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Scientific, Technical and Economic Committee for Fisheries (STECF)

Different Principles for defining selectivity under the future TM regulation (STECF-12-20)

Edited by Norman Graham & Hendrik Doerner

This report was reviewed by the STECF during its' 41st plenary meeting held from 5 to 9 November 2012 in Brussels

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THIS REPORT WAS REVIEWED DURING THE PLENARY MEETING HELD IN BRUSSELS, 5-9 NOVEMBER 2012

1.2 Request to the STECF

STECF is requested to review the report of the STECF Working Group meeting, evaluate the findings and make any appropriate comments and recommendations.

1.3 STECF observations

STECF notes that the EWG 12-14 Report discusses a variety of issues that need to be considered in the context of the function of technical measures in fisheries management under a reformed CFP and who should decide which, how and when technical measures are required. STECF agrees that the arguments and discussion presented in the Report are all pertinent and based on its review, wishes to draw out the following summary points.

The regulation of technical aspects of fishing operations, through so-called technical measures, defines where, when and how a fishing enterprise exploits and interacts with marine resources and the wider marine ecosystem. Technical measures can be loosely grouped into measures that regulate the design characteristics of the gears that are deployed such as the regulation of mesh size; measures that regulate the operation of the gear such as setting maximum limits on how long or what type of gear can be deployed; measures that set spatial and temporal controls such as closed/limited entry areas and seasonal closures; and measures that define minimum sizes of fish. Collectively, technical measures aim to control the catch that can be taken with a given amount of effort.

Technical measures (TM) are largely aimed to reduce catches of juveniles of commercial and non-commercial species, to improve species selectivity, to reduce discards and minimize the impacts on habitats.

STECF notes that current technical measures may have positive effects on conservation and protection of ecosystems, but that, given continued discarding, it can be concluded that their overall objective has not been achieved and to date their overall effectiveness has been sub-optimal.

Generally, the effects on fisheries of technical measures alone cannot be disentangled from the effects of other management tools implemented simultaneously, such as TACs and fishing effort restrictions. There is a lack of clear objectives for most TM and simultaneous application of other input and output controls only allows a comparison of the package of measures taken with the outcomes observed. In practice, it is not usually possible to quantify the extent that observed outcomes are attributable to one or other of the measures in place.

In general TM relating to gear selectivity have no clearly defined objective and, following the EU decision-making process, the measures finally adopted often differ from what was initially proposed and tested. Many measures are adopted just to improve selectivity.

Current applications of TM follow a ‘top-down’ approach that focuses on the technical specification rather than the outcome. Suuronen and Sarda (2007) carried out a review of gear-based technical measures and note that “the successful use of technical measures appears to depend largely on their acceptance by industry". Due to obvious short term financial incentives, vessel operators may try to circumvent technical measures whose implementation reduces their operating profit

STECF considers that the top-down approach may not be the most effective means of introducing technical measures, especially with regard to technical “details”. There are a number of examples where regulations specify quite complex design features of gears, e.g. article 2 of Regulation (EC) No 2056/2001which provides a complex formula for calculating the mesh size for a beam trawl escape panel, which incidentally has little resemblance to the gear tested under scientific study, and regulations that describe in detail how to mend a broken mesh (Appendix 1 to Regulation (EC) No 2187/2005).

In general, and particularly concerning gear specifications, a result-based approach focusing on the output rather than on the input may be a more effective approach. Such an approach may provide incentives for fishermen to apply their knowledge (on gears, areas, behaviour of species, habitats) and innovative capabilities to achieve defined output objectives efficiently, instead of reducing the expected effect of detailed and prescriptive top-down regulations.

Under a results-based approach, it would be important to shift the burden of proof from current system where management must show that an infringement has occurred, to the situation where the industry makes a commitment to operate to certain standards. On the one hand, as in many other sectors, the industry should have the responsibility to show that their activities do not have unacceptable environmental impacts. However, on the other hand the industry should also have an interest in providing products that have an acceptance by consumers and thus an incentive to demonstrate that the methods they apply have minimized unnecessary impacts on the ecosystem.

There is a need to have a high level of transparency in policy discussions to create the trust between fishers and their customers. With greater demands for demonstrably sustainable fisheries customers of fish products are demanding higher standards of environmental responsibility as part of their purchasing policy. Ideally the fishing industry would demonstrate that it is using technological developments to benefit the environment rather than create additional environmental damage. This links to the concept of a commitment to agree, and then achieve objectives, rather than just a requirement to comply with a regulation. Here there is also a role for peer pressure to incentivize participation.

However, in order to ensure that those participating have the confidence that they will be treated fairly and the changes they make will not be negated by the behaviour of others, there is a need for sufficient checks on the effective performance of all involved in the fishery. This may still require relatively high level information to demonstrate that there is compliance with the objectives. Thus there will still be a need for significant commitment to monitoring and compliance checks.

In summary, STECF considers that it the long run there are three strategic elements in the planning of future development of technical measures in EU that need to be addressed:

1) Output control versus input control, creating an interest to develop technology supporting the achievement of agreed aims and acceptable levels of negative impacts.

2) Burden of proof is shifted from managers to the industry.

3) Enforcement is based more on the concept of commitment than compliance, and the monitoring of enforcement includes elements from peer pressure

1.4 STECF conclusions

STECF concludes that TM should have clear, well defined objectives and targets.

The management approach and the incentive structure can have a significant impact on the effectiveness of technical measures. Positive incentives with rewards for doing certain things may work better than penalties.

STECF considers that if control and enforcement problems can be solved, result based management may be the best approach for future TM. In such an approach, there should be a limited, if any, need for prescriptive TM regulations. The incentives created by a results-based system may improve the achievement of objectives. However minimum standards are likely to be necessary to achieve the objectives.

1.5 STECF recommendations

The discussion held at EWG 12-14 is an important first step in understanding the current deficiencies in technical measures and how to address these deficiencies in developing a new approach to technical measures based on a results based approach with appropriate impact metrics (impact referring to, e.g., F on fished stocks and damage to other ecosystem elements such as seafloor, seabirds). To assist the Commission further it is recommend that the EWG reconvene in quarter 1, 2013 with the following terms of reference:

a) Identify tactical objectives that potentially could be achieved using technical measures in the context of results-based management.

•

b) Identify appropriate metrics to quantify the progress towards the tactical objectives identified in a).

•

c) Discuss and identify how impact metrics can be monitored and controlled and how the effectiveness of an impact based approach can be evaluated. This should consider required levels of compliance and difficulties associated in achieving these levels.

d) Explore the need for minimum standards (baseline regulations), focusing on specifications of technical measures, considering there will be a requirement for a transitional phase from the current input based approach towards a full impact based system as well policy objectives not suited to a strict output based approach e.g. MFSD, NATURA 2000.

References

Suuronen, P & Sardà, F. (2007).The role of technical measures in European fisheries management and how to make them work better. ICES Journal of Marine Science, 64 (4), 751-756.

2 EXPERT WORKING GROUP EWG-12-14 REPORT

REPORT TO THE STECF

EXPERT WORKING GROUP ON
Different Principles for defining selectivity under the future TM regulation
(EWG-12-14)

Dublin, Ireland, 1-5 October 2012

This report does not necessarily reflect the view of the STECF and the European Commission and in no way anticipates the Commission's future policy in this area

3 EXECUTIVE SUMMARY

An integral part of nearly all fisheries management frameworks has been the regulation of technical aspects of fishing operations, through so-called technical measures. These define where, when and how a fishing enterprise exploits and interacts with marine resources and the wider marine ecosystem. Technical measures can be loosely grouped into measures that regulate the design characteristics of the gears that are deployed such as the regulation of mesh size; measures that regulate the operation of the gear such as setting maximum limits on how long or what type of gear can be deployed; minimum landing sizes and spatial and temporal controls such as closed/limited entry areas and seasonal closures. Collectively, technical measures aim to control the catch that can be taken with a given amount of effort.

The history of technical measures in EU waters and international waters fished by EU vessels is one of numerous regulations, amendments, implementing rules and temporary technical measures introduced into the annual Fishing Opportunities (TAC and Quota) Regulations as a stop-gap. All told across all the different sea basins, including non-EU waters, since 1980 no less than 90 different technical measures regulations or regulations containing technical measures have been enacted by the EU. In the main, the application of technical measures in the CFP has followed a top-down and highly prescriptive approach. To date this has focussed primarily on the legislation, monitoring and enforcement of technical measures (input controls), which over time, have increased in complexity, particularly in relation to species selectivity and habitat issues. This has necessitated detailed technical descriptions being specified in legislation, which are often difficult (or impossible) to monitor, control and enforce.

Despite the 'growth' in technical measures, there is a commonly held belief that technical measures as implemented in the EU have failed to deliver the desired level of protection for juveniles and reductions in unwanted bycatch. This is demonstrated by the continued discarding of juveniles and unmarketable species still prevalent in many EU fisheries. While causal links can be made, the lack of quantifiable metrics which can be used as a benchmark to estimate the success or failing of a given measures, are absent and this limits our ability to identify which measures have been successful in practice. In any case, specific impacts are likely to be obscured due to the simultaneous application of other management input and output measures e.g. fishing effort and TAC limits. There are very few examples of where individual measures have been evaluated post introduction. Similarly there are no evaluations as to the scientific basis of particular measures and whether they deviate from, or indeed, have any scientific basis.

Nonetheless the regulation of *exploitation pattern* (how fishing pressure is distributed across the age profile of a stock) through technical measures can be an important component in attaining sustainable exploitation. In general a high exploitation on juveniles will lead to a lower maximum exploitation rate than if the mortality on juveniles is limited. Additionally, species specific recovery and rebuilding plans often require the use of species selective technical measures which can be used to regulate *exploitation rate* (the proportion of fish, irrespective of age, that are being removed from the stock). Spatial and temporal technical measures are also widely used to reduce fishing impact on particular species or age groups, for example area closures to protect spawning or juvenile aggregations. Spatial measures and to a limited extent, gear-based technical measures are also important tools for the protection of sensitive habitats. In particular spatial measures are likely to continue to be the main management approach to the protection of vulnerable habitats. It can therefore be concluded that technical measures have an important role to play in management but the framework in which they operate needs to be re-examined.

Technical measures essentially try to achieve a desired exploitation pattern or rate through the control of proxy (input) measures such as mesh size or area restrictions. In other words, the regulatory framework specifies the technical details of what can and cannot be used rather than focussing on the intended and desired result (outcome) e.g. a specific catch profile or exploitation pattern. Systems that focus on regulating the technical inputs rather than the output can introduce strong incentives to negate regulations. The perversity of the system is that technical innovation emanating from the industry is more focussed on mitigating the potential losses of commercial catch, than conservation orientated industry initiatives. This can lead to the adoption of more legislation to counter the technical innovation. This is demonstrated by the cumulative growth in technical measures in the EU, many of which could be considered as 'catch-up' regulations. Such circularity is incentivised as technical measures place an additional business cost on the individual fishing enterprise through coercive incentives (enforcement), due to potential loss of catch, without clear future gains. This is further exacerbated by the lack of cost associated with the retention of unwanted catch. In essence, the primary business driver is to minimise the cost associated with lost marketable catch, rather than the reduction of unwanted catch as there is no direct or immediate cost benefit in doing so, in fact the opposite exists.

Taking the view that technical measures have *not* realised their full potential, there are a number of factors that need to be considered when discussing why this may be the case. In the absence of objective measures, there is a need to evaluate the *implementation* of technical measures and how these may have influenced their efficacy. This is important as it provides the opportunity to learn from past experiences and to consider these when formulating new policy. The majority of innovation to improve selection has been undertaken by national research laboratories and underpinned by national and EU research funding. In the main, results from research, particularly activities focussing on species selectivity and mitigation of habitat impacts, has not been fully realised in legislation. Implementation error can be attributed to the failure to adequately specify effective technical specifications in regulations. There are many cases where the technical specifications are different to those tested under experimental conditions or there are cases where the particular modification has absolutely no scientific basis. Often the specification of the technical measure is a compromise due to concerns over economic losses and capital costs that have to be borne by the industry. This can result in diluted regulations containing measures that are insufficient to meet intentions. While it is clear that technical measures as currently deployed have major shortcomings, it is important to note that the majority of management interventions all have implementation issues that impact on their effectiveness. For example TACs have limited ability in constraining catches due to discarding and effort limitations are often weakened through technological innovation (creep).

Where management approaches have a greater focus on the monitoring and control of outcomes, (e.g. Alaskan Pollock fishery) and the capture of unwanted catch incurs some cost (i.e. premature closure/movement to less productive areas/effort restrictions), there is a stronger incentive for fishermen to use gears and tactics that minimise these costs. Regulation focussed on the outputs (Results Based Management) in a fishery together with adequate monitoring, weakens the tendency to negate measures and actually present strong positive incentives for the development and application of measures that actually met their objectives.

While the majority of EU technical regulations focus solely on specifying input controls, there are examples where a results based approach has been applied in the EU. The Long Term Management Plan for Cod (Regulation (EC) No 1342/2008) and Catch Quota Management (CQW) as part of pilot projects to test the concept of Fully Documented Fisheries (FDM) currently being carried out in the North Sea have stimulated the fleets affected to fish more responsibly and to document and monitor their catches accurately. Initiatives emanating from the Regional Advisory Councils (RACs), national administrations and research establishments have also demonstrated that technical and tactical avoidance measures can be incentivised and used to help management objectives for specific fisheries. This has seen an exponential rise in both the demand and delivery of innovative technical measures within the EU with many industry-driven initiatives. The challenge is to ensure that these initiatives are sufficient to meet the management objectives and that they can be adequately monitored. Under a results based management approach, there will be a continued and probably elevated need for the deployment of technical measures, but if outputs are adequately monitored and controlled then the need for detailed measures enacted in law is reduced substantially.

The application of RBM thus far has still placed the onus of monitoring on the state i.e. through existing observer programmes. However, it is unlikely that further roll-out of an RBM approach could be achieved without substantive changes (expansion) of catch monitoring programmes and may require greater industry contribution to catch sampling or reversing the burden of proof away from the state to the industry itself. It is also uncertain as to what form of results would provide confidence that the overall objectives of the CFP, including sustainable fisheries, are being met. From a control perspective, shore based monitoring is cheaper than monitoring at sea and can be very effective at detecting infringements of certain measures due to higher inspection rates. The way forward should therefore be to aim at shifting as much as possible of the enforcement actions to land. For instance, even though discarding takes place at sea it is more cost effective to carry out the enforcement activity at land, with for example analysis of CCTV footage than it would be to enforce the measure at sea. Therefore, a shift towards a catch based approach needs to reconcile these issues and ensure that implementation is maintained within acceptable tolerances.

It is clear that the need for technical measures is very much dependent on the management framework under which the fisheries concerned are operating. Similarly, the desire of the industry to develop and effectively deploy technical measures is also reliant on appropriate incentive structures. While the ‘cod plan’ does rely on a coercive incentive, the approach has also provided a strong participatory approach due to the fact that the objectives (results) are clear (i.e. exemption from effort restrictions) and this has promoted bottom-up initiatives aimed at attaining these targets with measures that are more suited to local conditions. It is likely that with increasing consumer awareness that influence of market share may start to provide strong financial incentives.

Presently, there is still a great deal of uncertainty as to when the new CFP will be agreed and to the final shape of the new policy. It is apparent, however, that obligations to reach MSY levels for commercially exploited species, the obligation to land all TAC species and to eliminate discards are likely to be cornerstones of the policy. In addition the future CFP will require alignment with broader environmental and ecological policy objectives such as the MFSD and NATURA. Another central theme of the reform is the move to regionalised decision-making which is particularly relevant for the future use of technical measures as management tools. By doing this implies that only limited technical measures would be agreed at Union level (i.e. under co-decision of the European Parliament and the Council of Ministers) with the majority of technical measures developed regionally to the extent they are needed relative to the specificities of different fisheries.

In this context, while the Commission as yet has no definitive opinion on the shape of technical measures in a reformed CFP with regionalisation a central element, the Commission has identified three possible policy options for technical measures post-reform that were presented to EWG12-14. These three options are as follows:

- Consolidation of existing technical measures regulations into one regulation simplifying the rules where possible, deleting redundant measures and incorporating any recent changes in technical measures.
- Regionalisation with a framework regulation whereby a new approach to technical measures to replace the existing regulations would be developed. It would come into force in the form of a framework regulation under co-decision, with the necessary legal architecture (i.e. empowerments) to allow specific provisions to be developed regionally at a fishery or sea basin level as envisaged under the reform.
- Regionalisation without a framework regulation whereby all or the vast majority of the current technical measures would be abolished except for certain measures such as closed areas under NATURA 2000 and moving to a fully regionalised, results (or target) based management system. There would be no framework regulation as in option 2.

EWG 12-14 considered these options and concluded that Option 1 does not fit the objectives of the reform of the CFP, nor does it address many of the current weaknesses in the technical measures regime (e.g. overly prescriptive). It is clear that many of the developments in the performance of the fisheries required to achieve the objectives of the CFP can be achieved faster and with better results under a result based management system as advocated under both options 2 and 3 than under the present input system. Therefore EWG 12-14 agreed that the operational aspects of a results based approach should be the focus of a next meeting of the group.

4 CONCLUSIONS OF THE EXPERT WORKING GROUP

Given the available policy options and possible directions, the EWG 12-14 concludes that technical measures are relevant as management tools in relation to the objectives of the CFP in ensuring exploitation of the resources at levels consistent with maximum sustainable yield (MSY), of ensuring that negative impacts of fishing activities on the marine ecosystem are minimised and of eliminating discards by reducing unwanted catches and gradually ensuring that catches are landed.

Controlling exploitation pattern (EP) through the use of technical measures does have a significant role in terms of conservation benefit. However, in comparison to regulating exploitation rate (ER), ER has a more dominant effect. It is important to note that technical measures can also significantly contribute to the regulation of exploitation rate. Analysis shows the existence of a trade-off between exploitation rate and exploitation pattern; a low proportional exploitation of immature fish allows for the occurrence of moderately increased exploitation rates and vice versa.

For a given stock and assuming that life history characteristics (growth, stock - recruitment etc) remain constant, MSY is determined by the EP and stock status in relation to MSY for a given EP is determined by the ER. It has been shown that even subtle changes in selection (EP) can produce substantial differences in MSY and F_{MSY}. As a consequence, MSY and F_{MSY} for that stock will change and the assessed stock status may also change even if the overall ER remains constant. It is therefore important that MSY reference points be reviewed periodically, particularly if there is evidence of improvements in selection pattern associated with changes in technical measures.

In almost all cases, with one or two notable exceptions, technical measures have been introduced without specific objectives. As a consequence, the impacts of individual measures cannot be quantitatively measured due to the lack of reference points, nor is it possible to compare the merits of one measure against another. Field simulation and modelling studies do allow quantification of the relative impacts on selectivity of specific components of gear design such as mesh size, twine thickness etc, and the effect of species selective gears relative to baseline gears. However, there are few studies aimed and assessing the impact of individual measures post introduction. Disentangling the effect of an individual measures is confounded due to the application of other input and output controls and other external factors e.g. variability in stock recruitment.

For species that have high discard mortality, there is no empirical evidence to show the use of Minimum Landings Size has any conservation benefit and the rationale behind MLS is unclear, particularly in multi-species/multi-gear fisheries. There are many cases where there is a mismatch between MLS and gear selectivity and mismatch between species caught in the same fishery; this can significantly contribute to discarding or incentives fixes to reduce selectivity to avoid loss of fish greater than the MLS. Similarly, catch composition regulations are likely to have had no benefit and in some circumstances may lead to regulatory induced discarding as under the current CFP, catch composition rules simply regulate what is retained onboard and not what is caught. It is noted that the original intention of such rules were to classify fishing activity into broad metiers for management purposes and not as a means of controlling fishing mortality. Notwithstanding, catch composition regulations can provide a useful tool if fisheries are fully documented.

As currently applied, technical measures, can in principal adjust exploitation pattern and rate, but it is likely that the anticipated impacts of these measures have not been fully realised due to inability or unwillingness to deploy as intended and enforcement difficulties. So far technical measures have been implemented through negative incentives; trying to get fishermen to do something out of the risk of punishment. Measures tend to increase costs, through short-term losses and/or equipment costs and there are generally borne by the individual business without compensation. This incentivizes fishermen to circumvent technical measures, a response to minimise short term losses. This has resulted in a technological and regulatory arms-race, where subsequent rules are applied in response to technological innovation by the industry. Prescriptive input regulations can also stifle positive technical innovation as fishermen are encouraged only to use gears that comply with minimum standards and not to focus on the intention of the regulation. Additionally, individual technical rules are seldom removed but in practice amended and added to. This has led to a growth in the amount and complexity in technical regulations which has led to increasing control and enforcement burden. This has necessitated continual up-skilling requirements for enforcement personnel and overall has led to a reduction in control intensity of each rule.

