

Why do agreed TACs not always match the ICES scientific advice?

Summary

The EU Common Fisheries Policy (CFP) strives towards managing fisheries based on optimal or Maximum Sustainable Yield (MSY), consistent with economic, social and employment benefits with a long term aim of environmentally sustainable fisheries. This industry guidance note summarizes the types of scientific advice available to fisheries' managers and discusses the constraints which managers experience in managing fisheries. These constraints include; issues concerning the shared resource nature of fish stocks and the need to agree measures between the parties exploiting the stocks, uncertainty in the scientific advice, commitments to relative stability aimed at avoiding economic and social risks of rapid changes in catches, management of mixed fisheries, where not all stocks can be optimally harvested, issues relating to scales of assessment and management units and the evolving trends in the landings obligation. These constraints mean that measures to move stocks towards optimal harvesting levels have to be undertaken over long period of time and require management of more than just Total Allowable Catches (TACs) on a year by year basis. In their multi annual management plans for key stocks, the European Union has used, amongst other measures control of effort levels, technical and spatial and temporal management measures. The outcomes of this regime are discussed based on ICES data over the years since 2000, which shows a trend towards optimal harvesting at maximum sustainable yield during this period, and other data which shows increasing congruence between advised and agreed TACs. Future trends in management advice are discussed, particularly in relation to evolving advice in mixed fisheries, where trade-offs between stocks and which stocks are likely to become limiting or 'choke species' under different scenarios, are discussed. To enable this advice to be used effectively, managers need advice on the range of catches which would result in close to ($\pm 5\%$ of MSY) optimal long term harvesting, yet still allow sustainable harvesting. The EU is in the process of formulating multi annual management plans for a number of fisheries and these developments in advice should help shape these plans.

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Introduction

In a recent paper Carpenter et al (2016) cite the fact that the Total Allowable Catch (TAC) for many stocks as agreed by the European Union (EU) Council of Ministers, does not consistently coincide with the headline scientifically derived advised catch as given by the International Council for the Exploration of the Sea¹, as an indication that short-term concerns prevail over long-term sustainability of fisheries resources during the last decades.

This industry guidance note explains how the annual TAC advice process works in European fisheries and why the TACs agreed at the December Council negotiations do not always exactly match the annual scientific advice produced by the International Council for the Exploration of the Sea (ICES).

A central plank of the reformed Common Fisheries Policy (CFP) (COUNCIL REGULATION (EU) No 1380/2013) is the EU decision to manage fish stocks based on Maximum Sustainable Yield (MSY). Management of stocks at MSY corresponds to the optimal conditions for high long term yields. The decision stems from commitments made at the World Summit on Sustainable Development (WSSD), in Johannesburg in 2002, to aim towards MSY in world fisheries.

There are also commitments to ensure that fishing activities are environmentally sustainable in the long-term and are managed in a way that is consistent with the objectives of achieving economic, social and employment benefits and to implement an ecosystem-based approach to fisheries management to ensure that negative impacts of fishing activities on the marine ecosystem are minimised.

Therefore it is the overall aim of the EU Council of Ministers, in their role as EU fisheries managers, to strive towards these commitments. In moving towards MSY the fisheries' managers are faced with a number of constraints. In this guidance note we discuss the scientific information available to managers, some of the constraints which they are faced with when implementing management measures through negotiation, which result in the headline advice on MSY not being implemented in every stock. The outcome of the process in terms of stock trends over time is discussed along with some of the developments in advice which are designed to improve the management process in the future.

Advice to managers

ICES provides advice to competent authorities on marine policy and management issues related to the impacts of human activities on marine ecosystems and the sustainable use of living resources. In the context of the CFP, ICES provides annual advice on the status of fish stocks in waters of the Northeast Atlantic European Exclusive Economic Zone (EEZ), including advised catches for the following year. Outside the European Exclusive Economic Zone ICES also gives advice to Coastal States managing stocks, so called 'Straddling Stocks' which migrate across several EEZs and the high seas areas outside them, such as Northeast Atlantic mackerel, under the auspices of the North East Atlantic Fisheries Commission (NEAFC) and also to national governments such as Iceland and Faroes, whose stocks are mostly confined to their EEZs. While the stock assessments and draft advice are

¹ www.ices.dk

provided by ICES Expert Groups, comprising stock assessment scientists from the relevant member states, the advice is independently reviewed before signoff by the ICES Advisory Committee.

Several sources of advice are available to fisheries managers, and in Europe are discussed at the December Fisheries Council. The single stock assessments based on the dynamics of the individual stocks, which are produced annually for most assessed stocks in the Northeast Atlantic during the period May until October are the most relevant to December Council and recently advice has also been made available on mixed fisheries issues (see 'Future Advice Developments' below).

