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Technical Measures part III (STECF-15-05)

Edited by EWG Norman Graham, John Casey & Hendrik Dorner

This report was reviewed by the STECF during its 48th plenary meeting held

from 13 to 17 April 2015 in Brussels

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Contact information
STECF secretariat
Address: Maritime Affairs Unit, Via Enrico Fermi 2749, 21027 Ispra VA, Italy
E-mail: stecf-secretariat@jrc.ec.europa.eu
Tel.: 0039 0332 789343
Fax: 0039 0332 789658

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Abstract

The Expert Working Group meeting of the Scientific, Technical and Economic Committee for Fisheries EWG 13-01 was held from 2 – 6 March 2015 in Dublin, Ireland. The report was reviewed by the STECF during its 48th plenary held from 13 – 17 April 2015 in Brussels (Belgium).

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TECHNICAL MEASURES PART III (STECF-15-05)

THIS REPORT WAS REVIEWED DURING THE PLENARY MEETING HELD IN BRUSSELS, 13-17 APRIL 2015

1.1 Background

The European Commission is carrying out a comprehensive revision of the current technical measures regulations in light of the new CFP which entered into force at the end of 2013. This revision will provide an opportunity to bring about a general improvement in the technical rules to facilitate the implementation of the landing obligation and to further the ecosystem-based approach, which are key objectives in the new CFP.

To support this revision, STECF EWGs 12-14 and 13-01 considered different principles for defining selectivity under the future technical measures regulation. These EWGs have considered the idea of moving from the current prescriptive and detailed technical-measures regulations towards a results-based approach. The results-based approach is considered preferable, because it would reduce the complexity of current technical measures legislation. It would harness the industry's potential for innovation to develop technology supporting the achievement of agreed aims. It is also in line with the principle of management by result included in the new CFP. The EU legislator fixes objectives, targets and standards, and Member States cooperate regionally with input from all stakeholders to design the best suited tools to achieve these objectives and targets.

Direct implementation of the results-based approach is impossible in the current technical measures regulations due to the absence of more precise objectives and targets of conservation to which the technical measures and means need to contribute. This introduces the need to move to the identification of appropriate metrics if a results-based approach is to be adopted. These by definition, need to be measurable and easy to comply with.

EWGs 12-14 and 13-01 considered several alternatives for a result-based approach: the concepts of catch metrics and of selectivity profiles (there may well be other approaches that could be used). These approaches have been further considered during the November plenary meeting of STECF (STECF 14-03) where some general principles and methodology for establishing such catch metrics or selectivity standards were established.

1.2 Request to the STECF

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

1.3 Observations of the STECF

Result based management (RBM) is considered by the EWG to be a better management system than the current situation by focusing on the outcome instead of defining technical means to achieve it. A catch based approach negates the need for detailed gear prescriptions in TCM Regulations. EWG 15-01 reviewed what catch-based metrics could be used when moving from current TCM to RBM in order to evaluate the efficacy of "technical and/or tactical measures".

EWG 15-01 identifies two catch metrics categories (i) population dependent metrics (catch and CPUE @ age) which could provide comparisons between fleets but can not be used to assess trends in selectivity improvements over time and (ii) population independent (partial F/catchability) metrics which allow comparisons between metiers and between years. EWG 15-01 studied two examples of the use of those catch metrics and their variability. A comparison of the variability across both population dependent metrics and population independent metrics shows that in one example provided (Celtic Sea haddock) both partial F and catchability indicators are more stable than population dependent metrics while in the other example (North Sea plaice) shows a low variability between metrics. Further stock-specific analysis is needed to assess the variability between metrics and determine the ability to detect changes in selectivity between and within fleets.

The landing obligation, when fully implemented is expected to provide incentives to fishermen to use technical and tactical approaches that will minimise the catches of unwanted fish. The period from the current situation to the full implementation of the landing obligation is called the "transitional period". Until the landing obligation has been fully implemented EWG 15-01 considers that some level of minimum selectivity standards should be used as "backstop measures" to ensure that no move toward less selective gears appear.

EWG identified the main elements affecting gear selectivity and considers the backstop measures should take into account only those factors. The main elements to be considered are cod-end and panel mesh size, twine thickness, panel position, cod-end circumference and lifting bag.

The expert group proposed 4 options to define those backstop measures. Option 1 would oblige individual fishermen to use mesh sizes that they have previously used based on their historic track records. Option 2 is linked with current gear and mesh sizes band effort levels, switching between mesh bands is permitted provided effort within bands remains constant. Option 3 link gears and mesh sizes to fishing opportunities; with more selective gear there individuals could have fishing opportunities for more species than with a less selective gear. Option 4 link gears and mesh sizes with spatial considerations; based on historic records with a specific gear category fishermen could have access to certain defined geographical areas. Each of those options has advantages and disadvantages which are precisely described in the report. EWG 15-01 considers that these 4 options could be used as a toolbox by the Commission to define the required backstop measures depending on the different fisheries characteristics.

Finally EWG-15-01 considered what MCRS should be based on. The report presents for main species a comparison between the current MLS, the length at 50% maturity and the selectivity of towed gears. The analysis shows that although the MLS matches closely with the mean length at maturity in most cases the towed gears studied catch substantial numbers of fish below the MLS. In addition the EWG notes that reducing MLS would lead to higher catches of juvenile fish. A clear conclusion is that MCRS should be based on biological species characteristics and not on current selectivity profiles.

STECF notes that the analysis of selectivity, minimum landing size, length at 50% maturation and optimal maturation length were focussed solely on demersal towed gears (OTB). STECF considers that a further analysis focussing the selectivity of static gears would be informative.

STECF notes that the basis for gear related technical measures for size selection in pelagic fisheries appears weak due to apparent high rates of post escape mortality. STECF considers that in light of this observation, that a more detailed review of the role of technical measures in pelagic fisheries be considered.

1.4 Conclusions of the STECF

STECF concludes that the EWG 15-01 has appropriately addressed the TORs. STECF furthermore concludes that the report of the EWG 15-01 should form a basis for the Commission to proceed with the development for a proposal for a new regulation on technical measures and considers that the aim to avoid any decrease in fishing gear selectivity should be given high priority in order that the aim of achieving CFP objectives is enhanced.

STECF concludes that to reduce the risk of gears in use being less selective, rather than more selective following the neutralisation of the catch composition rules, regulators could consider adopting specified measures to prevent loss of selectivity of gear in use.

REPORT TO THE STECF

EXPERT WORKING GROUP ON Technical Measures part III (EWG-15-01)

Dublin, Ireland, 2-6 March 2015

1 EXECUTIVE SUMMARY

The European Commission (EU) is currently reviewing the technical conservation measures (TCMs) Regulations. Two previous STECF Expert Groups (EWG 12-14 and 13-01) were established to help with this review. These EWG's identified that the these regulations are characterised by being overly detailed and complex and the current legislative approach is overly focused on specifying the technical characteristics of fishing gear construction, generally relating to cod-end design that are permissible under Union law. EWG 12-14 noted that under current legislation, there are no clear objectives other than "*for the protection of juveniles*". In effect, the current approach uses TCMs as a proxy to obtain an undefined outcome. This has a number of disadvantages and has resulted in a business focus on mitigating the impact of technical gear regulations due to economic concerns. This has incentivised a legislative and technical "arms race" leading to an exponential growth in TCM regulations over the past decades.

EWG 13-01 considered that focusing on a specified outcome (i.e. a desired and measureable catch profile), would offer a number of key advantages over the current approach. Such c*atch based metrics* could potentially mean considerable simplification of the existing regulatory framework requiring only the specification of a desired profile. This would allow the fishing sector to develop solutions that could be tailored and optimised to the requirements and needs of individual business. It would have the added advantage of harnessing the technical ingenuity of fishermen to reduce unwanted catch. Deciding upon appropriate *catch metrics* as an indicator or measure of performance is problematic. The simplest approach could be to set thresholds that specify the maximum percentage of a catch (e.g. below Minimum Conservation Reference Size (MCRS)) that would be permissible. This approach is typically used in the Norwegian discard ban to initiate temporary closed areas and "moving on" provisions. However, it does not necessarily offer a metric that could be related directly to the selectivity characteristics of the gears as catch profiles are heavily influenced by the size structure of the fish populations being exploited.

STECF (PLEN 14-03) provided some further options and considerations that could be applied to a *catch metric* based approach. This focused on splitting TAC/quotas into fishing opportunities for fish above a particular length/age while setting a ceiling on the outtake of fish below - in essence a "big fish" and a "small fish" quota. EWG 15-01 was asked to consider this and other similar approaches. The EWG concluded that once implemented, the landing obligation would present a strong incentive to minimise catches of fish below MCRS as these would need to be deducted from the quota available to individual fishing business. Both catch based approaches would be capable of achieving similar outcomes in terms of presenting a means to cap fishing mortality while offering a disincentive to catch specific age or length groups.

EWG 15-01 considered that in the context of a more results based approach to technical measures, it would be necessary to have appropriate metrics that could be used to assess the relative contributions individual fleets make to the catches of juvenile (or other age groups where appropriate) and also to assess how age specific contributions may change over time within a fleet e.g. through the deployment of technical or tactical measures to avoid specific age groups e.g. fish <MCRS. These metrics could then be used as a tool to identify and enable adjustments to catch profiles that may be warranted (i.e. identify fleets that are considered to have undesirable levels of age specific catches). Population independent metrics (Catch and CPUE at age) can enable a direct comparison between fleets, but it is not

possible to disentangle whether inter-annual changes in catch or CPUE at age are a consequence of changes in population e.g. weak recruitment or due to changes in technical or tactical strategies of the fleet. Population independent metrics (partial fishing mortality and catchability at age) may provide a more robust means of comparing changes in exploitation pattern both between and within fleets over time as they are less susceptible to changes in the underlying population and could therefore be used by managers to assess the efficacy of technical and/or tactical measures aimed at avoiding certain age groups e.g. juveniles.

EWG 15-01 has provided a comparison of the variability (CV) across both population dependent (catch and CPUE) and population independent (partial fishing mortality and catchability) which shows that in the case of Celtic Sea haddock, both partial fishing mortality and catchability indicators are more stable in comparison to either of the fishery dependent indicators (catch and CPUE). An alternative example of North Sea plaice shows much lower variability between metrics. Further stock specific analysis is required to assess variability between metrics and therefore determine ability to detect changes in selectivity between and within fleets. It is important to note that both of the population independent metrics require quantification of the stock biomass which means that there would typically be a two year time lag between the analysis and the fishing year as this would require full analytical assessments. The population dependent indicators of catch and CPUE could be collated within a much shorter time frame, but still require age based sampling of catch. The precision of all of the metrics is predicated on reliable catch at age data.

While EWG 15-01 consider that the use of outcome based setting of management measures through results based management (RBM) provides many benefits in comparison to the existing prescriptive based approach (e.g. less complex legislation; harnessing the skills of fishermen to develop solutions suiting their business models), the success of such an approach is heavily predicated on compliance with catch documentation requirements. The application of a full RBM approach requires full confidence in the ability of management systems to adequately quantify catch. Until the Landing Obligation has been fully implemented it will not be possible to judge the success of accurate catch reporting. As a consequence, EWG 15-01 considers that some level of minimum selectivity standards will be required as "backstop" measures to ensure that a move towards using less selective gears does not occur. There is a need for some measures to ensure adequate protection for juveniles and allow for their subsequent contribution to spawning.

EWG 15-01 also assessed and identified the key cod-end design features that have been shown to have a significant influence on selectivity. These are mesh size; twine thickness/stiffness; presence or absence of lifting/strengthening bags; cod-end circumference; position and mesh size of square mesh/escape panels. EWG 15-01 consider that in order to maintain a minimum level of selectivity in demersal trawl fisheries then these factors will need to be considered in a legislative context.

While EWG 15-01 considers it appropriate to maintain a legal minimum level of selectivity (implemented though TCMs), the basis for defining this has been further complicated by the introduction of the Landing Obligation. Certain provisions of the previous technical measures run contrary to the landing obligation. This includes catch composition rules which previously obliged fishermen to discard any fish caught in excess of predefined percentages. This has necessitated the neutralisation of the catch composition rules as a consequence of the landing obligation on the basis of a Commission proposal (the so-called "omnibus" regulation). However, this impacts on other technical measures. The catch composition rules are inextricably linked with mesh size regulations in that the minimum mesh size an individual fishing business may use is defined by the composition of the retained catch. The removal of the catch composition rules necessitates the use of alternative means for defining TCMs to attain minimum selectivity standards. EWG 15-01 identified four possible approaches to doing this, each having different advantages and disadvantages.

Option 1 would oblige individual businesses to use mesh sizes based on their historic track record. This would maintain the current status quo but would represent a significant limitation on future flexibility. For example, if a business had previously used a larger mesh size (e.g. >100mm) to target cod and haddock and wished in future to switch to the targeting of *Nephrops* using a smaller mesh size (e.g. 80mm), then this would not be permissible unless gear modifications were introduced that gave a similar or better selectivity than that of the larger mesh size. Additionally, this would also represent a significant administrative overhead through the need for individual authorisations. Where changes in gear (e.g. reductions in mesh size) were sought; there would be a significant burden in the provision of the necessary evidence to demonstrate equivalence in selectivity.

Furthermore, in the case of demonstrating equivalence it would be necessary to select the species which would be used for such demonstration. In practice this may be difficult, given that modifications aimed at improved selectivity in smaller mesh fisheries (e.g. *Nephrops*) have species specific efficiencies (e.g. square mesh panels may be useful in improving selectivity for haddock and whiting, but have limited effectiveness for cod).

Under option 2, to provide more flexibility, current gear and mesh band effort levels (e.g. TR1, BT2 etc. as defined in the cod plan) would be capped. In essence this would result in a similar approach to option 1 above, but switching between effort groups could be permitted either through penalties where business wish to switch between a “high” selectivity group (e.g. TR1) to a “lower” selectivity group (e.g. TR2). The penalties could be calculated on the ratio of old/new selectivity. Similar equivalence rules could also be applied as under option 1. This approach would also represent similar issues in terms of administrative burden and choice of demonstration species as noted above.

The third option is to link mesh size to fishing opportunities. Under this approach, business will only be permitted to sell a range of predefined specific species, the scope of which would depend on the mesh size or selectivity characteristics of the gear used. The principle being that the greater the selectivity, the broader the range of species that can be sold. For example, if a business uses a mesh size >=120mm, then it would be permitted to sell catches of all species. If however, a business opts to use a smaller mesh size (e.g. 80mm to target *Nephrops)* then it would only be permitted to sell a much narrower range of species unless equivalence in selectivity can be demonstrated (i.e. modifications would be required that give a selectivity profile equivalent to the higher mesh sizes) where the species in question may be sold. The rationale behind the proposed measures is to encourage fishers to adapt their fishing tactics so that they can take advantage of all of their fishing opportunities and at the same time, avoid unwanted catches.

There is a danger that in the transitional period leading up to full implementation of the landing obligation, skippers may choose to use a gear category that is not appropriate for all of their fishing opportunities. Such a decision may result in increased discarding of fish that cannot legitimately be sold if caught using the gear category deployed. This will particularly be true if fishermen are unable to devise and implement technical or tactical adaptations that can deliver equivalent selectivity.