The utility and effectiveness of technical measures is heavily dependent on the regulatory framework in which they are deployed and whether the approach promotes the use of technical measures through incentives. Experience from the cod LTMP has clearly shown that given stimulus, industry can rapidly develop and deploy fishing tactics, including gear and behavioural changes, when there are specific objectives and strong drivers to do so (e.g. exclusion from the effort regime).Legislative requirement of detailed technical measures could be minimised if outputs (e.g. catches) are adequately monitored and controlled. While a catch based approach will have the benefit of reducing the legislative burden, it will require the comprehensive monitoring and quantification of catch, and this is the primary issue regarding such an approach. This will be challenging. If alternative output based targets would be used instead, such as the setting of maximum catch levels of a given species, the industry are encouraged to continue the development of methods to achieve the desired targets rather than simply applying the prescribed technical measure.

It is important to consider controllability and cost-effectiveness before the introduction of a technical measure or replacement regulations to avoid imposing rules that cannot be or is too expensive to enforce. Many of the current technical regulations are uncontrollable due to problems of detection, monitoring standards and legal complexity. EGW 12-14 note that there has been significant growth in technical regulations since the foundation of the CFP, however, few if any of these have been repealed. This has led a multi-layered and complex catalogue of legislation with technical measures that have become increasingly complex, some even requiring specific regulations on how to undertake net repairs! EWG 12-14 suggest that measures that have little benefit should be removed and only management measures aimed at improving the biological and/or the ecological status should be employed so that the general acceptance of the rules is improved. From a control perspective the number of regulations should be kept to a minimum. Rules and control activities have to be harmonised in regions to ensure a level playing field. The management measures have to be adaptive so that they can be changed following changes in the status of the stock. In that way unwanted effects (decreased selectivity etc.) can be avoided. The penalty level is closely related to the compliance level. The penalty level needs to be fair and high enough to be deterrent. CQM and FDF have the potential to be effective management measures but it is important to remember that it is a real challenge to ensure compliance of these rules.

One of the aims of the reform of the CFP is to have limited, global and standardised technical rules at Union level, and the majority of detailed technical measures developed regionally with extensive stakeholder consultation. However, it is important to recognise the impact that the choice on regionalisation may have on the revision of the technical measures regulations. The CFP reform proposal proposes to move to a situation where Member States are empowered and take responsibility for jointly agreeing on detailed technical measures with measures then adopted at Union level on the basis of a participatory, consultative process in the region. This move away from detailed, prescriptive rules agreed jointly at Council and Parliament is essential if technical measures are to contribute effectively to the overall management approach.

Technical measures have an important role in terms of wider ecosystem considerations. These include limiting fishing impacts on low productivity species caught in mixed species fisheries; protection of sensitive habitats as increasingly, sensitive areas are being closed to certain gear types. Technical adaptations to gears can help minimise habitat impacts. It is likely, however that area restrictions and closures will remain the central approach to protecting habitats vulnerable epifauna. However, it is important to consider possible unintended impacts, in particular the impact that effort displacement in response to area closures can have on areas that are presently lightly exploited.

Although technical measures are likely to continue to constitute central tools in achieving the objectives of the CFP it does not necessarily mean that these measures have to be implemented in regulations. EWG 12-14 believes that under a result based management system, where focus is on the achievement of clearly stated results and not on how the fishery is conducted, there will be a limited need to implement technical measures via regulations. However, it is noted that monitoring and control of catches is more difficult and expensive than regulations that can be monitored ashore. To date, where RBM is applied e.g. the Cod plan, the role of monitoring and the burden of proof largely resides with the member state, in order to expand catch or RBM approaches, it would be preferable that the burden of poof resides with the industry.

Incentive-based approaches can make management more robust by ensuring, in most cases, that those who have the greatest impact on fisheries have an increased interest in their long-run conservation and directly bear the cost of overexploitation (Grafton et al, 2006). The challenge is to introduce management measures that create incentives that lead to desired behaviours.

5 Recommendations of the Expert Working Group

The discussion held at EWG 12-14 is an important first step in understanding the current deficiencies in technical measures and how to address these deficiencies in developing a new approach to technical measures based on a results based approach with appropriate impact metrics (impact referring to, e.g., F on fished stocks and damage to other ecosystem elements such as seafloor, seabirds). To assist the Commission further it is recommend that the EWG reconvene in quarter 1, 2013 with the following terms of reference:

e) Identify tactical objectives that potentially could be achieved using technical measures in the context of results-based management.

f) Identify appropriate metrics to quantify the progress towards the tactical objectives identified in a).

g) Discuss and identify how impact metrics can be monitored and controlled and how the effectiveness of an impact based approach can be evaluated. This should consider required levels of compliance and difficulties associated in achieving these levels.

h) Explore the need for minimum standards (baseline regulations), focusing on specifications of technical measures, considering there will be a requirement for a transitional phase from the current input based approach towards a full impact based system as well policy objectives not suited to a strict output based approach e.g. MFSD, NATURA 2000.

6 Introduction

Fisheries management aims to regulate the amount and composition of fish species caught to ensure ongoing reproduction potential of commercially exploited stocks whilst minimising negative impacts on the marine ecosystem. This has traditionally focussed on regulating two aspects i) the exploitation rate - the proportion of fish that are being removed from the population and ii) the exploitation pattern- the proportion at each age or size of fish that are being removed from the population. This is illustrated in Figure 6.1.

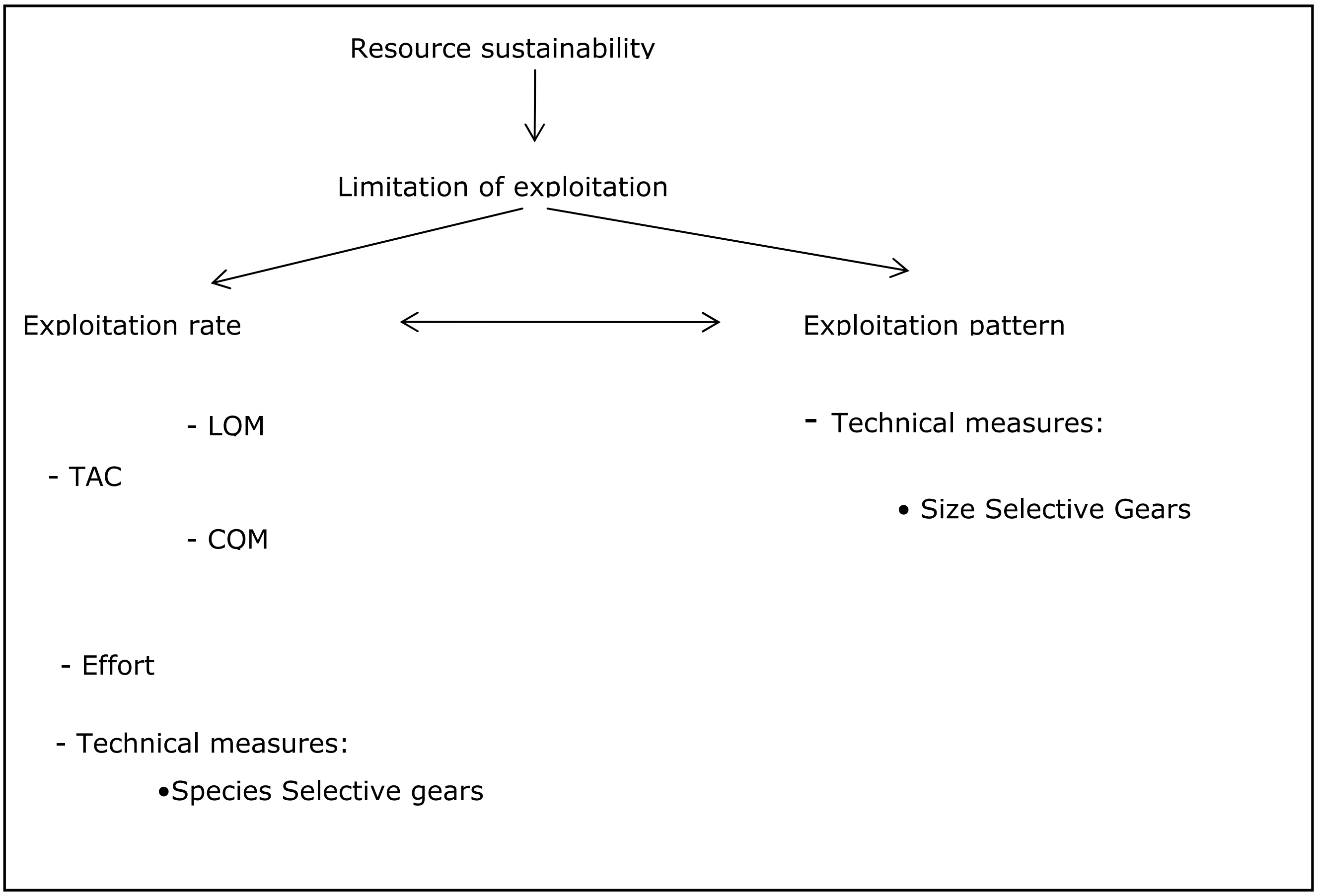

Figure 6.1 Management measures for the regulation of exploitation pattern and exploitation rate

An integral part of nearly all fisheries management frameworks has been the regulation of technical aspects of fishing operations, through so-called technical measures. These define where, when and how a fishing enterprise exploits commercial fish resources and interacts with the wider marine ecosystem. Technical measures can be loosely grouped into measures that regulate the design characteristics of the gears that are deployed e.g. mesh size; measures that regulate the operation of the gear such as setting maximum limits on how long or what type of gear can be deployed; minimum landing sizes and measures that set spatial and temporal controls such as closed/limited entry areas and seasonal closures. Collectively, technical measures aim to control the catch that can be taken with a given amount of effort.

Technical measures are generally considered to affect the exploitation pattern and the time spent fishing and catch allocations determine the exploitation rate. In practice, technical measures can be used to regulate both. Some measures affect exploitation rate through the regulation of the size or amount of gear that can be deployed (and how long it can be deployed), while others can be used to avoid the capture of vulnerable/threatened species or minimise impacts on vulnerable habitats.

Technical measures have been used extensively in EU fisheries since the adoption of the Common Fisheries Policy (CFP) in 1983. Despite the 'growth' in technical measures, there is a commonly held belief that technical measures as implemented in the EU have failed to deliver the desired level of protection for juveniles and reductions in unwanted by-catch (e.g. Suuronen and Sardà, 2007).

It is important to note that technical measures are part of a wider suite of input and output tools e.g. catch (TACs) and effort controls that are available to managers to implement a particular management strategy and management approach. This makes the evaluation of specific measures difficult if not impossible due to the simultaneous application of multiple measures and their interdependency. Analysing the success or effectiveness of individual measures in isolation will undoubtedly highlight the measures strengths and weaknesses, but this does not provide the basis of a more holistic view where the benefits and disadvantages of other input and output controls are evaluated simultaneously. Critically, the lack of clear and measureable objectives prevents any quantitative analysis of individual measures from being undertaken.

Recognising this, as part of the on-going reform of the CFP, the Commission has signalled its intention to develop a new approach to regulate technical measures based on simplification, adaptation of decision making to the Lisbon Treaty, increased regionalisation, greater stakeholder involvement and more industry responsibility. This approach will strengthen conservation and resource management through better selectivity and better protection of the environment. It is centred on the development of an overarching technical measures framework with specific regionalised measures included under multiannual plans. In this context it is important to note the future objectives for the CFP set out in the draft Basic Regulation (COM (2011) 425).

The purpose of this report is to explore the potential of technical measures as a management tool in the context of a reformed CFP, taking account of the frequently reported problems with the current technical measures contained in EU law. This report should be viewed as an exploration of the overarching principals of technical measures in the context of the current CFP and its ongoing reform. It is not the intention to provide a detailed roadmap of which technical measures should be deployed in the future; this will require further work which can only be undertaken once further clarity on the content of the final CFP agreed. It is also important to point out that EWG 12-14 did not consider the efficacy of area and seasonal closures in this report as these were extensively reviewed by STECF (2007) and the focus here is primarily on gear-based technical measures.

6.1 Terms of Reference for EWG-12-14

The ToRs are as follows:

- ToR 1. Discuss the historic effectiveness of technical measures considering technical, legal and control issues and identify which measures have been effective.
- ToR 2. Consider the future objectives of gear related technical measures in relation to overarching management objectives under the CFP, NATURA and MSFD polices.
- ToR. 3. Explore the need for appropriate metrics for defining minimum acceptable standards (baseline regulations) focusing on technical specifications of the gear and/or minimum catch profiles. For each metric consider monitoring, control and enforcement implications.
- ToR 4. Review management approaches for technical measures (e.g. existing prescriptive rules, results based approach, obligation to land all catches,) and how these affect uptake and application of selective gears. Discuss the advantages and disadvantages of these possible management strategies including issues surrounding monitoring, control and enforcement.
- ToR 5. Explore how technical measures can be regionalised within the context of the management strategies considered. How can the performance of regionalised measures are evaluated

The terms of reference given to EWG-12-14 are very broad, and aim to explore the salient issues surrounding technical measures. Given these issues are intertwined within the overall management approach it is not possible, nor advisable, to consider them in isolation. Therefore, the structure of the report does not necessarily follow the terms of reference in sequence.

7 TECHNICAL MEASURES

7.1 Historic Context

Technical measures have a long history as regulatory tools. Both area and seasonal restrictions and regulations governing mesh size and the setting of minimum landing sizes to protect juveniles can be found in national regulations going back hundreds of years. In his review of mesh regulations, *"Why Increase Mesh* Sizes", Burd (1986) describes the development of the regulatory framework of mesh size regulation in the UK and North East Atlantic. He notes discussions as far back as 1376 in the parliament of King Edward III relating to the use of small mesh sizes in the wondyrchoun (precursor to today's beam trawl) and resultant catches of small fish leading to potential damage of the "*Commons of the realm and the destruction of the fisheries*". Later in 1714, legislation introduce in England noted the need for the protection of juveniles through regulation of mesh size "*as the breed and fry of the sea fish has been of late greatly prejudiced and destroyed by the using of too small size of mesh, and buy other illegal and unwarrantable practices*" (Burd, 1986). The 1714 regulation also introduced minimum landing sizes for a range of species to supplement minimum mesh size regulations in an attempt to discourage the capture and marketing of juveniles.

The introduction of steam power and otter trawling in the late 1800's greatly increased the efficiency of fishing fleets; vessels could fish largely unaffected by wind and tidal conditions and expanded their operational range particularly into the highly productive waters of the North Atlantic. Within a matter of decades, otter trawling was introduced into all countries bordering the North Atlantic and associated sea basins (Graham, 2006). The combined advance of steam power and otter trawling in the 1900's and substantive technical developments following the end of the Second World War signified large increases in catching capacity due to innovations in ship design, on-board processing, fish finding and the introduction of synthetic fibres (Valsemarsen, 2001). In the first few decades of the 20th century there was increasing concern about the level of exploitation exerted on commercial fisheries and with it, observations of the high levels of juveniles being caught and discarded, became a primary management issue (Burd, 1986; Pinhorn and Haliday, 2001; Haliday and Pindhorn, 1996; Jensen, 1967). This led to a series of International Conventions on technical measures for the protection of juvenile fish where the basis of formal management frameworks and regulations were developed[1] "

Subsequently, a number of international conferences held in the following decades led to the formation of the North East Atlantic Fisheries Commission (NEAFC) in1963; International Baltic Sea Fishery Commission (IBSFC) in 1973 and the International Commission for the North West Atlantic (ICNAF) in 1950 which was superseded by the Northwest Atlantic Fisheries Organisation (NAFO) in 1979. Appendix I shows the development of mesh size regulations in the North East Atlantic between 1954 and 1971 under NEAFC and also the evolution of management measures in ICNAF.

As understanding of the factors that affect selectivity grew throughout the 20th century, differential mesh size regulations were introduced. These included different mesh size requirements for man-made synthetic (e.g. nylon) and natural fibres (e.g. manila); mesh sizes that were dependant on the use single or double twine. Much of this work was based on an ICNAF recommendation for the formation of a ICES/ICNAF Working Group on Selectivity Analysis tasked with exploring the variability in selection data, including the scientific basis of mesh size differentials for different twine materials (ICES CM 1969/B:13). Similarly, regulations on codend attachments (e.g. cow hide chafers) were introduced in both the NEAFC and ICNAF areas of jurisdiction. This is presumably as these were being used to restrict or mask codend meshes in some way. It is noted in Halliday and Pinhorn (1996) that issues relating to the control of these differential approaches were already causing problems as enforcement personnel were unable to distinguish between the various synthetic twine materials being used.

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1 International Convention for the Regulation of the Meshes of Fishing Nets and the Size Limits of Fish" (1937); Draft Convention Relating to the Policing of Fisheries and Measures for the Protection of Immature Fish (1943) and Convention for the Regulation of Meshes of Fishing Nets and the Size Limits of Fish (1946).

Halliday and Pinhorn (1996) also noted that while control of selection patterns formed the primary or even sole approach to fisheries management in the 1950's and 1960's, technical measures began to be superseded in the early 1970's by regulations aimed at controlling the overall exploitation rate through control of Total Allowable Catches (TACs). TAC regulations were introduced largely because the management commissions realised that technical measures on their own were insufficient for maintaining productivity. This change to managing fisheries primarily through TACs may also have in part been a response to difficulties in control and enforcement of technical measures regulations, and the relative administrative simplicity of allocating and monitoring catches, which in practice meant monitoring landings.

7.2 Regulatory Development of EU Technical Measures in the EU

The history of technical measures in EU waters and also in non-EU waters is one of numerous regulations, amendments, implementing rules and temporary technical measures introduced into the annual Fishing Opportunities (TAC and Quota) Regulations as a stop-gap. All told across all the different sea basins, including non-EU waters, since 1980 no less than 90 different technical measures regulations or regulations containing technical measures have been enacted by the EU. Figure 7.2 shows the progression over time, and the full list of regulations are given in appendix II. The following sections give a brief summary of the evolution of the technical measures across different sea basins, highlighting the proliferation of amendments and detailed implementing rules introduced since 1980.

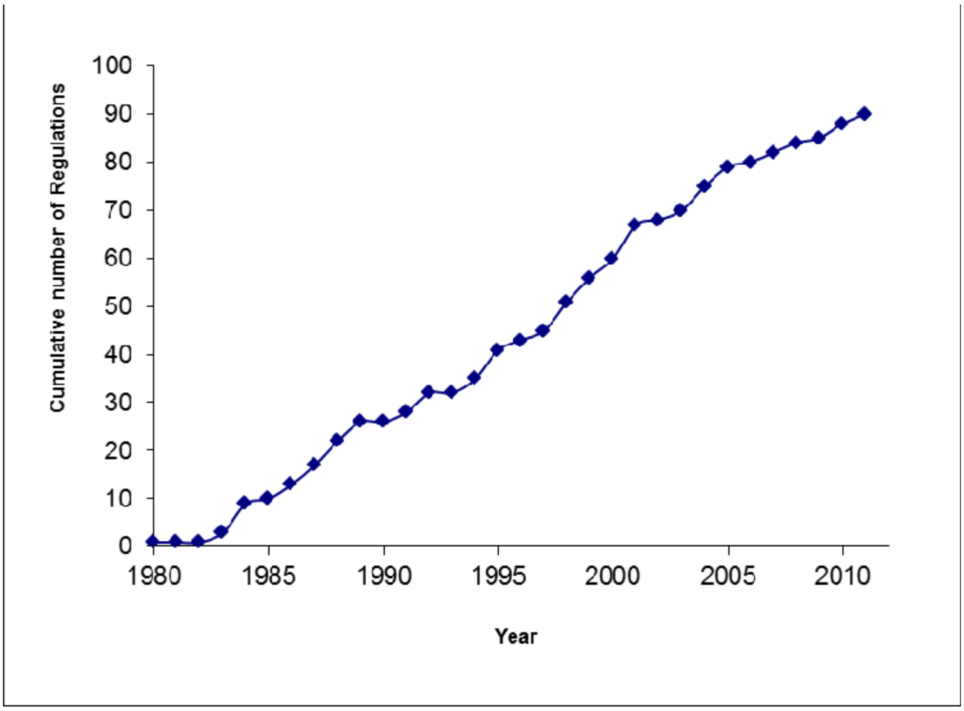


Figure 7.2 Cumulative Number of Technical Measures Regulations introduced since 1980

7.2.1 North-east Atlantic and North Sea

The first technical measures regulation for EU fisheries in the Northeast Atlantic and the North Sea was introduced in 1980 under Regulation (EEC) No. 2527/80 prior to agreement of the first Common Fisheries Policy (CFP) in 1983. This Regulation was originally supposed to remain in force for a very short period but in fact remained in place until the CFP was agreed in 1983. Regulation (EEC) No 2527/80 contained definitions of areas, mesh size and catch composition regulations, minimum landing sizes, prohibitions on certain gears, closed area/seasons and gear restrictions as well as the legal basis for the establishment of emergency measures.