Another layer of advice scrutiny is provided by the Commission's Scientific, Technical and Economic Committee for Fisheries² (STECF), which reviews the ICES advice and also evaluates additional advice requests raised by Member States or the Commission. ICES and STECF are also asked to give advice on other aspects such as trends in effort levels and economic and ecological issues.

In Europe the European Commission then consults with its stakeholder groups, the Regional Advisory Councils (RACs), which contain representatives of both the Seafood industry and other interests, predominantly environmental non-governmental organisations, prior to publishing its proposals around October for the next year's fishing opportunities.

Stock Assessments

ICES provides fish stock assessments against its Maximum Sustainable Yield (MSY) and Precautionary Approach (PA) or 'safe biological limits' frameworks; these are fully described in [link](#) and also ICES (2015). In essence the MSY approach corresponds to optimal harvesting at maximum sustainable yield and the PA approach is designed to ensure that the stocks reproductive capacity is not inhibited and it is harvested at a sustainable yield (see section on MSY ranges). ICES currently recognise six categories of stock assessment, based on the level of data available and assessment method used:

1. Stocks with quantitative assessments and for which full analytical assessments and forecasts are possible
2. Stocks with analytical assessments and forecasts that are only treated qualitatively (where for example forecasts are available as trends only).
3. Stocks with survey based assessments indicative of trends only. Most of these are based on indexes of biomass trends from research vessel surveys, but they also include trends in total mortality and recruitment in some cases
4. Stocks for which only reliable catch data are available
5. Landings only stocks.
6. Negligible landings stocks and stocks caught in minor amounts as by-catch.

For those category 1 and 2 stocks where management authorities have agreed a management plan for a stock and it has been evaluated by ICES to be consistent with the precautionary approach, then ICES provides advice in accordance with the plan. If no management plan/strategy has been agreed by the authorities (or it has been evaluated by ICES as not compatible with the precautionary approach), then the headline advice which ICES will provide is based on MSY. In the absence of

² <https://stecf.jrc.ec.europa.eu/>

defined MSY reference points, ICES will provide headline advice based on the precautionary approach. In stocks where the stock is outside safe biological limits advice may be given for a zero TAC, or to minimise catches to the lowest possible level. This is usually accompanied by a recommendation for a management plan aimed at recovering the stock.

For category 1 stocks ICES will also give advice in the form of an 'options table' which maps out the consequences of different TAC levels on predicted fishing mortality, spawning stock biomass and catches. In interpreting this advice it is important to understand that fishing at MSY is an optimum condition that managers are working towards. Stocks may be capable of sustaining a fishery and have a viable spawning stock biomass even though the fishing mortality is at a higher level than would be compatible with MSY which represents optimum long term yields. Transition to MSY may take several years, via reductions in fishing mortality staged on an annual basis at a rate which is compatible with reduction in effort levels (see below) as could be agreed in a management plan.

Data limited stocks

This term relates to stocks in categories 3-6. For category 3 to 6 stocks the available knowledge is insufficient to apply the ICES MSY approach and the advice is therefore based on the precautionary approach. That is to maintain the stock's capacity to reproduce and therefore remain within safe biological limits. In many cases the stock advice is aimed at keeping the stock at equilibrium. For category 3 stocks, this is achieved by basing catch advice on trends in recent survey data, with catch advice adjusted to reflect change in an index of abundance or biomass. When the trend over time in the index is increasing catches can be allowed to increase and when it is decreasing catches should be decreased subject to an annual maximum change of $\pm 20\%$. Category 4 to 6 stocks are assessed on the basis of previous catch data and/or other information.

To introduce a measure of precaution for data limited stocks, an additional reduction of 20% the precautionary approach (PA) buffer is introduced in the TAC advice when there is uncertainty. However, this reduction is not intended to be applied every year, and, as ICES notes, it is not applied where "*expert judgment determines that the stock is not reproductively impaired (that is inside safe biological limits) and where there is evidence that the stock size is increasing significantly or exploitation has reduced*". Where stocks are considered to be outside safe biological limits a zero or lowest possible level of catch can be advised on the basis of a data limited assessment.

Management Constraints

In this section we discuss some of the constraints faced by fisheries' managers in making their decisions on TACs and other management measures. This means that it is not always feasible or desirable that all TACs are set in accordance with F_{MSY} advice. Management actions are constrained by the limitations of the information available, and by the technical and commercial realities.

