeholder engagement, external communication, outreach, dissemination

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Document history

Version	Date	Description

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List of symbols and abbreviations

WP	Work Package
T	Task
DoW	Description of Work
MSY	Maximum Sustainable Yield
MEY	Maximum Economic Yield
SE	Stakeholder Engagement
TAC	Total Allowable Catch
DST	Decision Support Table
MSE	Management Strategy Evaluation
MP	Management Plan (or Management Strategy)
SSB	Spawning Stock Biomass
B_{lim}	Biomass reference point
$MSY_{Btrigger}$	Biomass reference point
$F_{0.05}$	The fishing mortality that leads $SSB>B_{lim}$ with 95% probability in the long term
F_{msy}	Either the fishing mortality that leads to MSY or $F_{0.05}$
HCR	Harvest Control Rule

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Table 1*:* Case Studies of species and fisheries.

Table 2: Questionnaire output

1 Executive summary

1.1 Introduction

Marine fisheries management now needs to optimize catches and profits while accounting for variability in productivity, species interactions, density-dependent effects on growth, and spatial distribution of fish. Besides stock assessments ('counting fishes'), stock simulations generating total allowable catches (or effort) and reference points are corner-stones of practical management. To meet the current challenges, Maximum Sustainable Yield (MSY) simulations conducted by Management Strategy Evaluations (MSEs) must be improved by applying an iterative approach that includes new information on both the biology and ecology of stocks (factors affecting mortality rates and carrying capacity) as well as the economic and social priorities of fishers (for more robust estimates of profitability and jobs). A step change in improvements in stock assessment tools and projections is now possible given recent technological and methodological advances in research such as genetics (stock discrimination, effective and absolute population size, fisheries-induced evolution), ecophysiology (cause-and-effect understanding of habitat utilization and climate impacts) and biotelemetry (small- to large-scale patterns of movement and habitat utilization). Moreover, there is a wealth of information from at-sea monitoring of catches and locations of fishing vessels (dynamics of fleets and their catches, fishers' behaviour) and improved mathematical models utilizing the increasing computer capacity. Nonetheless, a critical need exists to develop and implement tools which make it possible for advice and management to apply MSY within a multi-fleet and multi-species context. PANDORA is designed to harness the best available information to build and implement tools to increase the sustainability and long-term profitability of fisheries in EU waters as well as in international waters covered by the North-East Atlantic Fisheries Commission and the General Fisheries Commission for the Mediterranean.

To provide the scientific evidence and tools necessary for management to address current challenges, PANDORA has assembled a multi-disciplinary team of oceanographers, biologists, economists, stock assessors, fishery advisors and industry and Regional Fisheries Management Organisations (RFMO) to create a step change in our ability tomanage and increase the long-term profit from European fisheries resources. The specific objectives of PANDORA are:

1) Create more realistic assessments and projections of changes in fisheries resources (30+ stocks, Table 1) by utilizing new biological knowledge (spatial patterns, environmental drivers, food-web interactions and densitydependence) including for the first time proprietary data sampled by fishers.

2) Advise on how to secure long-term sustainability of EU fish stocks (maximum sustainable/'pretty good' and economic yields) and elucidate tradeoffs between profitability and number of jobs in their (mixed demersal, mixed pelagic and single species) fisheries fleets. Provide recommendations on how to stabilize the long-term profitability of European fisheries.

3) Develop a public, internet-based resource tool box, including assessment modelling and stock projections code, economic models, and region- and species-specific decision support tools; increase ownership and contribution opportunities of the industry to the fish stock assessment process through involvement in data sampling and training in data collection, processing and ecosystem-based fisheries management.

These three objectives have to be understood as inter-connected, i.e. asessments have to be hand tailored to fit advice in a way that ideally should be reproducable by interested parties in the public. This deliverbale summrises the state of the art based on recently concluded EU project MYFISH and outlines, how PANDORA will continue to improve scientific advice in fhjsieres and ecosystem-based fisheries management. This is outlined based on the survey conducted in PANDORA, the perspectice from the industry and the economics perspective separately. This report will be used in the second round of consultations wiht stakeholders in the PANDORA case study regions as basis for dicsussion and further development.

1.2 Defining the Challenge

The main objetive of the management work in PANDORA is to develop management scenarios that provide suitable options for ensuring the sustainability of the case study fisheries. This work will recursively draw on the findings of the work on biological knowledge (WP1), the stock assessment modelling work (WP2), as well as the economic work in WP3. At this stage, it is important for the flow of work and information in the project to define a set of considerations important for management scenario formulations that are specific for the focal species in PANDORA. The challenge is threefold.

First, the project has to build upon existing knowledge and codes of conduct in order to guarantee consistency in the scientific information that flows from H2020 projects to society and industry. This knowledge has subsequently to be expanded in a manner that is compatible with existing management routines and benchmarling procedures to secure its application.

Second, perverse economic incentives and organizational shortcomings, not yet really accounted for, should be adressed right from the start. There are some possible expansions of existing management routines that might not be readily integrated, but PANDORA aims to prepare the next generation of fisheries management as far as possible.

Third, there is a bulk of biological knowledge that is presently not only unapplied, but does not fit into the existing assessment and management routines. PANDORA's foci on spatial disitrbutions, density dependence, foodweb interactions and environmental forcing need to be inserted into stock assessements and management in a meaningful way, for example in short-, medium, or long-term projections or as narratives informing the decision-makers in a non-quantitative manner.

1.3 Approach

A first important step for co-framing PANDORA and gathering input for various deliverables (especially D1.1 and D4.1) has beeen the **informal dialogue** in the form of face-to-face or virtual conversations among the project partners and with individuals in the case studies' existing regional stakeholer networks. Topics of conversation in this context region-specific developments in fish biology/ecology as well as gaps in current stock assessment methods and fisheries management practices. These informal consultations have been carried out at the start of the project a, but will be a continously ongoing part of the activities through which PANDORA engages with its stakeholders.

An important scoping tool are **survey questionnaires** that are distributed among different stakeholder groups. To increase the efficiency of this survey, two separate questionnaires have been designed and distributed; one for fishers/fisheries managers/policy- and decision-makers/NGOs in the Case Study regions focusing on biological/ecological developments and management practices (*cf*. deliverabale 5.2, Appendix 2), and second one for stock assessment scientists focusing on the stock assessment process (*cf*. deliverabale 5.2, Appendix 3).

The survey was carried out in a number of consecutive steps.

1. ***September 2018***: survey questionnaire S1 was distributed to the Case Study leaders of the PANDORA project for initial input in.
2. ***October 2018***: survey questionnaire S1 is circulated among the regional networks of the Case Study leaders for input from fishers/fisheries managers/policy- and decision-makers/NGOs in the Case Study regions.
3. ***September/October 2018***: survey questionnaire S2 is sent to the Working Group Chairs of relevant stock assessment groups within ICES and the Mediterranean for further distribution.