Option 4 would see minimum mesh sizes based on spatial considerations. Analysis of current spatial distribution of gear and mesh size shows in most areas that the current mesh size and catch composition rules have led to the deployment of mesh sizes that are spatially explicit. For example large mesh (120mm) is used in areas in the Northern North Sea and West of Scotland to target gadoids. It may therefore be possible to apply the current mesh sizes based on specific areas. Such an approach could be further refined where there is a strong linkage between species and well defined habitat (e.g. *Nephrops*), where it could therefore be possible to specify mesh sizes based on the species distribution.

This approach has the benefit of being closely aligned with existing practices and therefore minimising the impact on existing business. However, in areas where there is no clear spatial (or temporal) delineation between species such an approach may not be appropriate without additional measures otherwise mesh sizes would need to be set in line with the current lowest selectivity (e.g. *Nephrops*). This could result in a deterioration in selectivity overall, otherwise larger mesh size would be required which would result in loses of yield.

All of the approaches identified above would only be successful if there was a high degree of compliance and trust in catch documentation and reporting. Using a split TAC/quota approach would require that fisheries would cease operation as soon as one of the components (marketable or sub-legal) was exhausted. While this should not present any problems when the marketable component was exhausted first, an incentive to underreport the sub-legal component would exist provided there was still marketable quota remaining. Similarly, using population dependent and independent methods to assess whether the catch profile of a specific metier or fleet is desirable relative to an objective target also would also be dependent on robust catch at age data being available.

EWG 15-01 elaborated on previous work exploring the role of selectivity and its role in sustainability. The EWG explored the relationship between species-specific minimum size and 50% length-at-first maturity and optimal length. Setting selectivity so that it is at least equivalent to the length at 50% maturity would ensure that the dangers of both growth and recruitment overfishing are lessened. Fish would fulfil more of their growth potential and more fish are allowed to spawn at least once or ideally at a length where the yield is maximised. Currently, minimum landing sizes are typically lower than the length of 50% maturity and the selectivity (L50) of many demersal gears, particularly where mesh sizes are less than 100mm. Theoretically, it should therefore be possible to better harmonise Minimum Conservation Reference Sizes (MCRS) with the length of 50% maturity (or optimal length) and where necessary, improve selectivity so that it is better aligned with a MCRS based on biological characteristics. While this may indeed be possible for single species single gear fisheries, in complex multi-species/multi-gear fisheries such an approach may more challenging as it may be technically complex to develop gears that can select several species in line with their biological targets.

EWG 15-01 considers that when deciding on MCRS and gear selectivity options, priority should be given where possible to aligning MCRS with the species biological characteristics rather than with current selectivity, particularly in settings where the current ratio between selectivity and maturity is shown to be sub-optimal. Such an approach would be consistent with the objective of the protection of juveniles.

2 INTRODUCTION

The European Commission is carrying out a comprehensive revision of the current technical measures regulations in light of the new CFP which entered into force at the end of 2013. This revision will provide an opportunity to bring about a general improvement in the technical rules to facilitate the implementation of the landing obligation and to further the ecosystem-based approach, which are key objectives in the new CFP.

To support this revision, STECF EWGs 12-14 and 13-01 considered different principles for defining selectivity under the future technical measures regulation. These EWGs have considered the idea of moving from the current prescriptive and detailed technical-measures regulations towards a results-based approach. The results-based approach is considered preferable, because it would reduce the complexity of current technical measures legislation. It would harness the industry's potential for innovation to develop technology supporting the achievement of agreed aims. It is also in line with the principle of management by result included in the new CFP. The EU legislator fixes objectives, targets and standards, and Member States cooperate regionally with input from all stakeholders to design the best suited tools to achieve these objectives and targets.

EWGs 12-14 and 13-01 considered several alternatives for a result-based approach: the concepts of catch metrics and of selectivity profiles (there may well be other approaches that could be used). These approaches have been further considered during the November plenary meeting of STECF (STECF 14-03) where some general principles and methodology for establishing such catch metrics or selectivity standards were established.

2.1 Terms of Reference for EWG-15-01

In order to further developed catch metrics and selectivity profiles, STECF EWG 15-10 was established to define "example" catch metrics and selectivity standards for the main towed gear fisheries (principally demersal fisheries) in North Western, South Western and the North Sea (including the Skagerrak and Kattegat). These should be based as far as practicably possible on current exploitation patterns and available catch data. The EWG was requested to take account of the findings from STECF 14-01 as well as the recent discussion document issued by the Commission in October 2014 on this particular issue.

3 SELECTIVITY ISSUES IN THE CONTEXT OF THE CFP

The discussion document produced by the Commission outlined that the new, co-decided technical measures framework regulation will presumably contain a section with a limited number of general rules applicable to all operators and administrations (general prohibition to fish with explosives, for example). This would be complemented by a section with the results-based management logic of the new CFP: objectives and general standards would be set for technical measures, instead of detailed and prescriptive top-down rules set by Parliament and Council. The measures in a fishery/area to meet the objectives and standards would be identified under regionalisation (Member States in consultation with stakeholders).

In this modality, objectives are expressed through baselines. Direct implementation of the results-based approach is impossible in the current technical measures regulations due to the absence of more precise objectives and targets of conservation to which the technical measures and means need to contribute.

This introduces the need to move to the identification of appropriate metrics. These metrics are linked to the baselines and will have to ensure that they meet the policy objectives (i.e. achievement of MSY, stock composition criteria, avoidance/reduction of unwanted catches, ecosystem-related targets). The metrics, by definition, need to be measurable and compliable.

3.1 Catch based metrics

EWG 13-01 considered that focusing on a specified outcome (i.e. a desired and measureable catch profile), would offer a number of key advantages over the current approach. Such catch based metrics could potentially mean considerable simplification of the existing regulatory framework requiring only the specification of a desired profile which would allow the fishing sector to develop solutions that could be tailored and optimised to the requirements and needs of individual business. This would have the added advantage of harnessing the technical ingenuity of fishermen to reduce unwanted catch.

Deciding upon appropriate catch metrics as an indicator or measure of performance is problematic. The simplest approach could be to set thresholds that specify the maximum percentage of a catch (e.g. below Minimum Conservation Reference Size (MCRS)) that would be permissible. This approach is typically used to initiate temporary closed areas and "moving on" provisions under the Norwegian discard ban, but does not necessarily offer a metric that could be related directly to the selectivity characteristics of the gears as catch profiles are heavily influenced by the size structure of the fish populations being exploited.

STECF (PLEN 14-03) provided some further options and considerations that could be applied to this approach. This focused on splitting TAC/quotas into fishing opportunities for fish above a particular length/age while setting a ceiling on the outtake of fish below - in essence a "big fish" and a "small fish" quota.

EWG 15-01 was asked to consider this and other similar approaches. The EWG concluded that once implemented, the landing obligation would present a strong incentive to minimise catches of fish below MCRS as these would need to be deducted from the available quota. Both catch based approaches would be capable of achieving similar outcomes in terms of presenting a means to cap fishing mortality while offering a disincentive to catch specific age or length groups.

3.2 Factors affecting cod-end selectivity

EWG 13-01 identified that there has been an exponential growth in Technical Conservation Measures (TCM's) over the past decades. This growth in regulations has been precipitated by responses by the industry to negate the impact of previous measures such as increases in mesh size. For example, the use of stiffer twines used in the construction of cod-ends to inhibit mesh opening to reduce fish escapement (lower L50 for a given mesh size) Lowry and Robinson, 1996) has resulted in regulations limiting twine thickness as a proxy for twine stiffness. Additionally, TCM's have been introduced in response to species specific conservation objectives (e.g. cod recovery plans). Several of the current regulations introduced in this context have little or no clear scientific basis and/or are difficult to monitor and control. In the context of any future revisions of TCM's an assessment of the necessity and utility of some elements of the current suite of measures is required. To assist with such a process, Table 3-1 summarises the scientific basis for the key measures that affect selectivity, over and above cod-end mesh size, contained in the current TCM's in the North East Atlantic, Baltic and Mediterranean.

Table 3-1 A summary of current gear specifications and an assessment of their scientific basis in various technical conservation regulations.

Key to acronyms:

- CC, CE: codend and extension circumference;
- SM, DM, QM: square-, quadrilateral- and diamond-mesh;
- SMP: square-mesh panel;
- TTS, TTD, TTM: single-, double- and multiple-twine thickness;
- CL, EL: codend length and extension length;
- BCP, BEP: bottom codend panel and bottoem extension panel;
- TCP, TEP: top codend and extension panel;
- CMS: mesh size;

Regulation	Area	Article	Gear specification other than mesh size	Scientific basis
850/98	All EU-area except Baltic and Mediterranean	6	For CMS 90-119 mm: CC ≤ 100 meshes CC must non increase	CC has documented effect on selectivity Ballooning effect - unclear basis
		7	SMP position SMP size SMP material	SMP position and size have documented effect on selectivity SMP material - unclear basis
		8	TTS ≤ 8 mm TTM sum ≤ 12 mm	TT has documented effect on selectivity
		9	SM or DM only	unclear basis

		Annex XIVa	*Nephrops* grid specifications: CC ≤ 100 meshes bar spacing ≤ 35 mm guiding funnel	CC and bar spacing - affects selectivity guiding funnel - unclear basis
3440/84		4-15	Specifications for: Bottom-side chafer Top-side chafer Strengthening bag and rope Chafing or protection piece Lifting and round straps Codline Flapper Sieve netting Torquette	Generally, these gear attachments are used to protect the cod-end but may affect selective properties to some extent Strengthening bags have documented effect on selectivity Specs for codline and torquette have unclear basis
2056/2001	IV, VI, IIa and Vb	5	QM prohibited CL+EL ≤ 36 m Symmetrical BCP-BEP & TCP-TEP SMP manufactured by one netting material Codend sewn to the extension TTS ≤ 8 mm TTD ≤ 5 mm For CMS 70-89 mm: CC ≤ 120 meshes For CMS 90+ mm: CC ≤ 100 meshes	TT and CC have documented effect on selectivity All other specs have an unclear basis

2187/2005	Baltic	5	<u>Specifications for</u>: Only a bottom-side chafer is permitted A catch sensor is permitted Strengthening bag and rope Lifting and round straps Flapper Floats attached to the codend	Strengthening bag has documented effect on selectivity Some of these gear attachments are used to protect the cod-end but may affect selective properties to some extent Specs for catch sensors and floats have unclear basis
		6	CC must non increase Not(SM or DM) only for CMS ≤ 32 mm Codend sewn to the extension For CMS 90+ mm: 40 ≤ CC ≤ 100 meshes Symmetrical BCP and TCP	CC has documented effect on selectivity The other specs have unclear basis
		Appendix 1	Specifications for BACOMA…	Panel mesh size and position have documented effect on selectivity The other specs have unclear basis
		Appendix 2	Specifications for T90…	Mesh size, mesh direction, TT and CC have documented effect on selectivity
1967/2006	Mediterranean	Annex 1	CC must non increase For DM: CE ≥ CC For SM: 2*CC ≤ CE ≤ 4*CC Not(SM or DM) prohibited Strengthening bag, lacing rope specs Codend: TTS only and ≤ 3 mm Not(Codend): TTS only and ≤ 6 mm	- For DM, CC+20%: -(10-40)% For SM: -20% but not consistent - - TTS+1: -(20-30)% -

EWG 15-01 consider that the core design elements that affect cod-end selectivity are mesh size; twine thickness/stiffness; presence or absence of lifting/strengthening bags; cod-end circumference; position and mesh size of square mesh/escape panels. EWG 15-01 consider that in order to maintain a minimum level of selectivity in demersal trawl fisheries then these factors will need to be considered in a legislative context. As noted in Table 3-1, several design elements (e.g. netting material used for the construction of square mesh panels, length of extension piece etc) have little or no scientific basis. In the context of simplifying any future TCM regulations, managers may wish to consider the necessity of such rules. It is important to note that EWG 15-01 has focussed exclusively on selectivity/TCMs relating to towed demersal gears. A further analysis of TCMs relating to fixed and static gears may be required to identify the key aspects of gear related TCMs that have the greatest influence on selectivity. .

The effectiveness of TCMs management tools aimed at regulating or contributing to overall exploitation pattern is predicated that escaping fish survive the process. If escape survival is shown to be low, then the efficacy of TCMs is limited as a management tool and could present a significant source of unaccounted mortality. Several studies have shown that escape mortality for demersal species is relatively low e.g. <10% for haddock and whiting (Ref SURVIVAL). It is noted that the there is a general paucity in the available information. However, studies conducted on small pelagic species have shown low levels of escape survival. Suuronen *et al* (1993) observed that the survival rate of Baltic herring escaping from the codend has been estimated at 10- 15%, and that of fish escaping through a sorting grid at 15-25% (Suuronen et al., 1993) EWG 15-01 consider that the use of gear based technical measures for the size selection of small pelagic species are unlikely to offer an effective means of adjusting the exploitation pattern. This is on the basis that there is some doubt whether many of the fish escaping from trawls through selectivity devices survive. Therefore, the use of size selective gears may simply transfer fishing mortality from the discard fraction to the escapee fraction.

3.3 Minimum mesh sizes and catch composition rules

In order to make the landing obligation operational it has been identified by the Commission, Member States and stakeholders that certain provisions within the current regulations that run contrary to the landing obligation and oblige fishermen to discard fish must be removed or amended. This technical adjustment will be achieved through a current Commission proposal (COM (889) final) which is currently under negotiation. This proposal (the so-called "omnibus") aims to amend a number of regulations by requiring all unintended catches (defined as incidental catches the fishing for which is prohibited in the relevant conditions) subject to the landing obligation caught in excess of legal provisions (catch composition rules, bycatch provisions) should be landed and counted against quota. It also requires the definition of minimum conservation reference sizes (MCRS) to replace the current minimum landing sizes. This is a change in name only and the sizes remain as they are currently. All catches below the MCRS subject to the landing obligation must be landed and counted against quota.

The changes made through the omnibus regulation effectively neutralise the catch composition rules contained in the technical measures regulations and link this to the concept of unintended catches. Unintended catches of species subject to the landing obligation are defined as catches in excess of catch composition rules limits or catches of species below minimum conservation reference sizes.

While the neutralisation of the catch composition rules is a necessary consequence of the introduction of the landing obligation, it does impact on other technical measures. The catch composition rules are inextricably linked with mesh size regulations in that the minimum mesh size an individual fishing business may use is defined by the composition of the retained catch. For example, if a fishing vessel has greater than 30% *Nephrops* retained on board then the business is able to use a mesh size of 80mm. If however, the *Nephrops* catch retained on board is expected to be less than 30% then the business would be obliged to use a larger mesh size e.g. 120mm.

If catch composition rules are no longer applicable, then in the scenario identified above, it would be technically legal to target any species assemblage with the lower mesh size. This could lead to a general deterioration in selectivity in the absence of any other means of setting minimum mesh size. The Commission sees this as only a temporary solution to remove any legal contradictions.