After adoption of the CFP in 1983, Regulation (EEC) 2527/80 was replaced by Regulation (EEC) No 171/83. It very much consolidated the measures contained in Regulation (EEC) No. 2527/80 and was subsequently amended six times to include specific regional provisions in certain fisheries (e.g.

restrictions on the length of beam trawls, changes in mesh sizes, new closed areas). Specific measures applying to Spain and Portugal were also introduced as an amendment to Regulation (EEC) No 171/83 following the Accession of Spain and Portugal in 1985. Also in 1984, a detailed Commission Implementing Regulation was introduced detailing legal attachments (e.g. chafers, strengthening bags) to towed fishing gears. Commission Regulation (EEC) No 3440/84 incredibly remains in force almost thirty years after its introduction and has been amended only twice.

In 1986, recognising that there was a need once again to consolidate the technical measures, Regulation (EEC) No 171/83 was repealed and replaced by Regulation (EEC) No 3094/86. This Regulation contained all the elements of Regulation (EEC) No 171/83 and all of the amendments to it as well as several new elements on scientific research and restocking and transplantation. Regulation (EEC) No 3094/86 remained in force for the next 11 years during which time it was amended no less than nineteen times. The majority of these amendments increased minimum mesh sizes or introduce new minimum landing sizes or closed areas/gear restrictions. However, several of these amendments introduced new elements into the technical measures regulations. Regulations (EEC) No 4056/89 and 345/92, for the first time, allowed the use of selective gears as derogations from the minimum mesh size regulations. In addition mitigation measures to reduce bycatch of marine mammals and seabirds were included in Regulation (EEC) No 2251/92, while Regulation (EEC) No 3071/95 introduced detailed rules for the use of static nets, in the form of minimum mesh size and catch composition regulations.

In 1987, the EU once again recognised that the technical measures had become unwieldy and in need of consolidation. Therefore Regulation (EC) No. 894/97 was enacted to replace Regulation (EEC) No 3094/86 and its associated amendments. This Regulation was only amended once, by Regulation (EC) No. 1239/98 which introduced more restrictive measures on the use of driftnets following global debates on the use of such gears. After a short period, the EU then decided that the measures included under Regulation (EC) No. 894/97 contained a number of inconsistencies and were unduly complex and therefore it was replaced almost in its entirety by Regulation (EC) No. 850/98. This was a first real attempt to adapt technical measures to the diversity of fisheries and the need for homogeneous rules across regions. It included new measures to improve the selectivity of towed gears by applying detailed rules on the construction of fishing gears (e.g. codend circumference, twine thickness), making the use of square mesh panels mandatory in certain fisheries, additional closed areas/seasons and gear restrictions as well as maintaining the legal architecture for emergency measures and the development of local measures for inshore fisheries within MS territorial waters.

Council Regulation (EC) 850/1998 remains in force and since its adoption, has been amended no less than ten times. In addition to Regulation (EC) 850/98 technical measures of relevance for the North Sea and the Atlantic are also found in a number of other regulations including Regulations 2056/2001, 494/2002 and 812/2004. Additionally specific ecosystem protection regulations for example on shark finning and protection of cetaceans as well as detailing implementing rules for the measurement of mesh size and the introduction of real-time closures in the North Sea and Skagerrak have also been enacted.

Technical measures were also included under the Fishing Opportunities Regulation for many years as a mixture of regionally specific measures and derogations from the provisions of Regulation (EC) No 850/98 up until entry into force of the Treaty of Lisbon (TFEU). These covered a wide area from the North Atlantic and North Sea, Skagerrak and Kattegat to measures for international waters (e.g. NEAFC).Following the entry into force of the TFEU, technical conservation measures could no longer be included in the annual fishing opportunities regulations. Therefore, the Council adopted Regulation (EC) No 1288/2009 to ensure that the temporary technical measures would remain in place. That Regulation provided for continuation of the temporary measures on a transitional basis for 18 months until 30 June 2011. These measures were then further extended for another 18 months under Regulation (EU) No 579/2011 until 31 December 2012. Recently the Commission has brought forward a proposal to incorporate these measures into Regulation (EC) 850/98 while a new approach to technical measures is developed in the context of the reform of the CFP.

7.2.2 Baltic Sea

The evolution of technical measures in the Baltic Sea is no less complex than in the Northeast Atlantic and the North Sea. The first regulation was introduced in 1986 and contained minimum mesh sizes, minimum landing sizes and seasonal and area closures. Regulation (EC) No 1866/86 was subsequently amended six times, with additional derogations to the technical measures included in the Fishing Opportunities Regulations for the Baltic on two occasions. Regulation (EC) 1866/86 was repealed in 1998 and replaced by Regulation (EC) 88/1998, which was amended three times before being replaced itself by the current regulation, Regulation (EC) 2187/2005. This has been amended three times, principally by Commission Regulation (EC) 686/2010, which increased the general mesh sizes of gears in the Baltic and also removed some detailed provisions that were deemed unnecessary (e.g. specifications of mending procedure for damage meshes in a Bacoma window).

7.2.3 Mediterranean

Technical measures were only introduced in the Mediterranean in 1994, ten years after the adoption of the first CFP. This was largely because the international dimension in the Mediterranean had made it difficult to introduce analogous rules as already existed in the other sea basins. The first Regulation (EC) No 1626/1994 contained not only minimum landing sizes, closed areas, gear restrictions for towed, encircling and static gears, and prohibited gears but also the first attempts at measures to protect other ecosystem components such as marine mammals, seabirds and sensitive habitats. These ecosystem measures were in the form of measures to be taken nationally by Member States. Regulation (EC) 1626/1994 was subsequently amended seven times over the next ten years before being replaced by the current Regulation (EC) No 1967/2006. In line with the original regulation for the Mediterranean, Regulation (EC) 1967/2006 contains a mixture of detailed gear restrictions and closed or restricted areas as well as measures aimed at protecting non-target species and sensitive habitats. Since its introduction it has been amended only once in 2011.

7.2.4 External Waters

In external waters (non-EU waters), technical measures are restricted to a specific regulation for the protection of vulnerable marine ecosystems in the high seas from the adverse impacts of bottom fishing gears (Regulation (EC) No 734/2008) and specific technical measures for the Antarctic and highly migratory species (tunas and billfish) covered by ICCAT, IOTC and the Agreement on the Inter-Dolphin Conservation Programme in the eastern Pacific. Additional technical measures for external waters were also included in the annual Fishing Opportunities Regulations pre-Lisbon Treaty but now are in a somewhat of a "legal limbo" as they no longer can be included under the Fishing Opportunities Regulation but have not been transposed into Union law.

8 SCIENTIFIC BASIS

8.1 Controlling exploitation pattern and exploitation rate

There are essentially two broad approaches taken to regulate the exploitation of marine species in order to influence and maintain stock productivity. These are generally used in parallel and can be enacted through a range of both input and output controls.

The regulation of measures that impact on the *Exploitation Rate (ER)* aims to control the proportion of a stock removed through fishing and can be considered as a metric of fishing intensity. Exploitation rate tends to be the main focus of management today and regulated through setting of catch (TACs) and effort limits as well as technical measures aimed at protecting specific species.

Exploitation Rate (EP) refers to how fishing intensity is applied across the demographic of a given stock, e.g. the level of fishing pressure is dependent on age or length of an individual within the population. EP tends to be regulated mainly through technical measures, for example the use of mesh regulations to limit fishing intensity on juveniles or the use of closed areas to protect spawning adults.

Catching fish after they have spawned at least once; i.e. protecting immature fish is an old intuitive concept predating fisheries science itself. Systematic studies carried out in the 20th century, most prominently the work done by Beverton and Holt (1957) and Myers and Mertz (1998) have shown that the expected benefits from allowing fish to spawn at least once before they are caught are mainly associated with letting fish grow towards the size associated with optimal yields (i.e. avoiding growth overfishing) and with giving spawners a chance to produce replacement spawners (i.e avoiding recruitment overfishing). However, there is an increasing body of literature suggesting alternative approaches to optimal exploitation patterns, including protecting large, mature females often at the expense of juveniles (e.g. Caddy and Seijo, 2002), fishing different demographic components evenly (e.g. Law et al., 2012) or arguing for controlling mainly exploitation rate rather than exploitation pattern (Halliday and Pinhorn, 2002).

In this context, recent studies (Vasilakopoulos et al., 2011, 2012, in prep.) have aimed to explore the importance of immature fish protection for sustainability, a prime function of technical measures. Vasilakopoulos et al. (2011) has created a metric of exploitation pattern (EP = F_{imm}/F_{mat}) that incorporates information on fishing mortality, maturity and abundance to act as an index of proportional exploitation of immature fish. This index was calculated annually for 38 ICES stocks and then averaged over a standardised-time-period; Respective exploitation rate values (ER; defined as F_{bar}, the reference age groups in a stock over which fishing mortality is estimated) for the same stocks and over the same time period were also calculated. The effects of ER and EP on resulting stock status at the end of the standardised time-period were then explored.

ER and EP were found to have independent negative effects on current stock status (CSS). CSS is defined as the ratio of the current SSB relative to the stock specific B_{pa} reference point. The model shows that with for stocks with high exploitation rates (ER); or high exploitation on younger age groups (EP), tended to have lower Current Conservation Status, with ER having a stronger impact (Figure 8.1.1). This result not only provides an empirical justification of the spawn-at-least-once principle but also translates into an existing trade-off between exploitation rate and exploitation pattern; a low proportional exploitation of immature fish allows for the occurrence of moderately increased exploitation rates and vice versa. By looking at individual stocks included in the study it can be seen that stocks can be sustained within safe biological limits through a combination of high ER – low EP (e.g. NE Arctic cod) or low ER – high EP (e.g. western horse mackerel), while stocks that are highly depleted are those with a high ER – high EP combination (e.g. North Sea cod).

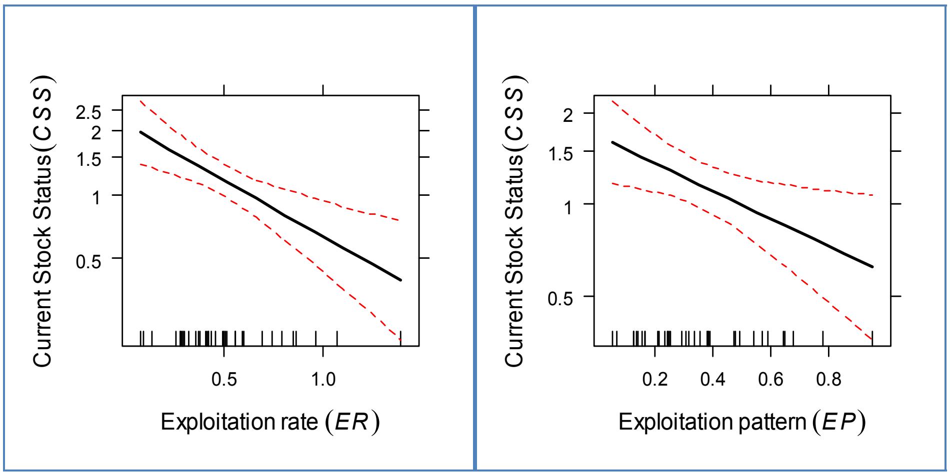


Figure 8.1.1 Modelled effects of exploitation rate (ER) and exploitation pattern (EP) on stock status (B/B_{pa}). Current Stock Status (CCS) is the ratio of SSB relative to B_{pa}, therefore a value of 1 corresponds to a stock at B_{pa} and a value less than 1 relates to stock where SSB is below B_{pa} (from Vasilakopoulos et al., 2011).

The greater effects of exploitation rate were underlined in a follow-up study of the same set of stocks that were divided into five groups of ecologically similar stocks, where the association of ER and EP with stock status was considered on an aggregate scale (Vasilakopoulos et al., 2012). Using cross-stock averaged values of ER and EP, thereby attenuating the signal coming from individual stocks, the ER effect was still detectable while the EP effect was not.

The benefits from protecting juveniles through technical measures in combination with moderate fishing mortalities were also illustrated in a generic simulation study designed to detect the optimal fishing intensity and selectivity of towed gear fisheries (i.e. sigmoid exploitation pattern) for a wide range of biological parameters (Vasilakopoulos et al., in prep). The combination of having selectivity that results in the retention of fish with a mean age (As50) higher than the mean age of maturity (Am50) and a moderate exploitation rate for the fully selected age classes (F_{max}) results in clear benefits in terms of both yield and stock biomass.

These benefits were verified by exploring the status of actual stocks with sigmoid exploitation patterns with optimal EP and ER identified by the simulations. Most of the empirical stocks where the mean age of retention is greater than the age of maturity (where As50-Am50>-0.5 and $F_{max} \leq 0.6$) were within safe biological limits (13 out of 14 stocks examined; e.g. N.E. Atlantic mackerel, eastern Baltic cod, North Sea sole). The simulation analysis also provided an additional insight into the trade-offs between exploitation rate and pattern; a greater positive difference between As50 and Am50 allowed for a greater increase of F_{max} with high sustained yields while as As50 becomes smaller than Am50 simulated stocks tend to collapse even for moderate levels of F_{max}. This finding agrees with previous studies made using specific rather than generic input biological parameters (e.g. Scott and Sampson, 2011).

The work presented here shows that controlling EP via technical measures can play an important role in maintaining and promoting stock productivity. The ratio of F_{imm}/F_{mat} (EP), in conjunction with estimates of exploitation rate, could also be used as a potential metric for estimating how effective aggregate management measures are in terms of regulating mortality on immature fish. It is also recognised that exploiting particular demographic segments of a stock may have broader implications e.g. genetic preference towards faster growing, earlier maturing fish (see section 11.3) and therefore the demographic form of the exploitation pattern may also be important (Law et al, 2012).

9 EFFECTIVENESS OF TECHNICAL MEASURES IN THE EU

9.1 Current weaknesses

The objectives set for technical measures are broadly defined in current EU legislation but establishing the effectiveness of these measures in an EU context is difficult due to the absence of any defined **quantifiable** metrics on which to measure success. For instance Regulation (EC) 850/98, the overarching regulation covering North Atlantic and North Sea fisheries, simply states without specified targets that technical measures should "*ensure the protection of marine biological resources and the balanced exploitation of fishery resources in the interests of fishermen and consumers in line with the objective of the CFP*". This Regulation also includes a number of broad sub-objectives again without quantifiable targets:

- reducing the capture of juveniles of marine organisms through mesh size and catch composition rules;
- protecting nursery and spawning areas taking into account the specific biological conditions in the various zones concerned;
- establishing a balance between adapting technical conservation measures to the diversity of the fishery and the need for homogeneous rules which are easy to apply; and

- Integrating environmental protection requirements with technical measures notably in the light of the precautionary principle.

As a consequence, in trying to assess the effectiveness of technical measures, it has only really been possible to compare the measures taken with the outcomes observed and not to quantify what the linkages between these are in practice. This is further confounded by the fact that technical measures are often part of an overall package of complex input and output controls including effort and TAC controls which prevents a comparative analysis. Given that the expected benefits have never been defined and there is no metric to use as measure of success, this is hardly surprising.

Technical measures have been largely introduced to reduce the retention and discarding of juveniles of commercial and non-commercial species and to improve species selective characteristics of fishing gears. A summary review of the latest scientific advice from ICES shows that for many assessed stocks discarding is prevalent in many areas and fisheries and many assessments show little or no change in exploitation pattern over time even with a range of detailed technical measures in place over many years, although there are some exceptions. It can therefore be concluded that the overall objective has not been achieved and that the effectiveness of technical measures has been sub-optimal in this regard.

Technical measures in EU fisheries have also suffered, like other tools employed to manage fisheries, from implementation error i.e. the expected benefits are not realised in practice. From a political perspective, technical measures often form part of a negotiation strategy, potentially leading to a dilution of the final measures agreed. This can often be driven by perceived negative impacts (losses of marketable catches) in the fishery and the desire of managers to broker a deal, even though the measures agreed may be sub-optimal. This sometimes results in measures being introduced without any scientific basis, making any judgement on how they may benefit the overarching policy objectives, impossible.

A further implementation problem is that the majority of gear related technical measures are developed by national laboratories and research groups and subject to extensive research and development. As a consequence, measures tend to be evaluated under idealised conditions where the key design features are controlled and monitored. This potentially leads to issues when they are implemented into the fishery with an over optimistic outlook of their potential benefits. This issue is likely to increase with technical complexity.

Quite often measures are introduced in response to a single species conservation issue where the stock prognosis is poor and is typically characterised as having high discards. This is often confounded by the fact that overexploited stock tend to have truncated age structure with few old fish in the stock. This means that the fishery relies heavily on young fish, and any increase in selectivity could result in significant losses of marketable fish. This fear of losing fish can provide a strong negative incentive to deploy tactics that mitigate these losses and has led to a technological race by the industry to develop and deploy technical fixes to minimise such losses. In response, regulations are subsequently amended as a result, and led to ever increasing complexity in the regulations, and elevated difficulties in terms of monitoring, controlling and enforcement – "*a technological and regulatory arms race*".

For example, the use of stiffer twine to offset previously introduced increases in mesh size from 90 to 100mm in the North Sea (EC regulation 345/92) became widespread in the early 1990’s. This subsequently led to research into the potential impact on cod-end selectivity (Lowry and Robinson, 1996). The results of the research were subsequently used as the basis to introduce additional legislation which limited the thickness of twine that could be used (EC regulation 850/98). Interestingly, it took another five years to develop and objective method to measure twine thickness and implement this into a control regulation (EC regulation 129/2003).

Another issue related to the use of minimum landings size (MLS) and catch composition (CC) regulations, which are assumed to act as a coercive incentive to avoid areas with high concentrations of juveniles or unwanted species. However, there is no clear evidence to suggest that this is the case. Intuitively these make sense as technical measures but in practice discarding can be encouraged if these regulatory controls are not correctly aligned (MLS with gear selectivity or CC with species composition) or if there is economic advantage to fishing in areas with high abundance of juveniles in order to catch the larger individuals in the population. STECF (2011) noted that fleets may comply with catch composition regulations simply by discarding components of the catch in order to balance the retained catch with the composition rules. Such regulations will, thus, not necessarily be effective at controlling fishing mortality. The predominant reaction to both catch composition and minimum landing sizes, is to comply through discarding, particularly if moving to other areas would result in a reduction in potential revenue i.e. movement to an area with fewer marketable fish. In mixed species fisheries, the relationship between mesh size and minimum legal sizes is often more complex, where a single mesh size is used to select a range of species often with differing minimum landing sizes. In practice, the choice of minimum landing size is often a compromise to discourage the retention of small fish rather than one based on biological suitability e.g. maturity and it is hard to find any biological justification for measures that in many instances are clearly conflicting e.g. input measures to control selectivity (mesh size) and output measures (MLS) to regulate the minimum size of fish that can be landed.

9.2 Control and enforcement

The current prescriptive approach to technical measures as an input tool without any objective output measure has resulted in control and enforcement focussing on the technical design characteristics of measures rather than on a desired output., Even basic measures such as material specific mesh sizes as used by NEAFC and ICNAF in the early 1960's started to cause problems for controlling officers.

Enforcement and management activities are interrelated and cannot be considered in isolation. It is quite clear that for many regulations, little attention has been given to the practicalities of control and enforcement, the fact that it took five years after the introduction of twine thickness regulation to introduce a method of monitoring the regulation is a good example of bad practice (see section 9.1). Management measures that are not controllable or too expensive to enforce will never be effective. In the same way, controlling rules which have no apparent benefit to stocks or the fishing activity has little meaning. Enforcement and compliance are affected by factors such as the type of fisheries, the general culture of compliance in the country, the fishing capacity, sense of stewardship etc. The factors that can be influenced through the management scheme are primarily the type of fisheries rules imposed and the incentives they create, planning of the enforcement actions as well as the efficiency of the applied tools.

Technical measures regulations have shown an almost linear growth since 1980 (see figure 7.2). Much of this can be attributed to regulatory responses to technical innovation aimed at negating the impacts of previously introduced measures. In addition, the demise of cod stocks in the Kattegatt, North Sea, West of Scotland and the Irish Sea, and hake and *Nephrops* stocks in the Bay of Biscay have increased the need to apply species selective measures and area restrictions through recovery plans which have contained quite complex regulations. These have added to the control and enforcement problems.

The growth in regulations has led to dilution of control capabilities and ever increasing complexity. Figure 9.2 below illustrates the effects of how the current framework of technical measures in the EU has affected control and enforcement activities. Technical regulations tend to be reactive rather than adaptive, where measures are modified in line with changes in fisheries. Instead additional and unnecessary rules have very often been added to the current legislations that MS are obliged to control adding to the complexity. Since the management system is out of line and does not take control and enforcement aspects into consideration throughout the whole design phase of management measures, management targets are currently only achievable through enforcement activities. This approach is not cost effective and has in many cases not resulted in the desired change of behaviour of fishermen.