The recently completed MYFISH project has **summarised** the scientific advances on MSY in general rules for the implementation of MSY management reflecting the general preference of stakeholders, managers and policy makers for flexibility, such as ranges of objectives, rather than points and for 'pretty good yield/ optimal yield' rather than maximum yield. An operational framework involving sequential steps was developed and put into practice across five regions. PANDORA takes the MYFISH output as a starting point for exploring management needs in its case studies.

For further co-creating of the scientific work in PANDORA, this deliverale report will be presented and discussed in the next round of regional stakeholder workshops in the case study areas.

2 Scoping of Management Key Questions and Scenarios

The work in PANDORA is conducted using Case Studies representing the broad regional differences in available tools and data, as well as important differences in European fished stocks, their habitats and their fisheries (Table 1). In the **Mediterranean Sea**, 85% of the few assessed stocks are currently overfished compared to a maximum sustainable yield reference value (MSY) while populations of many commercial species are characterized by truncated size- and age-structures. Rebuilding the size- and age-structure of exploited populations is a research objective that combines single species targets such as MSY with specific goals of the ecosystem-based approach to fisheries management, preserving community size-structure and the ecological role of different species. The result will be advancements transferable to most (if not all) commercially important European fisheries. In the **Bay of Biscay**, a range of species are exploited as target or bycatch in multi-species fisheries, though only a few stocks are analytically assessed. Many stocks constitute potential choke species (once quota for this species is hit, fishers have to discontinue operations due to the landing obligation), in particular while stocks rebuild. More realistic assessment models will allow reduced uncertainty buffers in Total Allowable Catches (TACs) and hence reduce their effects as choke species. The **Northwestern European Shelf** case study region in PANDORA comprises the sea areas west of Scotland and Ireland (ICES subarea 6a, 7b,c) and the northern North Sea (ICES IVa), which provide important spawning, feeding and nursery areas for some of the most abundant pelagic fish in the NE Atlantic; namely mackerel, herring, blue whiting and western horse mackerel. Priorities for conservation and managing these stocks at MSY necessitate improved understanding of the degree of mixing, fidelity to spawning areas and the ecological drivers determining their abundance, distribution and body condition. Mackerel, the single most valuable (and abundant) pelagic stock, spawns in waters of the western shelf edge, migrating north to northern Norway and west as far as Greenland during the summer and back southward in winter. The exploitation of this stock is highly valuable to many fleets of Europe, as well as Norway, Faroe Islands, Iceland and Greenland. A wide variety of commercially important species inhabits the **North Sea** leading to a complex food web structure and mixture of fisheries with strong technical interactions (more than one species are caught simultaneously and one species may be fished by different gears). Several stocks that have analytical assessments show decreasing fishing mortalities in recent years and biomass recovered above reference levels (e.g., cod, plaice, sole). However, many stocks are still categorized as data-poor, being landed primarily as bycatch and/or inadequately sampled by existing scientific surveys and/or commercial sampling programs. Management in the North Sea will benefit from improved information on sub-stock definitions (e.g. cod or Nephrops), exchange rates, spatial extent, predator-prey interactions and other factors governing dynamics, while data-poor stocks require the development of improved monitoring strategies to aid in their assessment and management. In the **Eastern Baltic Sea**, cod, herring and sprat fisheries constitute about 80% of the commercial catches. The Common Fisheries Policy foresees that these three species are managed accounting for cod predation in a multi-species approach. However, there is currently no population model for cod, since age-reading is impossible. Hence, natural mortality rates for herring and sprat have to be considered outdated. Furthermore, the invasive round goby is spreading, and its potential commercial importance is unknown.

***Table 1**: **Case Studies of species and fisheries.** Fisheries: Longline (LL), purse seiner (PS), trap (T), Ottertrawl (OT), static nets (SN), Trawl (TR), Set nets (SN), Gillnet (G), Demersal trawl (DT), Pelagic seine (PS), conventional gear (CG), pelagic trawl (PT), Beam trawl (BT). **Current management methods:** Total Allowable Catch (TAC) (1), effort (2), spatial measures (3); **Current assessment methods:** VPA-type (VPA), Data-poor (Poor), Multispecies (Mult), Statistical methods (Stat), not developed (Develop); **Current biological knowledge**: Spatial structure (S), food webs (F), density dependence (D), environmental drivers (E) indicated by traffic lights: red – poor knowledge, yellow – not implemented in current projections, green – knowledge currently used for projections.*

Case Study	Species	Fisheries	RFMO or IFO	Current Management method	Current Assessment method	Current Biological knowledge S F D E

Mediterranean (Lead: Patricia Reglero, IEO)	bluefin, albacore	LL, PS, T	ICCAT	1	VPA, Poor				
	hake, rose shrimp, red mullets	OT, SN, LL	GFCM	2,3	VPA				
	mackerel, jack mackerel, sea Breams	TR, PS, SN	GFCM	2	VPA				
Bay of Biscay (Lead:Verena Trenkel, Ifremner)	red seabream	LL, OT	EC	1	None				
	thornback, cuckoo, spotted & blonde rays	TR, G	EC	1	Poor				
North-western European Shelf (Lead: Chevonne Angus, UHI)	mackerel	PT	NEAFC, EC	1	VPA				
North Sea (Lead: Alexander Kempf, TI)	cod, haddock, saithe, whiting, sole, plaice hake	OT, BT, G	EC / Norway	1, 3	VPA, Stat				
	mackerel, herring, sprat	PS, PT	EC / Norway	1, 3	VPA				
	horse mackerel, brill, turbot	-	EC / Norway	1	Poor				
	shrimps (Crangon crangon)	T	EC	-	Develop				
Eastern Baltic Sea (Lead: Rüdiger Voss, CAU)	Cod	TR, G	EC	1,3	Mult, Stat				
	herring, sprat	TR, G	EC	1	Mult, Stat				
	round goby	-	EC	-	Poor				

EC= European Commission, NEAFC = North East Atlantic Fisheries Commission (RFMO), GFCM = General Fisheries Commission for the Mediterranean (RFMO), ICCAT= International Commission for the Conservation of Atlantic Tunas (IFO)

The **Baltic Sea case study** in MYFISH focused on the trade-offs between having a large stock and catch of valuable cod, which consume herring and sprat, or a smaller stock of cod together with a higher stock of sprat and herring as a smaller percentage of these fish are then eaten by cod.

The DST for the Baltic Sea accounts for species interaction (i.e. cod predation on herring and sprat). The table shows two potential management options and their respective outcome for cod, herring and sprat in terms of spawning stock biomass, catch, total profits, distribution of profits to the fisheries (evenness), as well as fishing mortality. Options are chosen to achieve a sprat spawning stock biomass respecting current biomass limit values applied in the management for this stock.