Acknowledging this, EWG 15-01 note that, if effectively implemented, the landing obligation will minimise the need for prescriptive legislation governing gear construction (STECF PLEN 14-03) as fishermen will tend to introduce technical and/or tactical measures to minimise the capture of fish below MCRS in order to maximise the economic value of their fishing opportunities. EWG 15-01 considers that until such time as the landing obligation becomes fully operational and there is evidence that demonstrates adequate compliance with catch documentation then there remains a need to prescribe minimum selectivity standards. These should be in line with the current mesh sizes and exploitation patterns and aim to avoid, at the very least, a potential deterioration in current selectivity characteristics.

3.4 Alternative means for the setting of minimum mesh size

EWG 15-01 has explored a number of alternative approaches and has identified the following broad alternatives for specifying the minimum mesh sizes that could be used as a replacement for the current mesh size and catch composition rules. These should be seen in the context of managing the transition towards full implementation of the landing obligation.

3.4.1 Constrain vessels to the gear categories they have used in the recent past

If the overarching objective is to maintain exploitation at current levels, obliging fishermen to use the same mesh size as they have used in the recent past would at least maintain the current status quo. This could be further linked to fully documented catch programmes, where fishing business could opt to freely change gear configurations on the basis that their catch is fully-documented. This would incentivise tactics to avoid the capture of fish below minimum size as this would be removed from the fishing quota available to the individual fishing business (Ulrich *et al*, 2015).

While this approach may be attractive in principle, there are a number of disadvantages. Such an approach would require a vessel-by-vessel analysis to determine the mesh size currently used. It would also require the issuing of individual prior authorisations which would specify the minimum mesh size that an operator could use. In practice this would present a significant administrative overhead. Secondly, unless businesses opt to enter a fully documented fishery scheme or they can demonstrate that any alternative gear has a selectivity pattern that is at least as good as their previous gear then they would effectively be “pigeon holed” based on historic track record. This would be a considerable constraint on business flexibility.

3.4.2 Cap effort within existing gear groups

Under the cod recovery plan (Regulation (EU) 1342/2008), effort caps have been implemented for individual gear and mesh categories (e.g. TR1 [Bottom trawls and Seines mesh size $\geq 100mm$]; TR2 [Bottom trawls and Seines $\geq 70mm < 100mm$]; BT1 [Beam Trawls $\geq 120mm$]). It would be possible to maintain these effort caps and prevent effort transfers between fleets with a higher selectivity to ones with lower selectivity (e.g. from TR1 to TR2) thereby maintaining the status quo. Transfers could be permitted by the application of a penalty function for transfer from a higher selectivity to a lower selectivity group similar to the current transfer rules allowed for under the cod plan or where selectivity equivalence can be demonstrated. This pre-supposes that the effort regime under the cod plan will be maintained at least until full implementation of the landing obligation in 2019.

3.4.3 Linking mesh size to fishing opportunities

To provide an incentive to encourage fishermen to adapt their fishing behaviour to available fishing opportunities ahead of full implementation of the landing obligation, the EWG suggests fishing opportunities for different species could be linked with the gear categories that deliver the most appropriate selectivity for the species concerned.

Full implementation of the landing obligation will require that fishermen adjust their fishing tactics to avoid catches of species for which they have no fishing opportunity or catches of individuals below minimum conservation reference size. Adjustment of tactics could be achieved by using more selective gears or through other avoidance tactics. During the transitional period to full implementation of the landing obligation, linking fishing opportunities to different gear categories would provide fishermen with a transitional period to adjust their fishing tactics to avoid unwanted catches. EWG 15-01 considers this approach potentially provides a disincentive to using less selective gears.

The principle:

Fishermen wishing to take advantage of their fishing opportunities would be required to use a prescribed category of fishing gear. The rationale being that the gears used to exploit species that attain a relatively large size (e.g. cod), should be more selective for large fish than gears used to exploit species that attain a smaller size (e.g. *Nephrop*s). For example to exploit cod would require vessels to use a gear that is selective for large fish rather than a gear required to exploit whiting.

The general principle is illustrated below in relation to demersal towed gears and TAC species in the North Sea. The example provided is illustrative rather than definitive. Analogous gear category/TAC species combinations could be derived for other sea areas.

Example of potential basic technical conservation regulation framework for demersal towed gears in the North Sea

The approach is summarised in Figure 3-1 and the list of alternative gear categories described in Figure 3-2. These are best on the current regulations and gears commonly used in the North Sea.

If fishermen use demersal towed gears and have fishing opportunities for cod and wish to sell catches of cod for human consumption, then they would be required to use the gear category DTG1.

Fishermen choosing to use a demersal towed gear other than DTG1 and wishing to take advantage of their fishing opportunity for cod and sell their catch would have to modify their gear or adjust their fishing tactics to achieve the equivalent or better selectivity for cod as that achieved by gear category DTG1.

If a vessel using gear category DTG3 wishes to sell its catches of hake, it will be a requirement to demonstrate that the selectivity of the DTG3 gear for hake is equivalent to that of gear category DTG2. Similarly, if a vessel using gear category DTG3 wishes to sell its catches of haddock, it will be a requirement to demonstrate that the selectivity of the DTG3 gear for haddock is equivalent to that of gear category DTG1.

Figure 3-1 North Sea – Demersal towed gear categories and associated catches of TAC species that may not be sold for human consumption.

Gear Category+	Minimum mesh size ranges	Restricted TAC species *
DTG1	>=120 mm	None
DTG2	100 mm- 119 mm	cod, saithe, haddock, anglerfish (*Lophius spp.*), Pollack, skates and rays (*Rajidae*),
DTG3	80 mm – 99 mm	As category DTG2 plus hake
DTG4	32 mm – 79 mm	As category DTG3 plus whiting, *Nephrops*, all flatfish *spp.*
DTG5	17 mm – 31 mm	As category DTG4 plus *Pandalus*
DTG6	<=16 mm	As category DTG5 plus all other TAC *spp.* except sandeel

*+ Gear categories are described in Table ****

**The species listed are those that may not be sold for human consumption if caught by the associated gear category. However, such catches may be sold for human consumption provided that the business has a fishing opportunity for those species and the selectivity of the gear category in use can be shown to be equivalent to or better than the gear category for which the species in question can be landed for sale. For example, if a vessel using gear category DTG3 wishes to sell its catches of haddock, it will be a requirement to demonstrate that the selectivity of the DTG3 gear for haddock is equivalent to that of DTG1.*

Figure 3-2. Gear category definitions:

Gear Category	Codend mesh size (diamond, knot to knot)	Maximum No. meshes round	Maximum twine thickness	Lifting bag
DTG1	>=120 mm	100	5 mm double (8 mm single)	Mesh size at least 2 x codend mesh size
DTG2	100 mm – 119 mm	100	5 mm double (8 mm single)	Mesh size at least 2 x codend mesh size
DTG3	80 mm – 99 mm	100	5 mm double (8 mm single)	Mesh size at least 2 x codend mesh size
DTG4	32 mm – 79 mm	NS	NS	NS

DTG5	17 mm – 31 mm	NS	NS	NS
DTG6	<= 16 mm	NS	NS	NS

NS = not specified

Demonstrating equivalent selectivity between gears

This approach could include flexibilities that permit Member States to use alternative gear designs provided they can demonstrate that the alternate gear has at least equivalent selectivity to the specific gear category. Using DTG1 as an example, Member States could opt to use combinations of smaller cod-end mesh sizes (less than 120mm) coupled with for example square mesh panels provided that the selectivity characteristics are the same as would be obtained with a 120mm cod-end. This is similar in principle to the flexibilities provided for in the Long Term Management Plan for cod (EC Reg 1380/2008) where Member States can opt to use any modification provided that it maintains cod catches <1.5% of the overall catch.

Noting that there are a number of potential methods that could be adopted to demonstrate equivalent selectivity, Member States would be free to choose their preferred method such as catch comparison or selectivity experiments, the results of which could be evaluated by an appropriate scientific body. As with the provisions of 1380/2008, this would place the burden of proof on Member States to demonstrate equivalence.

Pros and cons of the proposal

The EWG notes that the proposed framework is simple in concept and provides fishermen with a transitional period to adapt to the practical demands that implementation of the landing obligation will bring.

From a control perspective the gear specifications for each gear category are easy to check and are measurable but to be effectively enforced would require that vessels are subject to a one-net rule. The means to demonstrate equivalent selectivity for all species between gear types may be more problematic and technically challenging particularly in multi-species fisheries as unlike the provisions of 1380/2008, where the focus is one species, the approach identified here would require selectivity equivalence for all species. Using GTR1 as an example, Member States/fishermen may wish to use a smaller (<120mm) cod-end to permit the sale of both *Nephrops*, haddock and cod. Under this scenario the introduction of a square mesh panel may provide an appropriate alternative that would give equivalence for haddock, but given that square mesh panels (unless situated close to or in the cod-end) are less effective for cod, this option may not provide equivalence for both haddock and cod as such, further modifications may be required to obtain cod equivalent selectivity which may result in substantive losses (>MCRS) of other species.

The rationale behind the proposed measures is to encourage fishermen to adapt their fishing tactics so that they can take advantage of all of their fishing opportunities. At the same time, it provides an incentive to avoid unwanted catches. However, there is a danger that in the transitional period leading up to full implementation of the landing obligation, skippers may choose to use a gear category that is not appropriate for all of their fishing opportunities. Such a decision may result in increased discarding of fish that cannot legitimately be sold if caught using the gear category deployed. This will particularly be true if fishermen are unable to devise and implement technical or tactical adaptations that can deliver equivalent selectivity.

The EWG acknowledges that for some fisheries, finding technical or tactical solutions may not be straightforward. For example, the existing TR2 fleet as defined under the cod management plan use gears rigged to exploit *Nephrops*. Under the proposed approach such vessels would fall into the gear category DTG3 so if they wish to take advantage of any fishing opportunity for cod, they would need to demonstrate selectivity for cod equivalent to gear category DTG1. As noted above, to do so may prove be problematic if both cod and *Nephr*ops are exploited in the same fishing operation. Technical adaptations to the gear that will deliver the required selectivity for cod may mean significant losses of *Nephrops* catch by the gear. This may move fishermen to consider tactical means to optimise their fishing opportunities for both species by fishing with different gears over different trips (e.g. fish for *Nephrops* with DTG3 on some trips, and switch to DTG1 gear (e.g. 120mm) on other trips to catch their fishing opportunity for cod).

Furthermore, it is conceivable, that if a skipper uses gear category DTG3 to take advantage of fishing opportunity for example, for hake, it may be more profitable to lease or sell any fishing opportunity for cod and haddock and discard catches of those species, rather than to opt to use gear DTG1 and land catches of cod and haddock. This is contrary to the objective of the landing obligation and would mean that the opportunity to try to adapt tactical behaviour ahead of full implementation of the landing obligation would be missed.

The proposed gear categories in Figure 3-1 are suggested because they are roughly in line with existing gear groupings used to exploit North Sea stocks. The EWG recognises that consideration may need to be given as to whether such gear categories need to be reviewed in the light of any proposals to set minimum conservation reference sizes that are not in line with existing minimum landing sizes.

3.4.4 Baseline technical measures using a spatial approach

Another option for establishing baseline technical measures is to adopt a spatial approach requiring vessels to use mesh sizes appropriate to the particular area of operation. This approach is especially applicable where the species being fished are sessile and their distributions are well defined. An obvious example is *Nephrops*, a species distributed on areas of soft mud that have supported clearly defined small mesh fisheries for many years.

In the case of more mobile species of fish less dependent on particular habitats, the use of a spatial approach may present more of a challenge although in some areas, discrete fisheries are well documented. Examination of recent fishing effort information recording the distribution of different gears targeting different species suggests that spatial approaches could be applied in some areas. Figure 3-4 to Figure 3-7 shows an example of the effort distribution compiled by STECF (EWG 13-13) for 4 important towed gears in the North Sea. This clearly illustrates spatial separation of some of the gears.

Using a combination of STECF maps and expert knowledge, examples of possible technical measure baselines using a spatial approach are worked up for two of the Regions – North Sea and North West Waters. The approach seeks to provide a spatial arrangement which broadly reflects recent fisheries but necessarily involves defining areas which do not perfectly match observed activity.

North Sea

Figure 3-3 below provides details of technical measures considered to be appropriate in each of three zones identified in the North Sea.

The northern zone - north of 57.5^0N – is mainly characterised by larger mesh fisheries targeting a range of gadoids and groundfish. This zone currently supports much of the North

Sea cod population implying that a baseline mesh of >=120mm is appropriate. Within the zone there are also significant populations of *Nephrops*, in particular on the offshore Fladen Ground. An additional, spatial provision is therefore proposed which would operate on the mud areas see Figure 3-8). A mesh size of >=80mm would be allowed when fishing on mud, but owing to the high likelihood of catching cod, improved selectivity would also have to be provided by the addition of a selective device.

The central zone - between of 54.5^0 N and 57.5^0 N – is characterised by the use of two main gears. In inshore fishing grounds such as the Farne Deeps, a *Nephrops* fishery operates using >=80mm mesh while to the north and east of the zone, beam trawling using a 100mm mesh net targets mainly plaice. Both of these gears would be permissible but again, owing to the relatively high incidence of cod (particularly off the NE coast of England, an additional selective device would be needed in the >=80mm *Nephrops* gear.

The southern zone - south of 54.5^0 N – is also characterised by the use of two main gears. Over much of the zone and particularly in the south-west, small meshed >=80mm demersal trawls operate in a fishery mainly for whiting. In order to maintain this fishery the use of additional selectivity devices (normally for the purpose of releasing small fish) may be required if it is shown that there is substantial discarding occurring in the fishery currently

A small meshed beam trawl fishery for sole and plaice also operates throughout the zone and existing measures such as large mesh panels in the upper parts of such trawls should continue to be required.

Area	Principle Gears	Additional spatial provisions	Notes
Northern N Sea north of 57.5^0 north	>=120mm demersal trawl	>=80mm demersal trawl with 120smp (or alternative selectivity device with equal/better selectivity) in 'mud areas' FL, MF etc	
Central - between of 54.5^0 and 57.5^0 north	>=80mm demersal trawl with 120 smp >=100mm beam trawl		80mm demersal trawl mainly for *Nephrops* FF, FD 100mm beam trawl for plaice
Southern - south of 54.5^0 north	>=80mm demersal trawl >=80mm beam trawl		80mm demersal for whiting (and Botney Gut *Nephrops*) 80mm beam trawl for sole and plaice

Figure 3-3 Potential minimum selectivity requirements for the North Sea

West of Scotland

Table 3-2 provides details of technical measures considered to be appropriate in the West of Scotland VIa inside cod recovery zone.

