Myfish : Maximising yield of fisheries while balancing ecosystem, economic and social concerns

Legacy booklet

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Welcome to Myfish!

The Myfish project aimed to provide science on the challenges of Maximum Sustainable Yield (MSY) management that was both high level and highly relevant to the managers, industry representatives, NGOs and scientists who would make use of it. To ensure this, the project was designed to be inclusive all the way from the proposal writing phase to the project completion five years later.

Embarking on this ambitious route, the project faced challenges from the very beginning: if the project partners had failed to demonstrate the value of participation or the potential users were not able to prioritise participation over their many other tasks, Myfish would have become a scientific exercise without a strong link to implementation and as such would have failed at achieving all aims. The sustained effort made by all project participants towards involving stakeholders throughout the process, together with the unfailing support and activity of hundreds of stakeholders in the process made Myfish a success. Therefore, we would like to take this opportunity to thank all participants including managers, industry representatives, NGOs and scientists for their effort and show both participants and non-participants the highly significant results we obtained, both in terms of science and the process to ensure that this science remained relevant and feasible for implementation.

On behalf of all of the Myfish team,

Anna Rindorf

Project coordinator

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The Myfish Background and Approach

The European Common Fisheries Policy (CFP) has made a commitment to direct management of fish stocks towards achieving MSY by 2015 with a full implementation by 2020. However, reaching this goal is difficult because achieving MSY for one stock may affect the achievement of MSY for other stocks and compromise ecological, environmental, economic, or social aims. The objective of the Myfish project was to face these difficulties and provide examples of scientific advice on MSY consistent with all aspects of sustainability. The project approached this through defining limits to sustainability and relevant measures of yield to be maximised; evaluating the effect and desirability of aiming for these yield measures while respecting sustainability; and finally providing an operational framework for their implementation.

These tasks were approached through case studies addressing single species, mixed species, pelagic, and demersal fisheries across Europe. The relevance of the recommendations made was ensured by the active involvement of stakeholders throughout the project.

Myfish decomposed MSY into three aspects: What to maximise (yield variants), what to sustain (constraints to sustainability) and how to manage fisheries aiming for MSY (management measures). The project was initiated with a workshop aiming to determine which variants are acceptable and feasible in practical management in each of five European regions: the Baltic Sea, the Mediterranean, the North Sea, Western Waters and Widely Ranging Stocks.

The results showed a clear preference for maximising inclusive governance and ensuring precautionarity. As a result, Myfish continued to produce test cases for how an inclusive governance process can be conducted in practice while adhering to the precautionary and MSY principles. The work has involved various aspects of scientific modelling to predict what aiming for e.g. MSY in tons or value of landings would mean to the yield, the status of stocks and the status of other factors such as other ecosystem components and income associated with fishing, visualisation and elicitation of responses to different scenarios.

Right at the beginning of Myfish, the new CFP was agreed. This introduced a landing obligation for selected species, the concept of Multiannual Plans (MAPs) and the principle of MSY. While this change was not part of the original work description

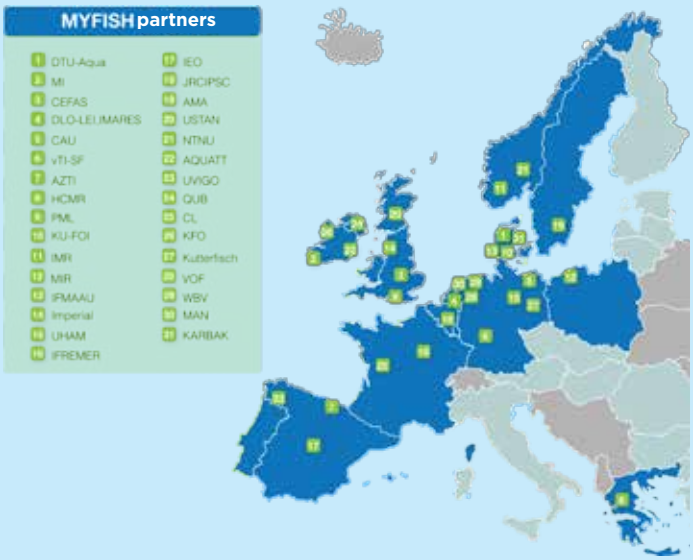
in Myfish, it increased the need for scientific advice which is consistent across species and which is sustainable from ecological, economic and social perspectives.

Over the second half of the project, the project participants made a dedicated effort to provide the scientific input needed by the European Commission to construct Multiannual Plans aiming at MSY using a series of descriptions of the consequences of aiming at maximising different yield definitions. For example, aiming at MSY for all species individually will lead to choke species problems as the fishing effort required to reach MSY of the most sensitive species is much less than that required to achieve MSY of more robust species. This issue became highly relevant with the gradual implementation of the landing obligations for a number of species.

Myfish gathered 31 partners including national fisheries institutes, universities and commercial enterprises across all European regions in a consortium coordinated by DTU Aqua. The partners cover a broad range of knowledge, from traditional fields in fisheries science and fisheries management over expertise in bycatch of sensitive species, effects of fishing on environment and sea bottom, resource and environment economics, to social science and industry involvement. The project was initiated in 2012 and ended in 2016.

Structure of the project followed the main objectives to define limits to sustainability and relevant measures of yield to be maximised, evaluate the effect, desirability and variability when aiming for these yield measures while respecting sustainability variability, and finally providing an operational framework to implement these. Further, the project structure reflected the focus in the project on the need to synthesise and communicate results.

More details about the project can be found at our website, **www.myfishproject.eu**.



Including stakeholders from day one

Stakeholders, scientists and managers met across case studies in a series of workshops throughout Myfish to ensure that only the most relevant results and trade-offs were analysed and presented and that the recommendations remained appropriate as the settings changed over time.

In the early stages, the workshops focused on identifying and ranking objectives for the management of a given fishery. Together, participants identified the need for governance to be inclusive, and for stakeholders of all kinds to have both a role and a willingness to participate. By having an inclusive process from the beginning, the objectives and underlying hypotheses for management could be identified, debated and agreed. This facilitated a co-creation process where less relevant choices could be excluded, returning an operational set-up for evaluation of management measures. There was broad agreement among participating stakeholders that trade-offs are most appropriately addressed in a participatory approach. This was reflected in the high preferences for Inclusive Governance and the subsequent preference for ranges in management.

Throughout the series of workshops, it was seen as an advantage to keep trade-offs and management as simple as possible. This presents a challenge in most systems and conflicted with the large amount of information required to make informed decisions. Several of the workshops touched on the issues of making the trade-offs understandable to a variety of people and ensuring that the most important trade-offs were included. As the most important aspects differ between stakeholders, this led to suggestions from participants for more complexity while trade-off illustrations were often seen as already being too complex. Striking the right balance between including all key aspects and retaining comprehensible illustrations of the outcome will be crucial to the success of inclusive governance.

All Myfish case studies showed that participation of the stakeholders from the beginning helped to eliminate irrelevant options and settings and the inclusion of their insights helped validate and legitimise the approach. The approach facilitated identification of conflicts between user groups' objectives and potentially enhances the fishery management compliance. Even when the results of e.g. a Management Strategy Evaluation (MSE) model output were not what was expected, the transparency and understanding of the process was a clear benefit. When asked about reactions to limiting constraints or changed management measures, a slight majority of fishers and other fishery representatives indicated a willingness to change as a consequence of more or new restrictive management measures to reach MSY. However, they commented that their "willingness to change" was mainly seen as a result of the lack of alternatives. In the current management approach, fishers considered management a "top-down management" and did not feel included in decisions. As perceptions and knowledge differ between fishers, scientists, NGO representatives, and decision makers; knowledge, information systems, perceptions, issues of trust and recognition of different stakes and interests need to be taken into account more explicitly in fisheries management.

Influencing the decision arena through the participatory process

The full series of workshops showed how an inclusive process could work in practice, although the exact characteristics of such a process and in particular how it is embedded in institutional settings were not defined. In a participatory process, we investigated aspects of inclusiveness including information sharing, consultation and establishing dialogues. This led to a co-creation process between scientists and stakeholders primarily using Advisory Councils (ACs) as the stakeholder forum and collaborators when drafting input to potential management plans, including agreement on objective settings and the process to deal with trade-offs. Myfish has contributed to drafting of several MAPs e.g. in the Atlantic Iberian waters and the Baltic Sea, bringing the input of stakeholders in defining the important trade-offs into the decision making arena. The experiences from Myfish demonstrate that participatory governance, by engaging ACs and regional stakeholder associations in drafting MAPs and providing recommendations to the decision-making system, is an effective modus operandi to establish a platform for stakeholder-science interaction supporting the implementation of the reformed CFP.

Another element of inclusive governance – multi-level governance – is related to regionalisation in the reformed CFP. There was high expectation at least among stakeholders that regionalisation would allow for genuine multi-level governance opening up for their involvement in the decision-making process. Nevertheless, the way multi-level governance is practiced in the reformed CFP has primarily lead to decentralisation by creating regional mini-councils rather than opening-up for larger stakeholder engagement in the decision-making. The present lack of interaction between regional groups and ACs, and the scientific community during the decision-making process of MAPs at the regional level has to a large degree undermined the positive social acceptability of MAPs obtained through the participatory governance process leading to draft MAPs by ACs. In continued decision making, inclusive governance requires a policy commitment embedding the approach in the institutional framework. However, even without this formalised setting, the participatory process allowed stakeholders to influence the type of information and trade-offs that entered the decision arena.

Kenn Skau Fischer

North Sea RAC –Stakeholder participating at the Myfish 2nd Annual Conference

Myfish is a win-win project. MSY values necessary for a sustainable fisheries management in the EU are defined through regional case studies where scientists and all stakeholders are working together and learning from each other.

The potential of this working method in respect of improving the management fish stocks in the EU should not be underestimated.

Defining limits to sustainability

Myfish has made a specific effort not only to identify indicators and associated reference points, but also to get these indicators accepted and used in management through advice given by International Council for the Exploration of the Sea (ICES). Focus areas included: the definition of biomass reference points for exploited stocks (Marine Strategy Framework Directive (MSFD) descriptor 3); indicators and reference points for Good Environmental Status (GES) on biodiversity and bycatch of sensitive species (MSFD descriptor 1); indicators and reference points for GES of food web indicators (MSFD descriptor 4); indicators and reference points for GES of the pelagic ecosystem (MSFD descriptors 1, 3 and 4); and socioeconomic indicators such as the Gini index of inequality in the distribution of benefits in Baltic fisheries. Here, we provide summaries of the last two efforts as examples.

Towards Good Environmental Status for small pelagic fish

Small pelagic fish have an important role in marine food webs, where they serve as prey for many larger fish, birds and marine mammals. By feeding on smaller food items such as plankton, they contribute greatly to the flow of energy from small to large marine animals. Managing fisheries relating to these species is therefore of great importance, not only to ensure sustainable exploitation of the small pelagic fishes themselves, but also to ensure that food is available for larger predatory fish, birds and marine mammals.

In Myfish we identified the elements that contribute to GES for small pelagic fish together with a large variety of stakeholders. Through a number of workshops, an extensive list of elements was compiled, which were prioritised according to stakeholder preferences and data availability.

The top ranking elements were further analysed and linked to specific indicators that can be measured in the field. These indicators include metrics of the total biomass of all pelagic fishes which should be large enough to serve as food for other species. As these fish migrate over large distances, it is also important to have enough adult fish around to guide younger fish. And, as pelagic fish tend to rapidly respond to changes in the environment, changes in condition of the fish were also chosen. A final indicator described the relationship between what we know of the most common pelagic fish species and the ones that are less common in the catches. Given this (short) list of objectives and indicators, we concluded that in the northeast Atlantic, the pelagic ecosystem almost has a good status. Some species, such as sandeels, require additional attention, in both the North Sea and the Celtic Seas.

The management plans that currently exist for many small pelagic species in the northeast Atlantic aim for high catches from year to year, while individual pelagic stocks need to remain above certain biomass thresholds. These plans may not necessarily result in good status of the pelagic ecosystem and therefore possible new management plan concepts were discussed. The outcomes of these discussions are extremely valuable in designing management plans for the future. Through intensive collaborations between all groups we will work towards robust management plans for the future that not only achieve high and stable fish catches, but also ensure a good status of the pelagic ecosystem.

Inequality in the distribution of benefits

Myfish investigated whether information on the inequality in distribution of benefits between countries was seen as an aid in decision making in the Baltic. In this area, there is a complex interplay between catches of the three main species and increasing catches of a specific species benefit specific countries to a varying degree. This makes trade-offs particularly complicated as one nation is predicted to gain while other are likely to lose from aiming for a specific management objective. The opinion of participating managers, industry and NGO representatives was that this type of analysis could provide valuable information for discussing trade-offs. The scientific advice should not determine the exact trade-off as this decision should remain in the policy domain.

Defining what we should aim to maximise

At the very beginning of the project, Myfish defined general and regionally relevant limits to sustainability and variants of yield which we could aim to maximise, considering in the process several yield variants in a workshop with participating scientists, NGOs, managers and industry representatives. The objective of the workshop was to determine which yields would be acceptable and feasible as objectives to maximise in practical management in each of our five European regions. The results showed that five yield variants occurred in the top 10 preferred of all groups and the variant 'Maximise inclusive governance' had a 'very good' performance in all groups, making this the top ranked maximisation variant (fig. 1). All regions rated 'GES descriptors of commercial species above reference level' in the top ten ranked constraints, indicating that ensuring ecological precautionarity is an important aspect in all areas. Management measure rankings were considerably more variable resulting in few obvious high ranking measures.

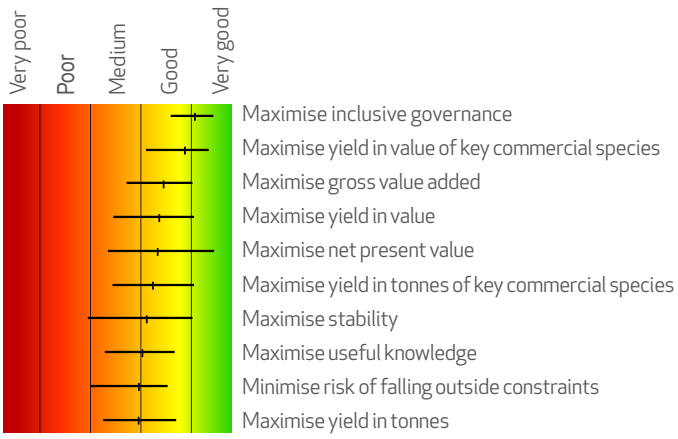


Figure 1: Graphic summary of means and ranges of rankings assigned to the top 10 ranked MSY variants – indicates the average and vertical lines indicate the minimum and maximum ratings across all regions.

Sean O'Donoghue

Killybegs Fishermen's Organisation Ltd (KFO): The industry perspective

KFO, together with its associate members the Pelagic Freezer-trawler Association, the Netherlands, and the Danish Pelagic Producers Organisation, was a vital component of the partner line-up in Myfish. These organisations brought a wealth of experience and knowledge to the table when considering the effects of implementing MSY. The workshops and annual partner meetings featured project work structured around actual case studies. This gives Myfish a basis of credibility and reality with wide acceptance among the stakeholders.