These results were discussed in detail at a joint meeting of the Baltic Sea Advisory Council (BSAC), Myfish and its sister project SOCIOEC (Socio Economic Effects of Management Measures of the Future CFP, www.socioec.eu) (http://www. socioec.eu/media-centre-4/socioec-press-release). The results were discussed while keeping the current problematic status of the eastern Baltic cod stock in mind. There was agreement that even though there may be current problems, there is still a need to agree on long term targets for the Baltic Sea. A structure where scientists provide advice on the combination of management targets, which were considered sustainable and would provide yields reasonably close to the estimated MSY was considered to be a potentially useful route forward. One option to provide some flexibility for decision makers is to use MSY ranges. Following the meeting, Myfish contributed to the development of F_{MSY} ranges for the major Baltic stocks through the joint ICES/Myfish workshop on the topic and these ranges were subsequently used as input for the draft Multiannual Plan for the Baltic Sea.

The models developed in MYFISH will be used in PANDORA to provide advice on the consequences of aiming for different combinations of fishing mortality within these ranges.

In the analyses of issues relevant to implementation of MSY management, nearly all restrictions were expected to lead to a substantial loss of income, number of vessels and employment. There was lack of satisfaction with regulations, stock improvement, collaboration with science and participation in decision making. The development of scientifically-based 'what if' scenarios represented a major vehicle for discussion of potential ecosystem developments and importantly trade-off options, exemplified in DSTs, seen from the perspectives of multiple stakeholder groups. However, the Baltic Sea currently lacks a cohesive regional forum for bringing together scientific advice, consultation and dialogue, and eventual decision-making.

During MYFISH discussions, it became obvious that basic conservation goals, e.g. the need for minimum stock sizes, are largely undisputed, while the path towards sustainable use is controversial. There are a number of 'beyond-profit' interests in fisheries: enhanced stability and resilience as well as reduced uncertainty are key objectives which have been raised both from fishing industry and from nature conservation (i.e. environmental NGO) representatives. There was, however, no comprehensive agreement on how far into ecology (e.g. species interactions, ecosystem considerations) fisheries management should go. Furthermore, it was especially pointed out by the fishing industry that science should see its role in elaborating and displaying the costs and benefits of various scenarios/options, and leave decision-making to the policy system, i.e. scientists should act as ‘honest brokers’.

The request for longer time perspectives and enhanced stability of fishing opportunities and reduced uncertainty is encompassed in the draft Multiannual plan (MAP) proposals for the key commercial Baltic Sea fisheries. The proposals leave space for trade-off analysis, as the fishing mortalities (F_{MSY}) are provided as a range of values for each of the stocks, instead of a non-negotiable F_{MSY} point estimate. Within this range, the ecosystem will provide a ‘pretty good yield’, and in doing so provide a practical and acceptable solution for the combined fisheries. This has to be considered as a first step only, as the task of fully incorporating species interactions as well as socio-economic considerations remains open. As the Baltic ecosystem, including its socio-economic aspects, are frequently changing due to the influence of various human and naturally induced drivers, it is prudent to regularly review, revise and adapt the above-mentioned multispecies MAP. MSY/MEY value estimates are dependent on the changing status of the ecosystem and the agreed MAP needs to anticipate these changes.

In the **eastern Mediterranean case study of MYFISH**, the multi-species bottom trawl fisheries that exploit the demersal resources of the Aegean Sea, also relevant in PANDORA, were considered. The medium term effects of various input control management measures on economic MSY variants were examined, taking into account biological (i.e state of key stocks) and social constraints (sustainability of the jobs in the fisheries sector). The DSTs summarised the comparisons among temporal closures, capacity reductions and gear selection changes. Effort reductions implied through temporal closures seemed to be the more realistic scenario as they seem to improve profits per vessel, satisfying to a large extent the biological and social constraints. Drastic capacity reductions would decrease the ecosystem impact of the fisheries and also lead to high profit increases in the medium term, but subsidies may be necessary for their application.

During a MYFISH meeting with stakeholder representatives from the Pan-Hellenic Union of Middle-Range Ship Owners, the MSY variants identified to have the highest priority were related to production and income based on key-species composing the main bulk of catches in the area. Input control schemes were considered to be the most appropriate management tool, and preference was given to effort controls and temporal fishery closures as management measures. Two types of constraints were identified as being most important: (a) biological constraints that included the state of key stocks; and (b) socioeconomic constraints that were focusing on the sustainability of the jobs in the fisheries sector and in the maintenance of small fishing communities.

DSTs were presented and discussed during the annual meeting of the Union gathering app. 100 participants. Although the stakeholders generally agreed with the main outcome that additional effort cuts would be beneficial in the short/medium term, they claimed that under the current financial circumstances it is impossible to maintain the viability of the fisheries if additional management measures are imposed without subsidies. The communication with stakeholders suggested that the management tools used were generally accepted but improvements are needed in the decision making approach. For instance, it was broadly accepted that stocks and fisheries should be managed through input control schemes, but there was a lack of transparency and participatory mechanisms when it comes to planning and adopting specific measures. It was, however, difficult to identify commonly agreed harvest control rules given that management objectives are prioritized differently among stakeholders. Nevertheless, participatory structures would at least improve transparency and ensure a certain degree of acceptability of management decisions among stakeholders.

In the **North Sea case of MYFISH**, MSY variants compatible with a multi species and mixed fisheries context were defined, and the potential biological and economic consequences of reaching these alternative MSY targets were assessed. Results showed that sustainable multi species exploitation levels may be very different from those defined in a single species context. Lowering exploitation rates for all stocks may not solve all problems. Some stocks may suffer from increasing predation, for example by cod and saithe. MYFISH also showed that ecosystem conservation can be compatible with economic optimisation. With the imminent implementation of the landings obligation, the mixed fisheries context will become increasingly important in management. Fisheries will be constrained when they do not have enough quota for every species they catch.

Overall, a “Pretty good yield concept”, as envisaged in PANDORA, may be more suitable than trying to reach the absolute maximum of each component in a range of incompatible objectives. Sustainable ranges for FMSY in accordance with the pretty good yield concept are one option in this respect. The aim would be to keep all stocks within their individual sustainable ranges leading to pretty good yield (e.g., at least 95% of the maximum) instead of trying to fish all stocks simultaneously at their stock specific FMSY point estimate. This may lead to a broader interpretation of the MSY concept because ranges could also include sustainable fishing mortalities above FMSY but provides room to find compromises and allows minimizing the effect of choke species under the landing obligation. At the same time it gives a framework for policy makers to restrict the negotiation space to sustainable options.

ICES and MYFISH were tasked with identifying possible ranges for a number of stocks, using a standardised framework. These elements are the backbone of regional mixed-fisheries management plans currently being developed. For the North Sea, STECF evaluated with support from the MYFISH community that FMSY ranges could lead to more flexible sustainable management of mixed-fisheries, provided that TACs are not blindly set at the maximum of the range each year. However, the upper limits should be used only in well justified circumstances to avoid e.g., unacceptable losses in yield because of the choke species problem during the first years of the implementation of the landing obligation.

Another advantage of FMSY ranges is that they are more robust as management target than point estimates. Sensitivity tests carried out in MYFISH revealed that the point estimates of FMSY depend on environmental factors (e.g., productivity of stocks, eutrophication, abundance of predators), the assumed effort-catch relationship, type of optimisation (singles species vs. multi species) and the choice of the model. However, estimated FMSY or FMEY point estimates remained inside the ICES sustainable ranges in many cases even when conditions varied.