Area	Principle Gears	Additional spatial provisions	Notes
West Scotland VIa inside cod recovery zone	>=120mm demersal trawl with 120mm SMP (>=110mm with 110mm SMP for vessels <15m)	>=80mm demersal trawl with 120smp (or alternative selectivity device with equal/better selectivity) in 'mud areas' NM, SM CL	

Table 3-2 Potential minimum selectivity requirements for the West of Scotland

A demersal trawl fishery using mainly 120mm mesh takes a variety of gadoids and other demeral species such as anglerfish and megrim. At present much of the activity is located outside of the Hebrides and towards the continental shelf edge although in the past, activity was also more widespread in some inshore areas including the South Minch and Firth of Clyde where some gadoid spawning grounds are located. In the West of Scotland the cod stock is assessed to be far below Blim and this species drives management considerations. More stringent measures are required including a 120mm smp in the large meshed trawl.

Within the zone there are also significant populations of *Nephrops*, located in the North Minch, South Minch and Clyde. An additional, spatial provision is therefore proposed which would operate on the mud areas (see Figure 3-9). A mesh of >=80mm would be allowed when fishing on mud, but owing to the high likelihood of catching undersized haddock and whiting, and the risk of catching cod in some locations, improved selectivity would also have to be provided through the addition of a selective device. Currently under legislation a rigid grid or a 120mm square mesh panel must be used in this fishery.

Advantages and disadvantages

In common with other approaches for providing a set of baseline technical measures it is possible to identify a number of pros and cons associated with the spatial approach.

The approach is comparatively straightforward and simple to define and set up. There is no requirement to define fisheries based on catch profiles or more abstract concepts.

Similarly, the approach is easily understood relying on visually accessible positional information of the type used all the time on vessels.

At sea compliance would be expected to be fairly straightforward requiring only an assessment of a gear type and an observation of where the vessel hauled its net. In principle the use of VMS data would also provide a remote means of ensuring compliance – particularly if vessels sailed under a notifiable one-net rule linked to a fishing authorisation.

Disadvantages of the approach include the fact that identifying and delimiting areas tends to create boundary effects. These have often created problems in the use of other fishery management tools. While the use of VMS has many positive features, the interpretation of activity associated with VMS records often proves more difficult. Other forms of remote monitoring employed alongside positional monitoring (e.g. winch pressure etc) might be effective. While such an approach may be attractive where species and fisheries inhabit a reasonably well defined and discrete location in time and space, it does become complex in areas where the boundaries are poorly defined or absent and alternate approaches may be more appropriate in such circumstances.

A potential serious problem with the approach is the extent to which future activity and deployment of technical measures become locked into an historic observation. Clearly, if a species of fish requiring mitigation measures to improve stock status or selection profile shifts or expands its distribution into areas where inappropriate technical measures are specified, this would be counterproductive.

Regular review and adjustment of the spatial measures might be required to maintain a ‘future-proof’ status. Such review and adjustment rather contradicts the concept of a ‘baseline’ approach and could prove disruptive.

Finally, there is nothing inherent in this approach which generates any incentive to improve selectivity. Under the Landing Obligation, fishermen may eventually find that selectivity improvement is required in their business model. A baseline approach encouraging early consideration of difficulties ahead would be advantageous but the spatial approach does not readily offer this.

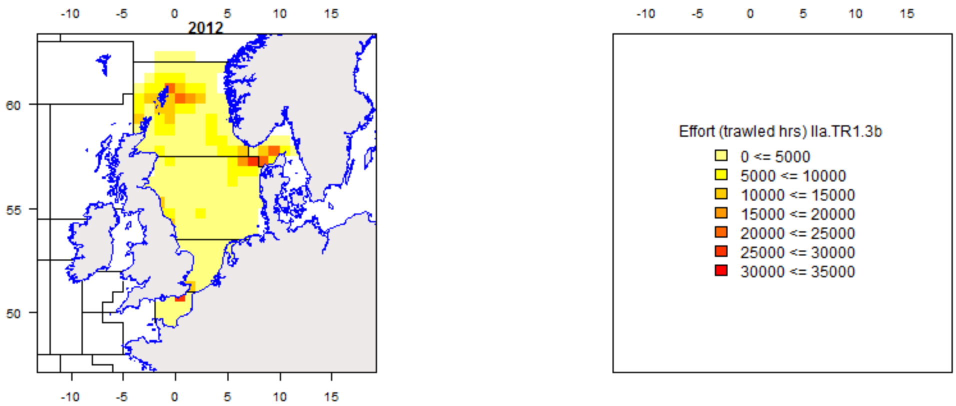


Figure 3-4 Spatial distribution of TR1 effort in the North Sea and Skagerrak (2012).

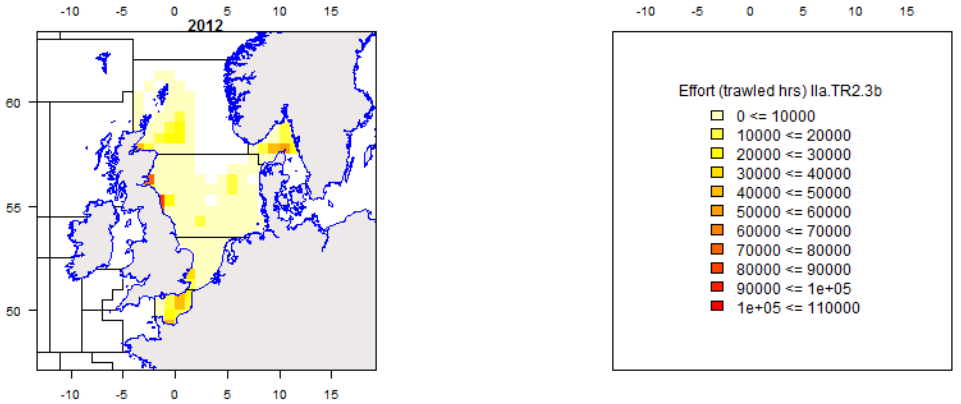


Figure 3-5 Spatial distribution of TR2 effort in the North Sea and Skagerrak (2012).

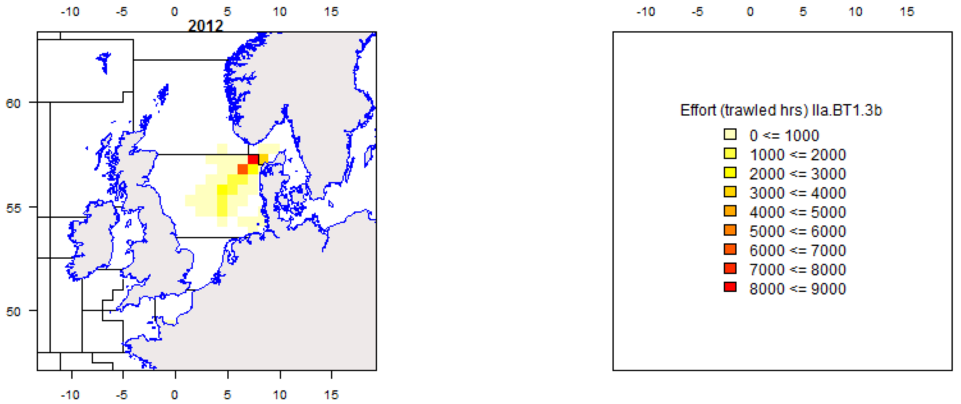


Figure 3-6 Spatial distribution of BT1 effort in the North Sea and Skagerrak (2012).

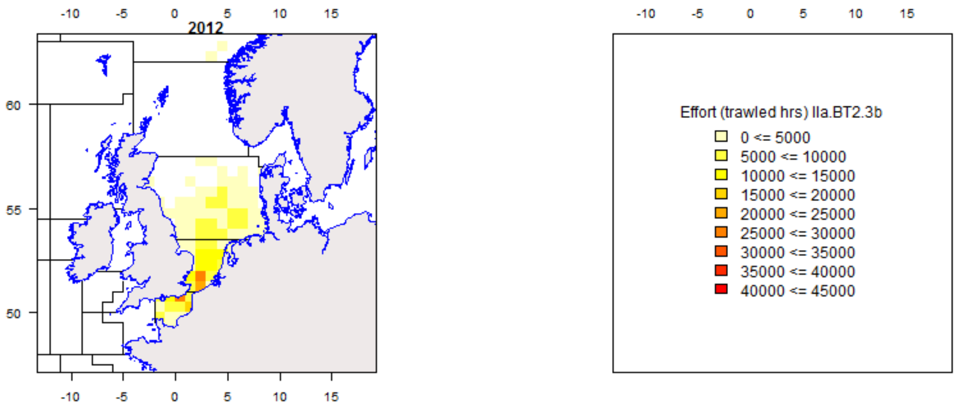


Figure 3-7 Spatial distribution of BT2 effort in the North Sea and Skagerrak (2012).

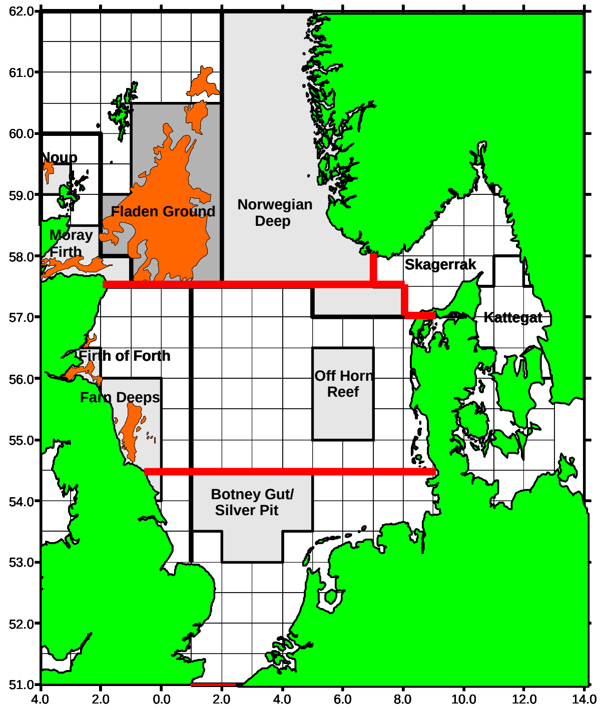


Figure 3-8 Spatial distribution of *Nephrops* habitat (Fladen Grounds, Moray Firth, Firth of Forth and the Farne deeps) and associated management areas (Functional Unit) for all North Sea *Nephrops* stocks.

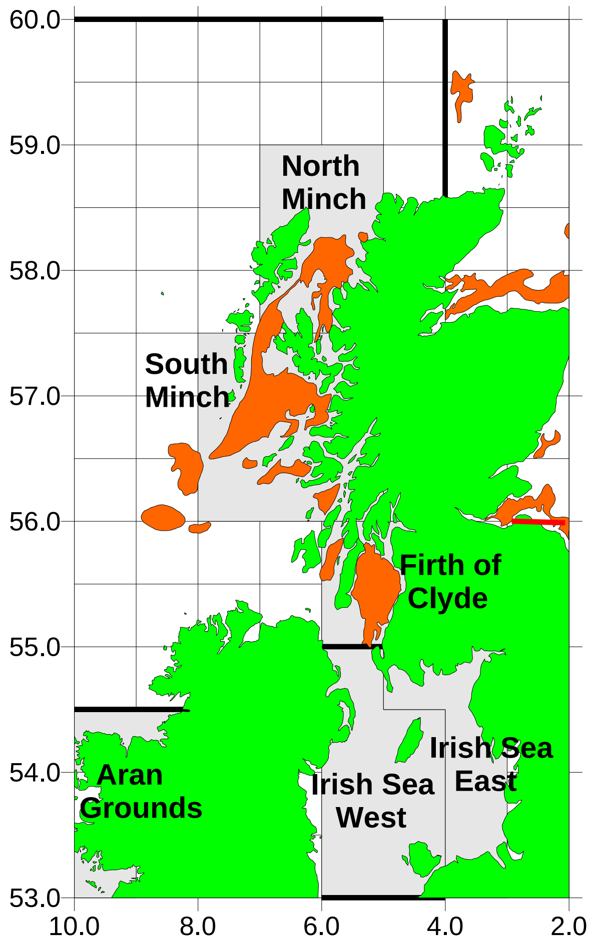


Figure 3-9 Spatial distribution of *Nephrops* habitat (in Red) and associated management areas (Functional Unit) for the West of Scotland and for *Nephrops* stocks (grey boxes) in the West of Scotland, East and West Irish Sea and the West of Ireland.

3.5 Methods to evaluate the efficacy of measures aimed at reducing the capture of juveniles

3.5.1 Exploitation pattern metrics

While TCMs have been routinely used to offer protection of juveniles in many fisheries, there have been few studies or monitoring programmes to assess the effectiveness of TCMs post-introduction. There are a number of metrics that can be used to monitor the relative contribution individual fleets make to the capture of fish of different ages. These may enable managers to decide upon the need and to identify fleet specific measures to reduce the capture of specific age groups (i.e. <MCRS) and therefore provide a measure of efficacy of measures aimed at limiting catches of certain age groups (e.g. juveniles; mature age classes).

Such metrics can be broadly split into those that are population dependent and those that are population independent. Population dependent metrics fluctuate depending on the underlying age structure of the population being fished and the selectivity of the fleets. Therefore they are heavily influenced by not only selectivity, but also by fluctuations in recruitment. This confounding effect means that while it may be possible to use age specific catch and CPUE as metrics to contrast between fleets for any given year, using these as a measure to assess changes in selectivity between years is problematic and would require population independent metrics. .

Developing population independent metrics (e.g. those independent of fluctuations in recruitment) may offer a more useful monitoring tool for managers. These are able to determine whether further improvements in selectivity are required for a given fleet in comparison to others but also provide a measure to track changes in fleet specific interventions.

To further the discussion on the utility of various metrics, it is helpful to distinguish between the components that interact to form the catch. The aim of this brief section is to clarify how components interact to form the catch with a view to monitoring aspects of the fishery (e.g. to allow direct comparisons between different fleets exploiting the same stock). A simplified theoretical catch model and real data from the Celtic Sea haddock and North Sea plaice fisheries and stocks to are used to illustrate the features of the metrics

Catch model

It is simplest to begin with a proportional catch-model given by:

$$C_{a,f,s,y} = q_{a,f,s} E_{f,y} B_{a,s,y} \qquad (1)$$

where $C_{a,f,s,y}$ is the catch at age *a*, fleet *f*, stock *s*, year *y*; E is effort (Figure 3-10) and B is biomass (Figure 3-11). This approach assumes the catch is removed at a given point in the year in contrast to the Baranov catch equation, which assumes the catch is removed continuously.

Example units of Equation (1) are:

$$[tonnes] = [kWdays^{-1}][kWdays][tonnes] \qquad (2)$$

so the interpretation of the catchability parameter here is the proportion of biomass removed per unit effort. This will depend on the gear selectivity and capacity of the gear and the density of fish on the grounds among others.

Catch-measures

It is clear from the simplified model that catch depends on the biomass of the population (Equation 1) and as such monitoring of the catch will depend on the population. Catch at age for the Irish TR1 over 10 metre fleet fishing in VIIfg illustrates the relationship, with catches at age (Figure 3-12) sometimes reflecting peaks in biomass (Figure 3-12).