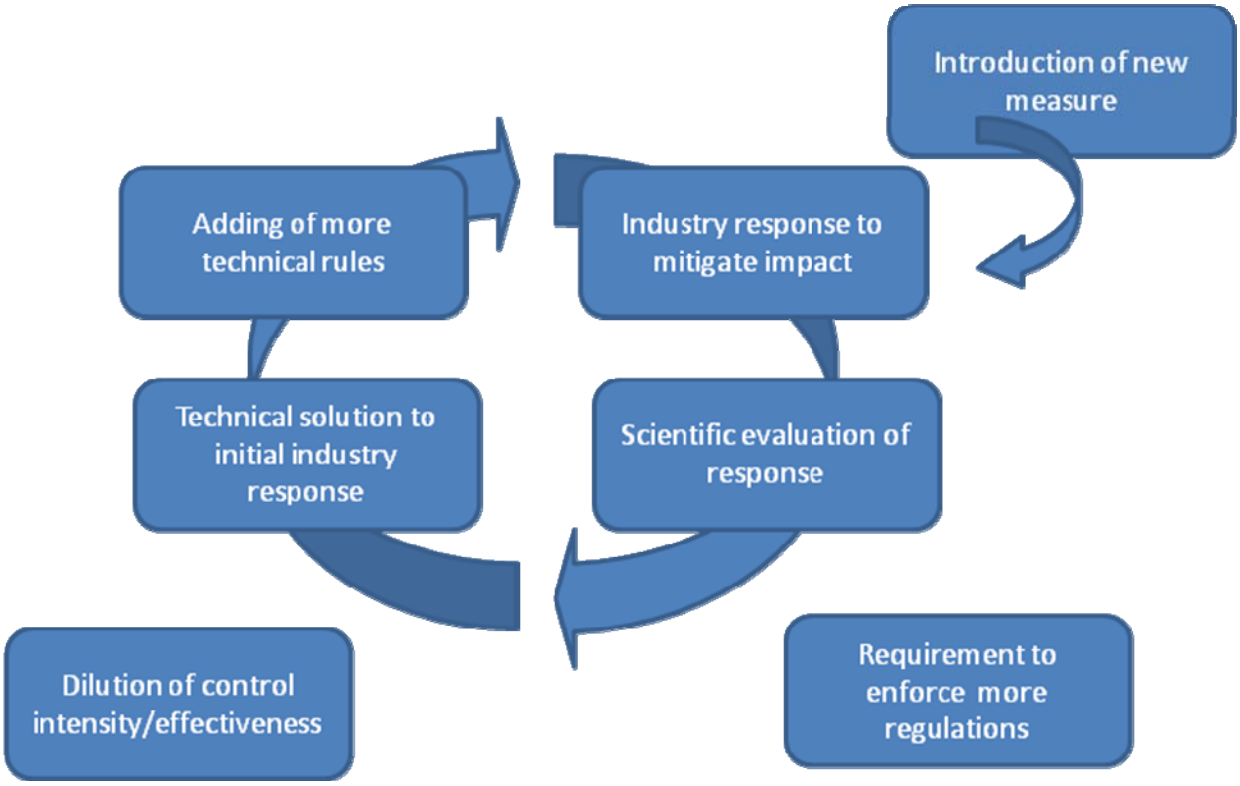


Figure 9.2 The effects of how the current framework of technical measures in the EU has affected control and enforcement activities

Suuronen and Sardà (2007) carried out a review of gear based technical measures and concluded that "*effective implementation and enforcement of technical measures can be extremely difficult*" and note that "*Fishers may resist in a variety of ways and they are capable of effectively sabotaging almost any management measure*" and that "*the successful use of technical measures appears to depend largely on their acceptance by industry*". What is clear from this rather damming appraisal is that our ability to adequately control and enforce technical measures is limited and in many cases, 'catch-up' regulations tend to be more complex further exacerbating control issues. The other important conclusion from Suuronen and Sardà (2007) is that for technical measures to work optimally, they need to have support and buy-in from the industry.

9.3 Examples of bad practice

To illustrate some of the current weaknesses within technical measures regulations, three examples are given that highlight the main failings and weaknesses.

The first two examples relate to the specification of an escape panel for beam trawls and otter trawls to reduce by-catch of cod in the North Sea and West of Scotland (contained in Regulation (EC) 2056/2001). This Regulation aims at "*establishing additional technical measures for the recovery of the stocks of cod in the North Sea and to the west of Scotland*" but contains no specific measurable objectives other than "*The immediate requirement is to reduce catches of juvenile cod by establishing a general increase in the mesh size of towed nets and static nets used to catch cod*" and "*additional conditions to ensure that capture of juvenile cod by towed nets of mesh size less than 120 mm is reduced*".

The particular panel introduced for beam trawls (Figure 9.3.1) is defined using a detailed formula for the construction of the large mesh (180mm) panel section and the position for insertion in the upper part of a beam trawl. Points (a)-(d) as shown in Figure 9.3.1, determine in great detail, how long the panel needs to be. This overly detailed description clearly illustrates the undue complexity inherent in the current technical measures.

> 2. By way of derogation from Article 2(6) of Regulation (EC) No 2549/2000, it shall be prohibited to carry on board or deploy any beam trawl of mesh size equal to, or greater than, 80 mm unless the entire upper half of the anterior part of such a net consists of a panel of diamond-meshed netting material of which no individual mesh is of mesh size less than 180 mm attached directly to the headline or to no more than three rows of netting material of any mesh size attached directly to the headline.
>
> The panel of netting shall extend towards the posterior of the net for at least the number of meshes determined by:
>
> (a) dividing the length in metres of the beam of the net by 12;
>
> (b) multiplying the result obtained in (a) by 5 400;
>
> (c) dividing the result obtained in (b) by the mesh size in millimetres of the smallest mesh in the panel, and
>
> (d) ignoring any decimals or other fractions in the result obtained in (c).

Figure 9.3.1 Extract from article 2 of Regulation (EC) No 2056/2001

The second point from this example relates to the original basis of the measure. This would appear to be research undertaken during two EU funded projects which included extensive field testing and showed that such designs were capable of reducing cod catches by up to 40% (van Marlen, 2003). However, the key design features tested by van Marlen (2003) were for very large mesh panels with mesh sizes up raging 2500mm (2.5m) from to 5000mm (5m) compared to the mesh size of the panel eventually agreed which was 180mm. This illustrates how measures agreed in regulations can depart substantially from the experimental designs actually tested and on which the measures are based. This particular measure also illustrates the regulatory focus on design elements rather than the desired outcome and issues relating to controllability. To enforce this measure requires fisheries inspectors to perform the same detailed calculation at sea to estimate whether the length of the panel is in accordance with the regulation.

The same regulation also specifies requirements for *Nephrops* trawls in the North Sea and west of Scotland as shown in Figure 9.3.2. This element of the regulation is interesting in that the panel described has no known scientific basis, nor is it supported by any experimental field evaluations. Even a cursory review by gear technologists would have concluded that the design features would have no impact on catch rates of juvenile cod due to their species specific behaviour. This illustrates how some measures have been introduced with the vain hope they may have some benefits.

> (iii) of mesh size range 70 to 99 mm unless the upper half of such a net consists of a panel of netting material attached directly to the headline of the net or to no more than three rows of netting material of any mesh size attached directly to the headline, extending towards the posterior of the net for at least 15 meshes and constructed of diamond-meshed netting material of which no individual mesh is of mesh size less than 140 mm;

Figure 9.2.2. Extract from article 2 of regulation (EC) No 2056/2001

The next example demonstrates how concern about how effective measures are following their introduction into the commercial fisheries leading to supplementary measures. The BACOMA window (see section 10.1.1) was introduced into the Baltic to improve the selection pattern on cod and in defined in detail in Regulation (EC) No 2187/2005. Due to a large step increase in selection pattern, and associated short-term losses (Tschernij et al., 2004), the efficacy of the gears were perceived to be often reduced by technical innovation or circumvention of the measures by the industry, to the extent that it was deemed necessary to introduce regulations governing the procedures to mend the netting in the BACOMA panel as shown in Figure 9.2.3. This illustrates a regulatory system overly fixated on input controls.

2. **Conditions for the repair of square mesh panels**

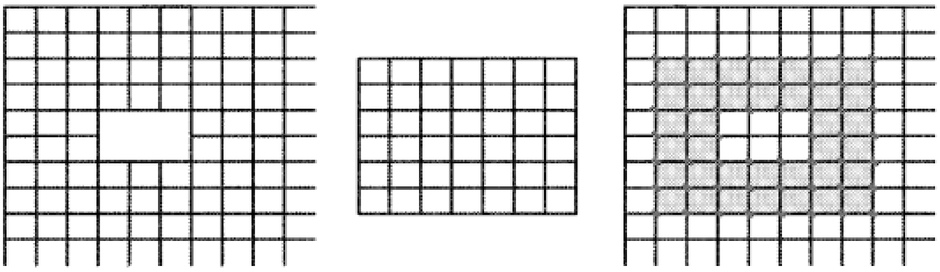
(a) *General conditions*

(i) The use of a square mesh BACOMA exit window which has 10 % or more meshes repaired shall be prohibited.

(ii) Square meshes which have been damaged shall be repaired according to the prescribed method.

(iii) A repaired mesh is any mesh where the mesh opening is reduced by a repair of damaged meshes or by the joining of two pieces of knotless square mesh netting.

(b) *Method for repairing the damaged meshes in the BACOMA exit window*



(i) Clean the hole.

(ii) Count the meshes to be replaced. Prepare a patch using knotless braided single twine that is the same material, diameter and strength of the net needing to be patched.

(iii) The patch should be no more than two meshes larger in each direction than the cleaned-up hole to provide sufficient netting to overlap the edges of the hole.

(iv) Lay the patch over the hole and lace it to the existing netting using braided twine, as shown in the illustration.

(v) Make sure to lace the crosses of the netting together.

(vi) Continue lacing around the hole so that you have at least two rows of lacing around the patch.

(vii) The patched hole will resemble the above illustration when finished.

Figure 9.2.3 Extract from Appendix 1 to Regulation (EC) No 2187/2005

While the above examples portrays a rather depressing picture of the limitations of technical measures as currently applied, this must be viewed in the context of the other measures used such as limiting total allowable catches and effort which also suffer from implementation issues. TACs are actually enforced as TALs (total allowable landings) and catches in many cases well exceed the intended outtake due to discarding of juvenile fish and over quota catches in mixed fisheries. The linkage between effort levels and fishing mortality are in many cases, tenuous and are blunt instruments incapable of achieving specified reductions in fishing mortality.

There are however, examples in EU fisheries where the regulatory framework has actually worked and promoted the use of technical measures including both gear and spatial/area based measures. The introduction of the Long Term Management Plan (Regulation (EC) No 1342/2008) has had one of the most dramatic impacts on the introduction of measures aimed at reducing cod catches. Two articles in the plan (articles 11 and 13) provide the possibility for vessels to avoid future restrictions on fishing opportunities in terms of TAC and effort adjustments (article 13) or to be exempted from effort restrictions provide that catch rates of cod are demonstrated to be below certain thresholds. This paradigm shift has had a number of substantive impacts in terms of the application of technical measures and the development role of industry. Focussing on the output elements rather than the specifics of the technological inputs, has made it possible for the industry to innovate through the development and testing of new and novel approaches to minimising cod catches and in return avoid or limit the impact on future fishing opportunities. This approach has several added advantages that collectively encourage greater ownership by encouraging more stakeholder involvement and innovation through closer involvement in the overall process, which by way of defined catch targets also promotes a more transparent approach and clear targets to aim for.

To our knowledge, this represents an entirely new management instrument in that the focus has shifted from detailing the specific construction of technical measures to one where a catch objective is specified. It reflects the EU's shift towards strengthened participation in fisheries governance (Green Paper on the CFP, 2009). According to this Green Paper, the general framework for fisheries policy would be set on the basis of a Commission proposal, but detailed implementing decisions, for example, on types of gear or on which area should be closed to fishing and when, could then be taken at a regional level where scientists would need to interact with stakeholders and governments. The Green Paper also foresees that the industry is asked to develop its own fisheries plans, for which they would need scientific advice – especially if this is to form part of a results-based management system. Current thinking in fisheries management is that such practices are more likely to be successful with regards to achieving these objectives. It is important to note this shift in policy towards regionalised decision making has filtered through into the draft Basic CFP Regulation.

10 INFLUENCE OF THE MANAGEMENT SYSTEM ON TECHNICAL MEASURES

Technical measures are part of an overall management system which influences fishermen's behaviour (Graham et al, 2007). The introduction or variation of technical measures may elicit different responses from fishermen depending upon the management framework that applies. Willingness to deploy technical measures in an effective and desired manner is heavily influenced by such frameworks. However, also of significant importance is the way in which access rights are granted and the degree of flexibility allowed in gaining fishing rights. Strong property rights can produce incentives that promote longer term views regarding resource management and can effectively down-weight the negative incentives associated with short term losses, if there is a view that the individual business will gain in the longer term. Essentially there are four managements systems available in which technical measures assume slightly different roles.

The current management approach (with the exception of the articles 11 and 13 in the 'Cod Plan') largely follows a prescriptive approach and is reliant on detailed input measures. This approach is widely used and is generally highly dependent upon technical measures that need to be defined in statutory provisions. They include detailed gear specifications, at macro and micro level, and the use of specific 'add-on' devices or modifications. The issues surrounding the prescriptive based approach are considered in Section 9 of this report. In practice management uses a combination of the above and as a result fishermen's reactions to specific management approaches, particularly with a prescriptive based approach can be confounded by their responses to other factors and therefore expected outcomes/results can be affected by combinations of factors and in many cases the measures can be mutually contradictory. The issues surrounding the prescriptive based approach are considered in section 8

Results-based Management (RBM) focuses on the achievement of a specified and desired outcome, rather than the current approach of specifying technical inputs without any quantifiable objective or target (Fitzpatrick et al., 2011). A useful analogy to contrast prescriptive and RBM approaches is to consider how traffic speed is regulated. The prescriptive approach would be akin to specifying the technical attributes of a car e.g. engine power, and how to drive it in the hope of achieving traffic speeds that are safe, without defining what a safe driving speed actually is. Traffic speed is managed on a RBM approach, simply specifying the maximum permissible speed and monitoring and controlling it.

Implementing a catch/results-based approach in fisheries would mean that there would be fewer requirements for input controls, especially technical measures. Under such a system there would be sufficient incentives for fishermen to avoid unwanted catch, through tactical adaptations, as unwanted catch would represent a cost to the business; where exceeding desired catch levels would result in some form of penalty such as premature closure of the fishery or limitations in future fishing opportunities. The added advantage is that such an approach can provide significant incentives for fishermen to innovate and deploy tactical methods aimed at remaining within target levels rather than under a prescriptive system that incentivises tactical adaptations to negate the effectiveness of technical measures or circumvent them altogether. There are a number of other key advantages to RBM type approaches depending on the type of metric selected. Where the output metric relates to the catch of specific species, then by virtue of elevated monitoring of catch for control purposes, has the advantage in that it can significantly improve the information base for scientific purposes e.g. high resolution catch data for stock assessments.

However, the RBM approach requires adequate and substantive at-sea monitoring and control. This presents two distinct issues, (i) the selection of appropriate metrics and (ii) establishing acceptable levels of monitoring for compliance purposes. Fitzpatrick et al. (2011) and Anon (2008) discuss in detail the issues surrounding the choice of appropriate metric. If an RBM type approach is to be followed in the future, it is recommended that further consideration be given to the choice of appropriate metrics. At-sea monitoring and control is expensive and due consideration must be given to how specific metrics could be effectively monitored. In almost all EU fisheries, the cost of monitoring and control has fallen to the state. However, in jurisdictions where RBM type approaches are applied e.g. Bering Sea and Aleutian Islands, Canadian pacific Coast Groundfish Fisheries, these are subject to high levels of observer/CCTV coverage, but the costs are extensively borne by the industry. The current proposal on the future CFP specifies that there will be an obligation to land all commercial species and have them discounted against quota allocations. If adequately monitored, this can provide a strong incentive to reduce unwanted catch and provide accurate catch information that will benefit stock assessments procedures and allow for the potential to implement TACs on the basis of catch rather than landings controls. The incentive to reduce unwanted catch through technical measures will be largely driven by practical issues which will present a ‘hindrance’ factor at an individual business level. These relates to issues such as onboard storage and delivery of unwanted catch, potential costs incurred with onshore processing and handling and overall increases in workload at sea and onshore. In practice, discard bans could incentivise the use of more selective gears in ways similar to the RBM approach outlined above and could result in a significant streamlining in the need for prescriptive technical measures. Again, at-sea monitoring and control will present significant challenges, particularly if discard band are applicable only to part of the overall catch e.g. species specific bans. The effectiveness of such a policy approach is highly dependent on monitoring, control and enforcement.

Adjustment of fishing effort as a means of regulating fishing mortality generally focuses on the limitation of the number of days an individual or fleet of vessels can spend at sea in any given management period. However, there are a number of measures applied that can limit the amount or size of gear that can be deployed and how long it may be deployed. Several static gear fisheries are limited in the number of nets or hooks that may be deployed at any given time and also limits on how long they can be fished e.g. soak-time regulations. While the regulation of effort is relatively simple to control and monitor, in many case the linkage between fishing mortality and effort is tenuous. In practice it may be hyper-stable in that effort adjustments do not lead to measurable changes in fishing mortality due to technological innovation (technology creep), which is difficult to monitor and quantify. This can potentially result in the addition of more regulations with more complex gear specifications and restrictions. However, as seen with the 'cod plan', the provision of discrete choices, where individual business are faced with either reductions in fishing effort (or other fishing opportunities) or the application of measures that reduce fishing mortality (or other objectives) adjustment of effort can present a strong incentive to adapt fishing tactics and gears to improve exploitation pattern/rate.

10.1 Case studies on the management framework and technical measures

The following two case studies compare a prescriptive type approach used in the Baltic to a RBM approach used in Alaska.

10.1.1 Lessons from the Baltic Cod fisheries

Technical conservation measures have a long history in the Baltic Sea. The work with trawl modifications to reduce catches of young fish in trawls started in the early 1900´s (Ridderstad, 1915). Before most of the countries around the Baltic became EU members, the International Baltic Sea Fishery Commission (IBSFC) was responsible for fisheries management in the Baltic Sea. After its establishment in early 1970´s, the IBSFC soon recognized that there was a need for investigating a mesh size increase, and many mesh size experiments were conducted (see Madsen, 2007 for a review). The work was further intensified in the mid-1990s but this time the focus was changed from increasing mesh size to developing alternative devices to improve the size selectivity of the Baltic cod trawls.

Gear regulations for cod trawlers in the Baltic have changed many times during the last 20 years as shown in Figure 10.1.1, and are now mainly gathered in EC Council regulation 2187/2005. Before 1994 the minimum mesh size (MMS) was 105 mm, when the IBSFC decided to increase MMS to 120 mm and minimum landing size (MLS) from 33 to 35cm. At the same time, two other codend designs with side panels in a 105 mm codend (105 mm exit windows) were introduced as legal alternatives to the conventional diamond mesh codend. This was one of the first European Communities regulated regions where selective sorting devices were adopted into legislation (Madsen, 2007).

With effect from 2002 and based on advice from the Bacoma project (Suuronen et al., 2000), IBSFC exchanged both exit windows codends with a 120 mm BACOMA codend and at the same time increased mesh size in conventional diamond mesh codends to 130 mm. Use of the BACOMA-window codend was widespread in early 2002 but due to the markedly increased selectivity, initial catch losses for trawlers that used the BACOMA codend were substantial (Tschernij et al., 2004). Therefore, most trawlers rapidly switched to the alternative 130 mm diamond-mesh codend (Suuronen et al., 2007). Furthermore, in January 2003, the MLS for cod was increased from 35 to 38cm and as a result of a major mismatch between selectivity in the trawls used and the increased MLS discards increased. This led to an emergency closure of cod fisheries in the Baltic EU waters in April 2003. When the fishery reopened in August 2003, conventional diamond mesh codends were prohibited and BACOMA panel mesh size was reduced to 110mm.

For some years, the BACOMA-cod end was the only legal gear. In 2006, the T90 codend was introduced as an alternative to BACOMA after an evaluation of existing data by ICES, which did not find any significant difference in selectivity between that of 110mm T90 codend and that of 110 mm BACOMA. The next major change occurred in 2010 when the mesh size of the T90 codend and the BACOMA window was increased from110 mm to 120 mm mesh size to further decrease discard. At the same time, a high grading ban for all quota species was introduced while the minimum landing size was kept at 38 cm (Regulation (EC) No 1226/2009). Furthermore, with effect from January 2011 amendments to the technical specifications for BACOMA- and T90 codends in EC Council reg. 2187/2005 were introduced (EU No 686/2010).

Despite all changes, technical conservation measures related to gear are still today much debated in regional forums and member states, especially in light of the anticipated ban on discards in a reformed CFP. Anon (2010) reported that cod discard rates in the demersal trawl fishery for cod in the Eastern Baltic varied with year, quarter, country and total catch weight. On a yearly scale, the average discard rate for all countries fluctuated without a clear trend around an average value of 10% (Anon, 2010). Annual variability in discard rates is to a large extent a result of variability in year class strength.