Shared resources

Fundamentally fishery resources are shared resources, where competitors from the scale of individual fishers to nation states compete to catch their 'share' of the resource. The European Union has achieved an agreed management structure for the common resource species within its member states' EEZs. However, where stocks are shared with third countries, such as Northeast Atlantic mackerel, there is a risk that Nations set autonomous quotas without an overall agreement.

On the high seas and in areas where there are many straddling stocks, stocks are managed by agreement between coastal states under the auspices of Regional Fisheries Management Organizations such as NEAFC. Inevitably, the rate of progress towards optimal conditions will be influenced by the competitive forces at work between parties.

Management plans are a key ingredient in these circumstances and are used inside and outside the European Union to manage fisheries. If parties are able to agree on a target and a set of decision rules which would be implemented under given conditions, this contributes to progress. Science can support the design of these management plans; however agreement to design and implement a plan has to be made at a political level and is subject to political constraints.

However, fish stocks' migratory patterns can change and so the parties exploiting the stock can change over time and allocated "share" under previous agreements may become contested. For example the expansion in the migratory range of the North Atlantic mackerel over the past decade (Nøttestad, 2016) has resulted in the Iceland as well as the EU, Norway and the Faroes exploiting the stock.

Data limitations

Single stock fish stock assessments, which form the basis of most of the advice on category one stocks, are based on population models of the stocks. Stock size; spawning stock biomass (SSB), is modelled using inputs from growth and recruitment of incoming young fish into the population, with estimates of egg deposition and larval/juvenile fish numbers being core requirements. Member states conduct regular research vessel based surveys, specifically targeted at obtaining this information, for example, groundfish surveys and pelagic fish surveys, as well as larval fish surveys and egg production surveys. SSB and recruitment data are used to determine the reproductive capacity of a stock and hence assess whether it is within safe biological limits. The total mortality (Z) experienced by a year class or cohort will determine future recruitment and is a combination of rates of death due to fishing (fishing mortality or F) and death due to natural causes (natural mortality or M). Errors in the estimation of any of these parameters will result in inaccuracies in the assessment models.

Fishing mortality is estimated by summing catches (discards and landings) of all age classes in the fishery as a proportion of the overall cohort size. However, estimation of natural mortality is much more challenging and ideally would require contemporary data on predator/prey relationships via fish stomach contents and also direct and indirect impact of environmental conditions on larval/juvenile fish survival. This information is unavailable for many stocks, so natural mortality has often been based on historical levels when exploitation was low. The balance between these two sources of mortality determines the advised level of fishing mortality, including that required to achieve F_{MSY} .

Age based stock assessments require ability to age fish to identify numbers at age in the population and in the catch. For most teleost or boney fish in temperate regions, this is feasible because it is possible to age fish using growth rings on their otoliths or ear bones. In contrast elasmobranch fish are more difficult to age.

For these reasons data remains limited for many fish stocks and therefore in 2012 ICES developed methodology to deliver advice for data limited stocks. By 2014 64% of the 254 stocks assessed by ICES were assessed using these methods. In data limited situations trends can at least provide assurance of stability or trigger further investigation. However, for certain stocks such as long lived elasmobranch species there is a higher risk of stock decline and there is poor knowledge of their biology and growth rates and for most data limited stocks there is a difficulty estimating fishing mortality. An important constraint is the ability within current resources to adequately assess data limited stocks, especially the more vulnerable ones such as elasmobranchs.

Given these constraints, considerable effort is expended in trying to improve data availability and quality and in developing and refining assessment models. Specifically, European Commission Regulation (EC) No 1693/2001 requires member states to establish national programmes for the collection and management of fisheries data to directly support CFP implementation, while ICES has an on-going process of revaluating data and updating stock assessment methodologies via periodic scientific “benchmark” workshops on individual stocks.

Relative stability, social and economic implications

Landings stability over time is considered economically desirable; particularly where the processing sector is geared up for particular volumes of supply and hence large inter-annual changes would have negative socio economic outcomes. Other relevant socio-economic considerations may include dependency of a fleet or member state on particular stocks for fishing opportunities. The CFP requires that fishing opportunities should be allocated to Member States in such a way as to ensure relative stability of fishing activities of each Member State for each fish stock or fishery. The speed of getting to MSY targets is a managers’ decision and is not a fully biological consideration, as the socio-economic implications as well, as the practicalities of moving a stock or stocks to MSY must also be considered.