Aiming for MEY rather than MSY led to lower fishing effort in both North Sea sub-case studies and as such was more beneficial for by-catch species, benthic habitats and the size structure in ecosystems. However, as discussed above, employment and market opportunities most likely suffer when aiming for MEY. Among fishermen operating in the southern North Sea flatfish and brown shrimp fisheries, 25% agreed to change fishing areas to avoid catching sensitive rays whereas another 38% would discard the species due to their perceived high discard survival.

Before ecosystem aspects can be implemented in management plans, reference points or ranges have to be agreed. Although for many species, suggestions are available from ICES working groups or MYFISH, an official acceptance of such reference points has not been achieved so far. Therefore, an official agreement (also in conjunction with the MSFD) on reference points besides the main target stocks in the North Sea is needed as a first implementation step.

The current approach to manage fish stocks by TACs is seen by interviewed fishermen to be the most effective. However, management by TACs is complicated under the landing obligation and some fishers felt that the current TACs do not correspond to the fishing opportunities and that discards are primarily an effect of a mismatch between TACs and fish population sizes and a decrease in the amount of complex technical measures was seen as a potential improvement.

An important outcome of Management reflection workshops was the view that science should not make the decisions but should provide advice on the range of potential options within a sustainable exploitation space. It is then up to other stakeholders groups to make final decisions. In the MYFISH approach, different stakeholder groups were included from the beginning to enable discussions on difficult trade-offs and to provide options for a sustainable exploitation. Overall, MYFISH gave insights on how inclusive governance can help in difficult political processes to reach consensus and how science can be used to make informed decisions inside a multi-dimensional trade-off space.

Implementing the landing obligation for mixed fisheries is more complicated in Europe than in other parts of the world because of the “relative stability” principle. This principle ensures that each year countries achieve the same quota shares based on historical fishing rights of a given stock. This may lead to situations where fishermen cannot adapt their landing rights to the expected catch composition. In the case study on the mixed demersal roundfish fishery, the losses in yield and NPV were substantial in comparison to a system where at least redistributions inside a country were allowed. Currently a system of quota swapping is used to overcome the limitations caused by the principle of relative stability. However, it is unclear how such a system of voluntary quota exchanges will function under the landing obligation. Discussions on the relative stability principle may be needed again at the next CFP reform in case the implementation of the landing obligation suffers from insufficient flexibility.

3 Questionnaires scoping in PANDORA

An important early part of PANDORA’s stakeholder engagement activities was the conduction of a survey about regional changes in fish biology/ecology and management needs in the project’s case studies. The survey questionnaire was distributed to a range of stakeholders such as fishermen associations, NGOs, policy-makers and ministry staff in PANDORA’s Case Study areas.

Questions posed to the stakeholders:

1. What species and stocks are of greatest interest to you?
2. What is your perception of the effectiveness and quality of current stock
3. Is there anything that you would like to change in current stock assessments?
4. From your perspective, what are the most pressing management issues
   a) currently
   b) potentially in the future?

5. Is there anything that you would like to change in current management practices?
6. Are any new fisheries developing in your region? If yes, for which target species?
7. Have you seen changes in the spatial distribution of certain fish stocks? If yes, which ones?
8. Have you observed any changes in fish biology (size, weight, feeding, behaviour etc.)? If yes, please give examples.
9. In your opinion, what are the reasons for the changes in fish biology that you observed?
10. Are you currently collaborating with fisheries scientists or did you in the past? If yes, please state how.
11. Do you know any examples of how data/information from fishers are used by fisheries scientists?
12. In your view, what data/information from fishers would be particularly valuable to fisheries scientists?
13. What challenges do you perceive in cooperation with fisheries scientists? Please give brief examples from your experience.
14. Are you aware of any initiatives to increase collaboration?
15. Additional to existing initiatives, which measures would increase cooperation between fishers and fisheries scientists?
16. May we contact you during the lifetime of PANDORA regarding an interview about your perspective on science-policy or science-industry cooperation?

Results from this survey are constantly being returned to the project and collected centrally by WP5 leader UHAM (P4). This section gives an overview over the current state of survey returns in late December 2018. The questionnaire database will be updated constantly for the urpose of continuously adjusting PANDORA's work to the needs of its stakeholders.

Table 2 below lists the results from the questionnaires (status December 2018):

NORTH SEA			
Species	**Current management needs**	**Future management needs**	**What should be changed?**
Important for con-sump-tion / pro-tected species	Implementing fishery regulations in Natura2000 areas; Implementing better controlling and discard ban; Aligning TACs and scientific advices; Recovery of Mediterranean stocks	Incorporating Ecosystem Based Management approaches	Implementing better controlling and discard ban
Cod, turbot, haddock, whiting, saithe, anglerfish	Implementation of the landing obligation in mixed fisheries; Find a balance between flexibility (e.g., FMSY ranges, banking and borrowing, inter species flexibility) to maintain the economic and social viability. Is it sufficient if we just manage the target stocks to reduce the level of complexity in management? Can we get rid of TACs for by-catch species? But what are the alternative management measures?	Strongly recovering stocks due to MSY based management may cause problems in the food web either via predator-prey interactions or density dependent processes; Climate change may alter the whole North Sea ecosystem. Fish stocks are expected to change distributions. This will influence the catch composition and economy of fleets and questions principles like the relative stability between countries used	TAC areas should reflect stock areas (e.g., whiting, sole in 7d); Current management system needs adaptations to cope with climate change and landing obligation; Outdated relative stability keys are major problem for implementing landing obligation and hinder climate change adaptation. Main management measure in the North Sea are TACs. Many stocks have TACs although

	Currently many North Sea stocks have a low productivity (cod, haddock, herring) despite much lower fishing mortalities compared to the last decades. What are the reasons for this? How can management adapt to this? Do we have to adapt biomass reference points or will the productivity increase again in the near future? Currently, West of Scotland ICES advice is for zero catch. Fishermen continue to experience significant catches of cod while fishing for other demersal species, particularly in the northern part of the assessment area. It is their belief that the West of Scotland cod stock consists of several components and that further work is required to determine the appropriate areas for assessment and management.	for TAC management. The productivity of fish stocks will also change. This may lead to the need to adapt reference points. Brexit could have a serious influence on the management of North Sea fisheries. A closure of UK waters for foreign fleets or changes in the relative stability keys would have a serious impact on many fleets. However, currently it is unclear what will happen. Once more information becomes available, the impact of Brexit may be evaluated in more detail.	they are bycatch only. The number of TAC stocks could be reduced, however, we need alternative management measures to ensure sustainable exploitation of stocks. A (simple) effort management (e.g., kw days are not allowed to increase above the level of a certain year any more) or closed areas in situations where species prefer certain areas, may be beneficial as alternative management tools for by-catch stocks. In general, management should be more results based instead of micro-management with complex rules. However, effective control systems are a prerequisite for successful results based management.
Cod (only)			We need ways to deal with North Sea cod in different regions of the North Sea. This includes questions about stock structure and reasons for the stock developments. Is the further decrease in the southern North Sea already a result of climate change that cannot be reverted by fisheries management?
New fisheries developing in the North Sea: Pulse trawl fisheries in the southern North Sea for sole, plaice and brown shrimp			
BALTIC SEA			
Species	**Current management needs**	**Future management needs**	**What should be changed?**
Cod, Herring, Sprat	To rebuild the cod stock. To abandon the landing obligation; alternatively, to enforce the landing obligation to create just conditions for all; Find ways to help the fishery through current bad phase.	Maintain the principle of relative stability; Refrain from ITQs; Take account of changes in distribution; Better understand changes in growth/reproduction	Be more flexible; Account for fisheries economics; Include practitioners knowledge; Move towards long-term plans in order to get more stability
New fisheries developing in the Baltic Sea: Maybe, round goby			
BAY OF BISCAY			
Species	**Current management needs**	**Future management needs**	**What should be changed?**