Following his participation in the project workshops, Sean O'Donoghue, Chief Executive of KFO, said: "Myfish has provided a sensible forum, scientific but not academic, where industry stakeholders can engage with fisheries scientists, economists and policy-makers to ensure MSY is implemented in a commonsense and workable format." He went on to commend the approach the Myfish project had taken by examining the wide range of possible MSY variants and the innovative strategies and techniques available for their implementation. The fishing industry hopes Myfish will go a long way in providing the effective means of implementing MSY without serious negative impact on fishing activities and fisheries-dependent communities while still achieving GES as required.

Developing the models necessary to evaluate different objectives

The project progressed from the definition of suitable limits to sustainability and objectives to be maximised to develop and adapt the models required to estimate the likely outcomes of aiming for the preferred MSY variants. The models were used to populate the Decision Support Table (DST) with the scenarios identified as relevant in each area by stakeholders in the first phase of the project. Subsequently, the DSTs were discussed with stakeholders to identify priorities based on the best estimates of the effect on the ecological, economic and social aspects of the fishery when pursuing specific aims.

To allow this progression, model development was a large part of the work in Myfish. Specific efforts were made to evolve models which were consistent and scientifically sound in the modelling of ecological, fishing and economic processes to ensure that no conflicting recommendations were made due to divergent or unlikely model formulations. Further, models of data limited stocks were also developed. Following this development, a total of 94 scientific papers were produced along with 32 DSTs demonstrating 119 scenarios and covering all five regional cases.

Understanding MSY: unravelling common assumptions

The MSY concept has been used in fisheries management for more than 50 years. During this time, we have acquired more and more knowledge, particularly about how the MSY principle applies to stocks which do not exist in isolation and how MSY objectives relate to other objectives. In Myfish, we encountered a number of frequent common assumptions, and here we discuss the scientific basis for a selection of these to find a common ground on which to base discussions on MSY principles in management.

"Multispecies approaches are too uncertain"

So far only single species related reference points are used in European management although it is well known that species interact with each other. The main argument often used is that multispecies approaches are too complicated and uncertain.

However, both MSY and the average biomass (B_{MSY}) achieved when fishing at a fishing mortality providing MSY (F_{MSY}) estimates are highly sensitive towards assumptions on the future productivity of stocks and whether predator-prey relationships are taken into account or not. Changes in productivity have been related in literature not only to the level of spawning stock biomass (SSB) but often to changes in e.g. temperature and associated changes in the food web. When taking single species F_{MSY} values and making a long-term simulation with a multispecies model, the yield and the SBB that can be reached are considerably lower compared to what is predicted in standard single species models because fish eat each other and any recovery of a predator stock has its cost (Table 1). While the absolute value of MSY and B_{MSY} varied greatly with the productivity of stocks, F_{MSY} was more robust towards these changes. Hence, while the model appears to be more uncertain in the MSY which they will provide, this is a result of more realistic assumptions about the ecosystem than is the case for single stock models.

Definitions of key terms

Yield in Weight: Weight of landings of a species.

MSY: The maximum yield which can be taken, on average, when fishing with a constant fishing pressure.

F_{MSY}: The constant fishing pressure leading to MSY while ensuring that the biomass of spawning fish remains at levels where recruitment is not impaired at least 95% of the time.

B_{MSY}: The average biomass of spawning fish when fishing at F_{MSY} for a long time.

$MSYB_{Trigger}$: The biomass of spawning fish below which ICES recommends to decrease fishing pressure to a level below F_{MSY}. The level must be no less than the biomass of spawning fish at which the risk of falling to levels where recruitment is impaired is 5%.

Single species: All variables are estimated ignoring biological (e.g. predation) and mixed fisheries interactions

Multi species: All variables are estimated while accounting for either biological (e.g. predation), mixed fisheries interactions or both.

MEY: The maximum economic yield which can be taken, on average, when fishing with a constant fishing pressure.

F_{MEY}: The constant fishing pressure leading to MEY.

B_{MEY}: The average biomass of spawning fish when fishing at F_{MEY} for a long time.

Table 1. MSY, B_{MSY} and F_{MSY} derived from different modelling approaches

Type of MSY	Single Species MSY						Multi Species MSY					
Explanation	Full Productivity			Reduced Productivity: Stock recruitment relationship based on currently observed lower recruitment levels			Maximising total yield in tonnes from the main target species in the North Sea. Full productivity.			Testing single species F_{MSY} values in the multi species model SMS. Full productivity.		
	MSY[1]	B_{MSY}[1]	F_{MSY}[1]	MSY[1]	B_{MSY}[1]	F_{MSY}[1]	MSY[2]	B_{MSY}[2]	F_{MSY}[2]	MSY[3]	B_{MSY}[3]	F_{MSY}[3]
Cod	102903	466778	0.33	52765	232811	0.33	49000	172000	0.34	42239	154880	0.33
Saithe	128899	259062	0.32	71305	160000	0.29	128000	200000	0.38	127809	261076	0.32
Haddock	114190	329127	0.37	not tested	not tested	not tested	67000	125000	0.6	49912	142961	0.37
Herring	611000	1639000	0.33	349000	1272000	0.35	523000	1274000	0.35	431414	1202390	0.33

1 Values come from the Myfish-ICES WKMSYREF III report for herring, haddock and saithe. For cod the values come from ICES WGNSSK 2015. All values were derived with the model Eqsim and no harvest control rule with $B_{trigger}$ was used for the estimation of F_{MSY}. High recruitment events for haddock are highly sporadic and do occur suddenly. Reduced recruitment levels were therefore not tested during WKMSYREF III.

2 Optimisation based on the ICES WGSAM keyrun 2014. The maximum total yield in tonnes was estimated with a penalty for solutions where stocks are predicted to fall below the precautionary reference point for SSB (Bpa).

3 Long-term simulation until 2050 based on the ICES WGSAM keyrun 2014.

"Fishing at F_{MSY} will provide much higher yields"

It is often reported that adopting MSY principles in fisheries management will lead to substantially higher fishing yields, larger stock sizes and lower ecosystem impacts. Whereas this is not likely for stocks which have already been fished around the levels leading to MSY for years, such as many North Sea stocks, this is true in systems which have historically been fished at levels much higher than those providing MSY, such as the Mediterranean Sea. The two case studies that examined the bottom trawl fisheries and also the small-scale fisheries exploiting the demersal resources of the Aegean (eastern Mediterranean) and Balearic (western Mediterranean) Seas investigated the effects of various management strategies on the stocks and the fisheries. Although the multispecies nature of the fisheries does not allow fishing at F_{MSY} levels for all stocks simultaneously, decreasing the fishing pressure to levels securing the optimum exploitation of most important stocks would increase catches and income. As an example, Figure 2 shows how demersal catches in the Balearic Sea would vary in relation to relative fishing mortality changes as well as the medium-term projections of income per coastal vessel at various levels of fishing pressure in the Aegean Sea.

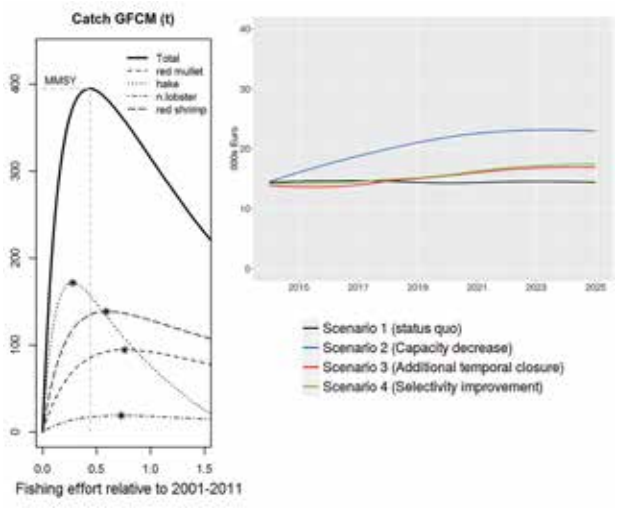


Figure 2. Equilibrium catches (total and by main species) of the Balearic demersal fishery at various hypothetical levels of fishing mortality (left) and income per vessel for the Aegean Sea coastal fishery under different management scenarios (right).

"Maximising yield ensures ecological and economic sustainability!"

According to traditional fisheries science, MSY requires the population abundance to be sufficiently high, which seems to imply that ecological conservation criteria for this stock will be met under MSY. It has furthermore been advocated that when processing, distribution and marketing of fish products are taken into account, MSY would also be an appropriate target for fisheries from an economic perspective. These statements are, however, based on generalised single-species biomass.

For the Baltic cod fishery, MSY is not compatible with either ecological or economic sustainability. Using an age-structured single-species ecological-economic model for the cod fishery, we showed that maximisation of yield would theoretically be reached by fishing with large mesh size, targeting only the oldest cod. Effort at MSY would be 10 to 34 times higher than at maximum economic yield (MEY) (depending on trawl type used). Due to the high effort levels needed, the potential profits at MEY would be completely lost, and in contrast, the MSY fishery would have to be heavily subsidised. In an age-structured, single-species world the MSY objective would therefore be good for cod stock size and the number of jobs, but detrimental for economy. A "Pretty Good Yield" concept could come much closer to MEY.

We re-considered these findings under more realistic conditions:

(i) using an age-structured population model and (ii) a multispecies, i.e. predator-prey, setting. The central Baltic Sea fishery is dominated by cod, herring, and sprat, with cod being a major predator for sprat and juvenile herring. Our results challenge the conventional wisdom on MSY-related results.

In a multispecies setting, single species MSY is not compatible with ecological or economic sustainability. Maximising yield of cod in tonnes would correspond to a large cod biomass which in turn would exert a large predation mortality on sprat. This increase in mortality would decrease the sprat stock to levels below the precautionary biomass reference point.

The MSY of all stocks together (maximising total tonnage caught) would be reached by depleting the stock of cod, the top predatory fish in the Central Baltic. Highest yields in tonnes are possible if no predator is around and the catch is based purely on the clupeids. This would be highly cost-intensive, as an unprofitable cod fishery would continue to keep the cod stock low. Opting for a pure total MSY is therefore neither economically nor ecologically sustainable. However, allowing for deviations from MSY in a certain range and/or including additional constraints (e.g. minimum stock sizes) may offer a way forward.

"MSY and MEY do not match in multispecies fisheries"

MSY and MEY tend to mismatch each other as MSY strategies will require larger effort levels than MEY in a single species environment (Figure 3). However, this pattern is less clear in mixed fisheries. In mixed fisheries, the effort and catches are driven by the effort allowed by the portfolio of quotas for different species. In this context, equal or larger fishing efforts than those depicted by single species MSY may be reached for some stocks as the total economic yield is maximised. Under a landing obligation, this becomes even more apparent as the quota of the most restrictive species (the so called choke species) determines the which effort can legally be exerted (Figure 3).

The Atlantic Iberian waters case study in Myfish evaluated the consequences of managing by MSY or MEY under the landing obligation. We examined whether managing by a single species MEY is a more economically appropriate solution when a choke species and a target species are considered simultaneously. We showed that there are cases where the economic inefficiency of using the MSY strategy for managing the choke species is counterweighted by the increase of catches (and landings) of the target species.

Our conclusion is that multispecies fisheries require multispecies based management. MSY and MEY can both be operational in a multispecies context. Following this, we created multi-stock reference points. Figure 3 illustrates that the solution of considering the multispecies problem is to select the effort of the target species applying MEY to the target species. However, in cases of a system with four or five stocks fished simultaneously, the final solution is quite complex to operationalise.

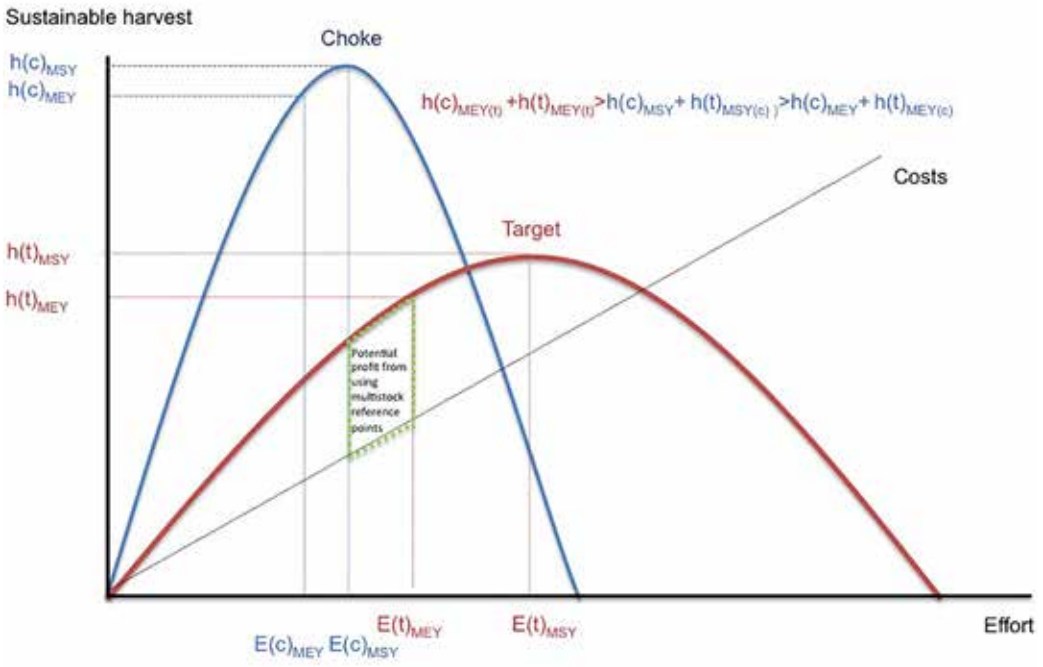


Figure 3. Stylised picture of the problem of selecting the target under a landing obligation. Choke species is limiting the effort that a fleet can applied up to E(c)MSY (the fishing effort that corresponds to managing the choke species using the MSY strategy). The target species is not captured using their sustainable catch possibilities (MSY or MEY).
Multi-stock reference points are able to increase the effort up to E(t)MEY (the fishing effort that corresponds to managing the target species using the MEY strategy) in some periods, and fishing possibilities are not wasted.

"MSY works even when data are limited"

There are a number of stocks within the EU that can be categorised as "data limited". In such cases we are unable to calculate the generally used F_{MSY} reference values, and in many cases unable to calculate fishing mortality, or estimate biomass. An example is the skate and ray populations in the Irish Sea. Data on landings was limited to a generic "skates and rays" category until recent years, and many species identification issues still remain.

Total allowable catches (TACs) continue to be agreed for the generic category. However, in the Irish Sea a small number of vessels are apparently able to target these stocks and avoid major declines in catch rates in spite of declines in abundance. In Myfish we examined ways we could use the limited information available in the Irish Sea to propose management approaches based on the principles of MSY. Interviews and discussions with stakeholders indicated that a spatial management strategy would be an acceptable method for this fishery. We also examined the use of survey data to develop MSY type harvest ratios (HR_{MSY}) as proxies for the more standard F_{MSY} reference values. This allowed us to calculate the proportion of each species that would need to be protected from exploitation to maintain a healthy stock.

Finally we used a novel modelling approach to map the abundance distribution more accurately than previously. Bringing these different strands together, and including maps of fishing effort, we were able to propose candidate areas for closure to protect sufficient levels of each stock to help maintain a sustainable exploitation. An example of such a map for cuckoo ray is presented in Figure 4.