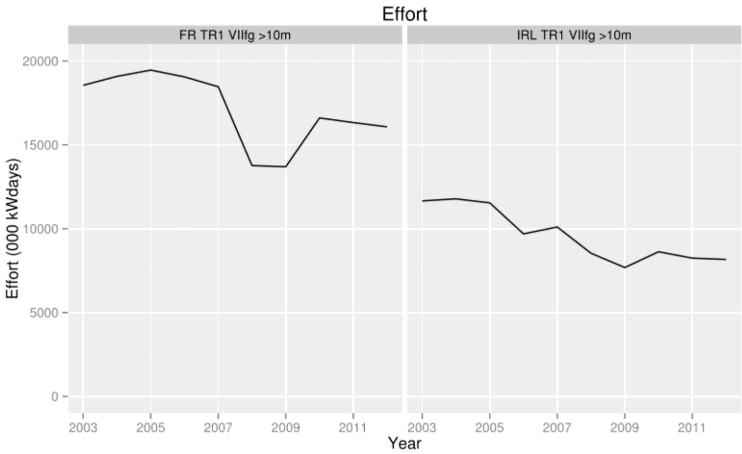


Figure 3-10. Effort for the French and Irish fleets fishing in the Celtic Sea. Data obtained from the STECF effort database.

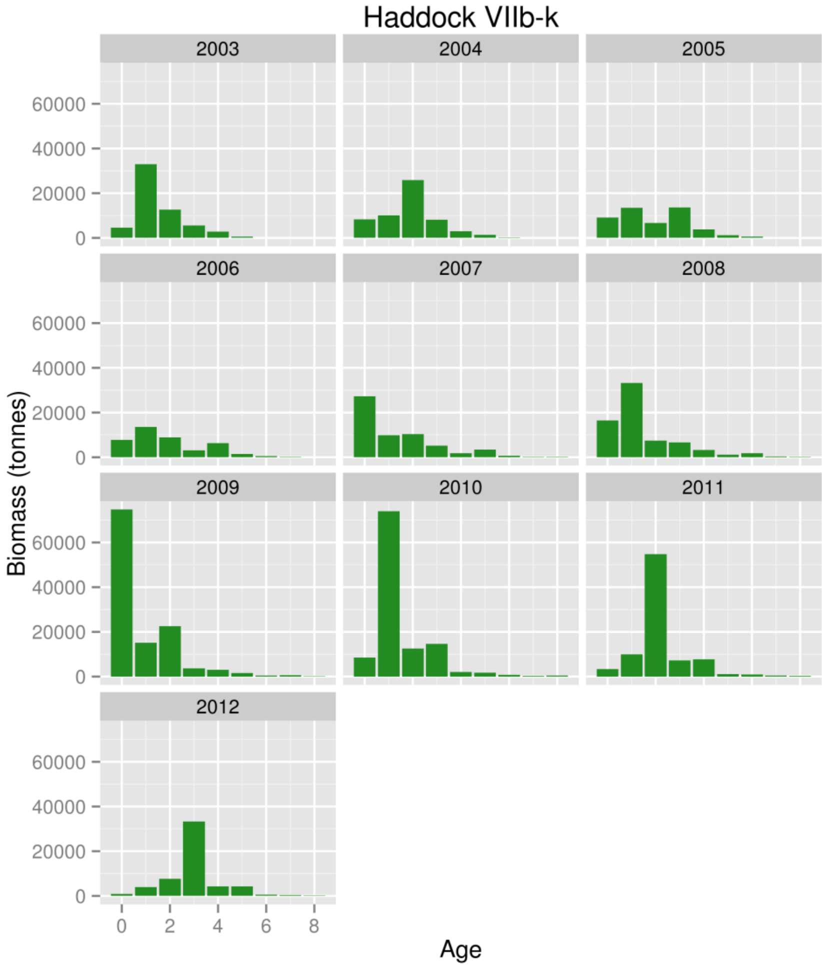


Figure 3-11. Biomass at age from the Celtic Sea haddock 2013 assessment.

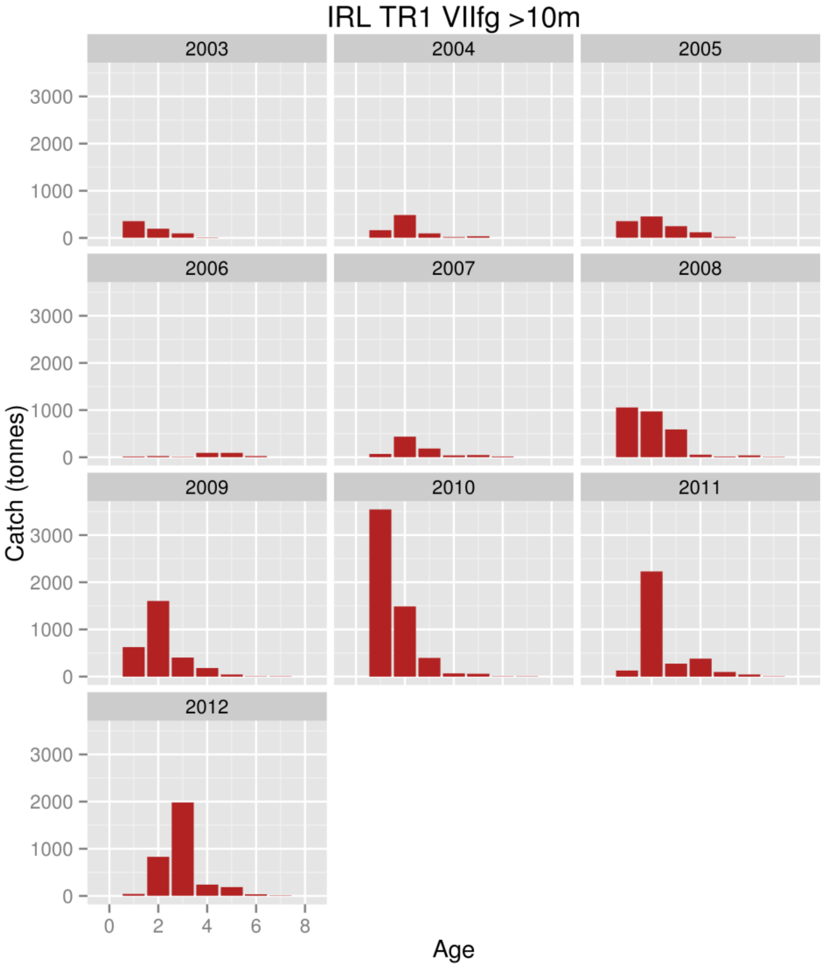


Figure 3-12. Catch at age from the Irish TR1 fleet fishing in area VIIfg. Catch data derived from a combination of STECF and ICES data.

CPUE-measures

Dividing Equation (1) through by effort provides the proportional catch-per-unit-effort:

$$C_{a,f,s,y} / E_{f,y} = q_{a,f,s} B_{a,s,y} \qquad (3)$$

with units $[tonnes. kWdays^{-1}]$, which is also population-dependent (Figure **3-13**).

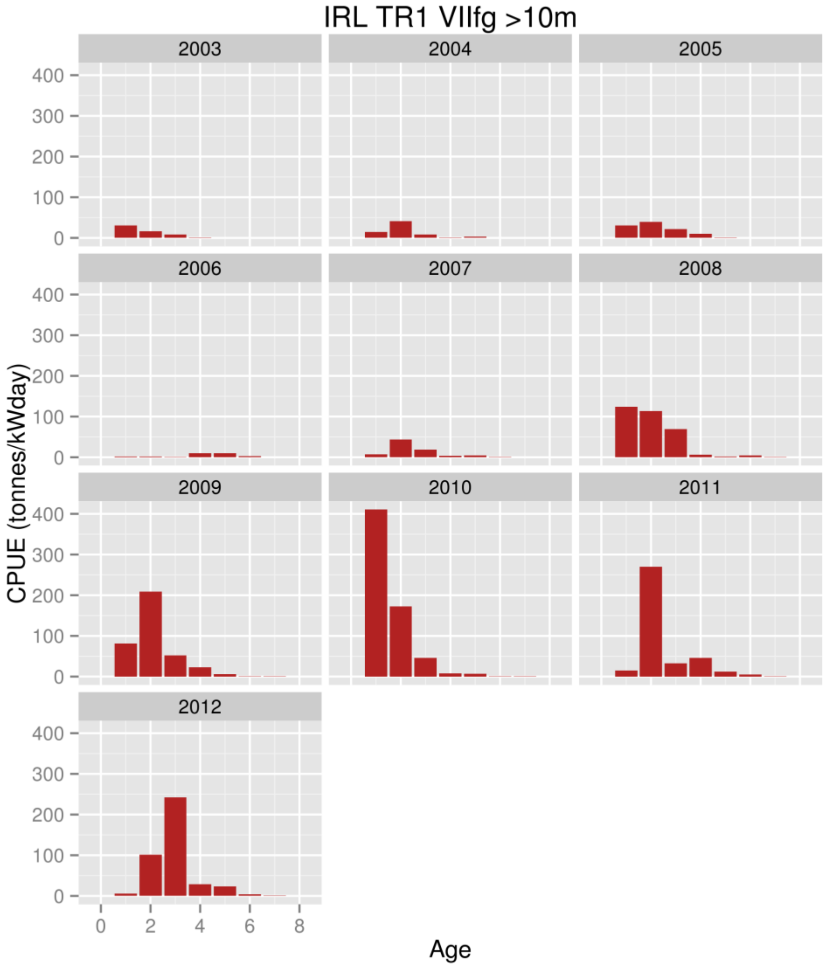


Figure 3-13. Catch per unit effort at age from the Irish TR1 fleet fishing in area VIIfg.

Partial F measures

Dividing Equation (1) through by biomass provides the unit-less discrete analogue of the partial fishing mortalities (formally a partial harvest rate):

$$C_{a,f,s,y} / B_{a,s,y} = q_{a,f,s} E_{f,y} \qquad (4)$$

which is the proportion of the population at age removed per fleet per year (Figure **3-14**). The partial F values scale the catchability by the effort. They may also be obtained from assessment output where the fishing mortalities are apportioned to fleets according to the proportion of the total catch removed by that fleet. Within the confines of the assumed catch model, the fishing mortality/harvest ratios are population-independent, as biomass at age is accounted for in the measure.

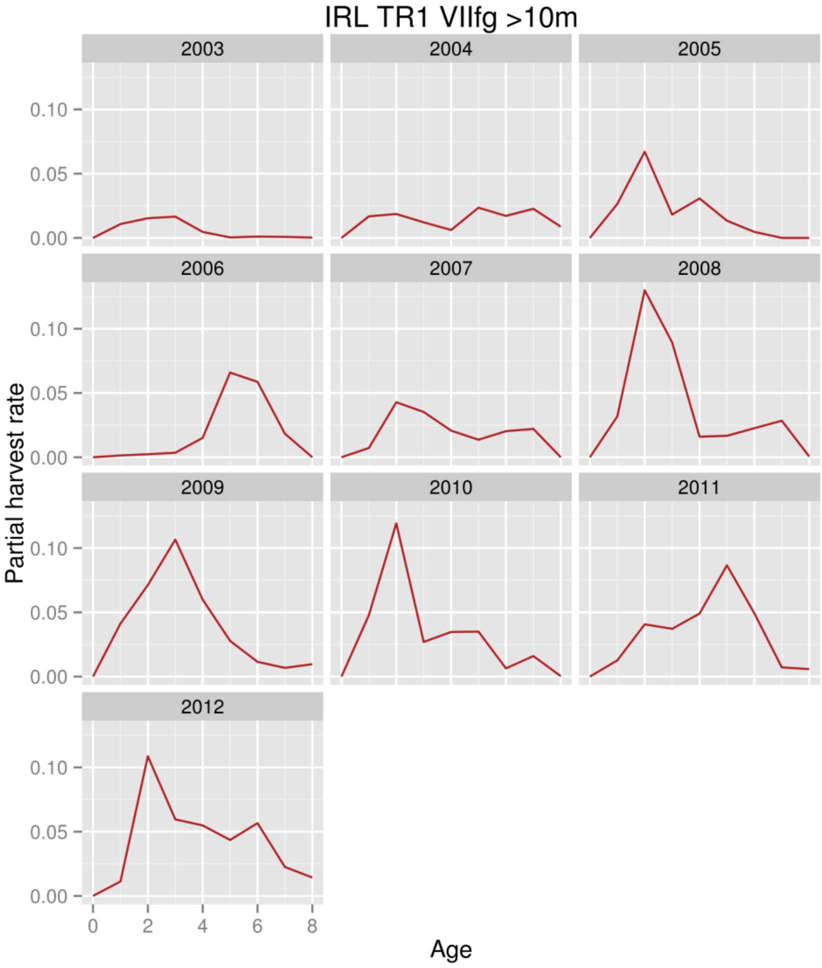


Figure 3-14. Partial harvest ratio (discrete analogue of partial F) at age for haddock in the Irish TR1 fleet in area VIIfg.

Catchability measures

Dividing Equation (1) by the product of effort times biomass:

$$C_{a,f,s,y} \big/ (E_{f,y} B_{a,s,y}) = q_{a,f,s} \quad (1)$$

isolates the catchability. For equivalent effort units for a given species, the catchability can be compared across fleets to represent efficiency of removal (Figure **3-15**). Again, as the biomass is accounted for, within the confines of the chosen catch model the catchabilities are population-independent though for many reasons not included above the catchability may be population/density-dependent. The degree of similarities in the catchability between fleets reflects similarities of the CPUE trends.

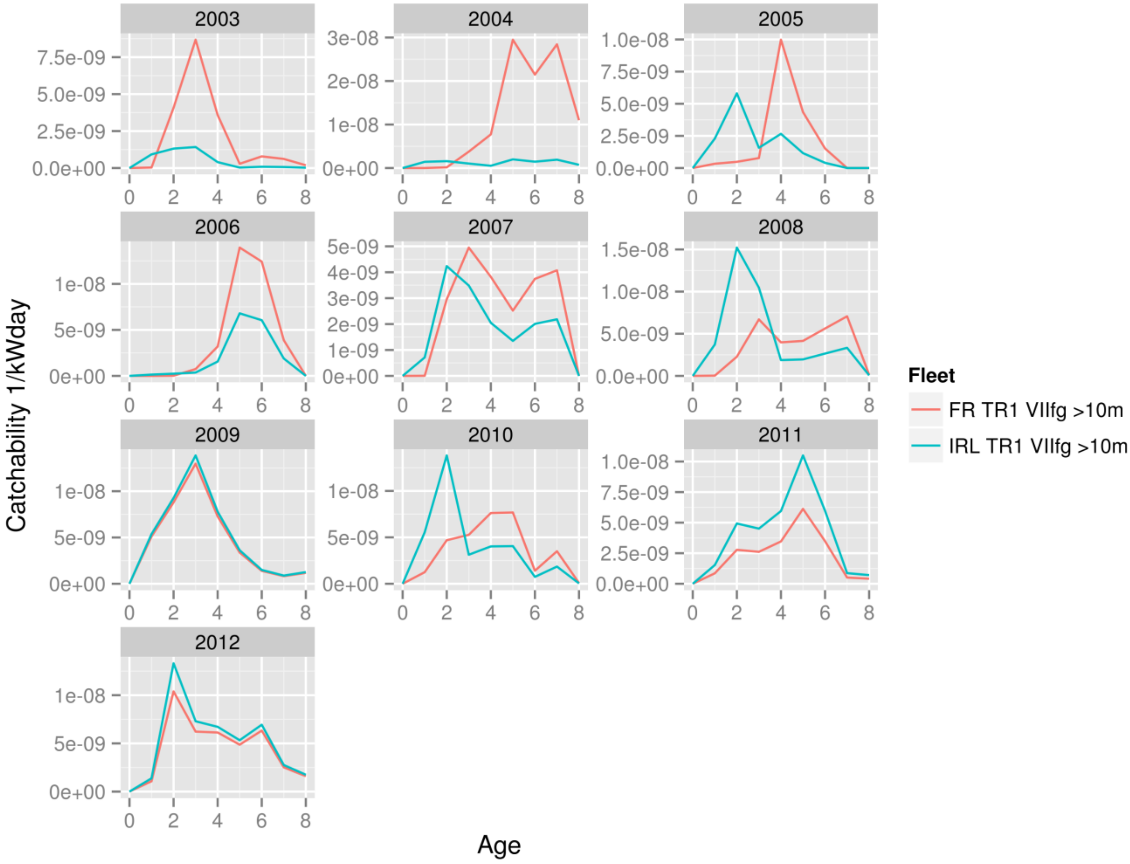


Figure 3-15. Estimated catchability at age for French and Irish TR1 fishing haddock in the area VIIfg.