Year	Reg. change
pre 1994	Mesh size (MMS) 105mm, Minimum Landning Size (MLS) 33 cm
1994	MMS increase 120 mm or 105 mm exit windows (2 variants)
1994	MLS increase 35 cm
2002	MMS increase 130 mm or 120 mm Bacoma panel
2003	MLS increase 38 cm
2003	Emergency closure
2003	110 mm Bacoma panel only
2006	110 mm T 90 introduced as alternative to Bacoma
2010	MMS increase to 120 mm in T 90 and Bacoma
2011	Amendments of some technical specifications in council reg 2187/2005

Figure 10.1.1 Changes in gear regulations in Baltic cod trawls during the last two centuries (taken from Tschernij et al., 2004)

10.1.2 Bering Sea and Aleutian Islands/Gulf of Alaska Groundfish Fisheries

In Alaska, groundfish fisheries within the US EEZ are managed under two fishery management plans (FMP), one covering the Gulf of Alaska and the other the Bering Sea and Aleutian Islands (BSAI) region. In both regions, species-specific TACs for walleye pollock (*Theragrachalcogramma*) are established annually and are apportioned by season, area, and gear type. Catches (including discards) are monitored through daily observer reports and landing reports from processing plants. Heavy reliance on observer data is supported by a requirement for partial or full observer coverage (depending on vessel size). Conservation and management measures have a goal of reducing bycatch to the lowest practicable level and to minimize mortality of the bycatch if it cannot be avoided. Bycatch is managed through a complex set of regulations including TAC set-asides to support bycatch requirements for target fisheries, as well as maximum retainable bycatch allowances that may constrain target fisheries as the overall TAC of a bycatch species is approached. Certain bycatch species are designated “prohibited species” (PSC), and this includes all salmonids harvested in the region, Pacific halibut (*Hippoglossushippoglossus*), and commercially important species of crab. Retention of PSC is prohibited, and regulations require fisheries to be curtailed or relocated when the bycatch of these species exceeds specified levels. The target fishery for walleye pollock in the BSAI is among the largest single-species fisheries in the world, the annual catch exceeding 1 million tonnes since the mid-1980s (Ianelli et al., 2005). All fishing is conducted by trawlers. The fleet includes catcher vessels (CVs) delivering their catches to onshore or floating processor plants, and catcher/processors (CPs) processing their catches at sea. Although bycatch rates in the fishery have always been relatively low, small percentages can represent large quantities. The North Pacific Fishery Management Council (NPFMC) has taken several actions during the past decade to reduce bycatch. Three main factors (management measures and/or operational developments) have influenced the efficiency of the fishery for walleye pollock in the BSAI and contributed to overall reductions in bycatch.

Historically, walleye pollock were harvested with non-pelagic (demersal) and pelagic trawls. Demersal fishing, however, had been discouraged to reduce bycatch and impact on the seafloor. Before implementation of the requirement to harvest pollock with pelagic gear (BSAI FMP Amendment 57), the National Marine Fisheries Service (NMFS) twice allocated the TAC among pelagic and non-pelagic gear types: once in the early 1990s, and again in 1999 when the entire pollock TAC was allocated to pelagic gear in anticipation of the approval of Amendment 57. The NMFS, however, had terminated the temporal use of non-pelagic trawls on many occasions when PSC limits for crab and halibut were exceeded. During the 1990s, these limits were decreased, encouraging the fleet to adopt pelagic trawling (NPFMC, 2000). Therefore, although all directed fishing for pollock with non-pelagic gear was finally banned earlier management action had encouraged a steady progression towards this goal. To discourage deploying pelagic gear on the seabed, regulations implementing Amendment 57 limit the number of crab on board at any time; fishing on-bottom is not expressly prohibited.

Secondly, in January 1998, Amendment 75 of the BSAI FMP was implemented. This required all vessels fishing for groundfish to retain all pollock and Pacific cod (*Gadusmacrocephalus*), and to establish minimum standards of utilization, prohibiting codend bleeding (releasing fish into the water from the codend before the net is brought on board) or at-sea discarding of cod.

Thirdy, the American Fisheries Act (AFA) of 1998 mandated significant changes in management of the BSAI fishery for walleye pollock. The regulations divided the remaining quota among three sectors. Within each sector, fishery cooperatives were established. As a direct result of AFA implementation, the fleets consolidated, and latent capacity was reduced. Moreover, elimination of the race for fish encouraged the fleet to work collectively on strategies to reduce bycatch, especially in situations where high bycatch levels might restrict fishing opportunities or otherwise increase the costs associated with harvesting. Cooperative and inter-cooperative agreements allowed the fleet to respond collectively and effectively to challenges, such as the implementation of strategies to comply with mitigation measures related to the listing of the Steller sea lion (*Eumetopiasjubatus*) and a programme that curtails fishing in areas when salmon bycatch rates are excessive (Karp et al., 2005).

This case study presents a clear example that restrictions on commercial practice provided incentives for fishers to accept the use of more-selective gears. This was also supported by full retention and bycatch management plans. Regulatory authorities provided rules that determined whether fishing was permissible based on predetermined “acceptable” bycatch proportions, whether consisting of fish below minimum size or bycatch species. Alaskan fishers voluntarily reduced their reliance on demersal trawling, and changed their fishing patterns to stay within the regulatory boundaries. Clearly, the incentive was the prospective closure of highly productive pollock fishing areas when salmon bycatch thresholds were reached. The result is an industry managed programme that shares bycatch information collected by observers and enforces agreements within and between cooperatives, requiring vessels to avoid areas with a high salmonid bycatch (Gauvin et al., 1996; Karp et al., 2005; Gilman et al., 2006). The industry was faced with choosing between the lesser of two evils: alter strategy and adopt more selective fishing techniques or face the underutilization of resources and substantial economic losses. When managers eventually mandated the use of more selective gears, implementation was facilitated because industry had been closely involved in the formulation of the solutions.

10.2 Incentives

The contrast between the ‘traditional’ approach to technical measures, with highly prescriptive input controls (i.e. Baltic Sea example), and the management approach which focuses on the results or outputs (Alaskan example), demonstrates that the management approach and framework can have a significant impact on the effectiveness of technical measures in practice, and critically the willingness of the industry to apply such measures. As previously discussed, the use of technical measures to minimise cod catches under the cod plan has created a strong incentive structure, where legislators, managers and fishermen are encouraged, in the face of more restrictive fishing opportunities, to develop and introduce solutions that are driven from the bottom-up. This has created an atmosphere where fishermen are dependent on the proper functioning of technical measures which is one of the key issues identified by Suronnen and Sardà (2007). While this could be viewed as a coercive incentive, in that the failure to act in a particular manner results in penalty, it does demonstrate that given sufficient incentive, the application of technical measures can achieve desired outcomes. It is therefore useful to explore the utility of incentives as a means of stimulating a behaviour which promotes the effective use of technical measures.

Regulations which create incentives to reach the management targets can make management more robust by ensuring, in most cases, that those who have the greatest impact on fisheries have an increased interest in their long-term conservation and directly bear the cost of overexploitation (Grafton et al, 2006). The challenge is to introduce management measures that create those incentives that then lead to the desired behaviours. This is not easy, and it has proven to be the central challenge of fisheries management. Linking incentives to outcomes is difficult enough when managing single species, with the relatively simple problems of limited exploitation and localised effects. It is even more complicated for entire ecosystems, where exploitation is interconnected with system-wide ecological and economic effects (Hanna, 1998).

Incentives can be defined as "*Any factor (financial or non-financial) that provides a motive for a particular course of action or counts as a reason for preferring one choice to the alternatives*". This is a very broad definition; therefore we focus here on incentives that can be applied by governance actors (state, market and NGOs/consumers) with the aim to influence the behaviour of fishermen to do the "right" thing. A downside is that incentives can also have undesired or perverse effects. For example, the stimulation of certified products can lead to an increasing demand for certified products (positive), but at the same time can stimulate mislabelling and misleading information.

We can broadly distinguish three types of incentives, which are not mutually exclusive and often operate in parallel

- Financial incentives exist when an actor can expect some form of material reward — especially money — in exchange for acting in a particular way. Subsidies (positive) and taxes (negative) are examples of financial incentives.
- Moral incentives exist when a particular choice is widely regarded as the right thing to do, or as particularly admirable, or where the failure to act in a certain way is condemned as indecent. This is also referred to as peer pressure.
- Coercive incentives exist when a person can expect that the failure to act in a particular way will result in removal of a right or having to pay a penalty (financial or non-financial). The penalty for detected infringements is one example of a coercive incentive

So far technical measures work generally with negative incentives -trying to force fishermen to do something out of the risk of punishment. These measures basically increase costs without compensation. This incentivises the industry to circumvent regulations by technical innovation. Experiences from other industries show that rewarding positive behavior thorough financial gain e.g. reductions in costs, improved market may work better than punishment. Fishermen will more easily accept regulations if they have gains from applying them. In many cases this also may include the search for more efficient ways to reach targets (as visible with the cod plan where technical innovation to avoid cod bycatch has occurred) as well as giving more responsibility to the industry to improve the achievement of clearly set objectives.

Almost inevitably, the application of additional technical measures will result in some loss of commercial catch. This can be quite significant particularly if a fishery is heavily reliant on young fish that may be close to minimum landing size for example. Increasing mesh size to reduce discarding and potentially benefit future yield from the fishery will, in this case will result in loss of marketable catch. Therefore there is often a conflict between short term losses and longer term stock considerations. In many cases technical measures are introduced to achieve stock conservation targets and in some cases the introduction of technical measures may, therefore, increase costs for fishermen in the short-term but lead to long-term gains (avoiding catching of juveniles may lead to increased catch possibilities in the future). As it is often unclear how or if individual fishermen will receive these gains the management system thus has a strong influence on the acceptance of legislation. A key element is that there is little financial gain in reducing unwanted catches as there is little direct financial benefit in doing so. In essence, there is no immediate business cost associated with the retention of unwanted catch and that actions to reduce unwanted catch will in fact incur costs at an individual business level (loss of target catch, costs of new fishing gear, avoiding certain areas, etc.). Any individual behaviour to reduce unwanted catch is not encouraged because the individual is unlikely to gain sufficiently from future yields (if at all). Acting in an altruistic way to benefit the common good is additionally not encouraged because it will more than likely result in short terms losses and the long term gains will be shared by all actors, including those who have not improved their exploitation pattern - 'free-rider effects'. All of these factors present strong barriers at an individual business level to 'do the right thing'.

We can distinguish two cases:

1. Measures that increase costs in the short-term but will lead to potential long-term gains. An example could be fishermen having to use larger mesh sizes resulting insignificant catch losses over an initial period but as stocks increase in the longer term through improved selectivity then there are gains from being able to catch larger fish with potentially higher value.
2. Measures that increase costs for fishermen without gains. This can be often the case when fishermen have to fulfil requirements under environmental legislation such as the MSFD or Habitats and Birds Directives which follow from overall policy objectives.

To contrast the short and long terms losses/gains, a standard economic method can be applied: a Cost-Benefit-Analysis at company level. CBA is a technique that compares the monetary value of benefits with the monetary value of costs in order to evaluate and prioritize issues. The effect of time (i.e. the time it takes for the benefits of a change to repay its costs) is taken into consideration by calculating a payback period. The CBA can also be used to place a financial value on intangible costs and benefits (e.g. the cost associated with negative impacts of fishing or the benefit of increased yields in the future) through measuring WTP ('willingness to pay' for an environmental gain) and WTA ('willingness to accept' compensation for an environmental loss). For the second possibility, where we have the political decision which fishermen also have to follow, management authorities shall at least make sure that the most cost-effective measure and approach to achieving that objective will be applied. For that we can use the Cost-Effectiveness-Analysis as the basic method.

10.2.1 Cost benefit analysis

The general idea behind a Cost Benefit Analysis (CBA) is to value all costs and benefits of an action in monetary terms to be able to compare them with alternative actions. In many economic activities, like commercial fishing, the operation generates positive or negative external effects. Destruction of bottom habitats is a negative external effect of fishing which is normally not part of the cost function of a company. Following the MSFD or Natura 2000 sites established under the Habitats and Birds Directives there is a political decision to avoid such destruction. This is often also justified as the general public, if asked, would probably say that they prefer to buy fish from fisheries which avoid methods that impact negatively e.g. bottom habitats. Schemes like MSC certify fisheries which fulfil certain requirements by basically avoiding negative externalities (bycatch, destruction of habitats, etc.). The idea is to give certified products an advantage on the market and reward the fishermen for following the rules of the certification scheme with higher prices.

In cases where consumers are not able to express their preferences on markets (e.g. buying only certified fish) they can be asked about their willingness to pay to avoid bottom habitat impact in marine ecosystems. In the meantime many of these so-called Contingent Valuation (CV) studies exist showing that people have a substantial willingness to pay for preservation of habitats, species, etc. However, it is nearly impossible in the case of technical measures to really assess the external costs of bycatch or negative habitat impact as it is simply impossible to make CV studies or use other methods to value all necessary parts. The other problem is that a positive willingness to pay will not result in payments for fishermen to avoid certain negative external effects. For many people this may be perceived as a strange concept i.e. paying fishermen for not doing the "wrong thing". However, from an economic standpoint it is only a question of who asks for certain actions and in this case fishermen received the rights to fish and society only afterwards asks for fish not to be caught or in a certain way. As the same species is often caught in several areas with different regulations pertaining to different permitted fishing gears, it is sometimes also a matter of competitiveness as fishermen who face costly restrictions may have to give up compared to fishermen who fish in other areas with less strict regulations. Therefore, a monetary compensation can be justified

Nevertheless, with all these methodological problems it seems unreasonable to ask for a comprehensive CBA in most cases for individual or a combination of technical measures. However, as a first step only assessing the market values can already lead to a better economic analysis. Avoiding the bycatch of juveniles is a measure which probably will improve catch possibilities in the future. The problem is that the benefits accruing from additional catch possibilities occur in several years, while the costs of changing the fishing activity have to be borne immediately. If we want to compare the benefits of increased catch possibilities in the future and the costs to achieve that today every money stream must be adjusted to today's prices/values (called present value). This can be done by discounting future benefits and costs. It doesn't make sense to invest 1,000 € today if we are not getting back 1,050 € in one year if we can get 5% by putting the 1,000 € in a bank account. Fishermen will, therefore, only invest today in avoiding bycatch if they get a sufficient reward in the future (1,050 € in one year for 1,000 € today if we use the simple example).

The main problem in the case of technical measures is that there are only associated costs for the fishing companies and most likely no guarantee of long term gains (or gains for somebody else). Most regulations simply increase the costs for fishing by limiting the possible actions of a company. The additional problem for the fishing company is, even if there are sufficient short- or long-term gains following certain actions, there is no security for the future gains except within a management system assigning clear property rights for future catches – and even then because of uncertainties in stock development, gains are not secure. Therefore, it is not surprising that fishing companies see only the costs from technical measures and forget the gains which may occur in the near future.

In summary, we can use a CBA framework also at a company level to assess if a measure creates more benefits than costs. This can also include an analysis of a management framework to assess possible winners and losers of certain measures.

10.2.2 Cost Effectiveness Analysis

In cases where a clear goal or target is agreed, like MSY or GES with associated targets and indicators, a Cost-Effectiveness Analysis can be used. In this case benefits do not to be valued as the political decision can be seen as an acceptance of benefits for society. The idea behind a CEA is now to find the least costly way to achieve the goal/target. The result will be a number of actions with associated costs so that trade-offs are clearly visible. Unfortunately, technical measures mostly do not fit into this 'easier' category as there may be some objective for the introduction of a technical measure (like avoiding catching of juveniles or fishing in a sensitive habitat). At the same time the regulation is very specific on the actions needed to reach the target which leaves no room for a decision between actions.

10.2.3 Governance, legitimacy and compliance

Another issue with respect to the implementation of technical measures is to consider which governance structure the fisheries operate. This is important to assess if the fishermen interpret the measures as legitimate which will influence their willingness to comply with the rules. There are examples where incorporating fishermen into the decision-making process often leads to better compliance with the rules as in a simply top-down management approach. However, simply including them in the decision making process in itself does not always provide improvement in terms of the *specifics* of the rules (Grafton *et al*, 2006), if the decision making process is overly biased towards one group with strong economic links, then could result the deployment of rules that are more focused on short term economic issues rather than longer term stock benefits (Parsons, 2003).

Governance in general can be defined as the "Sharing of policy making competencies in a system of negotiation between governmental institutions at several levels (international, (supra) national, sub-national) on the one hand and state actors, market parties and civil society organisations on the other in order to govern activities at sea and their consequences" (van Tatenhove, 2011). Important aspects are whether the rules are considered as legitimate; what is the dominant discourse that influence the definition of the problem (e.g. it is not acceptable to fish/discard juvenile fish); and which stakeholders have the power to make the decision to implement a technical measure (e.g. scientists, politicians, member states).

We can distinguish between three types of governance:

- Hierarchical governance
- Market governance
- Participatory governance

Hierarchical governance is a centralised hierarchical, command and control way of steering with the aim to safeguard the sustainability of fish stocks.

Market based governance takes the rationality of the fisherman as the main starting point. It deals with economic optimalisation. Property rights (ITQs) are an example of market governance.

In participatory governance communities play a vital role in resource management. Co-management is an example of participatory governance. It means the democratic participation of user-groups in regulatory decision-making. This is expected to improve the legitimacy of "fisheries management schemes and is assumed to result in a higher degree of "fishers' compliance (Jentoft, 1999). However legitimacy is not the only factor that influences compliance. Other factors include coercion, tradition, apathy, pragmatic acquiescence and instrumental acceptance.

Currently technical measures are based on negative, mostly coercive incentives (you cannot do this, or you will get punished) in a hierarchical governance system i.e. top-down rather than bottom-up. Fishermen do not feel part of a participatory process where these measures have been agreed and. therefore do not consider them as legitimate or equitable. Moreover, because of their hierarchical formulation they often perceive technical measures as not practical, not reflecting current fishing practice and contradictory. This combination of factors leads to the low compliance rates we see currently. Adapting the governance structure to more market based or participatory may well yield better compliance with necessary technical measures but also may reduce the need for numerous, detailed measures.

10.3 Evaluation

The Common Fisheries Policy is a collection of 4 pillars with different institutional layers of implementation (European Commission, Council of Ministers, European Parliament, Member States). That makes it important to identify who raises the question for an evaluation of what and when. The question about evaluation of effectiveness of technical measures originates from the European Commission as the executive agency implementing the policy. Generally only effectiveness (i.e. outputs) is reviewed but this does not address an evaluation of the processes (i.e. governance) of the implemented policy. However, in situations where the link between inputs and outputs is difficult to assess, as is the case with technical measures, it is important to include process evaluation into the evaluation framework because it allows for a deliberated outcome instead of a disputed outcome (Rauschmayer et al., 2009).

At the same time, there is a key argument for including process-based evaluation into the evaluation framework. Policy evaluation can be described as "a scientific analysis of a certain policy area, the policies of which are assessed for certain criteria and the basis of which recommendations are formulated" (Crabbe and Leroy, 2008). Policy evaluation is often promoted as an element in a policy cycle (Jann and Wegricht, 2006) that involves five steps - Agenda setting (problem identification); Policy Formulation; Adoption; Implementation; and Evaluation. In the straightforward version of policy evaluation the aim is to assess whether the goals that were set have been reached. This means that goals and outcomes are compared and that measurement techniques and criteria for success have been defined. For any policy evaluation, it is important to specify the anticipated links between measures and outcomes. A logic-model (also known as intervention logic or programme theory) describes the theory, assumptions and evidence underlying the rationale for a policy by linking the intended outcomes with the policy inputs, activities, processes and theoretical assumptions (HM Treasury, 2011). The logic-model is the way results of a policy can be understood with the actions that have been taken.

In practice such a rather straightforward analysis can be difficult to undertake as there are many uncertainties about the causality of the impacts (do they really link to the implementation of the policy) and there is a complex interplay between multiple actors from different sectors and different scales (do they really implement and adhere to the agreed policy) (Rauschmayer et al., 2009, Crabbe and Leroy, 2008). In order to address these more complex attributes of policy, it is important not just to verify whether goals have been reached but also the path along which the goals were (attempted to be) reached and the wider impact that the implementation of the policy has had. So it is not just a question of evaluating outcomes but also a question of what has been learned?

How can future policies learn from implementation of the current policy and the way it did or did not obtain planned results? These questions become increasingly relevant in the policy impact assessment in complex environments, not only because policies try to reach rather vague goals through a multitude of different measures but also because the impact of a particular measure can be perceived differently by different stakeholder groupings. Because impacts and causality can be debated, the perceived reliability of the evaluation is also important. This reliability is reflected in the credibility, salience and legitimacy of the evaluation (Cash et al., 2002, Eckley, 2001, Clark et al., 2010). Credibility reflects the believability of the results of the assessment. Salience refers to the relevance, the useability of the assessment and whether the evaluation addresses the concerns of a particular user. Legitimacy is a measure of the acceptability or fairness of the assessment. Determining who participates in an evaluation can have significant effects on the credibility, salience and legitimacy of the evaluation.