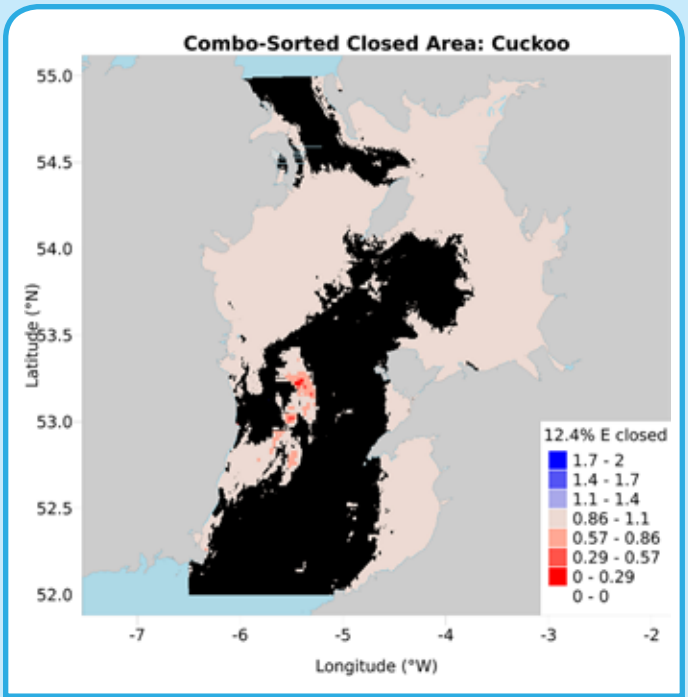


Figure 4. The black areas represent the area that might be closed, and was calculated to maximise the protection for the ray, while minimising the fishing effort displacement (in this case displacing around 12% of the effort). The precise areas blacked out do not represent a viable marine protected area (MPA) layout, but could be used as the basis for a more useable layout, informed by the knowledge of stakeholders. The software used for this analysis can easily be used to examine any MPA layout and illustrate how much of the ray population would be protected, and how much effort displaced. The approach has been presented to the North Western Waters Advisory Council (NWWAC) and was considered very promising, and a suitable way of dealing with a perennially difficult issue.

"Fishing at FMSY is inherently precautionary"

In Myfish, we investigated 19 European fish stocks to test the hypothesis that fishing at F_{MSY} is inherently precautionary with respect to impairing recruitment and no further precautions need to be taken. The precautionary reference point for each stock was defined as the fishing mortality resulting in a 5% probability of the spawning stock biomass falling below the biomass limit below which recruitment is impaired. It turned out that small bodied fish generally could not sustain as high fishing mortalities as large bodied fish.

Small bodied fish grow very little once they enter the fishery and therefore, they do not have any weight gain to buffer the losses to fishing and natural causes. Our study showed that fishing at F_{MSY} generally is precautionary with respect to impairing recruitment for highly exploited fish in northern European waters, though this is not always the case for small fish like sprat and herring.

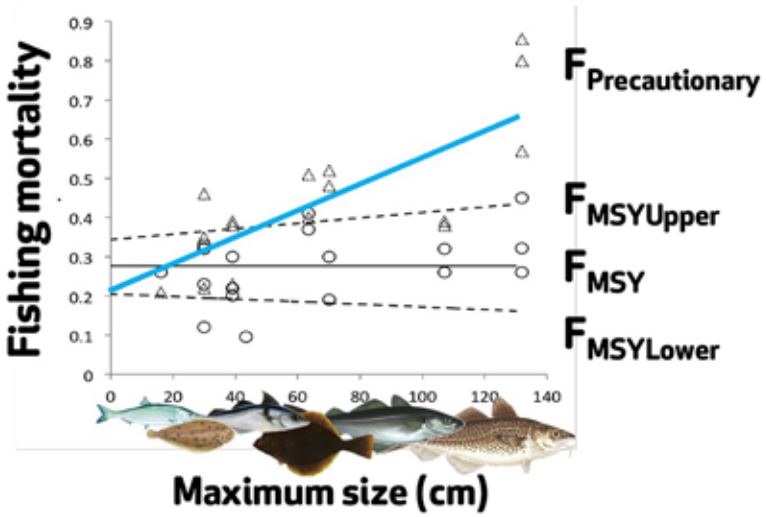


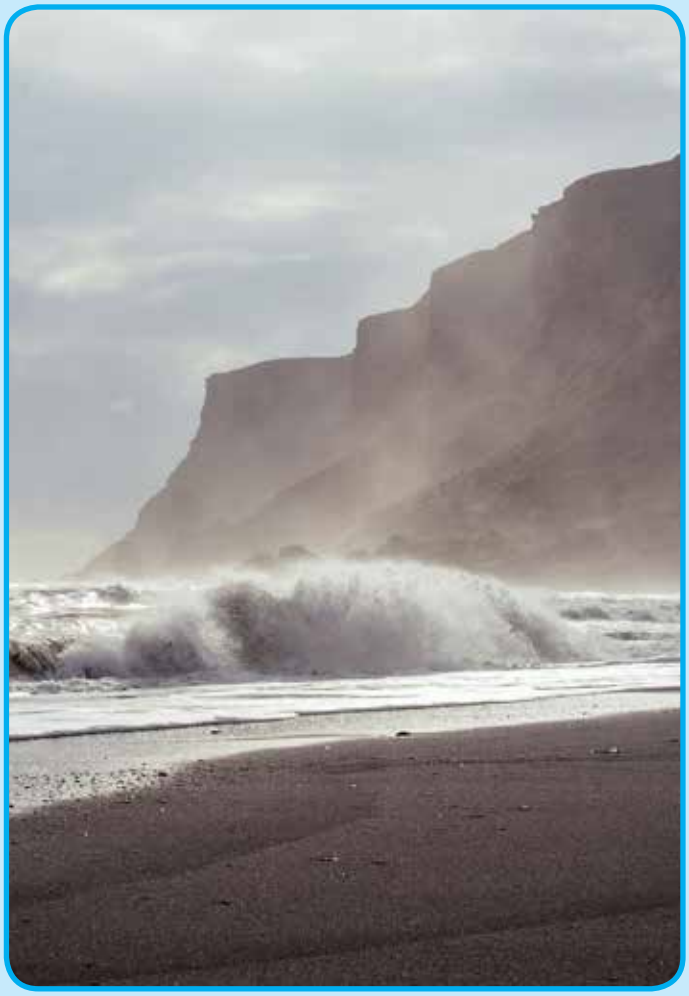
Figure 5. The fishing mortality leading to MSY (O) does not vary with body size in the highly exploited fish stocks in the North Sea, Baltic Sea and Barents Sea. However, the highest fishing mortality which is precautionary with respect to impairing recruitment (Δ) is lower for small rather than large fish as small fish experience little growth after entering the fishery to negate the effect of fish being removed by fisheries and natural predators. Below the x-axis, examples of species are shown to indicate their maximum size.

From left to right, the species are sprat, common sole, haddock, plaice, saithe and cod.

Variability and MSY

Changes in fish productivity affect the maximum fisheries yield, the fishing mortality at which this yield is obtained and all subsequent indicators dependent on yield such as revenue and employment. In addition to this, yield variants based on revenue, profit and cost structure are sensitive to changes in fish prices as well as the cost of fishing, including for example labour, fuel costs and distance to suitable fishing grounds. In many areas, the employment in the fishing industry depends at least partly on the availability and desirability of alternative employment opportunities. As a result of these dependencies on non-constant processes, MSY, MEY and other MSY variants change slightly every year. Much of the change is short-lived or gradual, but larger changes may occur where the ecosystem or economic and social considerations undergo abrupt shifts.

An example of such a sudden change is the change in productivity of the North Sea forage fish. Time-series of growth, recruitment and zooplankton abundance showed periods of high and low productivity and productivity of all five pelagic fish stocks in the North Sea changed over time. After 1993, a distinct decrease in productivity led to a substantial decrease in MSY for all stocks. In Myfish, we found this pattern to be synchronous across stocks. The absence of alternating high-and-low productivity across stocks had consequences for the combined MSY and the total forage fish biomass, severely decreasing total yield rather than simply changing the composition of this yield.



Case Studies

Showing the results of evaluations: Myfish Decision Support Tables (DSTs)

DSTs are graphical tables reflecting the effects and trade-offs of implementing different MSY options on ecosystem, economic and social constraints with a particular focus on the risk of exceeding acceptable levels for constraints. The goal of the DSTs is to convey a large amount of information on alternative management scenarios in an accessible manner, making it more understandable to fisheries stakeholders. The involvement of stakeholders in the Myfish project and their feedback is an integral component of the development of the project. DSTs have been used to present the results of the project to stakeholders in all regions. More information related to the details of the models used to produce the tables can be found at the Myfish website www.myfishproject.eu/project-myfish/deliverables

The Myfish DSTs integrate a number of graphical devices: (1) icon arrays which also incorporate 'fading out' to represent uncertainty; (2) icons that closely resemble the actual species concerned; (3) different types of icons to represent different quantities, fish stock or profit; (4) colour to show regions of particular concern and (5) embedded pie-charts to show progression or difference. The number of cod icons refers to the mass of cod, the number of Euro signs to profit, the colour red to problems, and fading to uncertainty. The goal is to convey information in a manner which makes comparison across several criteria of the merits of alternative management scenarios more accessible to stakeholders than would be achieved with a table of numbers. The models behind the DSTs have all been assessed against predefined criteria and details on the results can be found after the case studies in this publication.

myfish

Maximising yield of fisheries while balancing ecosystem, economic and social concerns

legacy booklet

Case Study 1: Baltic Sea

An introduction to the Baltic Sea Case Study

Ruediger Voss

Christian-Albrechts-Universität zu Kiel (CAU), Germany

Baltic Sea Case Study Leader

I coordinated the Baltic Sea case study, which focused on the trade-offs between having a large stock and large 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.

To describe this trade-off in detail, we developed an ecological-economic model for the three main species in the Baltic Sea (cod, herring, and sprat). The model describes predator-prey relationships and stock sizes as well as the economic costs and earnings of catching fish. The aim was to investigate the effects of the rebuilding of a large cod stock on herring and sprat. Economic optimisation leads to a cod-dominated system which is highly profitable. However, this system has two undesirable properties: the sprat stock becomes very low due to the higher number of sprat eaten by cod, and the country-specific increase in profits is very different; two Baltic countries would even make a loss in terms of combined profits from all three fisheries.

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) in June 2014. 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. There was a detailed discussion of the economic (price/kg and fuels costs) and biological (growth, interaction and the relationship with distribution) assumptions in the model. In general, the meeting participants were concerned that the results would be shown to managers who would then make decisions without understanding or discussing assumptions. At the end of the meeting, there was a general expression of the high value of having such joint meetings to discuss topics which relate to the management of fish stocks.

Substantial difficulties have arisen in the Baltic cod single species assessment over the past few years, presumably due to a range of factors such as reduced growth, changes in catchability and increased predation. In the analyses, the assumption is that the difficulties encountered in recent years are transient phenomena and hence will not affect long term considerations. Under these assumptions, the Baltic cod recovery plans raise two fundamental fisheries management questions involving trade-offs: (i) How much biomass and potential economic yield, provided by the high value cod stocks, needs to be sacrificed to allow for the protection of lower value, but ecologically important, forage fish species; and (ii) What are the additional costs of considering an equitable distribution of benefits between the demersal (cod) and pelagic (forage fish) fisheries sectors, given that the latter has expanded after the cod collapse?

Baltic Sea DST Description

The DST for the central Baltic Sea takes into account 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 (SSB, thousand tonnes), catch (thousand tonnes), total profits (million €), distribution of profits to the fisheries, as well as fishing mortality. Options are chosen to achieve a limit sprat spawning stock biomass of 410,000 tonnes, i.e. respecting the current limit reference point values applied in the management.

Management decision background: Total quotas are set annually for each species; distribution to country follows the 'relative stability principle'; the path towards each MSY option differs depending on constraint(s).

Originally published in: Voss R, Quaas MF, Schmidt JO, Hoffmann J (2014) Regional trade-offs from multi-species maximum sustainable yield (MMSY) management options. Mar Ecol Prog Ser 498:1-12

Impressions from the joint BSAC/Myfish/SOCIOEC workshop

Sally Clink (BSAC) and Alex Olsen (Federation of National Org. of Importers and Exporters of Fish (AIPCE-CEP)/BSAC)

The Myfish/SOCIOEC meeting emphasised more than ever the importance of holding regular dialogue and exchange between scientists and stakeholders.

The current discussions on how EU fisheries management is working to achieve MSY fall well into the framework of the Myfish project and even go beyond its scope, because the CFP reform came after the project got underway.

Stakeholders wanted to get a clear idea of what factors need to be taken into account when maximising yield. Economic yield is one objective, but there are other objectives as well and research can help to highlight all the options and models available in terms of maximising yield. It has to be a broad approach and then the trade-offs can be discussed and weighed up against each other.

The scientists need to bounce their ideas, models and findings off the stakeholders, especially when their findings can impact the day-to-day running of fisheries. Stakeholders can definitely benefit from knowing what is going on within science and from providing their input as well. Regular contact between scientists, industry and other stakeholders is useful for all and organising such meetings alongside or back to back with Advisory Council meetings is a helpful way of doing it.

Case Study 1: Baltic Sea

Baltic Sea management DST

Scenarios	Catch/SSB kT			Total Profit
	Sprat	Herring	Cod	
MEY with no constraint Gini index = 0.49	76/240 kT	160/1000 kT	200/680 kT	€97,000
MEY with high Sprat conservation Gini index = 0.48	41/570 kT	170/1000 kT	200/640 kT	€95,000
MEY with equity and high Sprat conservation Gini index = 0.70	200/570 kT	240/1200 kT	180/350 kT	€73,000

KEY

= 50 kT	€ = €10,000
SSB at B_{pa} or above	SSB at B_{lim}

Case Study 2: Mediterranean Sea

An introduction to the Mediterranean Sea Case Study

George Tserpes
Hellenic Centre for Marine Research (HCMR), Greece
Mediterranean Case Study Leader

I coordinated the Mediterranean regional study consisting of two sub-cases that examine the multi-species bottom trawl fisheries exploiting the demersal resources of the Aegean (eastern Mediterranean) and Balearic (western Mediterranean) seas. The medium term effects of various input control management measures on economic MSY variants were examined taking also into account biological (i.e. exploitation state of key-stocks) and social constraints (sustainability of the jobs in the fisheries sector). The DSTs summarise the comparisons among those management measures that, depending on the case, include various fishing effort control schemes in the form of temporal closures and capacity reductions, as well as changes in the selectivity pattern of the fishing gears.

Eastern Mediterranean DST Description

In the eastern Mediterranean case study, the multi-species bottom trawl fisheries that exploit the demersal resources of the Aegean Sea 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 summarise the comparisons among temporal closures, capacity reductions and gear selection changes. Effort reductions implied through temporal closures seem 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 the first meeting with eight 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.

Based on these identified priorities, a series of management scenarios were examined and we summarised the main findings in DSTs. The tables were presented and discussed during the annual meeting of the Union (nearly one hundred people) in June 2014. 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.