Hake, monkfish, common sole, pilchard, mackerel, seabass, albacore, Altantic bluefin tuna, Cuttle-fish, Sea-bass , Megrims, Mackerel, Cephalopods (Aqui-taine)	Effect of landings obligation (LO): How to reduce impact? What is the potential bias LO will inflict on commercial tuning indices used for stock assessment, e.g. because of quota being exceeded locally but not on national level, so effect of change in fishing strategy is not easy to detect? In general, dependence of our PO for species under quota (almost 80% of ship sales, in value, are species under Community quo-tas). For most quotas, full con-sumption. With the implementation of the landing obligation, the pressure will be maximum for the following stocks : - Mackerel - Horse Mackerel (both species) - Red seabream - Other stocks in the Celtic Seas (Haddock and Cod VII b-k, Plaice VIIhjk)	Maintain access to fish resource by fishers (climate change, Brexit, ...); Renewal of fishing vessels and fishers (both are ageing); Lack of visibility of future management measures Current management practices VS Landing Obligation Current management practices VS Climate change	Simplify management regula-tions The adequacy between man-agement of fishing opportuni-ties and the landing obligation; ,Better take into account the socio-economic impacts in management practices (socio-eco data, Impact study of man-agement measures).
Hake, pil-chard, monkfish, haddock, albacore (Bre-tagne)	Improve biological knowledge for Norway lobster, in particular linked to video counts of burrows which are used for direct abundance esti-mation (how many burrows are oc-cupied by how many individuals,...); Harmonize fleet definition used by scientist for mixed fisheries stud-ies and Producers Organisation for quota management (to make sci-entific results relevant); Implement multi-annual quotas (for species with stock assessment based on production models); Need im-proved definition of reference points; Improve data availability for stock assessment using fisher self-sampling etc.; Make decision support system available for local level quota management (by pro-ducer organizations) accounting for: • mixed fisheries • choke species • discards/landings obligation • socio-economic aspects	Evaluate effects of climate change on resource availability; Test and evaluate more empiri-cal methods of management es-pecially of DLS stocks (constant TAC + effort limitation)	Do not aim for annual fine adaptations via TAC modulation; Multi-year TAC with emergency review procedures
Blackspot sea-bream, sea bass, pollock	Assessment of pollack and sea bass stocks; Transmission of sim-plified stock assessment results to fishermen (not only the final quota).	Must stop fishing during the breeding season!	

New fisheries developing in the Bay of Biscay: Red porgy (Pagrus pagrus) is more and more present on our coasts. ***Bretagne***: Atlantic bonito (sarda sarda); Gilthead seabream (Sparus aurata); Blackspot seabream (Pagellus bogaraveo) (if not constrained by TAC); Atlantic bluefin tuna (Thunnus thynnus) (if not constrained by TAC)			
WESTER MEDITERRANEAN SEA			
All demersal species (hake, red mullet, deep shrimps)	Without having real management, there is no option to have management issues. So first, to have real management based on stock assessment.	To have management based on scientifically-improved stock assessment, and find tools to couple temporal assessment to spatial management (see response to next question)	Spatial management is the future for the Mediterranean Sea.
Bluefin tuna, Albacore, Bonito, large pelagic fish species	Better quality in the data that is used in current assessment models. Agreement between scientists and managers and politicians.	Adaptation to changes in spatial distribution of the stocks due to combination of climate change and fishing activity. Interactions between stocks.	Fisheries independent indices are needed. Trends between species should be compared. The quality of the reported data to the assessment models. More agreement between scientists and managers, even scientists with themselves. Simple models (but not too simple) that yield simple management options.
Bluefin tuna, albacore, coastal species targeted by artisanal fisheries and protected in coastal marine protected areas	The delay on the detection of over exploitation (some fisheries abundance indices are not updated every year), some stocks have assessment updates sporadically; The delay in the reaction to the evidencies on over exploitation, (once these evidences exist), convergence of multiple interests results in a lack of reaction by scientific committees and management authorities; International fish trading policies in EU are sometimes harmfull for local fisheries that needs to increase effort to reach a required profit, as fish market prices of local speceis get reduced (from the effect of supply/demand).	Loss of small scale fisheries from lack on generational renewal; Overcome ecosystem productivity for some species; Habitat loss; Increase of human uses and activities that are counter-productive with fisheries	Obligation for countries to provide required data to the international bodies; Better fisheries independent data; Link conservation policies (CBD for example) with fisheries policies; Link the various EU strategies with the fisheries focused strategy; Obligation for evaluating success of assessment and management with a clear obligation for adaptive management
New fisheries developing in the Wester Mediterranean Sea: New habits in the fisheries (eg. fattening to control the price in bluefin tuna). Recreational fisheries for albacore (and other tuna species). Attempts aquaculture for some tuna species (still not successful). Recreational fisheries for coastal species			
STRAIT OF SICILY			
Deep-water rose shimp, hake, red mullets,	In the last ten years Sicilian trawlers have suffered a declining in both productivity and economic performance due to several co-occurring factors such as: i) overfishing (i.e. decreasing	Competition with other fleets, lack of common management rules and approaches, uncertainty on the evolution of the ecosystem.	Enforcing the management plan adopted by the GFCM in 2016

giant red shrimp	CPUE); ìì) raising costs, iii) poor market condition (e.g. low gross prices of fish products), iv) competition with low-price sea food products; v) increased and unregulated access at the fishing grounds in international waters, vi) lack of common management rules shared between the national fleets exploiting the stocks (Italy, Malta, Tunisia, Libya, Egypt); vii) old age of the trawlers, viii) lack of marketing actions to increase the quality and value of the products.		
New fisheries developing in the Strait of Sicily: --			
AEGEAN SEA			
Hake, red mullet, deep water rose shrimp, horse mackerels	The unknown level of true effort/catches. This is attributed to the huge small scale fisheries fleet (~ 15,000 vessels) operating from more than 600 ports, making monitoring a very difficult task both for research as well as control authorities. Actually no output control measures can be applied; only technical measures such as gear configuration, MLS, spatio-temporal closures etc.	The effort based management approach implemented throughout the Mediterranean Sea, has proven to be inefficient; switching to output controls (TACs) seems the only alternative.	
New fisheries developing in the Strait of Sicily: Apparently thermophilic species are becoming more abundant (e.g. parrotfish-Scarus cretensis or spinefoots-Siganus spp.), however the consumers are still reluctant and the fishery has not started to target them. Fishing in deeper waters for red shrimps (Aristeus spp., Aristeomorpha spp.) is occurring in the recent years, however this is practiced by foreign vessels (mainly Italians) with the catches being landed in Italy. Local fishers are not yet familiar with deep water fishing.			