In trying to establish a new approach to technical measures the procedure for evaluating such measures in the future. This links for the need for setting measurable objectives and strongly supports a move to a results based approach to management where technical measures become a tool to achieve the objectives.

11 TECHNICAL MEASURES IN THE CONTEXT OF SUSTAINABLE EXPLOITATION AND THE REFORM OF THE CFP

In the context of the ongoing reform of the Common Fisheries Policy (CFP), the draft Basic Regulation (COM(2011) 425)) sets out future objectives for the CFP as:

- "*exploitation of living marine biological resources restores and maintains populations of harvested species at least **at** levels which can produce the maximum sustainable yield. This exploitation rate shall be achieved by 2015, where possible, and by 2020 for all stocks at the latest"* (article 2.2)

- "*gradually eliminate discards on a case-by-case basis and taking into account the best available scientific advice by reducing unwanted catches and gradually ensuring that catches are landed*" (Article 2.4(a))

- "*be coherent with the Union environmental legislation, in particular the objective of achieving a good environmental status by 2020, as well as with other Union policies*." (Article 2.4(g)).

Technical measures have an important and significant role in attaining each of these objectives as follows:

- The maximum exploitation rate consistent with MSY depends on the exploitation pattern. A relative high mortality on juveniles will in general lead to a lower maximum exploitation rate than if the mortality on juveniles is limited. By default, obtaining the maximum yield from a given stock will require that the exploitation pattern tends away from exploitation on younger age groups and therefore achieving this will require technical approaches.
- The gradual elimination of discards and minimisation of unwanted catch will require the application of technical measures as the central plank in obtaining this objective.
- The requirement for fishing activities being consistent with wider ecological considerations will depend on the application of fishing techniques that are sensitive to marine habitats and minimise capture of vulnerable and sensitive species.

11.1 Achieving MSY

The main management measures applied to limit the exploitation rate are TACs and fishing effort limits as discussed. The importance of technical measures as a tool to limit exploitation rate under a TAC system depends on how the system is implemented, i.e. as restrictions on landings or on catches. The current interpretation of the MSY policy objective in the CFP is that it is achieved by exploiting the resource at a fishing mortality of F_{MSY}. The estimation of F_{MSY} requires some knowledge of the productivity and dynamics of the stock, and where this information is available, values for the reference point are derived from simulation studies which explore the stock dynamics with robustness testing for sensitivity to recruitment models and contemporary selection in the fishery (ies). Where the data required for such simulations are not available proxies for F_{MSY} can be derived by making assumptions such as assuming equilibrium conditions. With such assumptions simpler per recruit production functions (such as Yield per recruit YPR) can be applied to estimate proxies for F_{MSY} such as F_{max} or F0.1. Because of the sensitivity of F_{MSY} estimates to selection in the fishery (Scott and Sampson, 2011), it should be noted that future technical measures adopted under the new CFP could result in a change in the exploitation pattern on a particular stock, and therefore the value of B_{MSY} and F_{MSY} for that stock will change and the assessed stock status may also change even if the overall exploitation rate remains constant.

However, for a given stock and assuming that life history characteristics (growth, stock - recruitment etc) remain constant, F_{MSY} is determined by the exploitation pattern and stock status in relation to B_{MSY} is determined by the exploitation rate. Scott and Sampson (2011) have shown that even subtle changes in selection (changes to Exploitation Pattern) can produce substantial differences in MSY and F_{MSY}. Hence, if under a new CFP, technical measures are adopted which result in a change in the exploitation pattern on a particular stock, then the value of B_{MSY} and F_{MSY} for that stock will change and the assessed stock status may also change even if the overall exploitation rate remains constant. Furthermore there will inevitably be a time-lag of at least 2 years to detect any such changes and to advise on stock status or the appropriate level of future exploitation.

11.2 Gradual elimination of discards and Limiting unwanted catches

The second objective of the CFP refers to the elimination of discards. Unwanted catches may be over-quota catches of quota species, individuals of quota species that are below the legal minimum landing size or saleable size and catches of quota species with no economic value. Unwanted catches[2] may also include species that are protected by legislation and cannot be retained and landed legally.

The move to a landing obligation represents a fundamental shift in policy. Under the current Total Allowable Catches (TACs) system used in the EU, the TACs set are in fact Total Allowable Landings (TALs) and represent the weight of the catch from each fish stock that can legally be landed. For a variety of reasons a TAL system alone does not necessarily restrict catches or fishing mortality on any of the stocks that are caught in the fishery. This is particularly true for fisheries that exploit several stocks simultaneously. In such cases, even if the TAL for one stock has been reached, fishing can continue provided that the vessels operating in the fishery still have quota availability for other stocks leading to over-quota catches that cannot be landed legally and must be discarded. Similarly if the quota for all quota species has been exhausted, the fishery could continue for species not subject to TALs. Hence under a TAL system there is a requirement to legislate for specific technical measures to complement TALs in an attempt to reduce or eliminate unwanted catches. Such legislation implies a cost in terms of control and enforcement and perhaps an implementation cost to fishers. Furthermore to limit catches under a TAL system complementary measures to control or limit fishing activity (fishing effort) are often required as has been the case in many EU fisheries,.

Moving towards an obligation to land all TAC species in the short-term, in theory at least, means that TALs will become TACs and start to reflect catches rather than just landings as per the current system. In principal under such a system there is no a priori reason to prescribe technical gear measures that should be used although there may be a need to prescribe gear types that should not be used, possibly in combination with spatial measures. The major challenge is to ensure that all catches are effectively monitored. If effective monitoring of catches can be achieved, then there is also no requirement to have complementary fishing effort restrictions to control catch although effort restrictions in combination with technical measures may be required to achieve environmental objectives. How fishermen take their catch allocation is inconsequential provided that there are no other overarching objectives to be met e.g. mitigation measures to avoid catching certain species or to mitigate any impacts on habitat. Such a system may incentivise fishers to develop technical measures that maximise their personal objectives e.g. in terms of revenue in relation to their catch opportunities. There will still be a requirement for scientists and gear technologists to develop and test new gears but their role will focus more on advising, monitoring and evaluating the effects of any technical measures applied.

Under this approach, compliance with the catch quotas must be demonstrated. Thus far, the onus of compliance has primarily rested with the management authority and not with the industry. Recognising that expansion of such results based approach on an EU wide basis will require substantial at-sea monitoring increasing monitoring and compliance costs. Considering this, it may be necessary that some or all the burden of proof is shifted onto the industry as in other fisheries e.g. Alaska (see section 9.1.2). However, where catch or landings restrictions are not part of the regulatory regime e.g. fisheries in the Mediterranean which are largely managed through the control of fishing effort and other technical measures, the approach described above is not applicable. If control of exploitation pattern is to continue as a management objective, then a prescriptive based approach will continue to be required. If there is a desire to move toward a result based approach, then in the absence of TAC controls, alternative Results based management metrics will be required.

11.3 Technical measures and their future role in attaining good environmental status

Limitation of exploitation rates to sustainable levels will contribute to limit the negative impacts of fishing on the marine ecosystem, but is unlikely to be sufficient on its own and technical measures will be required to achieve the overall objectives.

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[2] According to the general approach to the CFP regulation unwanted catches' means catches of species below minimum conservation reference size or minimum landing size, or of prohibited species, or of species subject to catch limits for which a Member State and/or a fisherman does not or does no longer have a quota

Even with a move to a results based approach, it is likely that technical measures, particularly gear-based measures and area closures or gear specific access limits, will continue to have a significant role within the broader context of the ecosystem approach to fisheries and associated implementation policies such as NATURA 2000 and the MSFD. Within the Ecosystem Approach to Fisheries Management (EAF) it is important to consider the effects of fishing (Jennings and Revill, 2007) and critically determine which of these effects actually matter in terms of ecosystem sustainability i.e. address in a management context, the aspects of fishing that compromise ecosystem function (Jennings and Quesne, 2012).

Jennings and Revill (2007) identify five key effects (other than the removal of the target species) that fishing has on broader ecosystem functioning; (i) Low productivity species in mixed fisheries; (ii) genetics of exploited populations; (iii) non-target species, by-catch; (iv) food-webs & biodiversity; and (v) habitats. Technical measures will continue to have a greater or lesser role to play in negating these effects as follows:

(i) Low productivity species

There are many well documented bycatch issues associated with commercial fishing activities impacting on the dynamics of low productivity species e.g. bycatch of marine turtles in tropical shrimp fisheries and bycatch of sharks in static gear fisheries. In a European context, many species of elasmobranchs are considered threatened and are caught in mixed species demersal fisheries. In this case gear-based technical measures are a possible solution to protect such species. A good example of this is the use of Turtle Excluder Devices (TEDs) in the tropical shrimp fisheries, the introduction of which (encouraged by trade embargos) has greatly diminished the anthropogenic affects of fisheries on these species.

(ii) Genetics

There is a growing body of literature which suggests that selective fishing e.g. the capture of a particular demographic component of a stock or stocks can induce evolutionary adaptation such as changes in mean age of maturation and growth. While there is still considerable debate surrounding this hypothesis, the methodological approaches taken as well as what the long-terms stock impacts could be, there is need to consider how technical measures may have a role in this context. As fishing tends to be directed towards larger older fish, genetically this tends to favour slower growth and earlier maturation over time. There is evidence that suggests that protecting older, large mature fish (BOFFF's – Big, Old, Fat, Fecund Females) may offer a potential method to mitigate this. This could be achieved be designing gears that have a dome shaped selection profile, that are capable of selecting out older fish. Incidentally, this type of selection pattern is already associated with many passive gears such as gillnets and longlines. The other alternative is simply to avoid them through spatial or temporal measures.

(iii) Non-target species bycatch

Many demersal fisheries using towed gears such as otter and beam trawls tend to catch a disproportionate amount of unwanted bycatch. The range and diversity of bycatch is considerable and includes catches of invertebrate animals in beam trawl fisheries up to the bycatch of marine mammals in gillnet and pelagic trawl fisheries. Limiting the capture of such species in multi-species fisheries has become an important management consideration and has resulted in some innovative developments to limit bycatches. The capture of charismatic species such as seals, cetaceans and seabirds in demersal static and pelagic gear fisheries has become a pressure issue for managers simply due to the high profile of the species or where populations are critically endangered or threatened e.g. stellar sea lions in the North Pacific and wandering albatross in the South Atlantic. Gear based adaptations have been developed, often in response to coercive incentives such as premature closure of fisheries, restrictions in fishing opportunities or wider public pressure.

(iv) Food-webs and biodiversity

It is noted that selective fishing in an ecosystem context is a function of both selection pattern (age demographics within species) and species exploitation rate specific mortality. As fisheries tend to target only marketable species, fishing activity tends to be skewed towards commercial species. Selective fishing is believed to have potentially negative impacts on both fish community biodiversity and on food web structure and function. Selective fishing, particularly for large bodied commercial species, will tend to also have an impact on other large-bodied, slow-growing, long lived and low fecundity species, so called K strategy species. Good examples would include the elasmobranchs. In terms of food webs, it has been suggested that selective fishing will tend to remove the larger bodied, higher trophic level, species, and lead to a depletion of these and subsequently a tendency to "fishing down the food web" (Pauly et al., 1998). One solution to these impacts has recently been proposed – "balanced fishing" (Garcia et al., 2012).

In essence, balanced fishing would aim to remove the same proportion of each size class of fish from the population, thus retaining the population demographic, while reducing overall abundance. To all intents and purposes this represents unselective fishing!! In principle, the idea is attractive, and may well have applicability in less developed fisheries where all fish can be landed and will be consumed. It may be less applicable in more developed and highly managed fisheries in Europe, and similar societies. The key issue in such areas would be the technical difficulties of designing and operating gears that could achieve "balanced fishing" across different ecosystems, species catchabilities and life histories, and relative species abundance. Additionally, it should be recognised that fisheries in Europe are generally species selective, and focused on a small percentage of the market driven species actually caught in mixed demersal fisheries. There would need to be considerable changes, and flexibility in the markets before all these species could be utilised productively. Essentially, fisheries in Europe are mainly about making money rather than just producing food.

(v) Habitats

While the largest impact of fishing is the removal of organisms from, the marine ecosystem, many demersal towed gears also have a significant and potentially negative (destructive) interaction with the marine habitat with the main issue being one of cumulative damage to habitats. The significance and spatial distribution of habitat impact is highly variable and depends not only on gear type but on the frequency of use e.g. effort. In some situations, for example biogenic reefs, a single impact may be serious or catastrophic and no level of interaction would be advisable. However, understanding what constitutes an acceptable level of impact from a productivity perspective is far more uncertain and the problem is not the same in all habitats. Essentially there are some habitats that would be expected to be robust and of high resilience e.g. high energy areas, and some that would be much less robust and would recover very slowly if at all, e.g. biogenic or natural reefs. The application of technical measures to manage habitat impact varies depending on the habitat type and gear types concerned, and solutions vary across this range (He and Winger, 2009). In the least robust/resilient the solutions are mainly in terms of spatial management. In the more robust/resilient, solutions are lower impact gears *combined* with spatial management. The development of low impact gears is still in somewhat of an infancy phase. There have been developments in our understanding of the physical impacts of the different towed gear components that are in contact with the seabed. Models have been developed which permit the quantitative assessment of direct impacts. (O'Neill and Summerbell, 2011; Ivanovic et al., 2011). These models can allow a linkage of gear type and size to seabed and habitat impacts.

12 Technical Measures in the Future CFP

12.1 Policy directions

Presently, there is still a great deal of uncertainty as to when the new CFP will be agreed and to the final shape of the new policy. It is apparent however, that obligations to reach MSY levels for commercially exploited species, the obligation to land all TAC species and to eliminate discards are likely to be cornerstones of the policy. In addition the future CFP will require alignment with broader environmental and ecological policy objectives such as the MFSD and NATURA. Another central theme of the reform is the move to regionalised decision-making which is particularly relevant for the future use of technical measures as management tools. By doing this implies that only limited technical measures would be agreed at Union level (i.e. under co-decision of the European Parliament and the Council of Ministers) with the majority of technical measures developed regionally to the extent they are needed relative to the specificities of different fisheries.

In this context, while the Commission as yet has no definitive opinion on the shape of technical measures in a reformed CFP with regionalisation a central element, the Commission has identified three possible policy options for technical measures post-reform that were presented to EWG12-14.

These three options are as follows:

Option 1: Consolidation

This involves continuing with the current policy of having multiple detailed rules agreed at Union level but simplified through harmonising technical measures across regions where appropriate, deleting redundant articles and measures and incorporating any recent changes in technical measures (e.g. measures introduced in the Celtic Sea earlier this year). It would essentially consolidate technical measures into one Regulation replacing existing technical measures (including Regulation (EC) No 850/98) and align them with the essential elements of the reform (i.e. landing obligation and regionalisation). This option assumes a gradual move to regionalisation and the implementation of the landing obligation over an extended timeframe and therefore many of the existing detailed rules at Union level are still required and can only be repealed or moved under plans as and when regionalisation and the landing obligation become fully operational. This new Regulation would be agreed under co-decision of the European Parliament and Council.

Option 2: Regionalisation with a framework regulation

This involves the development of a new approach to technical measures to replace the existing regulations. It would come into force in the form of a framework regulation under co-decision, with the necessary legal architecture to allow specific provisions to be developed regionally at a fishery or sea basin level as envisaged under the reform.

It would create the legal framework for implementing regionalisation of technical measures (i.e. through multiannual plans, discard plans or national measures). It would include common elements of the existing technical measures that are applicable to all sea basins and would remain in place permanently in the longer-term (e.g. definitions, prohibited gears, conservation reference sizes). Depending on the approach taken it could also include generalised standards such as selectivity patterns or reference gears that would replace minimum mesh sizes and catch composition rules. Potentially it would cover similar generalised standards to protect other ecosystem components such as cetaceans, seabirds and marine reptiles and possibly vulnerable habitats impacted by fishing.

Option 3 – Regionalisation without a framework regulation

This option would abolish all or the vast majority of the current technical measures (certain measures such as closed areas under NATURA 2000 may remain in place) and move to a fully regionalised, results (or target) based management system. There would be no framework regulation as in option 2. The overarching targets/objectives would be those set in the Basic Regulation and other relevant legislation (i.e. MSY by 2015; elimination of discards and achievement of GES by 2020). Specific targets, timelines/milestones and reporting requirements would all be set under multiannual plans. Member States in consultation with the RACs would decide on the fishing strategies, gears, operational methods and/or other measures to meet these objectives and targets. The role of technical measures within the management framework to achieve these targets in combination with other measures would be left to be agreed regionally. Member States could in agreement with each other decide to adopt detailed technical measures, rely on alternative fishing strategies or avoidance measures or a combination of measures and changes to fishing operations to help achieve the same results – possibly based on sustainable fishing plans developed by the industry. Under this option the burden of proof would be fully with the Member States and stakeholders to demonstrate compliance.

12.2 Case Study on the proposed discard ban in the Skagerrak

To illustrate the Commissions current thinking and as an example of how regionalised decision-making can work, it is worth considering the example of the introduction of a discard ban into the fisheries in the Skagerrak. This is a result of the revocation of the Skagerrak agreement and the joint ministerial declaration of 23 November 2011 by the Ministers responsible for fisheries in Denmark, Norway and Sweden. To develop a regional discard plan a joint EU-Norway working group was formed. The working group tasks where to provide recommendations on harmonisation of technical regulations for trans-boundary fisheries and control measures in relation to the forthcoming discard ban. The Working Group began by carrying out an audit of the relevant fisheries and identification of the problems associated with these fisheries. This help to inform the debate leading to EU and Norway agreeing a new package of technical measures for the relevant fisheries. This followed the option 2 approach described above by setting baseline codend minimum mesh size at 120 mm diamond mesh in demersal trawls and seines. Derogations where decided for the *Pandalus* and *Nephrops* directed fisheries provided these fisheries used additional selectivity devices (grids and square mesh panels). These derogations where estimated to be legitimate alternatives to the 120mm codend in terms of roundfish selectivity. It was also agreed that future alternatives to the decided gears that can be demonstrated to be at least as effective in terms of selectivity could be considered after approval by STECF. The actual description of these gear-based measures in the Commission proposal (COM(2012) 471) was included in one short article without any detailed descriptions and also allows innovation to develop other gears with similar selectivity characteristics in line with a results-based approach.

EWG 12-14 considered these options and also the Skagerrak case study. The EWG concluded that Option 1 does not fit the objectives of the reform of the CFP, nor does it address many of the current weaknesses in the technical measures regime (e.g. overly prescriptive, top-down, coerce incentives, control issues). The EWG identified that that many of the developments in the performance of the fisheries required to achieve the objectives of the CFP can be achieved faster and with better results under a result based management system as advocated under both options 2 and 3 than under the present input system. Therefore EWG 12-14 agreed that the operational aspects of a results based approach should be the focus of a next meeting of the group.

13 CONCLUSIONS

Given the available policy options and possible directions, the EWG 12-14 concludes that technical measures are relevant as management tools in relation to the objectives of the CFP in ensuring exploitation of the resources at levels consistent with maximum sustainable yield (MSY), of ensuring that negative impacts of fishing activities on the marine ecosystem are minimised and of eliminating discards by reducing unwanted catches and gradually ensuring that catches are landed.

Controlling exploitation pattern (EP) through the use of technical measures does have a significant role in terms of conservation benefit. However, in comparison to regulating exploitation rate (ER), ER has a more dominant effect. It is important to note that technical measures can also significantly contribute to the regulation of exploitation rate. Analysis shows the existence of a trade-off between exploitation rate and exploitation pattern; a low proportional exploitation of immature fish allows for the occurrence of moderately increased exploitation rates and vice versa.

For a given stock and assuming that life history characteristics (growth, stock - recruitment etc) remain constant, MSY is determined by the EP and stock status in relation to MSY for a given EP is determined by the ER. It has been shown that even subtle changes in selection (EP) can produce substantial differences in MSY and F_{MSY}. As a consequence, MSY and F_{MSY} for that stock will change and the assessed stock status may also change even if the overall ER remains constant. It is therefore important that MSY reference points be reviewed periodically, particularly if there is evidence of improvements in selection pattern associated with changes in technical measures.

In almost all cases, with one or two notable exceptions, technical measures have been introduced without specific objectives. As a consequence, the impacts of individual measures cannot be quantitatively measured due to the lack of reference points, nor is it possible to compare the merits of one measure against another. Field, simulation and modelling studies do allow quantification of the relative impacts on selectivity of specific components of gear design such as mesh size, twine thickness etc, and the effect of species selective gears relative to baseline gears. However, there are few studies aimed and assessing the impact of individual measures post introduction. Disentangling the effect of an individual measures is confounded due to the application of other input and output controls and other external factors e.g. variability in stock recruitment.