Eastern Mediterranean DST

East Mediterranean DST

Scenarios	Hake Conservation	Profit Per Vessel Per Year	Indicators			
			Viability of fishery	Employment	Dependence on Subsidies	Ecosystem impact
Current Yield F=0.56	Unsafe	€ 0				
MEY respecting bio-logical constraints F=0.50	Optimal	€€€€ €40,000				
Capacity Reduction F=0.45	High	€€€€€€€€ €€€ €105,000				
Improved Selectivity F=0.53	Unsafe	€€€ €25,000				

KEY

€	= €10,000	Score on a five point scale				
		1 very bad	2 bad	3 medium	4 good	5 very good

Western Mediterranean DST Description

The western Mediterranean case study primarily concerns fisheries around the Balearic Islands. From the beginning of the Myfish project, two different stakeholder organisations that are directly concerned with the fishing industry have been involved: The Fishery Association of the Balearic Islands and the General Directorate of Fisheries of the Autonomous Government of the Balearic Islands. There has been a continuous correspondence with representatives of both organisations to outline a framework for the attainment of MSY variants and the design of the DST. Ultimately, a workshop was organised with the participation of key active fishers and representatives of the fishing sector to discuss the main management scenarios and their corresponding constraints.

The current opinion of the stakeholders is that the viability of the fishing sector in the Balearic Islands depends on economic factors rather than on the exploitation status of the main stocks. Increasing fuel price is an important factor; however, fishers have concurrently had to cope with a constant decrease of the fish/fuel price ratio in recent years. All stakeholders agreed that the main problem is the fuel price and thus there is a need to substantially reduce fuel consumption in order to reduce the exploitation costs. These reductions could be achieved by different measures such as lower engine power and/or less time at sea (reducing working hours per day or days per week). Besides reducing costs of the fishery operations, there is a need to improve the commercialisation of fishery products by means of marketing strategies.

The Western Mediterranean DST addresses the management of demersal species exploited by the bottom trawl fishery, which is the most important in terms of total landings in the Balearic Islands. Although these fisheries are clearly multispecific, four target species can be considered corresponding to four different fishing tactics representing the exploitation of different depth strata: 1) striped red mullet (Shallow Shelf); 2) hake (Deep Shelf); 3) Norway lobster (Upper Slope); and 4) red shrimp (Middle Slope). These four species are regularly assessed in the framework of the General Fisheries Commission for the Mediterranean (GFCM) or Scientific, Technical and Economic Committee for Fisheries (STECF) and, although in better exploitation status than in nearby areas, all four stocks are overexploited.

The DST includes three different scenarios: 1) the current situation, which is considered unsustainable given that all four stocks are over-exploited; 2) the MEY predicted by the bio-economic model, which is considered unfeasible by the fishermen owing to the very high reductions in fishing effort required (up to 71% for hake); and 3) an intermediate scenario in between these two previous, extreme situations; although this intermediate scenario also demands important effort reductions, they are considered feasible by the fishermen.

The main management scenario agreed with stakeholders includes the reductions of fishing effort shown in the intermediate scenario. The benefits of such fishing effort reductions would be twofold. Firstly, an improvement in the exploitation status of the different target stocks and hence on the demersal ecosystems exploited by the bottom trawl fishery. Secondly, an improvement in the viability of the fishing industry by means of reducing fishing costs in terms of substantial reductions in fuel consumption. For fishers, the fuel price is the main constraint.

Given that bottom trawlers operate on different bathymetric strata depending on the target species, differential effort reductions should be put in practice according to the exploitation status of each single stock. As hake is the most over-exploited species, effort reductions should be higher on its fishing grounds (deep shelf). For hake, a recovery plan should even be considered.

The effort reductions should be in terms of hours per day or days per week. For fishermen, the most useful option would be reducing the days per week, which would also result in a considerable reduction of fuel consumption. Reductions in the number of vessels were not considered as the number of trawlers in the area is already low.

Western Mediterranean DST

Western Mediterranean DST

Scenarios	Stock Conservation	Fishery Gross Revenue	Indicators			
			Viability of fishery	Employment	Dependence on Subsidies	Ecosystem impact
Current	Unsafe	€€€€€€€€€ € 9.4 mil				
Intermediate reduction	High	€€€€€€€€ € 8.7 mil				
Predicted reductions needed for MSY	Optimal	€€€€€€€€ € 8 mil				

KEY

€ = €1,000,000	Score on a five point scale				
	1 very bad	2 bad	3 medium	4 good	5 very good

Towards a Participatory Management Approach to Mediterranean Fisheries

The Mediterranean has a long tradition in fishing activities and seafood has always been a very important part of the Mediterranean life. Fishing has always ranked highly in terms of economic value, although tourism has recently become increasingly important too.

Mediterranean fisheries are highly diverse, catching more than one hundred different commercial species. Fisheries are typically artisanal and only very few industrial fleets are operating in the area. Fishing exploitation is based on small-capital businesses that are most often owned by the fishers themselves. The majority of vessels are of small size with no onboard fish processing, as fishers generally return to their home ports on a daily basis to sell their catches.

Myfish adopted a new approach to fisheries management, going beyond the traditional MSY target by also giving significant attention to economic and social aspects. This on-going process is based on a participatory approach that involves stakeholders from both the western (Balearic Islands) and eastern (Aegean Sea) Mediterranean basins, strengthening collaboration in the Mediterranean fishery sector. The Mediterranean case studies deal with the most important demersal resources and aim to provide management advice that takes into account the complexity and multispecies nature of the Mediterranean fisheries. The project seeks to clarify the fishery management processes together with stakeholders. Fisheries management in the Mediterranean will ideally then be based on a tailored scientific approach aiming to contribute to the sustainability of the Mediterranean fishery sector by balancing four interacting pillars: 1) fishery resources; 2) economy; 3) social aspects; and 4) ecosystem conservation.

Traditionally, fishers in the Mediterranean have played a key social role in coastal communities and this role needs to be

preserved. In addition, fishers have considerable knowledge about how fish stocks behave, a knowledge that is obtained through their daily activities and which is difficult to acquire in other ways. Short-term fishing tactics employed on a trip-by-trip basis take into consideration the population dynamics of the fish species, leading to changes in catch composition and production output. Through their fishing activities, fishers can also track ecological changes which help scientists to evaluate the state of the ecosystem and provide management advice accounting for such changes.

Thus the contribution from fishers in relation to improving scientific estimates and management advice is essential. The role of fishers could be enhanced through the adoption of Inclusive Governance approaches which were identified as a priority by stakeholders at the Myfish kick-off meeting in Vigo. In collaboration with stakeholders, the Mediterranean case studies addressed these issues by developing tools and methodologies that bring together the interests and views of fishing industry, managers and scientists. Myfish formulated and developed DSTs quantifying views from stakeholders on specific general and specific aspects. For instance, issues related to the optimisation of effort towards the maximisation of profits were examined taking into account specific questions, such as the effect of increasing fuel prices on the dynamics of the fisheries.

Excess fishing effort leading to the degradation of fishery resources and significant economic waste is globally recognised by resource managers as a major problem for the implementation of the Ecosystem Approach to Fisheries (EAF) and European Union's Common Fisheries Policy (CFP). Such issues are addressed in the Mediterranean case studies applying DSTs. In addition, the DSTs address questions relating to ecosystem health and the state of the resources considering indicators mentioned under the Marine Strategy Framework Directive (MSFD).

Overall, Myfish improved the participatory approach in the Mediterranean, building on previous experiences and working towards a more inclusive mechanism.

Case Study 3: North Sea

An introduction to the North Sea Case Study

Alexander Kempf

Johann Heinrich Von Thuenen-Institut, Bundesforschungsinstitut für Landliche Raume, Wald und Fischerei (vTI-SF), Germany

North Sea Case Study Leader

I coordinated the North Sea case study, which dealt with complex multi species and mixed fisheries interactions. One focus is on the mixed demersal roundfish fishery for cod, haddock, saithe and whiting. In another sub-case study we deal specifically with the southern part of the North Sea where flatfish and brown shrimp fisheries dominate.

Fisheries management based on the MSY concept is a complex task in the North Sea. Multi species simulations show that the abundance of top predators like cod and saithe determine to a large extent the yield that can be taken from other species, leading to the need to trade yield of one country or one fishery against that of another. This was identified by stakeholders as being an area of high potential conflict. Mixed fisheries interactions further complicate the situation. So called "choke species" was a hot topic in discussions. Under the landing obligation, the maximum sustainable yield that can be achieved in mixed fisheries is constrained by these choke species because fisheries have to stop when the quota of these species is exhausted. Choke species can be target species like cod as well as by-catch species like turbot or elasmobranchs (skates, rays and sharks). As well as this, there are trade-offs between economic optimisation and social benefits such as employment that have to be taken into account when defining objectives for fisheries management in the North Sea. This complex system requires us to look beyond traditional single species fisheries management.

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

Impressions from the joint North Sea Advisory Council (NSAC)/Myfish workshop, July 2014

Barrie Deas (Chief Executive, National Federation of Fishermen's Organisations)

I found the Myfish workshop, held in July in Amsterdam, to be at the cutting edge of thinking about how to achieve MSY within the context of biological, economic, social and political realities. Very shortly we will face a landings obligation and the multi-faceted problem of choke stocks; this gives an added urgency to finding ways to make rational choices between divergent objectives within fisheries management.

A decision support platform such as that being explored and developed by Myfish should help fisheries managers and fisheries stakeholders in the Advisory Councils to understand the implications and consequences of their choices.

We know that "all models are wrong but some are useful". But, for example, it is important to understand that a policy approach based on maximising only economic objectives will extinguish large numbers of fishing vessels and reduce numbers of fishermen, but crucially also reduce the industry's contribution to food security. This is an example of how such modelling work can clarify issues and help make the difficult trade-offs that will be necessary.

As regionalisation finds its feet, I think that this kind of decision support tool will be employed extensively to help make these kinds of judgements in fisheries at the regional seas level. Management decisions have been based on an aspiration and the flimsiest kind of impact assessment for too long.

Biological Interaction DST Description

The effect of species interaction in the North Sea on long term yield and sustainability was assessed by producing 100 year forecasts with the stochastic multispecies model (SMS). The model forecasts stock size and catch under the assumption that fish are consumed by fish according to observed stomach contents and a food selection model, assuming constant preferences for prey of a given species and size. Catches of the interacting species cod, saithe, haddock, whiting, herring, sprat, Norway pout and sandeel are described. Cod and saithe are top predators feeding on all other species and, in the case of cod, younger conspecifics. Whiting is a mid-level predator feeding on juvenile cod;, haddock and whiting; and herring, sprat, Norway pout and sandeel of all ages. Haddock feeds on sandeel and Norway pout only. Herring, sprat, Norway pout and sandeel do not feed on fish in the model.

Three scenarios were examined: maximising the total landings in tonnes; maximising the value of total landings; and an iterative process where it is attempted to get a yield in tonnes close to the maximum of each species while assuring that no species are exploited unsustainably (pretty good yield concept). The probabilities of staying above the biomass reference points B_{lim} (below which recruitment gets impaired and the stock is outside safe biological limits) and B_{pa} (where the uncertainty in the assessments is taken into account to ensure that the stock is above B_{lim} with high probability) were also estimated. In cases where fish eat other fish, the yield in tonnes is generally highest when the predatory fish, which otherwise would eat smaller fish, are fished above the fishing mortality leading to MSY without considering species interactions. This is also the case in the North Sea case study examined here. However, as is seen in single species investigations, substantial changes in fishing mortality around the fishing mortality providing MSY only lead to very minor changes in the yield: yield of predatory fish is only mildly affected by the differences in fishing mortality and hence appear to be virtually identical between scenarios. However, to maximise total landings in kilos or value of the landings, a substantially higher fishing mortality than that leading to single species MSY of cod and saithe is required. This higher fishing mortality requires a higher fishing effort and leads to a cod stock below precautionary limits. In contrast, the scenario leading to all stocks being retained above biological safe biomass limits has a fishing mortality of cod and saithe which are less than that leading to the maximum total landings in the North Sea but above current single species estimates.

Biological Interaction DST

Three scenarios were examined to investigate the effect of fish eating other fish on MSY: maximising the total landings in tonnes; maximising the value of total landings; and an iterative process where it is attempted to get a yield in tonnes close to the maximum of each species while assuring that no species are exploited unsustainably (pretty good yield concept). Yield is indicated by the number of fish of each species. Colour indicates whether the average stock biomass is above the precautionary biomass reference points B_{pa} (green), between B_{pa} and B_{lim} (orange) or below B_{lim} (red).

North Sea DST (biological)

Scenario	Cod	Whiting	Haddock	Saithe	Herring	Industrial (Sandeel, Norway Pout and Sprat)
Maximum Sustainable Yield (Weight)	90 kT		40 kT	120 kT	400 kT	400 kT
Maximum Sustainable Yield (Euros)	100 kT		40 kT	120 kT	400 kT	100 kT
Pretty Good Yield	90 kT	30 kT	30 kT	130 kT	450 kT	840 kT

KEY

= 30 kT

All Species Above B_{pa}

At Least One Below B_{pa}

At Least One Below B_{lim}

Technical Interaction DST Description

In the North Sea technical interactions case study, traditional management, given fixed quota shares, has been compared with two MSY scenarios (based on maximising total caught weight and value respectively), and with one MEY scenario, based on maximising the total Net Present Value (discounted profit) for the total fishery over the time period considered (five years). All scenarios assume the landings obligation has been implemented, i.e. all catches are landed and sold. As illustrated in the DST, the comparison revealed that it is more profitable to pursue MEY compared to both traditional management and MSY. The reasons being: (i) traditional management is constrained by being subject to fixed fleet shares of the quotas based on historical landing shares, and (ii) MSY management does not take into account the costs. MEY on the other hand allows flexible fleet quota shares, and reallocates quotas to minimise effort and thus costs. The reduced effort comes at the price of reduced employment. Thus realistic scenarios should lie somewhere in between MSY and MEY acknowledging both the costs of fishing but also the costs of reducing effort and thus employment opportunities.

Technical Interaction DST

North Sea DST (technical)

Scenario	Cod	Whiting	Haddock	Saithe	NPV	Employment	Effort
Traditional Management	35 kt	20 kt	35 kt	60kt	€€€ 15 million	31 fte	300,000 days
Maximum Sustainable Yield (Weight)	35 kt	25 kt	40 kt	70 kt	€€ 11 million	50 fte	1,200,000 days
Maximum Sustainable Yield (Euros)	35 kt	25 kt	40 kt	70 kt	€€€€ 17 million	54 fte	1,500,000 days
Maximum Economic Yield (NPV)	35 kt	25 kt	40 kt	60 kt	€€€€ €€ 31 million	13 fte	500,000 days

myfish
Maximising yield of fisheries while balancing ecosystem, economic and social concerns

legacy booklet

Southern North Sea DST Description

In the southern North Sea case study, we analysed the effects of three different MSY targets (maximising yield in kg, maximising yield in Euro, maximising profit) on i) the ecosystem, ii) the economy of the main fleets (flatfish and brown shrimp fisheries) and iii) their employment. In addition, the constraints imposed by harvesting by-catch like turbot and elasmobranchs in a sustainable way have been investigated (in scenario MEY constrained) and the impact of those constraints has been assessed. The main conclusions from the DST are:

- The current definition of MSY (maximum sustainable yield in kg) is not optimal from an economic and conservation point of view. It leads to a substantial loss in profit and risks the sustainable exploitation of by-catch species.
- Economic efficiency and ecosystem sustainability are not mutually exclusive. Maximising profit leads to a low fishing effort and therefore to a relatively low by-catch and a better size structure in the ecosystem. There is no big loss in profit caused by the protection of by-catch species.