4 Economic Considerations

A set of economic considerations have to be considered for management purposes. There are linked to: 1°, the change of the fishing operations induced for instance by the climate change or oil price variations and; 2°, the perturbations and adaptations following the implementation of management measures such as the ITQs or the non-discarding and landing policy for instance.

While a change of price of inputs such as oil price drop or increase affects firstly the fishing unit, it consecutively touches the whole fleet (and other fleets using same fishing grounds or associated species for instance) as the revised strategy of fishing units interfere with each other. The same phenomenon occurs with the adaptation to new management measures. Fishing unit modify their behaviour to comply with measures and take advantage of new opportunities (market opportunities, gaps in measures, etc.) resulting from their implementation. This, in turn, influences the whole fleet operating system with pro-active and memetic adaptations to cope with changes and reduce externalities. Producer organisations play a key role to moderate externalities and increase the overall efficiency of the fisheries.

There are modelling possibilities to assess, at the scale of the fishing unit, the magnitude of the variation of input to the catches but overall it is rather complex to pattern externality incidences to the fleet. In the PANDORA project, some specific economic questions are addressed (see WP3 of the project). They will be altered to reflect the desiderata of the fishery managers and producer organisations.

In the context of improvement of the scientific advice, the economics will be combined with the biology around the concept of the Pretty Good Yield (presented in section 2 above) in order to provide more complete recommendations. In that regards, some modelling and economic activities will be carried on such as the one presented in this table:

Case study	**Economic modelling and analyses planned in PANDORA**
Baltic Sea	Use an age/size structured bio-economic optimization model. Can run external management strategies
North Sea	The FLBEIA model has a fully developed economic part to be parameterised with STECF data and data on Norwegian fleets.
Bay of Biscay	Analysis of economic interaction between collapse (and current increase) of high value wild stocks (blackspot seabream) and “replacement” aquaculture products (gilthead seabream, seabass) and Analysis of potential loss value in fisheries due to choke species (rays)
Strait of Sicily	From FAO-GFCM GSA 16 (South of Sicily) within the EU Data Collection Framework (DCF) Find estimates of annual landings per species per fleet, age composition, fishing mortalities, annual cost per fleet, annual revenue per fleet, annual profit per fleet.
Aegean Sea	The economic analysis will focus on the fleet interaction and the effects of oil price on profitability.
NW Mediterranean demersal mixed fisheries	Assess economic replacement potential of commercial bycatch to highly overexploited traditional target species (hake, red mullets, red shrimp); assess economic potential of local, high-value fish against imports
NW Mediterranean demersal mixed fisheries	Bio-economic projections of mixed fisheries with new reference points derived from data-poor assessment methods. STECF plus interviews with operators to disaggregate costs and revenues in time and space
Mediterranean Sea	Testing and exploring options in FLR for bio-economic analysis

Externalities will be examined in the Fishery Management WP in order to provide a holistic view of the fleet dynamism and interaction as well as Producer Organisations capacity to internaly regulate fishing unit behaviour to ensure long term profitability of the fleet. New regulation such as no-discarding and landing policy effects will also be captured from a holistic perspectives using a multi-criteria analysis. In summary, the economics of fishery will be looked at from a holistic perspective to improve its management and its overall sustainability.

5 Industry Viewpoints

Industry viewpoints presented in this section are somewhat subjective descriptions of key aspect, which are considered critical to improve fisheries management. The industry includes a large range of different viewpoints, which will be impossible to cover here. Some part of the industry prefers unregulated fishery trusting that the industry automatically will adapt to declining stocks such that rebuilding automatically will happen. Others will restrict unregulated fishery to cover certain stocks to avoid the problem of "choke" species, while again others do acknowledge the need for management such as regulatory TAC's based upon scientific advice. The viewpoints described here will be written in the context of the latter, acknowledging that scientific advice and management tools regulating the outtake of fish are needed and in the long term will benefit the fishing industry.

Total Allowable Catches (TAC's) is the key management tool for most fisheries in the PANDORA case studies. TAC's are politically decided however they are in most cases – but not all – aligned to the scientific catch advices delivered by various RFMO and IFO such as ICES. ICES aim at producing unbiased scientific catch advices based upon the best scientific knowledge available. But what is behind the term "scientific advice". In order to fully understand the nature of the scientific advice, it is important to keep in mind that all ICES catch advice is response to a request from managers, and that these requests are politically framed. Hence, a given scientific catch advice, although unbiased and based upon best available knowledge, will reflect political choices, such as exploitation level (in most cases F_{msy}), risk of stock size falling below a certain level (the aim is often to have SSB>B_{lim} with 95% probability) and a specific harvest control rule, describing the interaction between stocksize and exploitation level (reducing F when below $MSY_{Btrigger}$ in most cases). A scientific advice is a response describing consequences of applying an already political determined strategy to the stock in question. Therefore, a scientific advice does not reflect any scientific optimal fishing strategy and should not be view as such. Understanding this premises also allows for discussions on some of the choices behind the scientific advice which will be covered below.

In this document there is focus on three issues, which has been discussed both in the remedy of the Pelagic Advisory Council but also internally in the European and Danish fishing industry.

- **Rescaling stock sizes and reference points**. The point being that instability and lack of trust in the catch advice creates a system where long-term thinking is perceived risky for the industry.
- **Management Plan Evaluation.** Although thought of as tools to facilitate selecting the best future management approach, these evaluations are increasingly having focused on ensuring a plan being precautionary, on the cost of a realistic evaluation where performance parameters are meaningful.
- **Stock specific precautionary levels.** Here it is asked if the acceptable risk for a stock to fall below a given reference point should be constant for all stocks.

Beside the part with viewpoints, this section presents an objective analyse on the present status on Management Plans for relevant PANDORA stocks, and to what extent they are exploited according to F_{msy} or $F_{0.05}$.