Fishing capacity and mixed fisheries

The way in which fishing capacity is related to the overall catch available is an important constraint. Excess fishing capacity in mixed fisheries means that there is a risk of stocks for which the vessels’ quotas are used up first so called ‘choke stocks’ being discarded whilst fishers pursue stocks for which they still have quota. Clearly, just setting an MSY based TAC alone will not always achieve management objectives and there is a need to ensure that fishing effort levels and TACs are controlled in parallel, since, if effort remains high but TACs are decreased there is a risk of increased discarding. This is why the EU cod management plans include effort reduction. Reducing fishing capacity has to be carried out over long time periods to avoid adverse socio-economic effects, so the rate of reduction of effort and TAC has to be factored into the management plan for a given stock.

Mixed fisheries advice scenarios will inevitably introduce departures from MSY advice for some individual stocks, in order to achieve a balanced harvest scenario (introduces trade-offs among stocks). Mixed fisheries management objectives have not yet been defined by managers, therefore which scenarios are more likely to be adopted are not yet determined. The mixed fishery scenarios being explored by ICES, together with the recent ICES work on MSY ranges will help inform these decisions.

Unmatched assessment and management units

In a number of cases assessment and management units are not matched. TACs may be set for a combination of species for example turbot and brill, lemon sole and witch, dab and flounder in the North Sea, and ray stocks both in Celtic and North Seas. Alternatively there may be more than one biological stock unit (that is the units within which scientists assess the stocks) of the same species within a TAC area, for example there are eight Functional Units (FUs) of *Nephrops* within the North Sea and twelve within Celtic Sea TAC areas. The reasons for these arrangements are various, but measures to remove them may have effects such as reducing flexibility for the fleets exploiting the stocks and hence undermining relative stability, or increasing the complexity of monitoring and control of the fisheries to a level which is not practical to implement.

Managers are constrained to use measures which are practical for implementation given operational and commercial imperatives. Whilst these factors may reduce the effectiveness of TACs in controlling harvesting of stocks, there are measures which can be used in part to control exploitation of the weakest stocks. For example, in area VII the Porcupine Bank *Nephrops* functional unit continues to be managed with a sub-TAC and seasonal closure.

Landings obligation

As a part of the reformed CFP, the landings obligation or 'discards ban' will come into force in 2016 for demersal fisheries in the North Sea, north-western and south-western Atlantic waters. Compared to the 2015 landing obligation, which affected pelagic stocks, Member States have more liberty regarding the phasing in of the landing obligation under the called discard plans for each fishery (starting in 2016 for species which "define" the fishery and until end 2018 for the other species in the fishery).

For the fisheries concerned, the fixing of the TAC takes into account the change to reflect total catches instead of landings. In practice, this requires ICES to provide advice based on total catches (including catches formerly discarded that now have to be landed) and no longer on landings. TAC adjustments (colloquially termed 'quota uplift') form part of the overall package of measures to implement the landing obligation in the identified fisheries. In particular, provisions in the applicable discard plan may affect the need for and magnitude of the TAC adjustments. For instance, the introduction of a *de minimis* provision, allowing discarding where stocks are caught at relatively low levels in a fishery, may reduce the need for TAC adjustments. Improved quota management at national level (including adjusted quota swapping strategies) and the use of the inter-species quota flexibility may also affect the TAC adjustments.

One difficulty in adjusting TACs for discards is that discards are estimated with less precision than landings, so we are less certain about quantities discarded. Reliable discard information is not available for many key stocks. In fisheries on particular stocks falling under the landings obligation, a problem also exists with the existence of Minimum Conservation References Size (MCRS), formerly called Minimum Landing Size, as fish under MCRS must now be retained but cannot be marketed when landed. The introduction of the landings obligation is intended to ultimately reduce discarding and hence improve accountability and precision in the stock assessments. However, ensuring a reliable estimate for discards and a fair distribution of quota is likely to be a challenge in the transition phase.