Both partial fishing mortalities and catchabilities provide for population independent indicators that may be used to describe fleet and age specific profiles. These in turn can provide for a comparison of catchabilities (and partial fishing mortalities) between fleets and show fleets that may have undesirable selectivity in this context. Figure 3-16 provides a comparison between a "large" mesh (>100mm) fleet and a smaller mesh (80mm) fleet catching plaice in the North Sea. This clearly shows that the smaller mesh fleet (blue) has a much higher catchability of younger age fish (ages 0-3) than the larger mesh fleet (red) suggesting that improvements in exploitation patterns may be desired in the smaller mesh fleet.

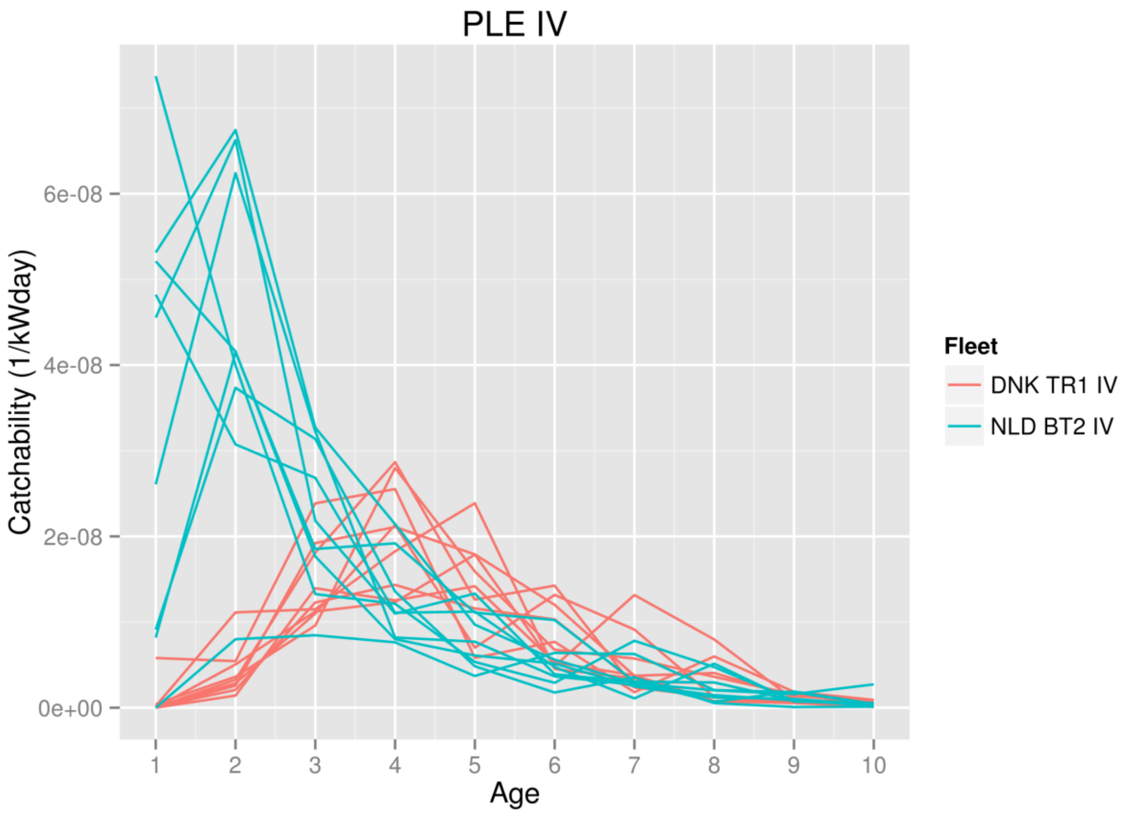


Figure 3-16 Compasion of catchabilities at age between two fleets fishing plaice in the North Sea. TR1 (red) uses a larger mesh size (>100mm) in comparison to BT2 (blue) which uses a mesh size of 80mm.

Inter-annual metric variability

Success of a monitoring metric will partially depend on how variable the metric is. To assess this, we calculate by age the coefficient of variation (CV) of the various metrics outlined above. Higher CVs reflect more variable metrics. For the simple example of two fleets targeting haddock in area VIIfg, the CV of the assumed population-independent metrics (partial harvest ratio, catchability) appears lower (younger ages for the French fleet; all ages for the Irish fleet). The CV of partial F at age 1 for the Irish fleet is less than half that of the catch or cpue CV (Figure 3-17). From this example, the inter-annual variability of the metrics at least for younger ages (of particular interest) typically follows: CV Catch > CV CPUE > CV catchability > CV partial harvest ratio. This implies that using population independent methods offers a more precise measure meaning that robust inferences can be made regarding the relative contributions individual fleets make to their contribution to age specific catch levels. However, for a different stock (North Sea Plaice) analysis of the CV of catch; CPUE; partial fishing mortality and catchability associated the example of the fleet specific catchabilities (Figure 3-16), shows that the CV's between both population dependent and independent metrics are closely aligned, possibly reflecting lower recruitment variability compared to haddock in the Celtic Sea.

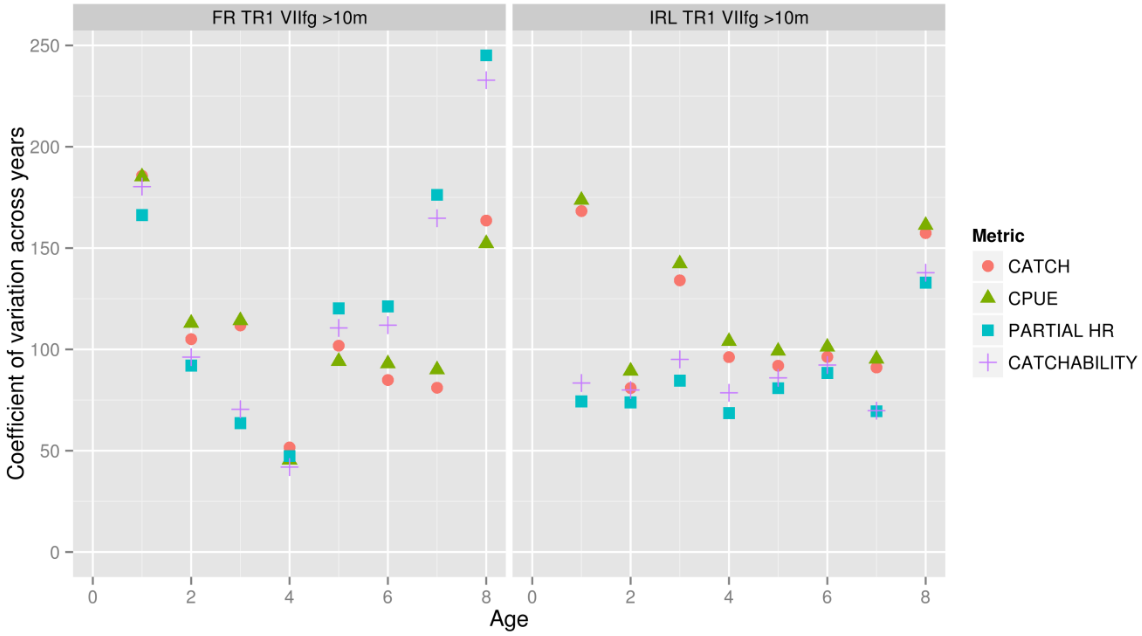


Figure 3-17. Coefficient of variation of exploitation pattern metrics by age for the example given in Figure 3-10 - Figure 3-15.

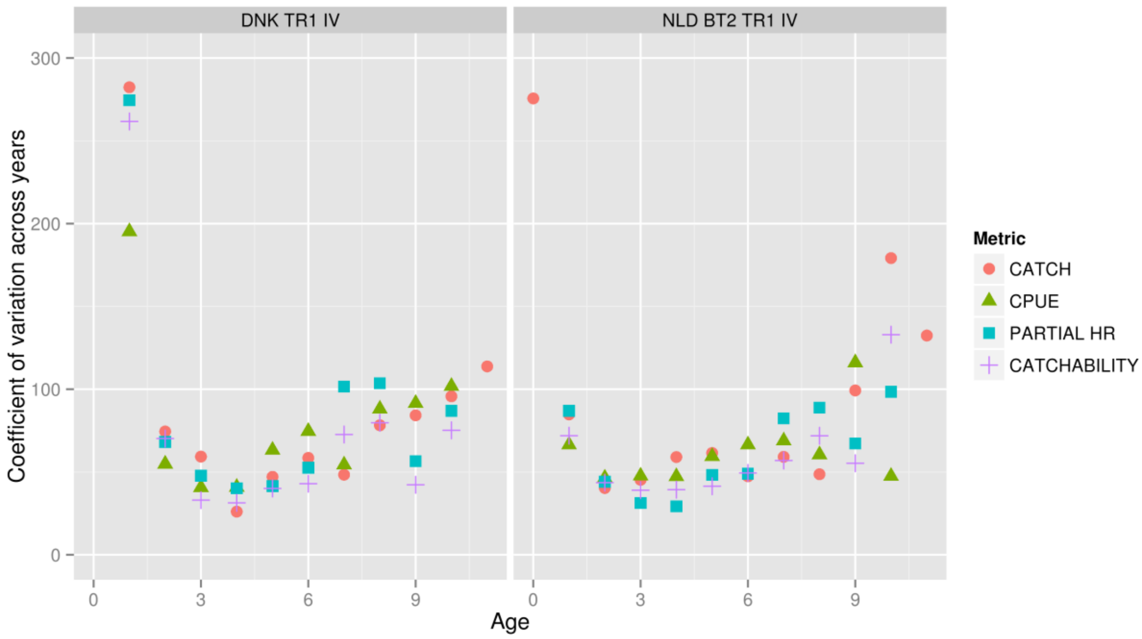


Figure 3-18 Coefficient of variation of exploitation pattern metrics by age for the example given in Figure 3-16

In practice the choice of individual metric will depend on what is being measured. To assess the contribution individual fleets make at a stock level, then population dependent methods (catch and CPUE at age) will be sufficient for comparisons. If managers are interested in assessing age specific changes in selectivity of specific fleets over time then age specific population independent measures of partial mortality or catchability would be required. From the haddock example presented in Figure 3-17, population independent metric are shown to have a lower (hence stable) variability (i.e. population dependent metrics are less certain).

However, this pattern is not replicated in the North Sea plaice example provided (Figure 3-18) where the CV estimates are closely aligned. This contrast highlights that managers should be aware that the precision varies between fleet and that the level of variation (if large) will often mask actual changes in selectivity of a given fleet, particularly if such changes are moderate.

3.6 Contrasting minimum size, selectivity and maturity in example demersal trawl fisheries in the EU

The use of minimum sizes has been an integral part of TCMs in many jurisdictions for decades. These aim to restrict the sale of fish below certain sizes and are typically used in conjunction with rules which limit catches of fish below minimum size. However, the objective basis for choosing stock specific minimum sizes is unclear in many instances. In practice it would be appear that they may be linked to either biological or economic considerations or a combination of both. EWG 15-01 explored the linkage between current gear selectivity (expressed as L_{25} and L_{50}), maturation and minimum landings sizes as established for the North-east Atlantic under Regulation (EC) 850/98.

A descriptor of the size of fish in the catch (selectivity of the gear), is the length of the fish at which there is a 50% probability of being retained by the gear on encounter (L_{50}). As part of an assessment of the catch profile of the key species caught in commonly used towed gears, selectivity L_{50} values were derived from a range of sources including published and grey literature as well as expert judgement. It was observed that few selectivity studies had been conducted recently. Instead there has been a tendency to conduct catch comparison experiments to assess the relative change in catches between existing and novel gears. Therefore, the selectivity data obtained, is not considered necessarily representative of all of the main fisheries, but allows the drawing of some general conclusions. The selectivity parameters were derived from conventional trawls and did not account for recent changes and improvements in selectivity (e.g. square-mesh panels).

The relationships between selectivity and the current legal minimum landing size (MLS), and the length at first maturity were examined where data were available. All regulated species for the North West, South West and North Sea regions were listed and selectivity data, maturity data and minimum landing size were obtained were possible.

Table 3-4 gives selectivity parameters, L_{25} and L_{50} for some of the main regulated species, also the legal minimum landing size and length at first maturity. This is given as the estimated mean length (Lm) at first maturity for the fish species in the relevant geographical areas, and was extracted from the Fishbase online database. The minimum and maximum mean length at first maturity is presented. For *Nephrops*, the values of Lm are from (ICES 2006)[1].

[1] ICES 2006. Report of the Workshop on *Nephrops* Stocks (WKNEPH). ICES CM 2006/ACFM:12. 85 pp

Table 3-3 Selectivity parameters (L50, L25), range in estimated length at first maturity (Lmaturity) and legal Minimum Landing Size (MLS) of species, gear and mesh size combinations for some important commercial species

Species	Gear	Codend mesh (mm)	L25 (cm)	L50 (cm)	Lmaturity[2] (cm)	Current MLS (cm)
Cod[3]	OTB	120 100 90 80	36.0 26.3 24.7 22.7	40.2 29.4 27.7 25.4	53-69	35 (30 Skagerrak/ Kattegat)
	TBB[8]	80	13	15		
Haddock[3]	OTB	120 100 90 80	32.6 23.8 22.3 16.6	34.5 27.7 24.3 18.4	31-34	30 (27 Skagerrak/ Kattegat)
Whiting[3]	OTB	120 100 90 80	35.8 26.2 24.6 22.6	41.8 30.6 28.7 26.4	20-28	27 (23 Skagerrak/ Kattegat)
Saithe[4]	OTB	120	41.7	46.4	39-71	35 (30 Skagerrak/ Kattegat)
Nephrops[5]	OTB	120 100 90 80	2.5 2.2 2.1 2.0	3.6 2.8 2.7 2.6	2.26-3.35[6]	8.5/2.5 (130/40 Skagerrak/ Kattegat)
Plaice	OTB	120[7] 100 90[89] 80	24 - 17;21 -	25 - 19;22 -	25-34	27
	TBB*	120 100 90 80	- - - -	- - - -		
Sole	OTB	90[9] 80	24 -	26 -	25-30	24
	TBB	120 100 90[10] 80[911]	- - 24 18;21	- - 27 21;24		

[2] Froese, R. and D. Pauly. Editors. 2014. FishBase. World Wide Web electronic publication. www.fishbase.org, version (11/2014).