5.1 Rescaling Stock Sizes and Reference Points

Year-to-year variation in catch advice often shows larger variations than what the fishing and processing industry can adapt to. This has long been recognized as a problem and most, if not all, management plans try to incorporate some TAC stability mechanism to mitigate this. The reason for year-to-year variations in catch advice can roughly be split into three, where variation in catch advice caused by natural fluctuation in SSB again caused by varying recruitment or uncertainty in the cohort strength, is one. The second and third reason, which will be the focus of this paragraph, is what can be refer to as the lack of stability in the scientific perception of stock size and a lack of stability in reference points. A lack of stability that leads to year-to-year rescaling of stock sizes or changing exploitation levels. The consequence of these changes is seen in the corresponding catch advice which will be uncoupled from stock development. An uncoupling which results in situations where stock can decline while catch advice increases and vice-versa.

On figure YY examples of historical rescaling of SSB for NEA mackerel and North Sea herring are shown (Pastoors, M. A. et al (forth.). "Documenting the history of stock assessments in ICES." ICES Journal of Marine Science.) For both stocks it does not appears as if stability in stock perception has increased in recent years although it is assumed that both model ability and data sources has been improved. On the contrary, especially for North Sea herring, which is considered a very reliable assessment, the problem with rescaling seems to have increased in the recent period. An increased with can be linked to the introduction of varying natural mortality used as input in the assessment. There are many and good reasons for using a varying natural mortality estimated with multispecies models, however, that it comes with a cost in terms of lack of stability, is probably perceived differently by scientist and end-users of the advice.

The lack of stability in advice and the rescaling is a fundamental problem as it undermines the trust in the advice system. A trust which is needed before the fishing industry starts to prioritize long term gain over short term profit. In a world where stock size or reference points can be rescaled without notice and hence catch advice changes independent of stock development, pursuing short time gain and not “saving” fishing opportunities for later utilization, appears to be the optimal behaviour for the fishing industry.

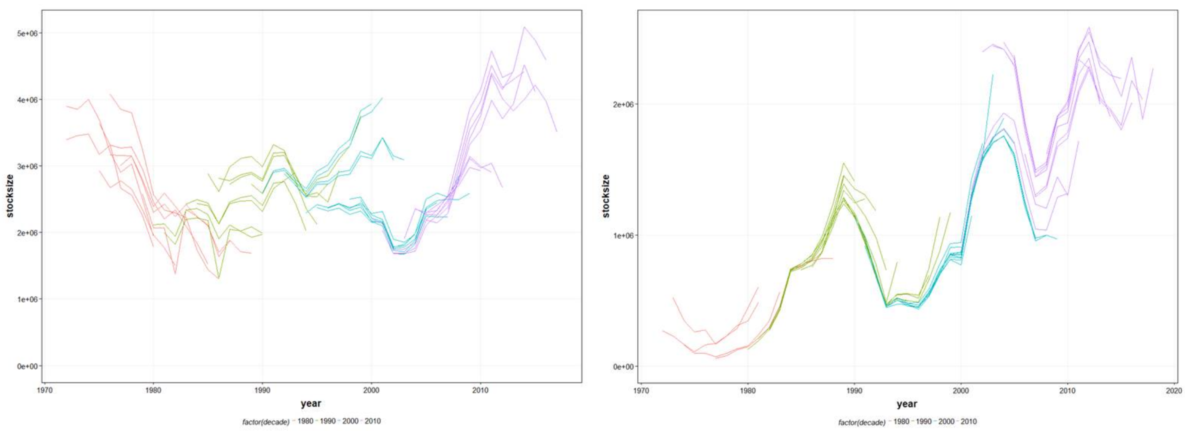

Fig. YY. Pastoors, M. A. et al (forth.). "Documenting the history of stock assessments in ICES." ICES Journal of Marine Science. Figure left is the historical perception of the stock size of NEA mackerel, where colour is decade. The stock perceptions on the right is North Sea herring.

5.1.1 Management Plan Evaluation

Within the last 10 years there has been and increasing use, and focus on, Management strategy, sometimes also referred to as Management plans. An advantage of agreed management plan is that long-term strategies gets preference over short term strategies and that discussions on the annual TAC are minimized. Discussion that are less relevant as managers and stakeholders, industry and NGO's, has agreed on the overall strategy for setting TAC's. This growing use of Management strategies has led to an increased request for evaluation of these, and several "best practice" papers have been published (e.g. Punt et al., 2016). The need for more effective evaluation has led to developments, especially when it comes to computer performance, increasing the possibility to simulate numerous scenarios with increasing precision using full feedback models. However, parallel to this development there have been shift in focus, such that Management Strategy evaluations are less about comparing alternative strategies and how these will affect stock development and future catches, to an exercise where one single specific strategy is parameterized such that it is precautionary with a probability that SSB falls below the reference points B_{lim}, being less than 5% (Rochet and Rice, 2009). However, this changing focus has also altered the underlying assumptions and the way these assumptions are selected. When comparing alternative strategies, focus can be on selection model and assumptions such that they mimic reality as much as possible. However, when using management strategy evaluations to judge if t a management strategy is precautionary or not, the model an assumption will also be selected such that the result can be judge as precautionary. The result being that assumption are not selected based on reality but based on how "precautionary" they are. One consequence of this is that implementation error is often ignored.

Figure 5 (ICES, 2018a) gives an example of what one might judge as an MSE which lack reality. It is an example of a fishery that has not utilized the quota for several years, in other words there is a considerable implementation error. Important knowledge that should be incorporated in the evaluation but is not. In this specific management strategy, it is ignored, and it is assumed that from year one in the evaluation period catches will be more than twice that observed in for recent historic catches. A catches trajectory that comes around, because of the (unrealistic) assumption that the entire TAC advice will be caught without any implementations error. Examples where the quota is set above the ICES advice are also frequent. An example of such is the Sandeel fishery in the North Sea, where a monitoring quota of 5000 t are typically given albeit the ICES MSY approach for short lived species (the escapement strategy) prescribes a zero catch (e.g. ICES, 2018b). Such a default management actions which leads to over fishery should be taken into

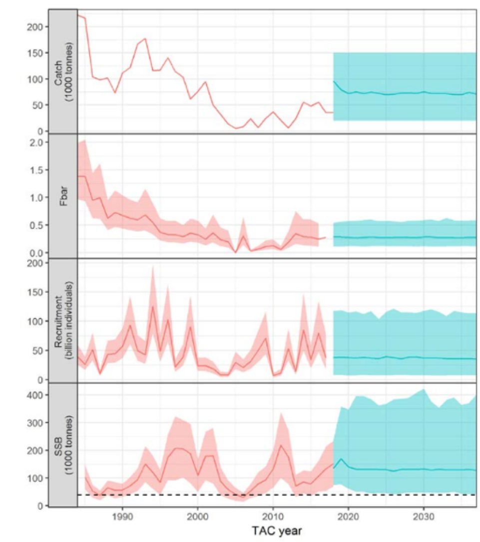

Figure 5 Summary result from the SESAM assessment of Norway pout (in red) and scenario values using an example HCR (in blue – F_{cap} = 0.3, TAC_{min} = 30 000 tonnes, and TAC_{max} = 150 000 tonnes). The lines show the median value and the shaded areas the 5th and 95th percentiles.