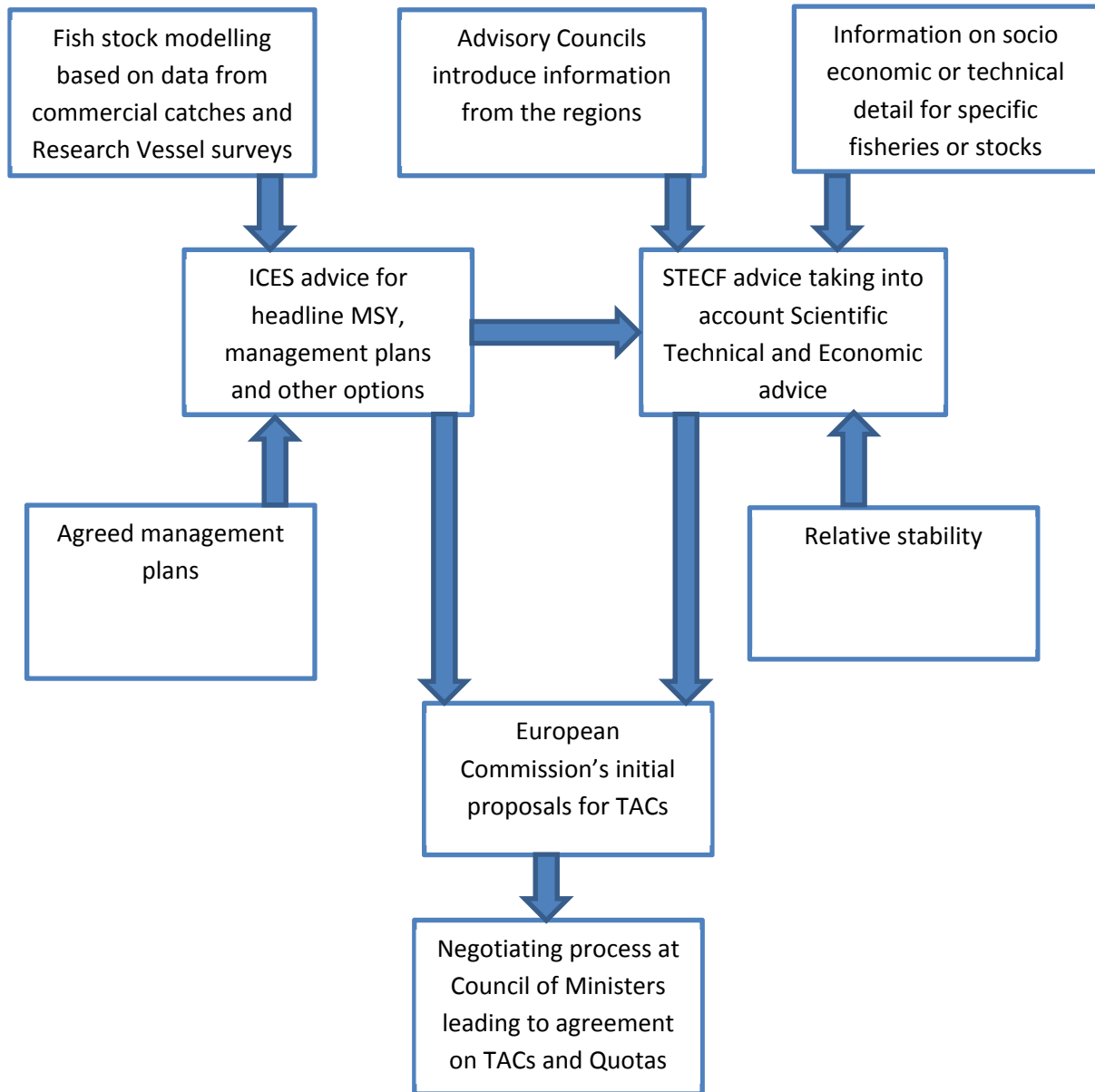


Figure 1 Schematic for main information flow into European Union Council of Ministers' December Council annual negotiations

Negotiating process

The European Commission sets the fishing opportunities for a given year, in the form of annual TAC and quota regulations (COUNCIL REGULATION (EU) 2016/72). These are published in January, following agreement reached at the previous December Fisheries Council negotiations. The objective of these negotiations is to agree fishing opportunities taking into account the scientific advice within the wider objectives of the CFP. Specifically:

- Conservation measures adopted take into account available scientific, technical and economic advice, including, where relevant, reports drawn up by the STECF and other advisory bodies, as well as in the light of any advice received from Advisory Councils.
- Total allowable catch (TACs) should be established, in line with the Common Fisheries Policy (Council Regulation (EU) No 1380/2013), on the basis of available scientific advice, taking into account biological and socio-economic aspects whilst ensuring fair treatment between fishing sectors, as well as in the light of the opinions expressed during the consultation of stakeholders, in particular at the meetings of the Advisory Councils.
- Fishing opportunities should be allocated to Member States in such a way as to ensure relative stability of fishing activities of each Member State for each fish stock or fishery.
- Management decisions relating to maximum sustainable yield in mixed fisheries should take into account the difficulty of fishing all stocks in a mixed fishery at maximum sustainable yield at the same time.

Given these objectives of the negotiations, the ICES and STECF advice forms the basic framework for the Commission's TAC proposals for the next year; therefore these proposals are central to the negotiations. Although the Commission's initial proposals set the scene for the negotiations at December council, there must remain room to achieve compromise between the scientific advice and the wider socio economic requirements of the CFP. Similarly, there is room for negotiations on the Commission's proposals where additional scientific advice can be considered, perhaps because the advice framework can only take account of various categories of available information about a stock and therefore if the advice was followed legitimate fishing opportunities may be lost. [Figure 1](#) shows a schematic for the main sources of information flow into the process of the December Council negotiations.