However, economic optimisation and the protection of by-catch species are achieved with much lower catch and at a high social cost (lower employment).

The spatially explicit bio-economic model Simfish and the ecosystem model Ecopath with Ecosim (EwE) were utilised in parallel. Optimisations were carried out in Simfish and afterwards the optimised fishing effort was transferred to EwE to evaluate the impact on bycatch species and a large fish indicator.

Similarly to the North Sea biological DST for fisheries on North Sea gadoids a compromise has to be found between economic optimisation and social constraints without jeopardising ecosystem related targets.

Southern North Sea DST

North Sea DST (southern)

Scenario	Plaice	Sole	Crangon	Employment	Profit (total)	Effort (total)
Maximum Sustainable Yield (Weight)	198 kt	17 kt	50 kt	2350 fte	-2.5 million	81 thousand days
Maximum Sustainable Yield (Euros)	188 kt	18 kt	51 kt	2250 fte	27 million	72 thousand days
Maximum Economic Yield	123 kt	14 kt	49 kt	450 fte	88 million	34 thousand days
Maximum Economic Yield (constrained)	121 kt	14 kt	49 kt	400 fte	87 million	32 thousand days

Case study 4: Western Waters

An introduction to the Western Waters Case Study

Dorleta Garcia
AZTI-Tecnalia, Spain
Western Waters Case Study Leader

Within Myfish, I coordinated the Western Waters case study which is divided into four regional sub-case studies, from north to south: the Celtic sea, the Irish Sea, the Bay of Biscay; and the Iberian Sea. Each sub case study dealt with different aspects of sustainability: the Celtic Sea case study focused on biodiversity; in the Irish Sea looked at vulnerable data-poor species; in the Bay of Biscay focus was on the role of spatial management in the achievement of MSY; and finally the Iberian Sea case study focused on the socioeconomic dimension of MSY.

Skating on Thin Ice

Skates and rays have long been known to be vulnerable to fishing, even when they are not actually the target species.

The vulnerability of these species is a result of them tending to be long lived, to grow slowly, mature late in their life, and have few young. For example, ironically, the common skate species complex is regarded as critically endangered by the International Union for Conservation of Nature (IUCN).

A critical problem for scientists and fisheries managers in trying to deal with this issue is the lack of any detailed data on what fishing is actually doing to the skates and rays. Until recently, landings have simply been labeled as "skates and rays" which made it impossible to determine what proportion of each species was being removed.

In Myfish we found a new way to show what proportion of these species populations are being caught in the fisheries. We used a combination of survey data, data from observers on fishing vessels and information on how easily the skate species were caught in the net. The "harvest ratio", or proportion of the population removed each year by fishing, was then determined for each species.

With this information, we were also able to estimate harvest ratios that could achieve this for each species. They were able to find out which species were "harvested" sustainably, and which were subject to potentially unsustainable pressure. The results showed that two species, the blonde ray and the cuckoo ray, were fished well above sustainable levels. While

another species, the thornback ray, was apparently exploited, or at least removed, at sustainable levels.

So for the first time, Myfish provided advice on the species that are and are not exposed to unsustainable pressure. Rather than simply assuming that there was "a problem", we can now articulate that in detail. This is the first step on the road to managing the threat, and protecting biodiversity.

Consultations with stakeholders showed that conservation of endangered species is an important issue which might constrain exploitation of other species, but at the same time they agreed that fisheries should be exploited in an economically rational way. The question therefore arose: what are the costs of protecting skates and rays in the seas?

Myfish scientists have developed and tested tools to compute the cost of conserving these species. We used models that consider the implications of conservation constraints to fisheries that impact skate and ray populations, and evaluate how one could respond to these constraints in an economically optimal way. The difference in profits between the situations with and without constraints can be understood as the cost of management measures to protect endangered skates and rays.

Conservation does not come for free. The costs of conservation are either to be borne by the fishing industry or will to be passed on to the public in the form of subsidies or higher prices for other seafood. Essentially this is a choice for society. Do we want cheaper fish at the expense of the ecosystem, or are we willing to pay a higher price for our fish to retain a healthy and biodiverse ocean?

Introduction to the Iberian Sea DST

The Iberian Sea sub case study is focused on the conflicting objectives between artisanal and industrial fleets and on the mixed-fisheries nature of both fleet components. The fishery has been divided into four main fleets:, drift netters, purse seiners, trawlers and hookers. In turn their activity has been divided in several metiers. In a mixed-fisheries context and in the framework of the landing obligation policy, the consistency among single stocks TACs is particularly relevant. In that sense, we have compared the performance of the fishery system under the actual TAC advice framework, the single stock MSY reference points defined by ICES and a set of reference points calculated simultaneously for all the stocks using and bio-economic optimisation model. In theory, if the overall selection pattern of the whole fishery were constant, the single stock TAC advices derived from the multi-stock reference point would be reached by the fishery simultaneously for all the stocks. On the other hand, when assessing the performance of the fishery system the fleet dynamics is a key element. In order to evaluate the robustness of management strategies to fishermen behaviour we have used two contrasting fleet dynamics, a traditional dynamic and a profit maximisation dynamic. In the scenarios where landings obligation applies, the TAC advice is given in terms of catch instead of landings and all the catches go against the quota share. The undersize individuals, which were discarded in the past count towards the quota but in economic terms they do not contribute to the revenue. The landing obligation has been implemented in the simulations since 2018.

We have used the multi-stock and multi-fleet model FLBEIA to simulate the fishery system from 2013 to 2025. Although the fleets considered catch a large number of stocks only few of them are assessed by ICES. In the model, only the stocks assessed by ICES have been considered explicitly,: Hake, monkfish, megrims (whiffiagonis and four spot), blue whiting, horse mackerel (south and western) and mackerel. The rest of the stocks caught have been introduced in an aggregated way because enough data to condition them was not available.

Iberian Sea DST Description

In the DST the performance of the system is compared using a set of indicators that measure the biological, economic and social status of the system. The value of all the indicators corresponds with the state of the system in the last year of simulation (2025). The indicators are grouped in three categories, overall level, stock level and fleet level.

Using current reference points the system is biologically sustainable for all the stocks, independently of the fleet dynamics used. However, there is high probability of falling below $MSYB_{trigger}$ when multi-stock reference points are used. The economic performance of the fleet is very different using traditional or profit maximisation fleet dynamics. Both approaches represent extreme plausible options for the dynamic of the fleet and presumably the true dynamics will be somewhere between both. The difference is especially significant in the case of drift netters for which the economic result is threefold using profit maximisation dynamics. The effort exerted, and hence the employment, is also higher in the case of profit maximisation dynamics. The multi-stock reference point combined with landing obligation results in higher profits without compromising the sustainability of the stocks. That is, the impact of landing obligation in the fleets

can be overcome using an integrated approach to generate TAC advice. In general, the increment in profits is derived from the catch of 'other' stock. This stock is an artificial stock with fixed quota and biomass. As its productivity is constant the income derived from its catch is directly related with the amount of effort exerted. In this type of highly mixed fisheries the quota of the stocks subject to the TAC and quota system is not only important by itself but because they allow fishing other valuable stocks that are not subject to the system. This will become especially important under landing obligation when over-quota discards will be forbidden.

Impressions from South Western Waters Regional Advisory Council (SWWRAC)

Jean-Marie Robert (Secrétaire Général du Conseil Consultatif Régional des eaux occidentals Australes (CCR Sud))

The Western Waters case study results were discussed at a meeting in Paris in June 2014. This meeting was organised in collaboration with the South Western Waters Regional Advisory Council.

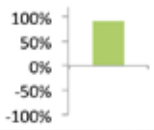
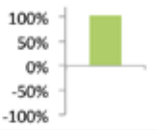
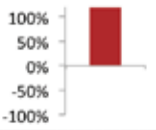
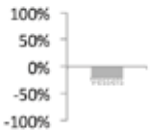
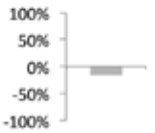
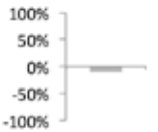
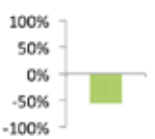
Under the new CFP, the exploitation of all EU stocks at a level that authorises MSY production has become the clear target. If some tools (e.g. landing obligation, management plans) are supposed to help in achieving this objective, some good questions remain. How and when exploitation occurs undoubtedly needs to be discussed further, and it will be. To me, it is clear that we will find better answers to such questions if we are able to really take into account the three pillars of sustainable development (social, environmental, economic).

That's why I'm sure that Myfish is a very interesting project, and that it should have great impacts on important and pragmatic issues. Developing new MSY indicators clearly addresses stakeholders' needs, and working on the ecosystem approach will prepare for future challenges.

Far beyond the ambition and first results of the Myfish project, it seems to me to be very important to highlight its methodology, and the assumed willingness of all partners to include the stakeholders in the life of Myfish. As an illustration, two meetings of Myfish were organised with the SWWRAC, which were a great opportunity to share opinions and experiences. Cooperation is key for further capitalisation, and obviously improves the possibilities for new science to contribute to fisheries regulations.

Western Waters DST

Iberian Sea Case Study DST: Single and Multistock MSY framework	
Background	**Subject of decision:** Iberian Sea fisheries and most important managed demersal stocks. **Management decision background:** Quotas aim at attaining MSY and distributed among member states, fleets following a "relative stability" principle. Multi Stock reference points aim to generate consistent TAC advice among stocks. **Nature of decision:** Single stock MSY and Multiple stock discounted MSY.

	Variant and *Constraint(s)*	Fcube Single Stock	Fcube Multi Stock Landing Obligation	Max Profit Single Stock
Options	Fleet dynamics	Traditional	Traditional	Optimise profits
	HCR	MSY	MSMSY	MSY
	Landing obligation	✗	✓	✗
	Constant effort in Artisinal Fleets	✗	✗	✗
	Capital dynamics	✓	✓	✓
Overall sustainability assessment indicators in 2025	Biological max (p(SSB<Bpa))	All species 	All species 	S. Horse Mackerel 
	Economic: min (NPV) (million €)	80 	100 	220 
	Economic: % Change in total catch from 2013 to 2025	91% 	103% 	119% 
	Social: % Change in number of vessels from 2013 to 2025	-23% 	-16% 	-11% 
	Ecological: % Change in discards to landings ratio from 2013 to 2025	-55% 	-43% 	-31% 

Western Waters DST (continued)

Hake landings (tonnes)	9,000	10,500	8,000
Horse Mackerel landings - North (tonnes)	27,500	28,500	29,500
Horse Mackerel landings - North (tonnes)	14,500	15,500	18,500
4-spot Megrim landings (tonnes)	1,400	750	1,700
Mackerel landings (tonnes)	11,000	11,000	11,000
Megrim landings (tonnes)	540	540	660
Monkfish landings (tonnes)	1,200	1,250	1,900
Blue Whiting landings (tonnes)	2,750	2,750	1,700
Other (tonnes)	72,500	81,500	121,500
Spanish Trawler - NPV (€ 100's millions)	3.6	4.1	4.8
Spanish Trawler - Effort (thousands of days)	13	17	29
Spanish Drift and/or Fixed Netters - NPV (€ 100's millions)	1	1.3	3
Spanish Drift and/or Fixed Netters - Effort (thousands of days)	34	47	118
Spanish vessels using hooks - NPV (€ 100's millions)	0.8	1	2.2
Spanish vessels using hooks - Effort (thousands of days)	10	14	89

Case Study 5: Widely Ranging Fish

An introduction to the Widely Ranging Fish Case Study

Niels Hintzen

Wageningen UR, the Netherlands

Widely Ranging Fish Case Study Leader

Within Myfish, I coordinated the Widely Ranging Fish case study where we focused on small pelagic fish in the northeast Atlantic Ocean and tuna in the Indian Ocean. These species are widely distributed and migrate over large distances to spawn and forage.

The fisheries focusing on the small pelagic fish in the northeast Atlantic are somewhat different to mixed fisheries, as fleets target one species at a time. Therefore, these fisheries could potentially best be described as a 'sequential monogamy'. In a way, this makes managing the fisheries somewhat easier as focusing on single-species approaches is often not too far from reality. An important thing not to overlook however is the role of these fishes in the ecosystem as food for others. These elements are of prime interest in our case study, relating MSY aims to Good Environmental Status or studying how the stock dynamics change with the introduction of the landing obligation. With respect to the large pelagic fish (tuna), multispecies considerations are of great importance together with environmental fluctuations. Our case study contributes to how MSY can be attained within a multi-species context, taking into account changes in the environment.

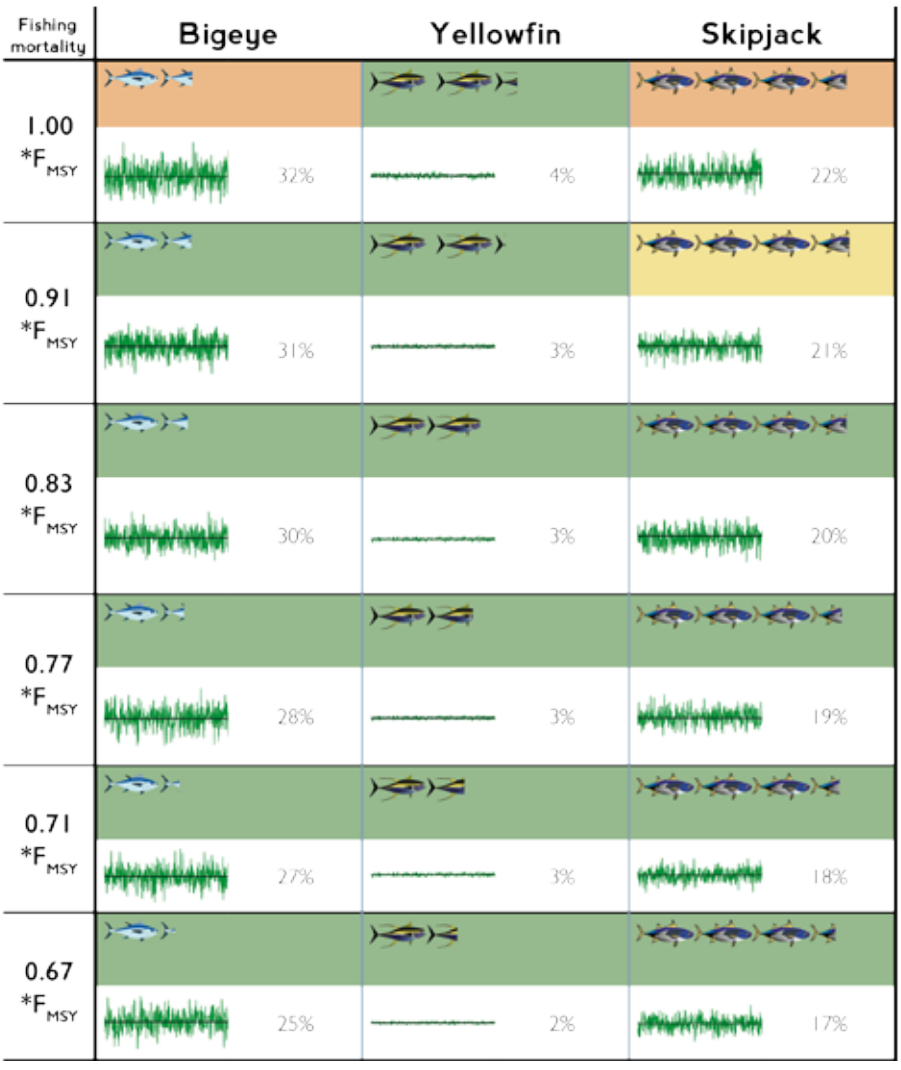
Description of the DST on tunas in the Indian Ocean