[3] Fryer, R.J., O'Neill, F.G. and Edridge, A., 2015. A meta-analysis of haddock size-selection data. Fish and Fisheries; based on no square mesh panel or lifting bag.

[4] Unpublished data Marine Scotland

[5] Modelled based on: ICES, 2006. ICES Working Group Report 2006 Working Group Name: Workshop on *Nephrops* Selection (parameters: diamond mesh, no lifting bag).

[6] Magnus L. Johnson, Mark P. Johnson. Editors. 2013. The ecology and biology of *Nephrops norvegicus*. Advances in Marine Biology. Vol 64. 352pp. ISBN 978-0-12-410466-2.

[7] Bent Herrmann, Harald Wienbeck, Waldemar Moderhak, Daniel Stepputtis, Ludvig Ahm Krag (2013). The influence of twine thickness, twine number and netting orientation on codend selectivity. Fisheries Research 145, pp22–36

[8] Frandsen, R.P., Madsen, N., and Krag, L.A. (2010) Selectivity and escapement behaviour of five commercial fishery species in standard square- and diamond-mesh codends. ICES Journal of Marine Science, 67, pp1721–1731.

[9] Rikke P. Frandsen, René Holst, Niels Madsen (2009). Evaluation of three levels of selective devices relevant to management of the Danish Kattegat–Skagerrak *Nephrops* fishery. Fisheries Research 97 pp243–252.

[10] van Beek, F. A., et al. (1982). Results of mesh selection experiments on sole and plaice with commercial beam trawlers in the North Sea in 1981. ICES CM 1982/B:17.

Hake	OTB	110 100[12] 90[9][12] 80[13][14]	34 31-37 17,24 16-24	38 34-47; 23-26 22,31 23-35; 20-23	20-59	27 (30 Skagerrak/ Kattegat)
Pollack	OTB				Unknown	30 (none Skagerrak/ Kattegat)
Megrim[15]	OTB	120 100 90 80	36 29.1 25 21.1	41 34.6 34 27	25-28	20 (25 Skagerrak/ Kattegat)
Ling	OTB				80-90	63 (no size Skagerrak/ Kattegat)
Blue Ling	OTB				65-85	70 (no size Skagerrak/ Kattegat)
Herring	OTB				22-31	20 (18 Skagerrak/ Kattegat)
Horse Mackerel	OTB				21-30	15
Mackerel	OTB				30	30 (20 Skagerrak/ Kattegat)
Lemon sole	OTB[9]		24	26	20-30	none
	TBB[11]		14	16		
Dab	TBB[11]		14	15	13-29	none

*Pulse trawling is used to a growing extent in the Dutch flatfish beam trawl fleet as an alternative to tickler chain beam trawling. There is no selectivity data available for this gear, but it is likely that it differs from conventional beam trawls with the same codend-mesh size. In comparative fishing experiments pulse trawl landings were lower and had fewer fish discards, including 62% undersized plaice (*Pleuronectes platessa L.*)[16].

[11] Jochen Depestele, Hans Polet, Kris Van Craeynest, Sofie Vandendriessche (2009). A compilation of length and species selectivity improving alterations to beam trawls; 19 January 2009

[12] BIM unpublished data

[13] Spanish unpublished data

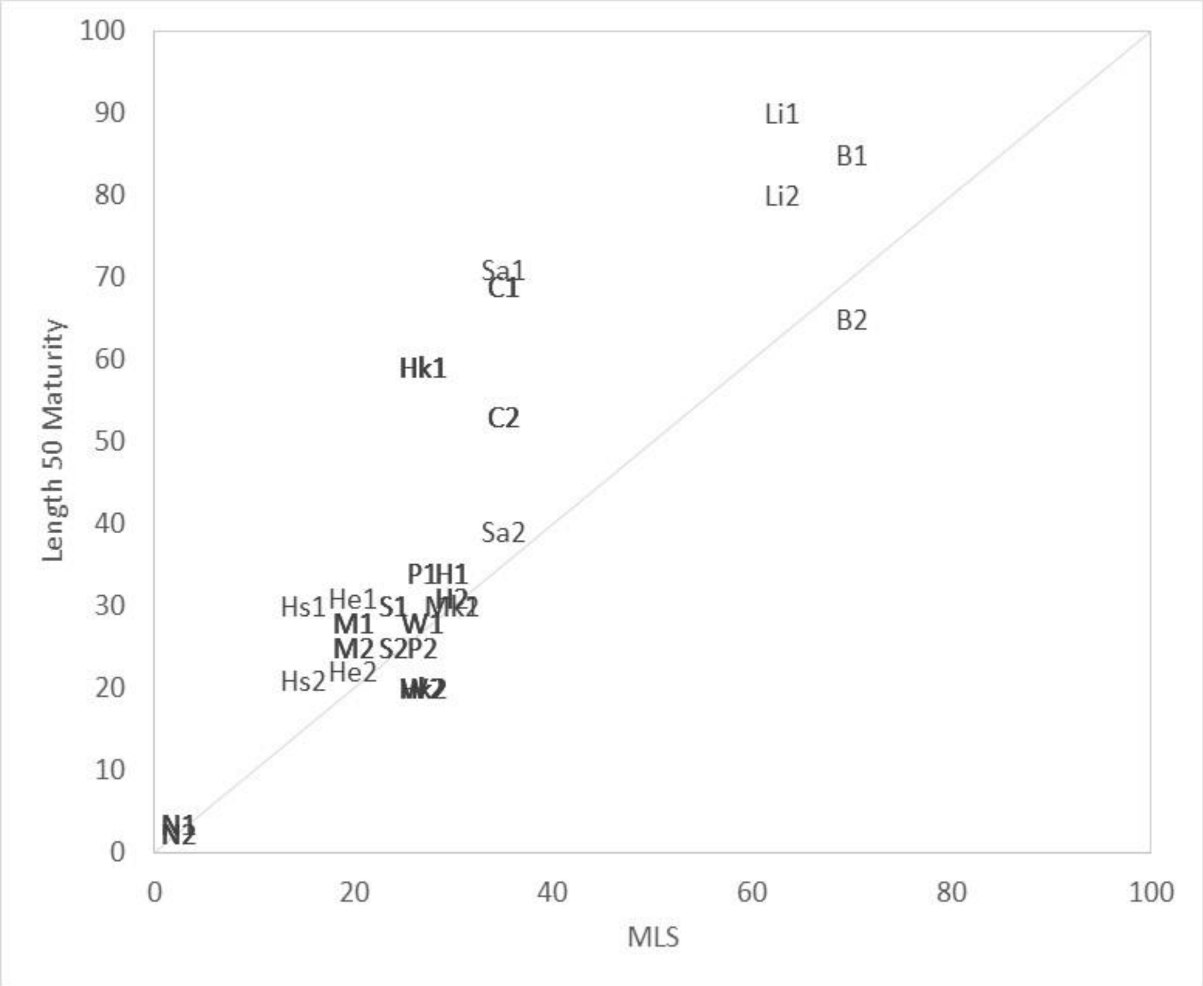
[14] Unpublished data - Hake Technical Measures meeting 23-31/10/2003

[15] BIM unpublished data

[16] van Marlen, B., et al. (2014). Catch comparison of flatfish pulse trawls and a tickler chain beam trawl. Fisheries Research 151(0): 57-69.

Plotting the mean length at first maturity against the MLS it can be observed that there is general alignment for most species, with some exceptions (**Error! Reference source not ound.**).

Figure 3-19 Current legal Minimum Landing Size (MLS) vs Length at maturity (minimum '2' and maximum '1' estimates) for some of the main commercial European regulated species.

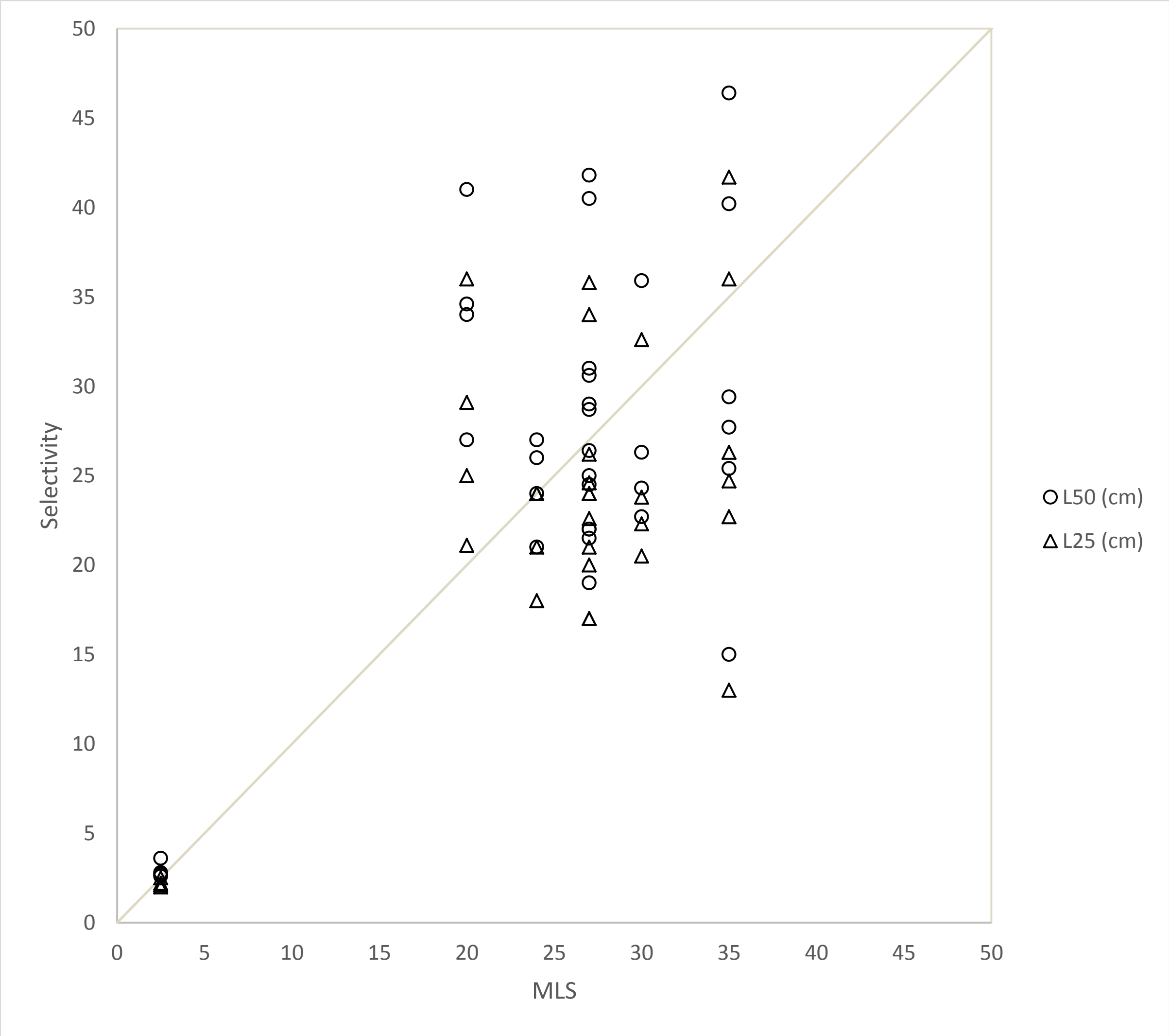


C	Cod	N	*Nephrops*	Mk	Mackerel
D	Dab	P	Plaice	He	Herring
H	Haddock	S	Sole	B	Blue ling
Hk	Hake	Sa	Saithe	Li	Ling
L	Lemon sole	W	Whiting		
M	Megrim	Hs	Horse Mackerel		

Both the minimum and maximum estimates of mean length of maturity were above the MLS for cod, saithe, ling, blue ling and marginally for horse mackerel. For the other species the data suggests that the MLS is representative of the mean length at first maturity and indicates that reducing the MLS would lead to higher catches of juvenile fish. For the five species mentioned, it indicates that where catches of fish are taken at or below the MLS, these will be catches of juvenile fish.

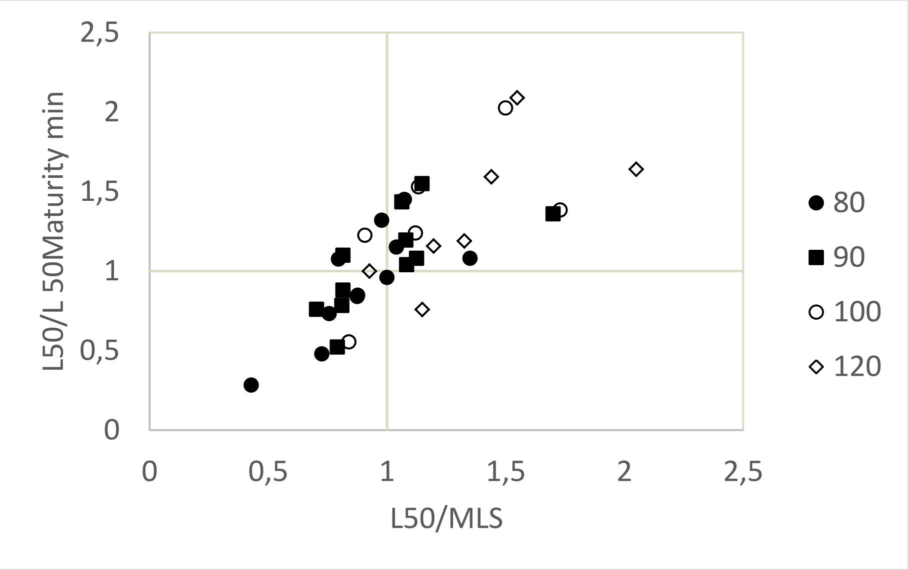
Plotting MLS against estimated selectivity parameters for towed gears provides an assessment of how well the gears select fish above the MLS. Figure 3-20 indicates that the main commercial species, except for those with the smallest MLSs, are caught with towed gear and mesh size combinations with a L_{50} and L_{25} which is below the MLS. Therefore, although the MLS matches closely with mean length at maturity in most cases, the towed gears examined catch substantial numbers of fish below the MLS. Because there is a close correlation between maturity and MLS, this indicates that the selectivity of some gears should be improved, rather than the MLSs lowered, if the objective is to reduce the catches of juveniles.