The negotiations therefore provide an opportunity for member states to introduce the socio economic and further scientific aspects and to work with the Commission to achieve the best possible outcome for the industry, while maintaining the overriding requirement to achieve *"economically viable fleets without overexploiting marine biological resources"* in the words of REGULATION (EU) No 1380/2013, article 2 (5d).

Although, STECF publishes an annual assessment of the economic performance of the EU fishing fleets (STECF 2016) this is aggregated at member state and fleet type, hence does not go into detail about fleets in regions within member states, including fleet segments that may depend heavily on

particular individual stocks. Therefore, it is important for member states to bring relevant socio-economic factors to the negotiating table so that they may be properly considered.

A certain amount of what could be tabled at the negotiations can be front loaded, in that member states can request the Commission to task STECF with examining socio economic, scientific or technical detail, in advance of December Council, so that agreement on the impact of the evaluation can be achieved without negotiation at Council. This is common and covers examples such as examining proposed management plans, or achieving commission approval for a new gear configuration or type that will reduce discards. Elements of interpretations of the advice, such as influence of discards become important in supporting Member state negotiating positions. Therefore it is not just the headline TAC that is of interest. For example, the availability of technical developments such as selective gears has an important bearing on how closely the Commission adheres to the original TAC advice.

Not all decisions on setting fishing opportunities require negotiation. This is particularly the case where an agreed management plan (or long term recovery plan) is in place and where typically the terms of the plan set out the fishing levels needed to achieve the management objectives. Even in the absence of a plan, there may be other influences encouraging the implementation of the MSY advice exactly, an example being the Irish Sea (ICES Division VIIa) herring fishery, where although a management plan is under development, the MSC certification of the fishery requires that the stock is fished at MSY, therefore the ICES MSY advice is followed without any need for discussion.

Outcomes

As discussed in the introduction, some recent commentary by Carpenter et al (2016) has focused on the perception that many of the TACs agreed as a result of the negotiation process depart regularly from the initial scientific advice and that this demonstrates systematic failure of compliance with the requirements of the CFP.

Indeed, rather than focusing on the minority of cases where there is variance from scientific advice, a better approach is to examine the extent to which management objectives are being met. This is the approach of the Commission, which publishes an annual assessment of the state of progress towards its objective of achieving MSY for all stocks covered by the CFP. The most recent review in 2015 (European Commission, 2015 and STECF, 2015) indicated that substantial progress has been made in moving towards the MSY objective; currently 32 stocks (out of the MSY assessed total of 62) are being fished at optimal levels (at or below F_{MSY}) in the Atlantic EU waters, the North Sea and the Baltic Sea. In terms of trends, pelagic fisheries in the Atlantic, and generally demersal fisheries in the North Sea and the Baltic Sea have improved their performance. The situation in parts of the western waters is still cause for concern, with several stocks, such as sole and cod in the Irish Sea and cod in the West of Scotland outside safe biological limits.

Trends

However, as discussed above the congruence of MSY advice with the final negotiated TAC for a given stock in any one particular year is influenced by a number of constraints and factors which may be difficult to control. Therefore assessments of success are best based on a time series of trends in

TACs set above scientific advice (defined as ‘excess TAC’ by Carpenter et al (2016)) and stock status across all the stocks in a mixed fishery, rather than the coincidence or otherwise of individual stocks with scientific advice in a particular year. Carpenter et al., (2016) show clearly that the percentage excess TAC has decreased from 33% in 2001 to 7% in 2015, with a consistent downward trend in the intervening years between those two years. ICES publishes advice on the basis of indicators of the overall status of the marine environment across ecoregions (ICES 2016). One indicator is the level of fishing mortality in relation to the optimal target level F_{MSY} . Figure 2 shows trends in F/F_{MSY} (that is the ratio between estimated fishing mortality and optimal fishing mortality at MSY; a high ratio indicates excessive fishing mortality) for a variety of fish types for the North and Celtic sea ecoregions. These graphs show a generally downward trend in F/F_{MSY} for demersal, pelagic, flatfish and short lived (predominantly sand eel) stocks since 2000, all of which are managed by TAC.