Since little, if any, considerations are given to implementation error one might ask how accurate is MSE in providing information on future average catch and how much trust can be put in the performance parameters, such as future catches and biomass development? Performance parameters which ideally should be used to guide managers and stakeholders in their decisions.

5.1.2 Stock specific precautionary levels

Most agrees that biomass reference points are needed in order to manage fish stock properly. The concept of applying a Harvest Control Rule in combination with a reference point - where the exploitation rate is diminished as the stock becomes smaller - are widely accepted as a logical way of adapting management to changing stock size. The downside of this approach is that it comes with an increase in catch advice variation, but an increased in variation that seem to be acceptable to most. That few disputes the need for biomass reference points is not same as there is no disagreement on how and where exactly these biomass reference points should be set. Further, there is not consensus on what an acceptable risk of SSB falling below the reference point, is. In the ICES realm, being precautionary is often defined when the probability of SSB falling below B_{lim} does not exceed 5%. In this section reflections on the 5% level are presented. It is asked if a 5% level is universal for all stocks and fisheries or whether it is sensible to differentiate depending on e.g. lifespan, natural fluctuations in stock size and scientist's ability and willingness to include more and more uncertainty sources when undertaking Management Strategy Evaluations.

By having the same risk level for all stocks, it is implicitly assumed that falling below this level will have similar consequences for all stocks, independent of stock characteristic, such as lifespan. But is it equally relevant to stay clear of stock size below B_{lim}, when managing Greenland shark, which mature at age 150 and can live up to 400 years, as it is for a sprat where around 40% mature at age 1? A sprat will, compared to a Greenland shark, show much higher fluctuations in SSB, and for some short-lived species these natural fluctuations in SSB can be so large that there is a real risk of falling below B_{lim} even in no-fishery situation. Similar, rebuilding from a situation where SSB is below B_{lim} varies in duration depending on generation time and recruitment variability. Sprat will have faster rebuilding than late maturing species. Such differences should be accounted for by politically differencing the acceptable risk such that it becomes more stock or trait specific.

The use of one risk level for all stocks is also problematic when stocks are being evaluated in differently. For some stock's variations in e.g. natural mortality are accounted for while in others it is not. In some evaluations autocorrelation in e.g. recruitment is modelled in other evaluations not. Including as much of the relevant variation in an evaluation is indisputable correct from a scientific point of view, however when this is done while keeping the precautionary level constant it creates a situation where the de facto fishing opportunities is lowered in a quite unclear way. One example of this is that the F_{msy} value presented by ICES is not always the fishing mortality that produces the highest yield. In table XX it is shown that out of 9 North Sea PANDORA stocks 4 is not managed according to stock specific F_{msy} value, as this value - although found to deliver the highest yield - will lead to a probability of falling below B_{lim} that is higher than 5%. As an alternative the $F_{0.05}$ is used as proxy, where $F_{0.05}$ refers to the maximum F that can be applied to the stock and having an SSB above B_{lim} with high (95%) probability.

5.2 Management Plans for PANDORA Stocks

Based upon past experiences and viewpoints described above, management plans are broadly considered key to ensure a proper management with stability in TAC's while still making sure that sustainability are meet and hence a analyse.

The results for relevant PANORA species are presented in table XX. In 2019, the catch advice was only based upon a management strategy or plan for 3 out of the 26 stocks where basis for advice was identified. These stocks were sole in the North Sea, sprat and herring in the Eastern Baltic sea. In 2017 the catches were higher for seven stocks and the advice was not exceeded in 11 cases.

Table xx. Cases tudy is: Med=Mediterranean, NWW=North Western Waters, NS=North Sea and EBS=Eastern Baltic sea. For all stocks, the basis for the 2019 and 2017 advice is presented, where "–" indicates the absence of a management plan and "+" the presence. If the catch in 2017 was not aligned with the 2017 advice and exceeded, it is shown with "-". If the advice was followed it is indicated by a "+". F_{msy} is the F values that leads to the highest long term yield, independent on whether the value is considered precautionary or not. $F_{0.05}$ is the highest F value that leads to a no more than 5% risk of falling below B_{lim} in the long term. If no $F_{0.05}$ value is presented F_{msy} is considered precautionary. In the other cases where the F_{msy} value that produces the highest yield is not considered precautionary $F_{0.05}$ is used as proxy for F_{msy} in ICES.

Case Study	Species	basis for 2019 advice	basis for 2017 advice	Aligment (2017 advice vs. 2017 catch	F_{msy}	$F_{0.05}$ used as Fmsy by ICES
Med	Blue fin tuna	?	?	?		
Med	Albcore tuna	?	?	?		
Med	Hake	-	-	-	0.25	
Med	rose shrimp	?	?	?		
Med	red mullet	-	-	*	na	
Med	mackerel	-	-	-	0.23	0.21
Med	Jack mackerel	?	?	?		
Med	sea bream	-	-	-	na	
BoB	red Seabream	-	-	-	na	
BoB	thornback ray	-	-	*	na	
BoB	cockoo ray	-	-	*	na	
BoB	spotted ray	-	-	-	na	
BoB	blonde ray	-	-	*	na	
NWW	mackerel	-	-	-	0.23	0.21
NS	cod	-	-	+	0.31	
NS	haddock	-	-	+	0.24	0.194
NS	saithe	-	-	+	0.358	
NS	whiting	-	-	+	0.356	0.15
NS	sole	+	+	+	0.388	0.20
NS	plaice	-	-	+	0.21	
NS	hake	-	-	+	0.28	
NS	mackerel	-	-	-	0.23	0.21
NS	herring	-	+	-	0.33	

NS	sprat	-	-	+	na	
NS	horse mackerel	-	-	+	na	
NS	brill	-	-	*	na	
NS	turbot	-	-	*	na	
NS	Crangon	?	?	?	na	
EBS	cod	-	-	-**	na	
EBS	herring	+	-	+	0.23	0.22
EBS	sprat	+	-	+	0.26	
EBS	round goby	?	?	?	na	

*ICES cannot quantify catches; ** Including catches of East cod in west baltic waters

6 Conclusions

The pathway towards sustainable use of marine resources is often controversial and can lead to unacceptable short-term economic or social outcomes. The main three short-term concerns are:

- Maintaining viable fisheries (economically and thus socially) and avoiding companies to go bankrupt on the way to MSY or during the implementation of the landing obligation.
- Keeping access to the valuable stocks while exploiting them sustainably and minimizing the choke species problem under the landing obligation
- Avoiding large variation in landings from year to year as this affects not only the economic viability of the fleets but also market conditions.

There is no simple solution satisfying all objectives of all stakeholders. Therefore, setting FMSY or FMEY as management target without flexibility for compromises must lead to dissatisfaction of some of the stakeholders.

A well-structured decision making process with clear responsibilities is needed in fisheries management to resolve trade-offs and to find compromises. In the current management system of the EU, the EU Parliament, the Council and the Commission must agree before any management plan or target can be implemented. Once an agreement is reached, necessary adaptions to management plans as a result of changes in e.g. the ecosystem should be facilitated rather than hindered by overcomplicated governance structures.