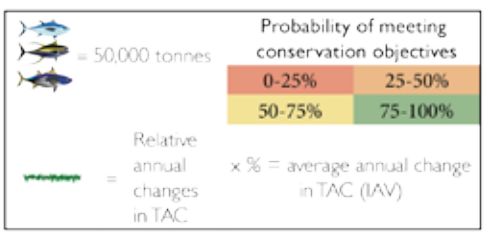
The Indian Ocean is an area of great commercial interest for European fishing industries. Among others, European fleets target bigeye, yellowfin and skipjack, three tuna species that form the tropical tuna fisheries in the Indian Ocean. In this DST we illustrate the consequences of management of these tuna species under the MSY framework aiming for high and stable yields, which was indicated to be the preferred outcome of fisheries management by stakeholders. We combined hypotheses on the fish stocks' interactions with the Southern Oceanic Index (SOI), and investigated the possibility of a management system, based on the overall productivity of large pelagic fisheries: Tropical tuna fisheries appear to operate

in a single species environment, but in fact make decisions in a multispecies context. In the case of tropical tuna, this is a salient aspect due to the compensatory influence of the SOI on the main three species considered (bigeye, yellowfin and skipjack tunas). In the DST, we compare the effect of reducing fishing mortality in a single species and multispecies environment. Taking multi-species considerations into account makes a substantial difference in the perception of stock management. The ability to manage the stocks with low TAC variability for bigeye (higher Inter Annual Variation (IAV)) and yellowfin (lower IAV) is markedly different. The catches are similar under both scenarios for bigeye and skipjack but markedly lower for yellowfin under the multi-species scenario. Overall, the probability to meet conservation objectives is higher under the multi-species scenario at values close to F_{MSY} than under the single species scenario where, on average, species must be fished 25% or more below F_{MSY} to meet these conservation objectives. The main driver behind the differences is the climatic influence on the different stocks. This necessity to incorporate multispecies consideration is highlighted by the results on yellowfin which differ most in yield and stability in yield between the two scenarios. If management were to pursue single-species management, there is a high risk of overexploitation of yellowfin at or below F_{MSY}. If multispecies targets would be implemented however, the risk is substantially lower, and will result in sustainable and precautionary management at values just below F_{MSY} but at a considerable loss of production potential.

DST on tunas in the Indian Ocean

Multi-species management DST





Description of DST for NSAS herring, WBSS herring and sprat

The complexity in the advice and management of herring and sprat in areas IV and IIIa is caused by the overlap between stocks, area and fisheries: two overlapping herring stocks (North Sea autumn spawning (NSAS) herring and western Baltic spring spawning (WBSS) herring), five fleets (three for human consumption and two for industrial use), TACs by area and scientific advice by stock, etc. In addition, there are further ramifications because different member states hold different TAC shares for the different areas. This DST visualises the trade-offs in close collaboration with relevant stakeholders in the Pelagic Advisory Council.

Under the current management regime (i.e. WKHERTAC), the TAC splitting is done according to the management plans for North Sea herring, the management strategy for WBSS herring and the $B_{escapement}$ strategy for North Sea sprat. Five management scenarios have been evaluated representing five different ways of splitting the TACs for the three fish stocks (North Sea herring, North Sea sprat, western Baltic herring):

Biological: make calculations as close as possible to following Fmsy advice per fish stock

Simple: make "back of an envelope" calculation of possible TACs

HERTAC: account for all political agreements currently in place

Industrial: double the F in industrial fisheries.

Landing obligation: Transfer 9% of the sprat TAC to North Sea herring outtake.

DST for NSAS herring, WBSS herring and sprat

Multi-species management DST

	North Sea Herring			West Baltic Herring				North Sea Sprat	
Scenario	Yield A	Yield B	IAV	Yield F	Yield C	Yield D	IAV	Yield B	IAV
Biological Approach	350 kT	16 kT	13%	26 kT	17 kT	2.6 kT	9%	160 kT	60%
Simple Approach	360 kT	9.8 kT	12%	26 kT	17 kT	2.6 kT	9%	160 kT	60%
WKHERTAC Approach	320 kT	12 kT	16%	24 kT	22 kT	2.6 kT	7%	120 kT	60%
Industrial Approach	310 kT	15 kT	16%	22 kT	22 kT	5 kT	8%		60%
Landing Obligation Approach	330 kT	11 kT	16%	24 kT	22 kT	3 kT	7%	10 kT	60%

KEY

= 100 kT

300 kT = exact catch in tonnes

= 5 kT tonnes

= x% average annual change in TAC (IAV)

<5% risk of falling below blim

>5% risk of falling below blim

Impressions from Pelagic Region Advisory Council (PRAC)/Myfish Workshop

Gerard van Balsfoort (Pelagic Freezer-trawler Association)

The Pelagic Freezer-trawler Association is an industry stakeholder and associate member involved in the Myfish project. We understand fully the importance of developing workable MSY-based management methods with direct input from relevant stakeholders.

This bottom-up approach, which is at the heart of Myfish, is very essential. Yet, it is not an easy approach; as was shown in the February 2014 workshop on management choices, variables and constraints for the widely distributed stocks, which was organised by the Pelagic Regional Advisory Council (PRAC) and Myfish in The Hague, the Netherlands.

After an in-depth discussion of the (socioeconomic) management objectives from the point of view of the different stakeholders, we were asked to score the many management measures, variables and constraints for some pelagic stocks. I have to admit, it turned out to be quite difficult, especially in such a short amount of time! Still, this exercise was useful to oblige stakeholders to precisely express their expectations, criteria, trade-offs and choices regarding MSY based management.

Credit: John Lord

Model Surveys

The surveys were undertaken in order to communicate uncertainty that is associated with model based results. Four sources of uncertainty are presented following questionnaire-based interviews with individual modellers. Subjective judgements were elicited about the quality of data and knowledge of processes that went into building models. These judgements were scored according to the template developed for such purposes in the Jakfish project. The template is reproduced in this publication. Two other sections were added: one about the ways in which the model has been tested and validated and another regarding specific sources of uncertainty and robustness which were examined.

Key: Data Input Scores

Survey	No	Ad hoc coverage in time and space	Partly covered	Good coverage and good sampling scheme
Recruitment observations	No direct data on recruitment	Partly covered but disagreements between scientists and fishermen about status	Partly covered by survey but the picture coincides roughly with fishermen's observations	Good survey coverage. In agreement with fishermen
Catch data	Quality unknown	Compliance problems or serious sampling problems	Compliance estimates included, and sampling scheme with some good coverage but some gaps as well	Full compliance and sufficient sampling schemes
Selectivity	Not handled	Poorly sampled and not predictable	Fairly well sampled, but not predictable	Fairly well sampled. Predictable due to stable fleet and gear situation
Bycatch	Unkown, not addressed	Some technical regulations, but a problem	All Bycatch counted against the quota	Very low bycatch

Key: Knowledge Scores

Stock recruitment	Unknown	No clear relationship, recent average used	Possible relationship	Clear visual and functional relationship
Growth	Unknown	Poor sampling, and environmental effects on growth poorly understood	Well sampled, but causes of fluctuations poorly understood	Well sampled and causes of fluctuations are well understood
Natural Mortality	Unknown predation by cod and other top predators of the ecosystem	Poor estimates of M.	Reliable estimates of M, but not at early life stages	Reliable estimates of M
State of stock(s)	Inadequate data and knowledge in assessment	Rather low quality assessment	High quality assessment, but limited focus on uncertainty estimates	High quality assessment with uncertainty estimates
Impact of Climate Change	No knowledge of temperature effects on stock	Limited knowledge, and not accounted for in modelling	Known impact on growth or recruitment or distribution	Well understood consequences of experienced temperature fluctuations
Stock interactions	Unknown and not addressed	Mixing, and not addressed adequately	Mixing occurs but is sampled and monitored	No mixing, not a problem
Spatial aspects	Unknown whether separate components exist	Not accounted for. Limited knowledge on how to separate components.	Partly accounted through spatial and fleet-based data	Fully accounted for
Implementation	Advice not followed and limited control	Limited control	Advice usually followed. Control increases compliance	Advice followed and adequate catch control

Models

Widely Ranging Tuna	Widely Ranging Herring	North Sea Tech. Interactions	North Sea Bio. Interactions	North Sea Southern Ecosim	North Sea Southern SimFish	East Med	West Med	Baltic		
									Survey data	Data
									Recruitment observation	
									Catch data	
									Selectivity	
									Bycatch	
									Stock recruitment	Knowledge
									Growth	
									Natural mortality	
									State of stock(s)	
									Impact of Climate Change	
									Stock interactions	
									Spatial aspects	
									Implementation of management decisions	
✓	✓	·	✓	·	·	·	·	·	Used alternative stock assessments	Model tests Yes/No
✓	·	·	✓	·	·	✓	·	✓	Performed MCMC	
·	·	·	·	·	·	·	✓	·	Sensitivity to small param. changes	
·	✓	·	·	·	·	✓	·	·	Performed MSE	
·	·	·	·	✓	✓	·	·	✓	Validated with data not used in the model	
·	✓	·	✓	✓	·	·	·	✓	Natural mortality	Uncertainty parametric or structural tests Yes/No
·	✓	·	·	·	·	✓	·	✓	Selectivity	
·	✓	·	·	·	·	·	·	·	Migration	
·	·	·	✓	✓	✓	✓	✓	✓	Stock recruitment	
·	·	·	·	✓	·	·	·	·	Assumption about unfished stock size	
·	✓	✓	✓	·	✓	·	·	·	Growth	
·	·	·	·	·	✓	✓	✓	✓	Prices and costs	
✓	·	✓	·	·	·	·	·	·	Effects of Climate Change	
✓	·	·	✓	✓	·	·	✓	·	Other environmentally forced regime shifts	
·	·	·	·	·	·	·	·	·	Standardization of catch statistics	
·	·	·	·	·	·	·	·	·	Underreporting	

Providing an operational framework to implement of MSY management

Myfish brought existing and new knowledge together in a single coherent framework to allow a consistent approach to the attainment of the MSY variants, while respecting local views and priorities. The core purpose of the framework was to provide a guide to good practice in the development of the regional proposals, both within and beyond Myfish. Here we present the investigation of guidelines for good governance based on experience in other jurisdictions followed by the agreed framework.

Lessons learnt from governance models outside the EU

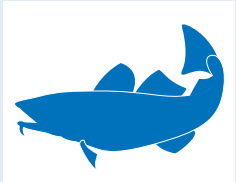
In a review of management measures outside EU borders, Myfish interviewed stakeholders and analysed fisheries management outwards from the EU (Australia, Alaska and the Faroe Islands) to investigate (as case studies) various aspects of sound governance from which the EU can potentially learn. As a result best practices and lessons learnt - regarding MSY variants, objective (i.e. aim or goal) setting and implementation processes (i.e. means to achieve objectives), including the strengths and weaknesses, constraints and trade-offs – concerning the overall governance system for the particular fishery have been identified. Detailed accessible summaries of these case studies are available on the Myfish website.

The Faroe Islands' fisheries governance system[2]: from output to input controls

Area: Faroe Islands

Type of fishery: Mixed-fishery: demersal gadoid stocks (cod, haddock and saithe)

FAROE ISLANDS



GADOID - CODFISH

[2] The authors consider fishery governance as the sum of the legal, social, economic and political arrangements used to manage the fishery.

Fishery governance

Years	Adopted measures	A closer look	Best practices for EU fisheries
1996 - 2013	**Managing organisation: Ministry of Fisheries** **Legislation: Commercial Fisheries Act** The Faroese Total Allowable Effort (TAE) is a fishing licence system framework regulating i) the number of participating vessels (assigned to diverse fleet categories/segments) in particular areas/depth zones, ii) fishing days (ie. the amount of time each vessel in a fleet category/segment is allowed to fish in approved areas/depth zones, and iii) the conservation of juvenile and spawning fish and protected species including comprehensive use of closed areas. Thus, the TAE system allocates Individual Transferrable Fishing Effort (ITE). The precondition for the use of the TAE system is that the total fleet is under Faroese control. A group F = 0.45 target for cod, haddock and saithe is one of the central components of the Faroese TAE system.	Bio-ecological sustainability is a central objective of the Faroese Commercial Fishery Act and accordingly the Faroese TAE/ITE system. However, the objective of constraining exploitation on the major demersal stocks by the effort management system, via controlling F at a level ≤ 0.45 on each of the three component stocks, has not been achieved partly because the original number of fishing days allocated was too high. Also, according to conventional scientific practice, as elucidated by ICES and other intergovernmental advisory organisations, the Faroese system allows too high fishing pressure on the three main demersal stocks.	• **BP1 - Large closed areas as established in the Faroe Islands are not incompatible with prolific fisheries, but the positive effects of the areas need to be documented to maintain legitimacy:** when the areas are as wide-ranging as in the Faroese context, they definitely have an effect in relation to the bio-ecological objective. Nevertheless, to maintain legitimacy, the effects need eventually to be documented, something that has not happened sufficiently on the Faroe Islands • **BP2 - Effort (input control) management can under some circumstances be a competitive approach as it goes a long way towards solving the discards issue:** although catch quota (output control) management for a variety of reasons is the preferred option in most European fisheries, the Faroe Islands have shown that it is possible to use effort management especially in mixed-fisheries due to problems that would otherwise occur with discards. • **BP3 - The experiences of the Faroe Islands show that self-regulation can be an important element in a TAE/ITE management system:** although there may in general be too many days-at-sea available in the system, it is argued that the TAE/ITE system is an example of a system where the presence of overcapacity does not lead necessarily to overfishing due to a combination of vessel owners deciding not to use their days and the presence of large closed areas, etc.