For species that have high discard mortality, there is no empirical evidence to show the use of Minimum Landings Size has any conservation benefit and the rationale behind MLS is unclear, particularly in multi-species/multi-gear fisheries. There are many cases where there is a mismatch between MLS and gear selectivity and mismatch between species caught in the same fishery; this can significantly contribute to discarding or incentives fixes to reduce selectivity to avoid loss of fish greater than the MLS. Similarly, catch composition regulations are likely to have had no benefit and in some circumstances may lead to regulatory induced discarding as under the current CFP, catch composition rules simply regulate what is retained onboard and not what is caught. It is noted that the original intention of such rules were to classify fishing activity into broad metiers for management purposes and not as a means of controlling fishing mortality. Notwithstanding, catch composition regulations can provide a useful tool if fisheries are fully documented.

As currently applied, technical measures, can in principal adjust exploitation pattern and rate, but it is likely that the anticipated impacts of these measures have not been fully realised due to inability or unwillingness to deploy as intended and enforcement difficulties. So far technical measures have been implemented through negative incentives; trying to get fishermen to do something out of the risk of punishment. Measures tend to increase costs, through short-term losses and/or equipment costs and there are generally borne by the individual business without compensation. This incentivizes fishermen to circumvent technical measures, a response to minimise short term losses. This has resulted in a technological and regulatory arms-race, where subsequent rules are applied in response to technological innovation by the industry. Prescriptive input regulations can also stifle positive technical innovation as fishermen are encouraged only to use gears that comply with minimum standards and not to focus on the intention of the regulation. Additionally, individual technical rules are seldom removed but in practice amended and added to. This has led to a growth in the amount and complexity in technical regulations which has led to increasing control and enforcement burden. This has necessitated continual up-skilling requirements for enforcement personnel and overall has led to a reduction in control intensity of each rule.

The utility and effectiveness of technical measures is heavily dependent on the regulatory framework in which they are deployed and whether the approach promotes the use of technical measures through incentives. Experience from the cod LTMP has clearly shown that given stimulus, industry can rapidly develop and deploy fishing tactics, including gear and behavioural changes, when there are specific objectives and strong drivers to do so (e.g. exclusion from the effort regime).Legislative requirement of detailed technical measures could be minimised if outputs (e.g. catches) are adequately monitored and controlled. While a catch based approach will have the benefit of reducing the legislative burden, it will require the comprehensive monitoring and quantification of catch, and this is the primary issue regarding such an approach. This will be challenging. If alternative output based targets would be used instead, such as the setting of maximum catch levels of a given species, the industry are encouraged to continue the development of methods to achieve the desired targets rather than simply applying the prescribed technical measure.

It is important to consider controllability and cost-effectiveness before the introduction of a technical measure or replacement regulations to avoid imposing rules that cannot be or is too expensive to enforce. Many of the current technical regulations are uncontrollable due to problems of detection, monitoring standards and legal complexity. EGW 12-14 note that there has been significant growth in technical regulations since the foundation of the CFP, however, few if any of these have been repealed. This has led a multi-layered and complex catalogue of legislation with technical measures that have become increasingly complex, some even requiring specific regulations on how to undertake net repairs! EWG 12-14 suggest that measures that have little benefit should be removed and only management measures aimed at improving the biological and/or the ecological status should be employed so that the general acceptance of the rules is improved. From a control perspective the number of regulations should be kept to a minimum. Rules and control activities have to be harmonised in regions to ensure a level playing field. The management measures have to be adaptive so that they can be changed following changes in the status of the stock. In that way unwanted effects (decreased selectivity etc.) can be avoided. The penalty level is closely related to the compliance level. The penalty level needs to be fair and high enough to be deterrent. CQM and FDF have the potential to be effective management measures but it is important to remember that it is a real challenge to ensure compliance of these rules.

One of the aims of the reform of the CFP is to have limited, global and standardised technical rules at Union level, and the majority of detailed technical measures developed regionally with extensive stakeholder consultation. However, it is important to recognise the impact that the choice on regionalisation may have on the revision of the technical measures regulations. The CFP reform proposal proposes to move to a situation where Member States are empowered and take responsibility for jointly agreeing on detailed technical measures with measures then adopted at Union level on the basis of a participatory, consultative process in the region. This move away from detailed, prescriptive rules agreed jointly at Council and Parliament is essential if technical measures are to contribute effectively to the overall management approach.

Technical measures have an important role in terms of wider ecosystem considerations. These include limiting fishing impacts on low productivity species caught in mixed species fisheries; protection of sensitive habitats as increasingly, sensitive areas are being closed to certain gear types. Technical adaptations to gears can help minimise habitat impacts. It is likely, however that area restrictions and closures will remain the central approach to protecting habitats vulnerable epifauna. However, it is important to consider possible unintended impacts, in particular the impact that effort displacement in response to area closures can have on areas that are presently lightly exploited.

Although technical measures are likely to continue to constitute central tools in achieving the objectives of the CFP it does not necessarily mean that these measures have to be implemented in regulations. EWG 12-14 believes that under a result based management system, where focus is on the achievement of clearly stated results and not on how the fishery is conducted, there will be a limited need to implement technical measures via regulations. However, it is noted that monitoring and control of catches is more difficult and expensive than regulations that can be monitored ashore. To date, where RBM is applied e.g. the Cod plan, the role of monitoring and the burden of proof largely resides with the member state, in order to expand catch or RBM approaches, it would be preferable that the burden of poof resides with the industry.

Incentive-based approaches can make management more robust by ensuring, in most cases, that those who have the greatest impact on fisheries have an increased interest in their long-run conservation and directly bear the cost of overexploitation. The challenge is to introduce management measures that create incentives that lead to desired behaviours.

14 RECOMMENDATIONS

The discussion held at EWG 12-14 is an important first step in understanding the current deficiencies in technical measures and how to address these deficiencies in developing a new approach to technical measures based on a results based approach with appropriate impact metrics (impact referring to, e.g., F on fished stocks and damage to other ecosystem elements such as seafloor, seabirds). To assist the Commission further it is recommend that the EWG reconvene in quarter 1, 2013 with the following terms of reference:

a) Identify tactical objectives that potentially could be achieved using technical measures in the context of results-based management.

b) Identify appropriate metrics to quantify the progress towards the tactical objectives identified in a).

c) Discuss and identify how impact metrics can be monitored and controlled and how the effectiveness of an impact based approach can be evaluated. This should consider required levels of compliance and difficulties associated in achieving these levels.

d) Explore the need for minimum standards (baseline regulations), focusing on specifications of technical measures, considering there will be a requirement for a transitional phase from the current input based approach towards a full impact based system as well policy objectives not suited to a strict output based approach e.g. MFSD, NATURA 2000.

15 REFERENCES

Berverton, R.J.H., and Holt, S.J. 1957. On the dynamics of exploited fish populations. Fishery Investigations, London, Series II, XIX, 533pp.

Burd 1986, Why increase mesh sizes? Laboratory, Leaflet, MAFF Directorate Fisheries Research, Lowestoft, 58, 20pp.

Bailey, P. D. 2000. Discourse and the Regulation of the Environment and Technology: Overfishing and Vessel Monitoring in European Fisheries.

Caddy, J.F., and Seijo, J.C., 2002. Reproductive contributions forgone with harvesting: a conceptual framework. Fisheries Research, 59: 17-30.

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., and Jäger, J. 2002. Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making. RWP02-046.

Clark, W. C., Tomich, T. P., Van Noordwijk, M., Dickson, N. M., Catacutan, D., Guston, D., and McNie, E. 2010. Toward a General Theory of Boundary Work: Insights from the CGIAR's Natural Resource Management Programs. RWP10-035.

Crabbe, and Leroy 2008. The Handbook of Environmental Policy Evaluation.

Davis, F.M., 1934. A mesh experiment indicating that small fish escape while the trawl is being towed.Rapports et Proces-verbaux, Conseil permanent International pour I'Exploration de la Mer 90, 22-26, Appendix C.

Eckley, N. 2001.Designing effective assessments: The role of participation, science and governance, and focus. No. 26.

Fitzpatrick, M., Graham, N., Rihan, D. and Reid, D.G., 2011. The burden of proof in co-management and results-based management: the elephant on the deck! ICES Journal of Marine Science 68: 1656-1662.

Garcia, S. M., Kolding, J., Rice, J., Rochet, M.-J., Zhou, S., Arimoto, T., Beyer, J. E., Borges, L., Bundy, A., Dunn, D., Fulton, E. A., Hall, M., Heino, M., Law, R., Makino, M., Rijnsdorp, A.D., Simard, F., Smith, A. D. M., 2012. Reconsidering the Consequences of Selective Fisheries conservation. Science, 335: 1045-1047.

Gauvin, J. R., Haflinger, K., and Nerini, M. 1996. Implementation of voluntary program in the flatfish fisheries of the eastern Bering Sea. In Solving Bycatch: Considerations for today and Tomorrow, pp. 79–86. Alaska Sea Grant College Programme, Report 96–03.

Gilman, E. L., Dalzell, P., and Martin, S. 2006. Fleet communication to abate fisheries bycatch. Marine Policy 30: 360-366.

Grafton, R.Q., Arnason, R., Bjørndal, T., Campbell, D., Campbell, H.F., Clark, C.W., Connor, R., Dupont, D.P., Hannesson, R., Hilborn, R., Kirkley, J.E., Kompas, T., Lane, D.E., Munro, G.R., Pascoe, S., Squires, D., Steinshamn, S.I., Turris, B.R., Weninger, Q., 2006. Incentive-based approaches to sustainable fisheries. Canadian Journal of Fisheries and Aquatic Sciences, 63: 699-710.

Graham, N., Ferro, R.S.T., Karp, W.A. and MacMullen, P., 2007.Fishing practice, gear design and the ecosystem approach – demonstrating the effect of management strategy on gear selectivity and discards in three case studies. ICES Journal of Marine Science, 64:744-750.

Graham, N. (2006) Trawling: historic development, current status and future challenges. Marine Technology Society Journal, 40, vol 3: 20-34.

Halliday, R.G., Pindhorn, A.T., 1996. North Atlantic fishery management systems: a comparison of management methods and resource trend. Journal of Northwest Atlantic Fishery Science, 20, 135 pp.

Hanna, S. 1998. Institutions for marine ecosystems: economic incentives and fishery management. Ecological Applications. Supplement: Ecosystem Management for Sustainable Marine Fisheries 8, S170–S174.

He, P., and Winger, P, D., 2010.Effect of trawling on the seabed and mitigation measures to reduce impact. In: Behaviour of marine fishes: Capture processes and conservation challenges. He, P. (ed). pp 295-314, Wiley-Blackwell.

HM Treasury. 2011. The Magenta Book. Guidance for evaluation. http://www.hm-treasury.gov.uk/d/magenta_book_combined.pdf.

Ianelli, J. N., Barbeaux, S., Honkalehto, T., Lauth, B., and Williamson, N. 2005. Assessment of Alaska pollock stock in the eastern Bering Sea.In Stock Assessment and Fishery Evaluation Report for the groundfish Resources of the Bering Sea/Aleutian Islands Regions, North Pacific.Fisheries Management Council Anchorage, AK.99 pp.

Jann, W., and Wegricht, K. 2006.Theories of the Policy Cycle.In Handbook of Public Policy Analysis, pp. 43-62.Ed. by F. FISCHER, G. J. MILLER, and M. A. SIDNEY.Taylor & Francis.

Jennings, S., and Revill, A.S., 2007.The role of gear technologists in supporting an ecosystem approach to fisheries. ICES Journal of Marine Science, 64: 1525-1534.

Jennings, S., and Le Quesne, W.J.F., 2012.Integration of environmental and fishery management in Europe. ICES Journal of Marine Science, 69: 1329-1332.

Jensen, A.C., 1967. A brief history of the New England offhshore fisheries. U.S. Fish and Wildlife service Fishery Leaflet 594, 14pp.

Karp, W. A., Haflinger, K., and Karp, J. G. 2005. Intended and unintended consequences: fisher responses to bycatch reduction requirements in the Alaska groundfish fisheries. ICES Document CM 2005/V: 3. 16 pp

Law, R., Plank, M.J., and Kolding, J., 2012. On balanced exploitation of marine ecosystems: results from dynamic size spectra. ICES Journal of Marine Science, 69: 602-614.

Madsen, N., 2007. Selectivity of fishing gears used in the Baltic Sea cod fishery. Rev. Fish. Biol. Fisheries, 17: 517–544.

Myers, R.A., and Mertz, G., 1998. The limits of exploitation: a precautionary approach. Ecological Applications, 8: 158-169.

NPFMC, 2000. North Pacific Fisheries Management Council 2000 Stock Assessment and Fishery Evaluation Report for the Grroundfish Resources of the Bering Sea/Aleutian Islands Regions, Appendix C Prohibited Species Catch in the BSAI. Fisheries Management Council Anchorage, AK.11 pp.

O'Neill, F.G., Summerbell, K., Breen, M., 2009. An underwater laser stripe seabed profiler to measure the physical impact of towed gear components on the seabed, Fisheries Research, 99: 234-238.

Parsons, L.S., 1993. Management of marine fisheries in Canada.National Research Council and Department of Fisheries and Oceans, Ottawa, Canada.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., and Torres Jr., F., 1998, Fishing Down Marine Food Webs. Science 279 (5352): 860-863.

Pinhorn, A.T., Halliday, R.G., 2001. The regulation of exploitation pattern in North Atlantic groundfish stocks, Fisheries Research, 53: 25-37.

Rauschmayer, F., Berghöfer, A., Omann, I., and Zikos, D. 2009. Examining Processes or/and Outcomes? Evaluation Concepts in European Governance of Natural Resources. Environmental Policy and Governance, 19: 159–173.

Ridderstad, G., 1915. A new construction of trawl-net intended to spare under-sized fish. Svenske Hydr.- Biol. Kommisionens skrifter Vol 6.

Scott, R.D. and Sampson, D.B., 2011. The sensitivity of long-term yield targets to changes in fishery age-selectivity, Marine Policy, 35: 79-84.

STECF, 2011.38th Plenary meeting report of the Scientific, Technical and Economic Committee for Fisheries (STECF), PLEN-11-03.

Suuronen, P. and Sardà, 2007.The role of technical measures in European fisheries management and how to make them work better. ICES Journal of Marine Science, 64: 751-756.

Suuronen, P., Kuikka, S., Lehtonen, E., Tschernij, V., Madsen, N., and Holst, R. 2000. Improving technical management in Baltic cod fishery (BACOMA). Final Report (EC 4th Framework Programme, Contract FAIR CT 96–1994). 106 pp.

van Marlen, B., 2003. Improving the selectivity of beam trawls in The Netherlands: The effect of large mesh top panels on the catch rates of sole, plaice, cod and whiting, Fisheries Research, 63: 155-168.

Van Tatenhove, J., 2011.Integrated Marine Governance: Questions of legitimacy. MAST 10 (1), pp 87-113

Tschernij, V., Suuronen, P., and Jounela, P. 2004. A modelling approach for assessing short-term catch losses of a mesh size increase. Fisheries Research, 69: 399 –406.

Valdemarsen, J.W., 2001. Technological trends in capture fisheries. Ocean and Coastal Management 44: 635-651.

Vasilakopoulos, P., O'Neill, F.G., and Marshall, C.T., 2011. Misspent youth: does catching immature fish affect sustainability? ICES Journal of Marine Science, 68: 1525-1534.

Vasilakopoulos, P., O'Neill, F.G., and Marshall, C.T., (submitted). Differential impacts of exploitation rate and juvenile exploitation on NE Atlantic fish stock dynamics over the past half century. Fisheries Research.

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17 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg14

List of background documents:

1. EWG-12-14 – Doc 1 - Declarations of experts.

18 APPENDICES

Chronology of mesh regulations introduced in the North East Atlantic from 1954 to 1971 (from Halliday and Pinhorn, 1996).

Authority	Year in Effect	Area of Application	Gear/Materials Affected	Mesh Size (mm)
1937 Convention	– (Convention did not come into effect)	Northern Norway and Barents Sea (north of 66°N, east of 0°E)	Trawls, seines or other nets towed or hauled at or near the bottom of the sea - of any material, measured wet.	105
		All other waters	Trawls, seines or other nets towed or hauled at or near the bottom of the sea – of any material, measured wet	70
1946 Convention	– (Original provisions did not come into effect)	Northern Norway and Barents Sea (north of 66°N, east of 0°E)	Trawls, seines or other nets towed or hauled at or near the bottom of the sea – of any material, measured wet	110
		Icelandic waters (62°–68°N, 10°-28°W)	Trawls, seines or other nets towed or hauled at or near the bottom of the sea – of any material, measured wet	110
		All other waters	Trawls, seines or other nets towed or hauled at or near the bottom of the sea – of any material, measured wet	80
Permanent Commission (created under 1946 Convention)	1954	Northern Norway, Barents Sea and Icelandic waters (coordinates as above)	Trawls or other nets towed or hauled at or near the bottom of the sea – of any material measured wet, except seine nets	110 [1,2,3]
			Seine nets	100
		All other waters	Trawls or other nets towed or hauled at or near the bottom of the sea – of any material measured wet, except seine nets	75 [1]
			Seine nets	70
Permanent Commission (inherited by NEAFC under 1959 Convention)	1964	Northern Norway, Barents Sea, Icelandic and eastern Greenland waters (north of 66°N from Norwegian coast to 10°W, south to 62°N, west to 28°W, south to 59°N, thence west to 44°W)	Seine nets	100
			Such part of any trawl net as is made of cotton, hemp, polyamide and polyester fibres	110
			Such part of any trawl net as is made of any other material	120
		Other waters	Seine net or such part of any trawl net as is made of single twine and contains no manila or sisal	70
			Such part of any trawl net as is made of double twine and contains no manila or sisal	75
			Such part of any trawl net as is made of manila or sisal	80
NEAFC	1966	NEAFC Region 3 (36°–48°N) (Not part of 1946 Convention Area).	Seine or part of trawl net	60
NEAFC	1967	NEAFC Region 1 except at Faroe Islands (N.B. extends large mesh area south to 62°N from 66°N along Norwegian coast)[4]	Seine net	110 [5]
			Such part of any trawl net as is made of cotton, hemp, polyamide or polyester fibres	120
			Such part of any trawl net as if made of any other material	130
		Faroe Islands (essentially ICES fishing area Vb)	Seine net	95 [6]
			Such part of any trawl net as is made of manila or sisal	100 [6]
			Such part of any trawl net as is made of any other material	95 [6]
		NEAFC Regions 2 and 3	No change	

Authority	Year in Effect	Area of Application	Gear/Materials Affected	Mesh Size (mm)
	1969	NEAFC Region 3	Seine net, or such part of any trawl net as is made of single twine and contains no manila or sisal	60
			Such part of any trawl net as is made of double twine and contains no manila or sisal	65
			Such part of any trawl net as is made of manila or sisal	70
	1971		Mesh regulations for all areas extended to include midwater trawls	

1 Agreed in 1955 that "light trawls", i.e. those of single twine and containing no manila or sisal could have a mesh size 5 mm smaller.

2 Agreed in 1961 that the 5 mm differential for "light trawls" be replaced by a 10 mm differential for trawl nets with codends of cotton, hemp, polyamide or polyester.

3 Effective 1 January 1963, mesh size in northern Norway and Barents Sea increased to 120 mm.

4 Agreed in 1970 to move boundary between Regions 1 and 2 from 62°N to 64°N to exempt pollock fishery at 62°–64°N from large mesh regulations.

5 Effective at Iceland and east Greenland in 1968.

6 Revised to 110 mm for trawls of manila or sisal and 100 mm for other nets in 1970. Made identical to rest of Region 1 (i.e. 130 mm manila equivalent) in 1974.

Year in Effect	Area of Application	Gear/Materials/Species Affected	Mesh Size (mm)
1953	Subarea 5 (Gulf of Maine and Georges Bank)	Trawl nets of any material, measured wet, when fishing **for haddock** (10% or 5 000 lb. by-catch exemption for small mesh gear). Equivalent dry measurement permitted from 1954.	114
1957	Subarea 3 (Grand Banks)	Trawl nets of manila, measured wet after use or the equivalent size when measured dry before use or when constructed of other materials, when fishing **for cod or haddock** (10% or 5 000 lb. by-catch exemption for small mesh gear).	102
	Subareas 4 and 5 (Gulf of St. Lawrence, Scotian Shelf, Gulf of Maine and Georges Bank)	As for Subarea 3	114
1968	Subarea 1 (West Greenland)	When fishing for **cod, haddock** and five other species:	
		– seine net	110
		– such part of any trawl net as is made of cotton, hemp, polyamide or polyester fibres	120
		– such part of any trawl net as is made of manila or any other material not mentioned above	130
		– (measured wet after use or equivalent when measured dry before use, no by-catch exemptions).	
	Subareas 2–5 (Labrador to Georges Bank)	When fishing for **cod or haddock** (all Subareas), **pollock** (in Subarea 3 only) and up to seven other species:	
		– seine net	100
		– such part of any trawl net as is made of cotton, hemp, polyamide or polyester fibres	105
		– such part of any trawl net as is made of manila or any other material not mentioned above	114
		– (measured wet after use or equivalent when measured dry before use, no exemptions in Subarea 2, exemption for small mesh redfish fishery in Div. NOP of Subarea 3, general small mesh fisheries exemption in Subareas 4 and 5, by-catch exemptions all 10% or 5 000 lb).	
1971[2]	Subareas 2 and 3 (Labrador and Grand Banks)	Mesh size increase only, equivalents remain and exemptions unchanged.	130 manila equivalent
1974	Subareas 4 and 5 (Gulf of St. Lawrence, Scotian Shelf, Gulf of Maine and Georges Bank)	Mesh size increase applies to codend only, other netting can be 114 mm, equivalents remain and exemptions unchanged.	130 manila equivalent

1 ICNAF Comm. Doc. 79/12, Ser. No. 5441 provides a key to regulations reported in ICNAF Annual Proceedings.

2 1972 for Poland, Portugal and Spain, and for Canada in Subarea 3.