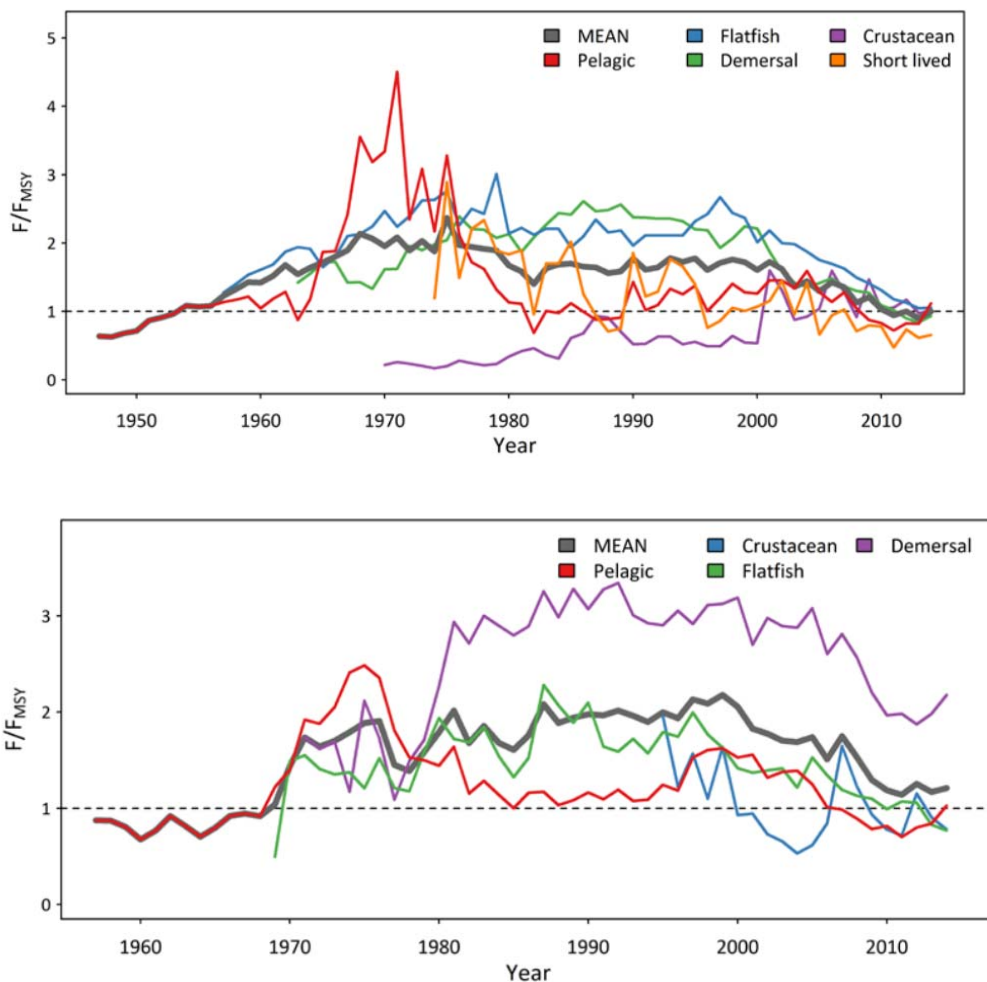


Figure 2 Time series of ratio of estimated ratio of fishing mortality to fishing mortality at Maximum Sustainable Yield F/F_{MSY} for North Sea (above) and Celtic Sea (below). $F/F_{MSY} = 1.0$ (dotted line) would indicate fishing at Maximum Sustainable Yield which is in line with the CFP objective (from ICES 2016; Ecosystem Overviews)

Whilst for some groups of stocks (most notably demersal in the Celtic Sea) there is clearly some way to go before F_{MSY} is achieved these results suggest that the measures taken, which include amongst others effort controls, technical and spatial management measures as well as TACs have been successful in moving the stocks towards optimal F_{MSY} .

Future advice developments

Modern fisheries science was developed from the 1950s onwards (Beverton and Holt, 1957). Initially methods were developed to understand the effects of fishing on exploited populations. The concept of optimizing yields at MSY originates from this time and was instrumental in the negotiation of international agreements on Pacific Salmon fisheries (Finley and Oreskes 2013). Models were initially developed for single stocks to optimize growth. The development of the modern European fleets resulted in increases in fishing effort during the 1970s and 1980s with subsequent increases in fishing mortality (see Figure 1) and by the 1990s it was clear that some stocks were being exploited at levels which were outside safe biological limits, that is reproduction was being impaired. The precautionary approach was introduced at the 1995 United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks with the aim of keeping the stocks within safe biological limits. By 2002, at the WSSD in Johannesburg in 2002, commitments were made to aim towards stocks being managed towards MSY targets. As discussed above, in mixed fisheries this requires compromises between different stocks. Hence the ongoing development of methods aimed at giving mixed fisheries advice.

Mixed fisheries advice.