Years	Adopted measures	A closer look	Best practices for EU fisheries
2013 - 2015	**Long Term Management Plans including Harvest Control Rules are under discussion** There is ongoing Faroese work to move away from the F = 0.45 target and to formulate a management plan for cod, haddock and saithe based on the precautionary approach (PA) and associated MSY target and limit reference points estimated by ICES.	With the exception of small fish regulations and protected species, fishers are allowed to land and sell whatever they can catch within their quotas. Technological creep coupled with improvement of knowledge regarding best fishing practice to maximise potential catches over time, acts to increase fishing efficiency of fishing vessels, and thereby increased fishing capacity in terms of catch levels per fishing day. One of the problems of the TAE/ITE system has been the lack of agreement on to what extent the system was self-regulating and thereby disagreement on the conditions on which the (from the outset) available pool of fishing days should be adjusted.	• **BP4 - Overall acceptance and ownership over management is crucial in fostering compliance:** the fact that the TAE/ITE system to a large extent came out of the fishing industry itself has resulted in a management system that is considered highly legitimate, and this has led to only negligible problems with compliance. • **BP5 - Clear, common understanding of the mechanisms of the system between scientists and fishers is needed from the outset:** one of the problems of the TAE/ITE system has been the lack of agreement on to what extent the system was self-regulating and thereby disagreement on the conditions on which the (from the outset) available pool of fishing days should be adjusted. • **BP6 - Allocation of durable rights based on the overall TAE system helps to overcome the tragedy of the commons:** on the Faroe Islands this has been done by ITEs. The actual transferability has been restricted to ensure the maintenance of a varied fleet structure • **BP7 - Systematic monitoring of effort creep in different fleet sectors or métiers is a vital element of an effort-based system:** the Faroe Islands failed to set up a credible system for monitoring effort creep and this has contributed to the problems of getting a systematic approach to adjusting the available pool of fishing days.

myfish

Maximising yield of fisheries while balancing ecosystem, economic and social concerns

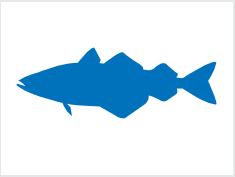
legacy booklet

The fisheries governance system for Alaska Pollock under the North Pacific Fishery Management Council (NPFMC): adaptive legislation and benchmarking

Area: Alaska (United States) Bering Sea, Aleutian Islands (BSAI)

Type of fishery: Large-scale highly industrialised gadoid fishery

ALASKA



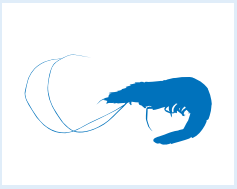
GADOID - POLLOCK

Fishery governance

Years	Adopted measures	A closer look	Best practices for EU fisheries
Since 1976, supported by additional Acts	**Managing organisation: North Pacific Fishery Management Council (NPFMC)** Legislation: US Magnuson – Stevens Act (MSA) The 1st policy objective of the MSA and standard to be achieved is the Optimum Yield (OY) based on MSY, thus preventing overfishing. National Standard No. 9 requires the minimisation of bycatch and bycatch mortality. To support the objectives set by the MSA's National Standard No. 1, a dynamic and adaptable BSAI groundfish policy has been adopted under the remit of the NPFMC, applying Long-Term Fishery Management Plans (LTMPs)/ Harvest Control Rules (HCRs), and the ABC (Acceptable Biological Catch) Control Rule which is precautionary regarding the setting of conservative (risk averse) and legally binding ACLs (Acceptable Catch Limits ≈ TACs) to prevent excessive fishing mortality/ effort and hence overfishing. Moreover, discarding of pollock in the targeted fishery is virtually banned.	The US Congress oversees the MSA and its revision/reauthorisation, and demands annual benchmarking reports on the performance of all federal fisheries. Part of the OY must be held as a reserve to allow for factors such as uncertainties in stock assessments and catch levels including incidental catch of a stock (e.g. pollock) in another fishery. Regulatory compliance is facilitated by a range of accountability measures including 100% coverage by scientific observers of key fleet components, funded by the industry, combined with Vessel Monitoring Systems (VMS) and near real-time reporting of catch and bycatch. Wider stakeholder participation is encouraged in the form of following NPFMC meetings, which are generally open. With very few exceptions, all NPFMC documentation is easily found on the internet and freely available. The National Standard No. 1 preventing overfishing was reinforced by the 1998 American Fisheries Act which cut fleet overcapacity, limited entry to the fishery, allocated durable catch shares (i.e. Individual Fishing Quotas) and opened for harvest cooperatives. Catch shares facilitated the requirement for better handling and full utilisation (no discarding) of the pollock catch leading to a wide range of products and needs, and greater catch value.	• **BP1 - The decision-making process:** the NPFMC represents a very good model for science-based, transparent, inclusive participation and responsible decision-making. The NPFMC forms the core of the governance system. **The model potentially provides, with appropriate adaptation, an extension to the EU's Regional Advisory Councils (RACs).** • **BP2 - The Acceptable Biological Catch (ABC) Control Rule as practiced in a MSY-related context:** this provides the basis for identifying and implementing legally binding overfishing limits (OFL) where OFL is set as the catch that corresponds to FMSY. The stock biomass for MSY is the initial target for rebuilding an overfished stock or stock complex. Thus, ABC is the annual sustainable catch limit (ACL) and shall be set lower than OFL (i.e. OFL≥ABC≥ACL), so that catch quotas (TAC) must not exceed the ABC level. Supporting the ABC Control Rule, comprehensive and dynamic Fishery Management Plans and HCRs adaptively counteract overfishing and aim to achieve OY. • **BP3 - Durable fishing entitlements with associated responsibilities:** limited entry to the fishery and catch shares have contributed to removing the "race for fish" and incentives to overfish. Given the setting of effective catch limits, fishing rights contribute to enhanced resource stewardship and regulatory compliance. However, one must appropriately consider the distribution and longevity of these entitlements to ensure fair access to the fishery. • **BP4 - Real-time, verifiable reporting on catch and bycatch at sea:** the EBS pollock fishery is at the forefront of such reporting, often promoted and even paid for by the industry itself. This includes use of a comprehensive trained observer system on the main fleet segments, VMS, and triggers for time and area closures. The latter includes identification, warning and avoidance of 'rolling hotspots' by collaborating vessels. • **BP5 - Benchmarking of fishery performance: the US regularly assesses the status of its federal fisheries concerning:** i) stock status with regard to overfishing, being overfished and achieving OY in a MSY context; and ii) bycatch (incidental catch) status. Corresponding action plans provide solutions to deficiencies. **Benchmarking has shown itself to be an important, complementary mechanism in improving the performance of U.S. fisheries.** • **BP6 - Full resource retention/utilisation requirements:** this has resulted in minimising discarding/waste and increasing resource utilisation and revenues from enhanced product diversity. **Thereby the industry is better able to face fluctuating resource dynamics.** • **BP7 - The Community Development Quota (CDQ) Programme allowing Alaskan natives to benefit from the target fish resource:** this may provide a potential model, with appropriate adaptation, for helping coastal communities participate in fishing opportunities (either directly themselves or leasing out their quota) in their near-lying sea areas.

The Australian Northern Prawn Fishery (NPF) under the Australian Fisheries Management Authority (AFMA): combating overcapacity, from MSY to MEY, and input controls


AUSTRALIA


PRAWN

Area: Australia

Type of fishery: Australian Northern Prawn Fishery (NPF)[3]

[3] http://www.afma.gov.au/managing-our-fisheries/harvest-strategies/harvest-strategy-for-the-northern-prawn-fishery-under-input-controls/

Fishery governance

Years	Adopted measures	A closer look	Best practices for EU fisheries
Since 1975 (FMA and FAA) and their subsequent amendments	**Managing organisation: Australian Fisheries Management Authority (AFMA)** Legislation: Fisheries Management Act (FMA) and Fisheries Administration Act (FAA; 1991); National Strategy on Ecologically Sustainable Development (NSESD; 1992); Environmental Protection and Biodiversity Conservation Act (1999); Commonwealth Policy on Fisheries Bycatch (2000); Ministerial Direction (2005); Commonwealth Harvest Strategy Policy (CHSP; 2007).	NPF adopted a 'basket approach' management (i.e. a suite of prawn species): it is acknowledged that not all the target species will be able to achieve the MEY target at the same point in time. The NPF continues to be input controlled in the form of total allowable effort (TAE) for the fleet, split into individual tradable effort (ITE) quotas (Q). Additionally, there are seasonal as well as time of day and areal closures, plus gear restrictions.	• **BP1 - Clear and comprehensible policies:** the EU could benefit from having the equivalent of the CHSP laying out its current approach to fisheries management as an umbrella to the FMPs. • **BP2 - Fishery specific harvest control system:** given that prawns/shrimps are challenging to carry out good stock assessments and management for, the approach of the NPF is well worth learning from with respect to applying harvest control rules for shrimp/prawn fisheries in parts of the EU. Although AFMA has a default preference for output controls in the form of TAC/ITQs, the NPF has demonstrated that input controls (TAE/ITE(Qs)) are an effective and viable option for this fishery. • **BP3 -** Net economic returns and MEY target: the bioeconomic model produced specifically for the NPF has led to a 'win - win' situation for both the industry and the environment. An MEY target may form an appropriate aspirational model for some of the EU fisheries given that appropriate data are available. Buying-in to an MEY target, fishers can also be motivated to provide improved fleet-related economic data in accord with the aims of the CFP's Data Collection Framework Directive. It is emphasised that the MEY target is recommended as the second stage in optimising sustainable fisheries, following a first stage which has adopted MSY and progressed to it. The Australian lesson has underlined that removal of fishing overcapacity is an essential precursor for facilitating the move to successful MSY and MEY management.

The Australian Northern Prawn Fishery (NPF) under the Australian Fisheries Management Authority (AFMA) - Continued

Years	Adopted measures	A closer look	Best practices for EU fisheries
Since 1975 (FMA and FAA) and their subsequent amendments	Since 1995, the fishery has been managed according to the 1995 NPF Management Plan, with periodic amendments. In 2001, the Northern Prawn Management Advisory Committee (NORMAC) of AFMA set a target of reaching S_{MSY} (spawner biomass that produces MSY), with 70% certainty, by 2006. In 2004, NORMAC established Maximum Economic Yield (MEY) - with industry support - as the overall management objective of the fishery, and S_{MSY} was redefined as a limit reference point. In 2007, the Northern Prawn Fishery Harvest Strategy under Input Controls (NPFHS) was introduced. The NPFHS aims to pursue MEY and maximise profit, by varying effort levels, using bio-economic assessment of the important tiger prawn fishery. The NPFHS includes catch triggers and decision rules for banana prawn and tiger prawn fisheries.	The status and trends of the NPF fleet's effort are closely monitored and the length of a unit of headrope is adjusted by NORMAC, based on scientific advice, to reflect needs to either decrease or increase the fishing effort. The NPF as a whole, and specifically via CSIRO, has developed an innovative system of Ecological Risk Assessment (ERA) and Ecological Risk Management (ERM) primarily for addressing threatened, endangered and protected (TEP) species.	• **BP4 - The AFMA governance model:** this model bridges diverse aspects of fisheries and environmental policy/ legislation focusing these in the operation of the NPF. What is important in the EU context is that the AFMA model, and more specifically AFMA itself, allows for the separation of politics from the everyday management of the fishery. Including wide and constructive stakeholder participation through both Management Advisory Committees (MACs, such the NPF's NORMAC) and Resource Assessment Groups (RAGs, such as the NPF's NPRAG) is also imperative. The model potentially can provide, with appropriate adaptation, a good outline for the EU's Regional Advisory Councils (RACs), especially when and if it is decided that the role of RACs should be strengthened. • **BP5 - Ecological Risk Assessment (ERA) and Ecological Risk Management (ERM) framework:** the Australian-developed ERA process framework uses a hierarchy of risk assessment methodologies which analyse the impact, both direct and indirect, that fishery activities have on five ecological components of the marine ecosystem (i.e.: target species; byproduct and bycatch species; threatened, endangered and protected species; habitats; and ecological communities). The ERM process then promotes the application of appropriate mitigatory actions/measures for components at significant risk from the fishery. Uptake of the NPF's ERA/ERM system would be a very important step towards improved assessment and management of bycatch issues and thereby in advancing an ecosystem-based approach in EU fisheries. • **BP6 - The 1992 NSESD and the 1999 EPBC Act as overarching policy:** these provide the Environment Minister with a mandate to oversee fisheries management and step in when important issues of marine environmental protection and biodiversity conservation arise. This third party intervention is indispensable not only for the conservation of the resource and other ecosystem components, but also for allowing the public to feel assured that the necessary 'checks and balances' are being applied with respect to agreed legislation and policy standards. An understanding of the implementation of the EPBC Act concerning Australian fisheries is likely to help the EU consider how its new Marine Strategy Framework Directive ('Environmental Pillar') may operationally interact with the CFP. • **BP7 - Co-management with cost-recovery system:** there has been an increasing movement towards co-management in the NPF. The delegation of more power to the industry in the management of the fishery has a cost recovery function where the NPF industry pays 100% of recoverable management costs. Therefore, those who have been given the right to fish through statutory fishing rights have the opportunity to co-manage the fishery, i.e. with rights come stewardship responsibilities. Given that the fishing industry has the right to benefit from the extraction of a public resource, there is a levy imposed for the government services provided in management of that resource (research/administrative component of the levy).

The Framework

The proposed draft framework is comprised of four steps (fig. 6):

1. Problem framing (to determine objectives not currently met)
2. Options (to agree dimensions for decisions)
3. Implementation (to address the resulting trade-offs moving to new variants)
4. Evaluation (to check that outcomes meet wider objectives)

Based on this Operational Framework, each of the Myfish case studies was evaluated. This served both to evaluate how broadly applicable the framework was across a range of different scenarios, but also allowed evaluation of progress within the case studies in this context. This evaluation was only possible for the first steps, as implementation in management was not completed during the project life time.

The framework adopted by Myfish to facilitate this process is outlined in Figure 6, which illustrates a structured series of interactions involving many diverse stakeholder groups in iterative steps.

The properties of the various regional fisheries models were also examined, through a questionnaire for fisheries scientists comparing the way management options are modelled. This overview of the models used in different fisheries hghlights that the many models involved are very diverse. There may be further possibilities to identify how properties of these models used to demonstrate management options may contribute to more effective stakeholder participation and acceptance.

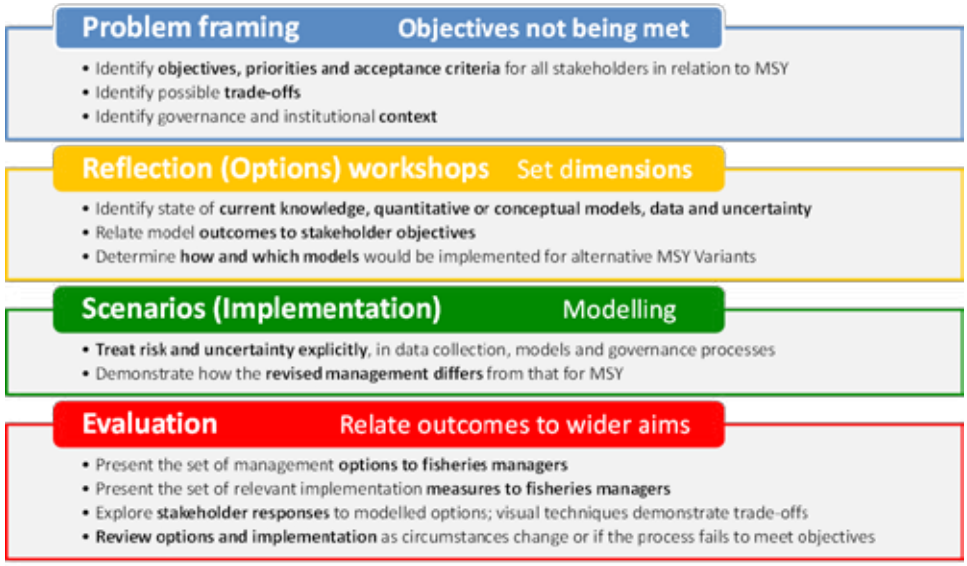


Figure 6: Structured series of interactions used by Myfish in stakeholder engagement process

Supporting Multiannual Plans

Myfish participants were dedicated to bringing their results all the way to management plans. Project participants coorganised ICES/Myfish meetings to support the development of guidelines to define F_{MSY} ranges and produce estimates of these ranges. Further, the participants actively participated in ICES and STECF working groups dedicated to introducing the results of Myfish in advice and draft Multiannual plans for the Baltic Sea, North Sea, Western waters, and the Mediterranean. In total, Myfish partners provided a total of 19 presentations in 5 STECF and 14 ICES working groups and the footprint of Myfish is clearly visible in many of the advisory documents and draft MAP texts. MSY principles reflect a focus on obtaining continuing high catches to provide food and livelihoods to humanity, while not compromising ecosystems. However, maintaining healthy stocks to provide the MSY on a single species basis does not ensure that broader ecosystem, economic and social objectives are addressed. In Myfish, we investigated how the principles of a Pretty Good Yield range of fishing mortalities (assumed to provide more than 95% of the average yield for a single stock) can be expanded to a Pretty Good Multispecies Yield space. The Pretty Good Multispecies Yield space is a practical concept that can address some ecosystem, economic and social trade-offs encountered and provides a safe operating space for management.