Appendix II – Inventory of EU Technical Measures Regulations

1980 1ST Regulation

Council Regulation (EEC) No 2527/80 of 30 September 1980 laying down technical measures for the conservation of fishery resources *Official Journal L 258, 01.10.1980 P. 0001 - 0015*

1983 New Regulation 171/83

Council Regulation (EEC) No 171/83 of 25 January 1983 laying down certain technical measures for the conservation of fishery resources. Official Journal L 024, 27.01.1983 P. 0014 - 0029

Amendments to 171/83

Council Regulation (EEC) No 2931/83 of 4 October 1983 amending Regulation (EEC) No 171/83 laying down certain technical measures for the conservation of fishery resources. Official Journal L 288, 21.10.1983 P. 1

Council Regulation (EEC) No 1637/84 of 7 June 1984amending for the second time Regulation (EEC) No 171/83 laying down certain technical measures for the conservation of fishery resources. Official Journal L 156, 13.06.1984 P. 1

Council Regulation (EEC) No 2184/84 of 23 July 1984 amending for the third time Regulation (EEC) No 171/83 laying down certain technical measures for the conservation of fishery resources. Official Journal L 199, 28.07.1984 P.1

Council Regulation (EEC) No 2664/84 of 18 September 1984 amending for the fourth time Regulation (EEC) No 171/83 laying down certain technical measures for the conservation of fishery resources. Official Journal L 253, 21.09.1984 P.1

Council Regulation (EEC) No 3625/84 of 18 December 1984 amending for the fifth time Regulation (EEC) No 171/83 laying down certain technical measures for the conservation of fishery resources. Official Journal L 353, 21.12.1984 P.3

Council Regulation (EEC) No 3625/84 of 18 December 1984 amending for the sixth time Regulation (EEC) No 171/83 in particular by the addition of technical conservation measures applicable to maritime waters falling within the sovereignty or jurisdiction of Spain and Portugal. Official Journal L 363, 31.12.1985 P.21

1986 New Regulation 3094/86

Council Regulation (EEC) No 3094/86 of 7 October 1986 laying down certain technical measures for the conservation of fishery resources. Official Journal L 288, 11.10.1986 P. 0001 - 0020

Amendments to 3094/86

Council Regulation (EEC) No 4026/86 of 18 December 1986 amending Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 376, 31.12.1986 P. 0001 - 0003

Council Regulation (EEC) No 2968/87 of 29 September 1987 amending Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 280, 03.10.1987 P. 0001 - 0002

Council Regulation (EEC) No 3953/87 of 21 December 1987 amending for the third time Regulation (EEC) No 3094/86 laying down certain technical measures for the conversion of fishery resources. Official Journal L 371, 30.12.1987 P. 0009 - 0010

Council Regulation (EEC) No 1555/88 of 31 May 1988 amending for the fourth time Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 140, 07.06.1988 P. 0001 - 0002

Council Regulation (EEC) No 2024/88 of 23 June 1988 amending for the fifth time Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 179, 09.07.1988 P. 0001 - 0002

Council Regulation (EEC) No 3287/88 of 20 October 1988 amending for the sixth time Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 292, 26.10.1988 P. 0005 - 0005

Council Regulation (EEC) No 4193/88 of 21 December 1988 amending for the seventh time Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 369, 31.12.1988 P. 0001 - 0002

Council Regulation (EEC) No 2220/89 of 18 July 1989 amending for the eighth time Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 211, 22.07.1989 P. 0006 - 0006

Council Regulation (EEC) No 4056/89 of 19 December 1989 amending for the ninth time Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 389, 30.12.1989 P. 0075 - 0077

1991. Council Regulation (EEC) No 3500/91 of 28 November 1991 amending for the tenth time Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 331, 03.12.1991 P. 0002 - 0002

Council Regulation (EEC) No 345/92 of 27 January 1992 amending for the eleventh time Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 042, 18.01.1992 P. 0015 - 0023

Council Regulation (EEC) No 1465/92 of 1 June 1992 amending for the twelfth time Regulation (EEC) No 3094/86 laying down certain technical measures for the conversion of fishery resources. Official Journal L 155, 06.06.1992 P. 0001 - 0002

Council Regulation (EEC) No 2120/92 of 20 July 1992 amending, for the 13th time, Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 213, 29.07.1992 P. 0003 - 0004

Council Regulation (EEC) No 3034/92 of 19 October 1992 amending, for the fourteenth time, Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 307, 23.10.1992 P. 0001 - 0002

Council Regulation (EC) No 1796/94 of 18 July 1994 amending, for the fifteenth time, Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 187, 22.07.1994 P. 0001 - 0002

Council Regulation (EC) No 1173/95 of 22 May 1995 amending, for the sixteenth time, Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 118, 25.05.1995 P. 0015 - 0015

Council Regulation (EC) No 1909/95 of 24 July 1995 amending, for the 17th time, Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 184, 03.08.1995 P. 0001 - 0002

Council Regulation (EC) No 2251/95 of 18 September 1995 amending for the 18th time Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 230, 27.09.1995 P. 0011 - 0011

Council Regulation (EC) No 3071/95 of 22 December 1995 amending, for the 19th time, Regulation (EEC) No 3094/86 laying down certain technical measures for the conservation of fishery resources. Official Journal L 329, 30.12.1995 P. 0014 - 0017

1997 New Regulation 894/97

Council Regulation (EC) No 894/97 of 29 April 1997 laying down certain technical measures for the conservation of fishery resources. Official Journal L 132, 23.05.1997 P. 0001 - 0027

Amendments to 894/97

Council Regulation (EC) No 1239/98 of 8 June 1998 amending Regulation (EC) No 894/97 laying down certain technical measures for the conservation of fishery resources. Official Journal L 171, 17.06.1998 P. 0001 – 0004

1998 New Regulation 850/98

Council Regulation (EC) No 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Official Journal L 125, 27.04.1998 P. 0001 – 0036

Amendments to 850/98

Council Regulation (EC) No 308/1999 of 8 February 1999 amending Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Official Journal L 038, 12.02.1999 P. 0006 - 0009

Council Regulation (EC) No 1459/1999 of 24 June 1999 amending Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Official Journal L 168, 03.07.1999 P. 0001 - 0005

Council Regulation (EC) No 2723/1999 of 17 December 1999 amending Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Official Journal L 328, 22.12.1999 P. 0009 - 0011

Council Regulation (EC) No 812/2000 of 17 April 2000 amending Regulation (EC) No 1626/94 laying down certain technical measures for the conservation of fishery resources in the Mediterranean and Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Official Journal L 100, 20.04.2000 P. 0003 - 0004

Council Regulation (EC) No 1298/2000 of 8 June 2000 amending for the fifth time Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Official Journal L 148, 22.06.2000 P. 0001 - 0002

Council Regulation (EC) No 724/2001 of 4 April 2001 amending Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Official Journal L 102, 12.04.2001 P. 0016 - 0019

Council Regulation (EC) No 1298/2000 of 8 June 2000 amending for the fifth time Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. Official Journal L 148, 22.6.2000, p. 1–2

Council Regulation (EC) No 602/2004 of 22 March 2004 amending Regulation (EC) No 850/98 as regards the protection of deepwater coral reefs from the effects of trawling in an area north west of Scotland. Official Journal L 097, 01.04.2004 P. 0030 - 0031

Council Regulation (EC) No 1568/2005 of 20 September 2005 amending Regulation (EC) No 850/98 as regards the protection of deep-water coral reefs from the effects of fishing in certain areas of the Atlantic Ocean. Official Journal L 252, 28.09.2005 P. 0002 - 0003

Council Regulation (EC) No 734/2008 of 15 July 2008 on the protection of vulnerable marine ecosystems in the high seas from the adverse impacts of bottom fishing gears. Official Journal L 201 30.07.2008 P. 8.

Transitional Technical Measures

Council Regulation (EC) No 1288/2009 of 27 November 2009 establishing transitional technical measures from 1 January 2010 to 30 June 2011. Official Journal L 347 24.12.2009, P.6

Regulation (EU) No 579/2011 of the European Parliament and of the Council of 8 June 2011 amending Council Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms and Council Regulation (EC) No 1288/2009 establishing transitional technical measures from 1 January 2010 to 30 June 2011. Official Journal L 165 24.06.2011, P.1.

Recovery measures containing technical measures:

Irish Sea cod

Commission Regulation (EC) No 304/2000 of 9 February 2000 establishing measures for the recovery of the stock of cod in the Irish Sea (ICES division VIIa).Official Journal L 035, 10.02.2000 P. 0010 - 0011

Commission Regulation (EC) No 660/2000 of 30 March 2000 amending Regulation (EC) No 304/2000 establishing measures for the recovery of the stock of cod in the Irish Sea (ICES Division VIIa).Official Journal L 080, 31.03.2000 P. 0014 – 0014

Council Regulation (EC) No 2549/2000 of 17 November 2000 establishing additional technical measures for the recovery of the stock of cod in the Irish Sea (ICES Division VIIa). Official Journal L 292, 21.11.2000 P. 0005 - 0006

Council Regulation (EC) No 300/2001 of 14 February 2001 establishing measures to be applied in 2001 for the recovery of the stock of cod in the Irish Sea (ICES division VIIa). Official Journal L 044, 15.02.2001 P. 0012 - 0014

Council Regulation (EC) No 1456/2001 of 16 July 2001 amending Regulation (EC) No 2549/2000 establishing additional technical measures for the recovery of the stock of cod in the Irish Sea (ICES Division VIIa). Official Journal L 194, 18.07.2001 P. 0001 - 0001

Council Regulation (EC) No 254/2002 of 12 February 2002 establishing measures to be applicable in 2002 for the recovery of the stock of cod in the Irish Sea (ICES division VIIa). Official Journal L 041, 13.02.2002 P. 0001 - 0003

North Sea and West of Scotland cod

Commission Regulation (EC) No 259/2001 of 7 February 2001 establishing measures for the recovery of the stock of cod in the North Sea (ICES subarea IV) and associated conditions for the control of activities of fishing vessels. Official Journal L 039, 09.02.2001 P. 0007 - 0010

Commission Regulation (EC) No 456/2001 of 6 March 2001 establishing measures for the recovery of the stock of cod to the west of Scotland (ICES Division VIa) and associated conditions for the control of activities of fishing vessels. Official Journal L 065, 07.03.2001 P. 0013 - 0016

Commission Regulation (EC) No 714/2001 of 10 April 2001 amending Regulation (EC) No 259/2001 establishing measures for the recovery of the stock of cod in the North Sea (ICES subarea IV) and associated conditions for the control of activities of fishing vessels. Official Journal L 100, 11.04.2001 P. 0005 - 0006

Commission Regulation (EC) No 715/2001 of 10 April 2001 amending Regulation (EC) No 456/2001 establishing measures for the recovery of the stock of cod to the west of Scotland (ICES division

VIa) and associated conditions for the control of activities of fishing vessels. Official Journal L 100, 11.04.2001 P. 0007 - 0008

Commission Regulation (EC) No 2056/2001 of 19 October 2001 establishing additional technical measures for the recovery of the stocks of cod in the North Sea and to the west of Scotland.Official Journal L 277, 20.10.2001 P. 0013 - 0016

Council Regulation (EC) No 1342/2008 of 18 December 2008 establishing a long-term plan for cod stocks and the fisheries exploiting those stocks and repealing Regulation (EC) No 423/2004. Official Journal L 348, 24.12.2008, p. 20–33

Hake

Commission Regulation (EC) No 1162/2001 of 14 June 2001 establishing measures for the recovery of the stock of hake in ICES sub-areas III, IV, V, VI and VII and ICES divisions VIII a, b, d, e and associated conditions for the control of activities of fishing vessels. Official Journal L 159, 15.06.2001 P. 0004 – 0009

Commission Regulation (EC) No 2602/2001 of 27 December 2001 establishing additional technical measures for the recovery of the stock of hake in ICES subareas III, IV, V, VI and VII and ICES Divisions VIIIa, b, d, e. Official Journal L 345, 29.12.2001 P. 0049 - 0051

Commission Regulation (EC) No 494/2002 of 19 March 2002 establishing additional technical measures for the recovery of the stock of hake in ICES sub-areas III, IV, V, VI and VII and ICES divisions VIII a, b, d, e. Official Journal L 077, 20.03.2002 P. 0008 - 0010

Southern Hake and Norway lobster

Council Regulation (EC) No 2166/2005 of 20 December 2005 establishing measures for the recovery of the Southern hake and Norway lobster stocks in the Cantabrian Sea and Western Iberian peninsula and amending Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. *Official Journal L 345, 28.12.2005, p. 5–10*

Baltic Sea Technical Measures

Council Regulation (EC) No 1866/1986 of 12 June 1986 for the conservation of fishery resources through technical measures in the Baltic Sea, the Belts and the Sound. Official Journal L 162 18.06.86.P.1.

Council Regulation (EC) No 88/98 of 18 December 1997 laying down certain technical measures for the conservation of fishery resources in the waters of the Baltic Sea, the Belts and the Sound. Official Journal L 9, 15.1.1998, p. 1–16

Council Regulation (EC) No 1520/98 of 13 July 1998 amending Regulation (EC) No 88/98 laying down certain technical measures for the conservation of fishery resources in the waters of the Baltic Sea, the Belts and the Sound. Official Journal L 201, 17.7.1998, p. 1–3.

Commission Regulation (EC) No 677/2003 of 14 April 2003 establishing emergency measures for the recovery of the cod stock in the Baltic Sea. Official Journal L 097 15.04.2003 p. 31.

Council Regulation (EC) No 289/2005 of 17 February 2005 amending Regulation (EC) No 88/98 as regards the extension of the trawling ban to Polish waters Official Journal L 49, 22.2.2005, p. 1–1

Council Regulation (EC) No 2187/2005 of 21 December 2005 for the conservation of fishery resources through technical measures in the Baltic Sea, the Belts and the Sound, amending Regulation (EC) No 1434/98 and repealing Regulation (EC) No 88/98. Official Journal L349 31.12.2005.P.1.

Commission Regulation (EU) No 686/2010 of 28 July 2010 amending Council Regulation (EC) No 2187/2005 as regards specifications of Bacoma window and T90 trawl in fisheries carried out in the Baltic Sea, the Belts and the Sound. Official Journal L 199, 31.7.2010, p. 4–11

Mediterranean Technical Measures

Council Regulation (EC) No 1626/94 of 27 June 1994 laying down certain technical measures for the conservation of fishery resources in the Mediterranean. Official Journal L. 171 6.07.94. p.1

Council Regulation (EC) No 1075/96 of 10 June 1996 amending Regulation (EC) No 1626/94 laying down certain technical measures for the conservation of fishery resources in the Mediterranean. Official Journal L 142, 15.6.1996, p. 1–2

Council Regulation (EC) No 782/98 of 7 April 1998 amending Regulation (EC) No 1626/94 laying down certain technical measures for the conservation of fishery resources in the Mediterranean .Official Journal L 113, 15.4.1998, p. 6–7

Council Regulation (EC) No 1448/1999 of 24 June 1999 introducing transitional measures for the management of certain Mediterranean fisheries and amending Regulation (EC) No 1626/94. Official Journal L 167, 2.7.1999, p. 7–8

Council Regulation (EC) No 2550/2000 of 17 November 2000 amending Regulation (EC) No 1626/94 laying down certain technical measures for the conservation of marine resources in the Mediterranean. Official Journal L 292, 21.11.2000, p. 7–8

Council Regulation (EC) No 813/2004 of 26.4.2004 amending Regulation (EC) No 1626/94 as regards certain conservation measures relating to waters around Malta. Official Journal L 150, 30.4.2004, p. 32–41

Council Regulation (EC) No 1967/2006 of 21 December 2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea, amending Regulation (EEC) No 2847/93 and repealing Regulation 9EC) No 1626/94. Official Journal L409 30.12.2006 p.11.

Regulation (EU) No 1343/2011 of the European Parliament and of the Council of 13 December 2011 on certain provisions for fishing in the GFCM (General Fisheries Commission for the Mediterranean) Agreement area and amending Council Regulation (EC) No 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. Official Journal L 347, 30.12.2011, p. 44–61

Non-EU waters Technical Measures

Council Regulation (EC) No 973/2001 of 14 May 2001 laying down certain technical measures for the conservation of certain stocks of highly migratory species. Official Journal L.137 19.05.2001.p.3.

Council Regulation (EC) No 600/2004of 22 March 2004 laying down certain technical measures applicable to fishing activities in the area covered by the

Convention on the conservation of Antarctic marine living resources. Official Journal L. 97 1.04.2004.p.1.

Council Regulation (EC) No 831/2004 of 26 April 2004 amending Regulation (EC) No 973/2001 laying down certain technical measures for the conservation of certain stocks of highly migratory species. Official Journal L 127 29.04.2004. p.33.

Council Regulation (EC) No 520/2007 of 7 May 2007 laying down technical measures for the conservation of certain stocks of highly migratory species and repealing Regulation (EC) No 973/2001. Official Journal L 123 12.05.2007 p.3.

Gear Specifications and Operational Measures

Commission Regulation (EEC) No 3440/84 of 6 December 1984 on the attachment of devices to trawls, Danish seines and similar nets. Official Journal L 318, 7.12.1984, p. 23.

Commission Regulation (EEC) No 955/87 of 1April 1987 amending Regulation (EEC) No 3440/84 on the attachment of devices to trawls, Danish seines and similar nets. Official Journal L 90, 1.04.1987, p. 29

Commission Regulation (EEC) No 2122/89 of 14July 1989 amending Regulation (EEC) No 3440/84 on the attachment of devices to trawls, Danish seines and similar nets. Official Journal L 203, 15.07.1989, p. 21

Council Regulation (EC) No 1434/98 of 29 June 1998 specifying conditions under which herring may be landed for industrial purposes other than direct human consumption. Official Journal L 191, 7.7.1998, p. 10–12

Commission Regulation (EC) No 1922/1999 of 8 September 1999 laying down detailed rules for the application of Council Regulation (EC) No 850/98 as regards conditions under which vessels exceeding eight metres length overall shall be permitted to use beam trawls within certain waters of the Community

Commission Regulation (EC) No 129/2003 of 24 January 2003 laying down detailed rules for determining the mesh size and thickness of twine of fishing nets. Official Journal L 022, 25/01/2003 P. 0005 - 0014

Commission Regulation (EC) No 146/2007 of 15 February 2007 amending Regulation (EEC) No 3440/84 as regards conditions for certain trawls for vessels operating pump aboard systems. Official Journal L46 16.02.2007, p.9

Council Regulation (EC) No 809/2007 of 28 June 2007 amending Regulations (EC) No 894/97, (EC) No 812/2004 and (EC) No 2187/2005 as concerns drift nets. Official Journal L 182, 12.7.2007, p. 1–2

Commission Regulation (EC) No 517/2008 of 10 June 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 850/98 as regards the determination of the mesh size and assessing the thickness of twine of fishing nets

Commission Regulation (EU) No 724/2010 of 12 August 2010 laying down detailed rules for the implementation of real-time closures of certain fisheries in the North Sea and Skagerrak.Official Journal L 213, 13.8.2010, p. 1–5

Ecosystem Measures

Council Regulation (EC) No 1185/2003 of 26 June 2003 on the removal of fins of sharks on board vessels. Official Journal L 167, 4.07.2003. p.6

Council Regulation (EC) No 812/2004 of 26 April 2004 laying down measures concerning incidental catches of cetaceans in fisheries and amending Regulation (EC) No 88/98. Official Journal L 150, 30.04.2004. p.12

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Abstract

The Expert Working Group meeting of the Scientific, Technical and Economic Committee for Fisheries EWG 12-14 was held from 1 – 5 October in Dublin, Ireland, to aim to explore the salient issues surrounding technical measures. The report was reviewed by the STECF during its 41st plenary held from 5 to 9 November 2012 in Brussels (Belgium).

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The Scientific, Technical and Economic Committee for Fisheries (STECF) has been established by the European Commission. The STECF is being consulted at regular intervals on matters pertaining to the conservation and management of living aquatic resources, including biological, economic, environmental, social and technical considerations.

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