Since most European demersal fisheries catch a mixture of stocks, and each stock is likely to have a different optimal management regime, management decisions concerning the catch of one stock are likely to have an effect on the catches of other stocks. For example there may be more catch available of one stock in a mixed fishery even after the TAC of other stocks captured in the fishery have been used up.

Accordingly, ICES is developing advice based on mixed fishery considerations, where managers are presented with advice showing the impact of a range of fishing scenarios on the spawning stock biomasses and catches of all the relevant stocks. Mixed fisheries advice is based on the assumption that fishing patterns are the same from year to year and uses information from single stock assessments. As the advice is currently delivered, it does not give a specific recommendation but it presents a range of scenarios enabling the managers to understand the trade-offs between stocks and which stocks are likely to become limiting, that is so called 'choke species'. For the North Sea, Skagerrak and Eastern English Channel, mixed fisheries advice incorporates cod, haddock, plaice, saithe, sole, whiting and Nephrops and the fisheries using otter trawls, seines, beam trawls, static gear, longlines and other gears. Mixed fisheries advice has been given annually for the North Sea since 2013, and also for Celtic Sea gadoid (cod, haddock and whiting) fisheries since 2015.

MSY ranges

To enable the mixed fisheries advice to be used effectively, a new set of reference points is required to enable managers to understand the implications of trade-offs between stocks. To this end ICES has produced advice on fishing mortality for maximum sustainable yield ranges which would deliver a long term yield of no more than 5% reduction in long term yields compared with MSY and consistent with the stock being inside safe biological limits. This concept is illustrated in the schematic in Figure 3. The single stock catch options and mixed fishery scenarios would be related to these MSY ranges, hence enabling more flexibility for managers in optimising long term yields close to MSY. The EU is in the process of formulating multi annual management plans for a number of EU

fisheries. The combination of mixed fisheries advice with F_{MSY} ranges should help to shape these plans.

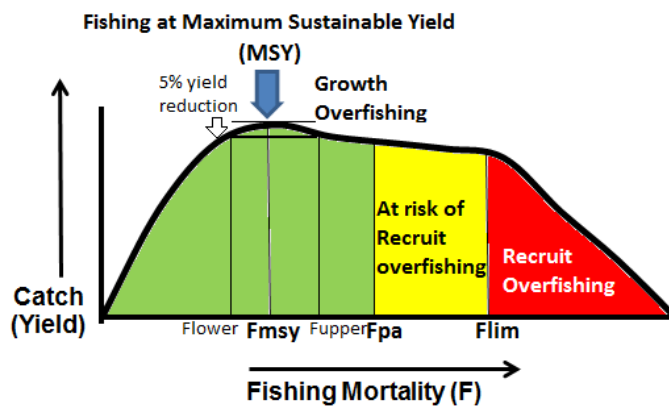


Figure 3 Schematic illustrating the concept of F_{MSY} ranges and safe biological limits. Yields are optimal at F_{MSY} and F_{lower} and F_{upper} are calculated to result in no more than a 5% reduction in long term yield. Between F_{MSY} and F_{lim} the stock is considered 'growth overfished'; that is the growth of the stock is not optimal. Yields are sustainable below F_{pa} ; above this level 'recruitment overfishing' that is reproductive impairment may occur. If fishing mortality is estimated to be at F_{pa} , the stock it is considered 'at risk' (circa 5-10%) of being exploited above F_{lim} or outside safe biological limits. Different stocks have different characteristic yield curves so where F_{upper} exceeds F_{pa} , this is the upper limit of the advised F_{MSY} range.

Ecosystem considerations

The above discussion relates to fisheries advice on fishing possibilities in accord with the MSY or precautionary approaches. Future requirements for assessment of the effects of fisheries under the ecosystem approach will require assessments of effects on other ecosystem components for example seabed effects and bycatch species. ICES is currently providing 'Ecosystem overviews (ICES 2016)' which have the potential to inform on this aspect.

Conclusions

Given the sometimes competing complexities of fisheries management objectives there will always be compromises involved in implementing scientific advice in some stocks and some situations and these bring some attendant risks. However, implementation of the CFP is introducing greater reliance on well-defined and objective management criteria, notably via the MSY framework and the adoption of multi-annual management plans which include measures to control not just catches but fishing effort and mixed fishery approaches to management. It is notable that the least departure from scientific advice tends to occur in situations where the scientific data are sufficient to allow full analytical stock assessments and forecasts and where an agreed management plan or MSY can be adhered to. This suggests that there is scope to further improve the assessments for data-poor stocks, though a balance will have to be struck between the advantages vs the practicalities including the financial costs of doing so.

Authors

Walter Crozier and William (Bill) Lart, June 2016

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