While this space adheres to the principles of MSY, it allows the consideration of other aspects to be included in operational management advice in both data-rich and data-limited situations. Furthermore, it provides a way to integrate advice across stocks, avoiding clearly non-feasible management combinations and thereby hopefully increasing confidence in scientific advice.

The European CFP gradually implements a discard ban in all European fisheries and under this ban, all catch must be landed and counted against the allowed catch for the stock. Fishing will have to cease once the allowed catch of one stock is exhausted. This provides a substantial incentive on behalf of the fishery to avoid the less productive species in landings. As this can be ensured either by avoiding the catch of the species or through illegally discarding catches, the system is likely to require a high intensity control system to be in place. One way to limit this is to change the advice for all stocks to avoid clearly non-feasible combinations (e.g. high fishing mortality combined with low fishing mortality for two species caught in mixed fisheries). Concurrent with the implementation of the discard ban, the European Commission has shifted from a focus on F_{MSY} as a point estimate to a focus on F_{MSY} as a range where the proportion of yield obtained is 95% of MSY.

Scientific advice on annual catch based on ranges for mixed fisheries could have four steps: 1) Determine the single species ranges, 2) Determine which combinations of fishing mortalities of the different species are compatible with mixed fisheries, multispecies and ecosystem considerations, 3) Determine which combinations are desirable from an economic perspective and 4) Determine which combinations are desirable from a social perspective. In the North Sea, Myfish studies provide a demonstration of this for cod and haddock. In an ecosystem context, due to the cannibalistic nature of cod, low values of fishing mortality on cod lead to cod yields below 95% of MSY as well as increased risk of prey stocks falling below biomass reference points. On the other hand, technical interactions in the fisheries mean that it is not possible to retain a high fishing mortality of haddock together with a low fishing mortality of cod (Figure 7).

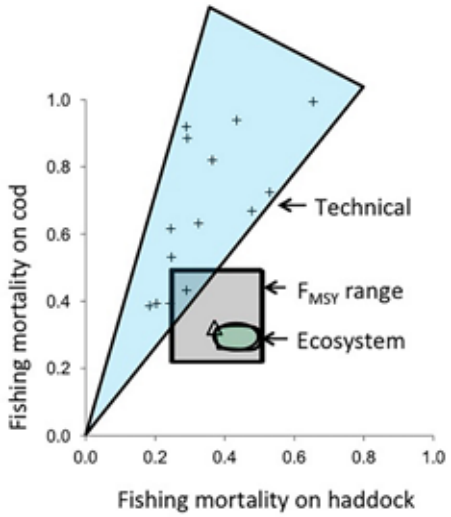


Figure 7. Pretty Good Multispecies Yield spaces for North Sea cod and Northern shelf haddock caught in mixed fisheries. Combinations leading to Pretty Good Multispecies Yield are indicated in overlapping shadings, shaded forms indicate the combinations of F_{MSY} ranges, desirable ecosystem combinations, technical interactions indicated by the area of observed combinations of observed fishing mortalities from 2001 to 2014 (+, from ICES).
Reference: Rindorf, Anna, et al. "Food for thought: pretty good multispecies yield." ICES Journal of Marine Science: Journal du Conseil (2016): fsw071.

Δ indicates the current single-species F_{MSY} point estimates.

Communicating globally: the ICES/Myfish symposium and the Myfish policy meeting

Communication has been a key focus throughout the project, resulting in a total of 160 presentations, 89 scientific journal papers, and a dedicated volume of ICES Journal of Marine Science. In addition to this, two targeted meetings were held; a symposium focusing on scientific results and stakeholder involvement in Myfish and similar efforts globally and a policy meeting aiming to discuss how Myfish results are relevant to EU management.

The ICES/Myfish symposium on "Targets and limits for long term fisheries management"

Best quality scientific approaches to fisheries management advice and implementation under potentially conflicting objectives were the main topic of the final Myfish symposium held in Athens (Greece) from 27-31 October 2015. The event, held under the auspices of ICES, brought together experts from across the world to discuss targets and limits for successful long term fisheries management. The ICES/Myfish symposium brought together 80 high-level experts from 12 European countries, Canada, the USA, Chile, New Zealand, Australia and Japan including internationally recognised key note speakers and conveners. A total of 46 presentations and 6 posters were included. At the symposium, successful case studies from the different geographical areas were presented and discussed to assess possible future implementation in European fisheries management. The symposium programme, abstracts and the majority of the presentations given can be found at the Myfish website together with word clouds of the written comments given to each session (www.myfishproject.eu/final-symposium-2/scientific-programme).

Long term targets and limits are extensively used in fisheries management advice to operationalise the way fisheries management reflects societal priorities on ecosystem, economic, social and institutional aspects. The reflections over the literature and studies presented at the symposium, together with the views expressed in group discussions and free text comments were gathered in a review concluding with ten major challenges for the future implementation of targets and limits in fisheries management.

The Myfish policy meeting

The Myfish project hosted a policy information meeting on 25 February 2016 as the project approached the end of its four year duration. The meeting provided an opportunity to discuss how the results are relevant to fisheries management, which challenges have been solved and which challenges still remain. Representatives of Advisory councils, GFCM and ICES, European fisheries managers, NGOs, regional groups and the European Parliament were invited to the meeting. The meeting assembled 76 participants in the premises of the European Commission, Directorate General for Research and Innovation, in Brussels (Fig. 8).

The meeting was opened by Sigi Gruber (DGRTD) and Ernesto Penas Lado (DGMARE) continued by describing how he perceived the Myfish project.

The Myfish project coordinator Anna Rindorf emphasised that MSY needs adaption and understanding to accommodate sustainability of stocks, ecosystems, economic and social considerations, rather than wholesale replacement. The meeting was a mixture of scientific presentations on selected topics and interactive sessions including online voting and group work. All presentations from the meeting are available here: www.myfishproject.eu/policy-meeting

After an introduction to MSY and trade-offs, the interactive sessions engaged the participants to clearly demonstrate that the amount of information on e.g. yield, ecological, economic and social aspects greatly influences which fisheries management goals seem most appropriate. There was a lively discussion following the presentation touching on topics such as whether employment would be a national policy matter and not a regional fisheries management issue and whether rebuilding stocks will lead to increased employment or increased yield to participants in the fishery. The conclusion was that the more information is given, the more views and opinions change. Further, even though MSY is stated in legislation, in reality one cannot maximise everything simultaneously, thus within the text of the law, we need to be operational and have room for interpretation. Following this session, 76% of the participants who gave their opinion thought the presented DSTs could provide useful input for decision-making if explained by a scientist whereas only 26% of the participants who gave their opinion thought the presented DSTs could provide useful input for decision-making if not explained by a scientist. 26-32% abstained from giving their opinion on the questions.

The concept of F_{MSY} ranges as an approach to MSY management was discussed in detail. Substantial concern was expressed around whether fishing in different parts of the range could be considered equally sustainable. The ranges were considered as a way to mitigate mixed-fish issues in relation to the discard-ban.

In discussions of the role of social acceptability and inclusive governance in MSY management, it was commented that transfer of knowledge through a participatory process should be transparent, which is not currently the case. Key questions

should be discussed and facilitated in cooperation. The transfer of information from science to management is not generally working ideally. It was recognised that MSY changes over time, and that management therefore should be adaptive. It was discussed if and how adaptive management could be conducted under the current CFP. It was suggested that scientists should define the 'safe space', and a socioeconomic 'filter' can then be applied to further limit feasible management options. Inclusive governance was considered useful to provide transparency and ownership and to understand different objectives and means. The governance capacity of existing groups can be used if they are given a clear mandate. Socially acceptable decisions are important to decision-makers and it should be made obvious how this can be facilitated by inclusive governance. It is important to ensure the inclusive process does not exclude certain people. Inclusive governance requires commitment, time and effort, so perhaps at times will need to be short-circuited in cases of urgent decision needs.

Ernesto Penas-Lado

EC Directorate-General for Maritime Affairs and Fisheries (DG MARE)

Very few times I have seen a research project so well focused to find scientific guidance on an essential issue of fisheries management as Myfish. After the adoption of the new CFP in 2013, the management system, and thus the scientific community, are confronted with a fundamental problem: how to achieve the MSY objectives in a context of mixed fisheries having to implement the landing obligation, and all in a way that will respect the objectives of fisheries management as laid down in the Treaty. The work of Myfish provides very useful insight into the way in which these challenges can be underpinned by science.

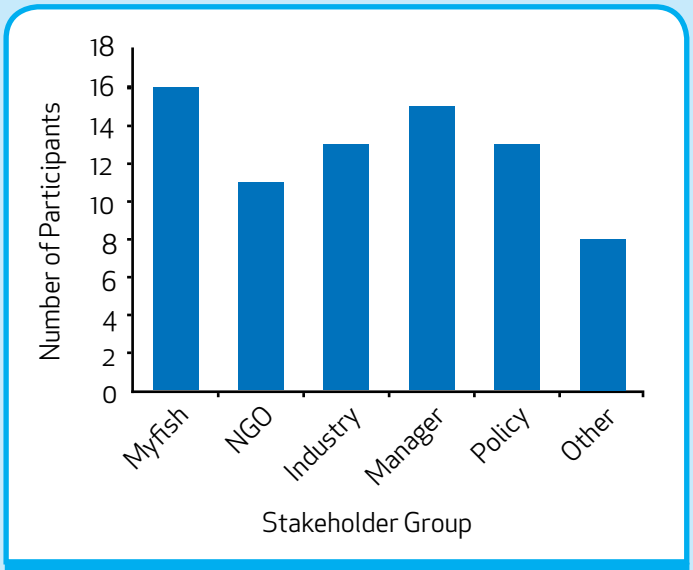
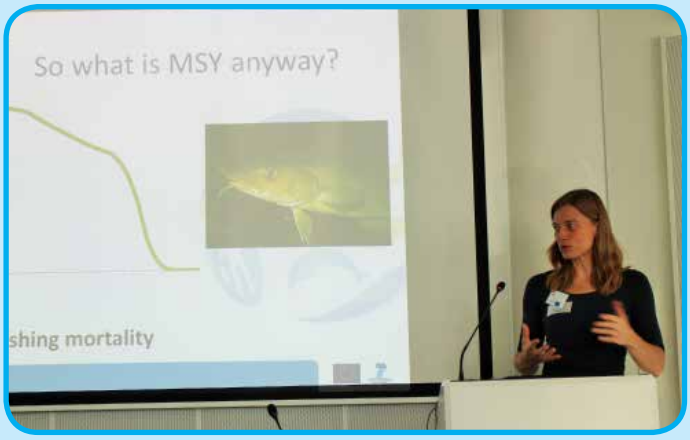


Fig. 8. Group composition of the 76 registered participants in the meeting. 'Policy' refers to participants associated with European Parliament and 'Manager' refers to national managers and participants from DGMARE and DGENV.



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Maximising yield of fisheries while balancing ecosystem, economic and social concerns

legacy booklet

Myfish at a Glance

TITLE: Maximising Yield of Fisheries while Balancing Ecosystem, Economic and Social Concerns

PROGRAMME: FP7, Cooperation, Food, Agriculture and Fisheries, and Biotechnology

INSTRUMENT: Collaborative project

TOTAL BUDGET: €6,513,288.34

EC CONTRIBUTION: €4,999,999.00

DURATION: March 2012 – February 2016 (48 months)

COORDINATOR: National Institute of Aquatic Resources, Technical University of Denmark (DTU Aqua), Denmark

CONSORTIUM: 31 partners from 12 countries

WEB: www.myfishproject.eu

PROJECT PARTNERS

BELGIUM
- Joint Research Center – Institute for the Protection and Security of the Citizen

DENMARK
- National Institute of Aquatic Resources, Technical University of Denmark
- Institute of Food and Resource Economics, University of Copenhagen
- Innovative Fisheries Management – Aalborg University
- KARBAK ApS

FRANCE
- Institut Français de Recherche pour l'Exploitation de la Mer
- SARL Code Lutin

GERMANY
- Christian-Albrechts-Universitæt zu Kiel
- Johann Heinrich von Thünen-Institut
- University of Hamburg
- Kutterfisch-Zentrale GMBH

GREECE
- Hellenic Centre for Marine Research

IRELAND
- Marine Institute
- AquaTT UETP Ltd
- Killybegs Fishermen's Organisation Ltd

NETHERLANDS
- Dienst Landbouwkundig Onderzoek
- VOF de Drie Gebroeders
- Wilma BV
- Visserijbedrijf J. 't Mannetje

NORWAY
- Havforskningsinstituttet
- Department of Sociology and Political Science, Norges Tekniske-Naturvitenskapelige Universitet

POLAND
- Morski Instytut Rybacki w Gdyni

SPAIN
- Fundación AZTI/AZTI Fundazioa
- Instituto Español de Oceanografía
- Universidad de Vigo

SWEDEN
- AquaMarine Advisers

UNITED KINGDOM
- The Secretary of State for Environment, Food and Rural Affairs
- Plymouth Marine Laboratory
- Imperial College of Science, Technology and Medicine
- The University Court of the University of St Andrews
- School of Biological Sciences, Queen's University Belfast

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Conclusions and challenges remaining after Myfish

The Myfish project has been a journey into the unknown attempting to satisfy the broad range of ecosystem, economic, social and governance objectives while the new CFP was only just entering into force. We have challenged ourselves and the NGO, industry and management stakeholders joining us in the process with high aspirations to provide the scientific advice needed to make relevant, effective and informed policy decisions. A large part of this work has involved identifying criteria which are clearly undesirable and other criteria that are both desirable and feasible. Our main conclusions after this process are:

- The principle of MSY can be expanded from single to multiple interacting species and fisheries, as well as to ecosystem, social, and economic objectives
- Fisheries yields in biomass and/or economic terms can be optimised (MSY and MEY). Social and ecosystem objectives are best used as constraints on the biomass or economic optimisation. In other words, we should avoid solutions that may be attractive in terms of yield, but that compromise ecosystem or social sustainability
- An inclusive process of problem framing, management reflection, modelling scenarios and systematic evaluation of modelled outcomes has been demonstrated and this operational framework is key to defining strategic objectives for local fisheries management
- The implementation must be adaptive to follow the variation in processes both in the ecosystem and in economic and social aspects, as well as the specific characteristics of individual fisheries
- Options, modelled scenarios and outcomes need to be presented in consistent and comprehensible formats to ensure broad and effective stakeholder participation
- Decision support tools need to present choices and particularly trade-offs in a format that is readily understandable, and ideally would allow users to experiment with these choices
- European MSY results are recognised as being at the innovative forefront of management advice, and incorporating aconsistent and inclusive framework to extend MSY to a wider set of criteria enhances this leading role
- Further work is needed on developing MSY ranges that provide "Pretty Good Yield" rather than focusing on specific reference points, and that allow flexibility to work within social and ecosystem constraints

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