Figure 3-20 Current legal Minimum Landing Size (MLS) vs selectivity parameters (L25, L50) for some important gears and species



By plotting L_{50}/MLS against L_{50}/mean length at first maturity it was possible to investigate the relationship between these three variables. Figure 3-21 shows a general trend that as the mesh size increases the data points move from the bottom left towards the top right reflecting the fact that L_{50} increases as mesh size increases. Ideally all points would be in the top right quadrant as it would mean that $L_{50} > L_{maturity}$ and L_{50} > MLS implying that the fishery is catching mature fish greater than minimum landing size. Points in the top left quadrant would be fisheries which are catching undersized but mature fish. Points in the bottom quadrants indicate that immature fish are being caught: those in the bottom right are where they are above the minimum landing size, whereas those in the bottom left are both immature and below the MLS.

Figure 3-21 L50/MLS versus the L50/L_{mat} (mean length at first maturity) for the data presented in Table 3-4 separated by mesh size band. Maximum of mean estimated length at first maturity (below); minimum of mean estimated length at first maturity (above).



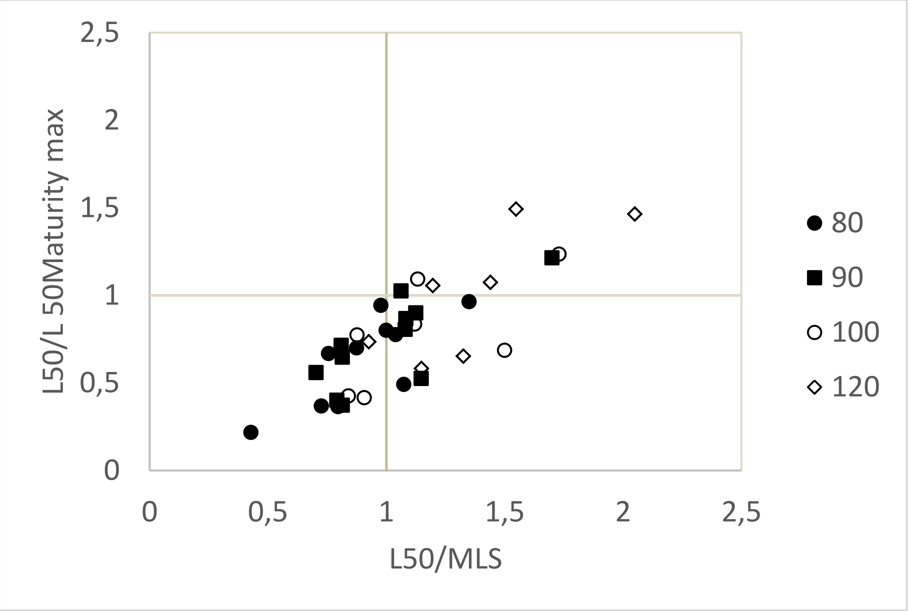
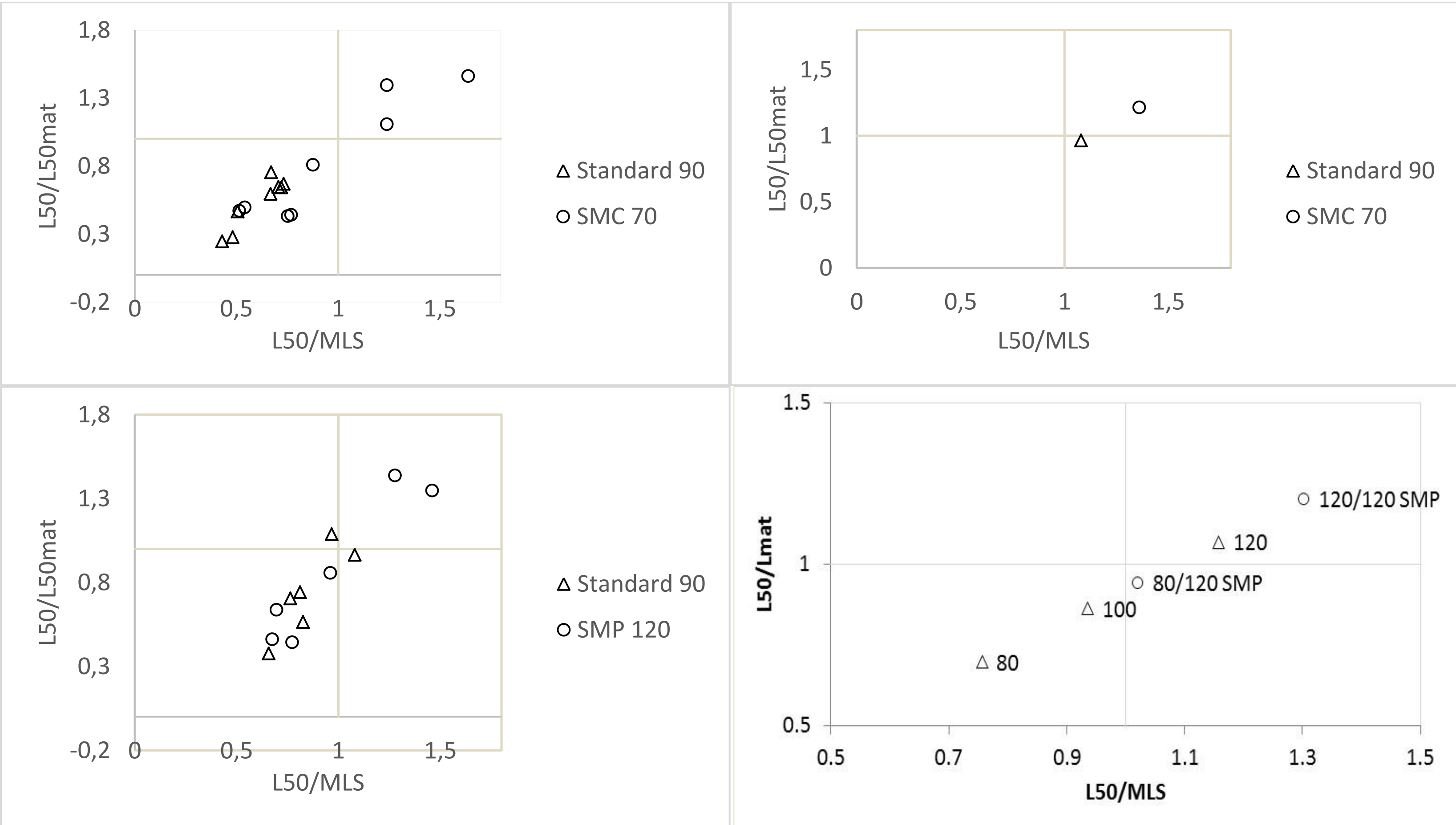


Figure 3-21 provides this analysis for both the maximum and minimum estimated length at first maturity, whereby the minimum estimated length at first maturity is the more optimistic scenario. The data are presented by mesh size range and shows that even with the minimum estimate of the length at first maturity, there are many species in the bottom left quadrant, where catches below the MLS are prevalent. The larger the mesh size, the more the gears are in the top right quadrant, where the catch is of mostly mature fish above the MLS.

As stated above, the data presented are representative of trawls to which no modifications have been made to improve selectivity. There have been numerous selectivity improvements taken up in recent years. Figure 3-22 demonstrates the utility of these changes through the improved relationship between the MLS, length at first maturity and the L50.

Four examples are given of the positive effect observed of installing square mesh panels and switching to square mesh codends from experimental trials. It is concluded that positive changes have occurred in the selectivity of the gear and there is potential for further improvements to the gear so that the catch comprises of mostly mature fish which are above the current legal minimum landing size.

Figure 3-22 Examples of positive change in selectivity observed in the relationships between selectivity L50, length at first maturity (mean) and the MLS. Top left- the effect on fish of replacing a 90mm diamond codend with a 70mm square mesh codend (SMC) in an otter trawl; top right – the effect of installing at square mesh panel in a 90mm codend otter trawl; bottom left – the effect on *Nephrops* of replacing a 90mm diamond codend with a 70mm square mesh codend (SMC) in an otter trawl; bottom right – the effect on installing square mesh panels in to 80 and 120mm codends in whitefish otter trawls.



3.7 Considerations on setting Minimum Conservation Reference Sizes - Linking selectivity, minimum size and maturity

3.7.1 Background and biological basis

Section 3.6 has highlighted that in many cases there is a mismatch between minimum size and gear selectivity, which can result in substantial catches of fish below MLS. It also highlights that the current minimum sizes (MLS) tend to be lower than the length of first maturity.

In the context of the landing obligation where MLS will be replaced by MCRS, a pragmatic solution may be to simply harmonise minimum size with existing selectivity profiles in order to minimise the retention of fish below MCRS. Alternatively, it may be more appropriate to consider whether harmonising MCRS with maturity and then to adjust selectivity accordingly as this is likely to offer greater conservation benefits. This is explored in detail below.

In the new CFP the current minimum landing sizes (MLS) are to be replaced by Minimum Conservation Reference Sizes (MCRS). It is intended that current MLS values will simply be retained and renamed MCRS. Both STECF 12-20 and STECF 14-01 noted that for species that have high discard mortality, there is no empirical evidence to show the use of MLS as defined currently has any conservation benefit and the rationale behind MLS is unclear (Table 3-4). For many species MLS seem to be driven mainly by market demands (Froese *et al.*, 2008) or as a compromise in the context of mixed fisheries.

Article 4.1(17) of the CFP (Regulation (EU) 1380/2013 notes that 'minimum conservation reference size *means the size of a living marine aquatic species taking into account maturity, as established by Union law, below which restrictions or incentives apply that aim to avoid capture through fishing activity; such size replaces, where relevant, the minimum landing size*'.

If MCRS in the future are to be set with more of a biological, rather than an economic objective then they could be set on the basis of:

- Length-at-maturity (Lm50), i.e., the length where 50% of the fish are mature. This length is usually greater than MLS (Table 1-1) and ensures that both growth and recruitment overfishing are eased as fish fulfil more of their growth potential and more fish are allowed to spawn at least once (Myers and Mertz 1998; Froese 2004; Vasilakopoulos et al. 2011).
- Optimal length (Lopt), i.e., the size where a cohort's biomass is maximised. This size is usually greater than Lm50 (Table 1-1) and ensures cessation of growth overfishing and the extraction of the highest possible yields (Froese et al. 2008).

Table 3.3 shows the relationship between these sizes and the current mls for some specific species.

Table 3-4 Minimum landing size (MLS), length-at-maturity (Lm50) and optimal length (Lopt) in cm of selected fishes in the North Sea, Western and Eastern Baltic. From Froese et al. 2008

Species	Area	MLS	L_{m50}	L_{opt}
Cod, *Gadus morhua*, Gadidae	North Sea	35	61	86
Cod, *Gadus morhua*, Gadidae	West Baltic	38	43	80
Haddock, *Melanogrammus aeglefinus*, Gadidae	North Sea	30	29	49
Whiting, *Merlangius merlangus*, Gadidae	North Sea	27	25	37
Saithe, *Pollachius virens*, Gadidae	North Sea	35	58	118
Plaice, *Pleuronectes platessa*, Pleuronectidae	North Sea	27	25	46
Herring, *Clupea harengus*, Clupeidae	North Sea	20	22	24
Herring, *Clupea harengus*, Clupeidae	East Baltic	11	20	20
Sprat, *Sprattus sprattus*, Clupeidae	East Baltic	–	8	10

In setting MCRSs it should be taken into consideration that size/age-at-selection affects both biomass and F_{MSY}. Increasing size/age-at-selection allows greater exploitation rates and greater yields to be extracted at lower levels of stock depletion. Figure 3-23 shows how different combinations of exploitation rate and selectivity can impact on the long-term SSB (upper panel) and yield (lower panel) of a hake stock. As selectivity increases, the stock can be subject to higher levels of fishing mortality whilst attaining the same long-term stock biomass (expressed as a percentage of the virgin biomass). For example, if the selectivity (A_{50} – the age at which 50% of the fish are selected) is centred around 4 year olds, then the long-term SSB would be in the order of 15-20% of the virgin (unfished) SSB with a fishing mortality rate of ~0.5.

Conversely, if the A_{50} is centred around 2 year old fish, for the same long term impact on SSB, then fishing mortality would need to be closer to 0.25. The lower panel in Figure 3-23 shows how this would be translated in long-term yields from the stock. For a given level of F (e.g. 0.5), a selectivity centred around an A_{50} of 4 years, would result in an almost doubling of the potential yield from the stock in comparison to an A_{50} of 2 years. Figure 3-24 shows that increases in selectivity, expressed here as incremental positive changes in L_{50} associated with the main trawler fleets catching hake, would result in higher yields per recruit for a given level of F.

These examples illustrate how an optimal exploitation regime is more than applying a single value of F (aggregated across age groups) applied at an optimal selectivity level. Rather, there is a stock-specific continuum of optimal combinations of F and selectivity corresponding to areas of high long-term yield and SSB. Implementing a similar simulation approach on a stock-by-stock basis could assist in defining MCRSs that would meet the regional needs of the fishing industry; (e.g., a low MCRS would mean lower potential yields taken at low levels of exploitation rate, while a higher MCRS would mean higher potential yields consisting of bigger fish harvested at higher exploitation rates). This is illustrated by Figure 3-23 and Figure 3-24. Approaches to obtaining selectivity which operates to release all but the very largest/oldest fish ultimately result in less than optimal catches (because a higher proportion of the population is lost to natural mortality than can be recovered by fishing – movement to selectivities of this type is, however, considered unrealistic given the loss in potential yield and so the problem is unlikely to occur.

Figure 3-23 indicates that catching fish after they mature (larger than L_{m50} or older than A_{m50}) comes with significant and quantifiable gains both in terms of yield and in terms of SSB. However, when examining the potential effects of different combinations of exploitation rate and selectivity, particular care should be put into using realistic natural mortality values (Charnov *et al.* 2013) and acknowledging density-dependent and environmental effects on growth (Lorenzen and Enberg 2002). These aspects are often not fully addressed in stock assessments and can greatly affect population dynamics and the obtainable yields.

Many stocks, particularly demersal, are caught in varying amounts in single gear, multi-species fisheries. Each species and age group has gear and age specific chances of capture; this will depend on species behaviour, fish size and the type of technical measure (e.g. codend mesh size or square mesh panel mesh size and position). In practice this means that in mixed species fisheries, it is more challenging to biologically optimise a species specific minimum size (e.g. MCRS) while linking this to fishery and gear selectivity optimally simultaneously based on biological considerations

Additionally, lengths at first maturation and gear selectivity (e.g. though mesh size), are often not considered in formal stock advice. From a management perspective, it may be useful to provide such information (.e. the potential stock impacts of different exploitation patterns) and how this may impacts on potential yields. This would allow managers to assess the potential trade-offs between improvements in selectivity and potential short term losses and medium term gains in yield. Such advice could also be given in the context of mixed fisheries, where the benefits of improvements in selectivity for one species could be contrasted with the impact on catches of another.

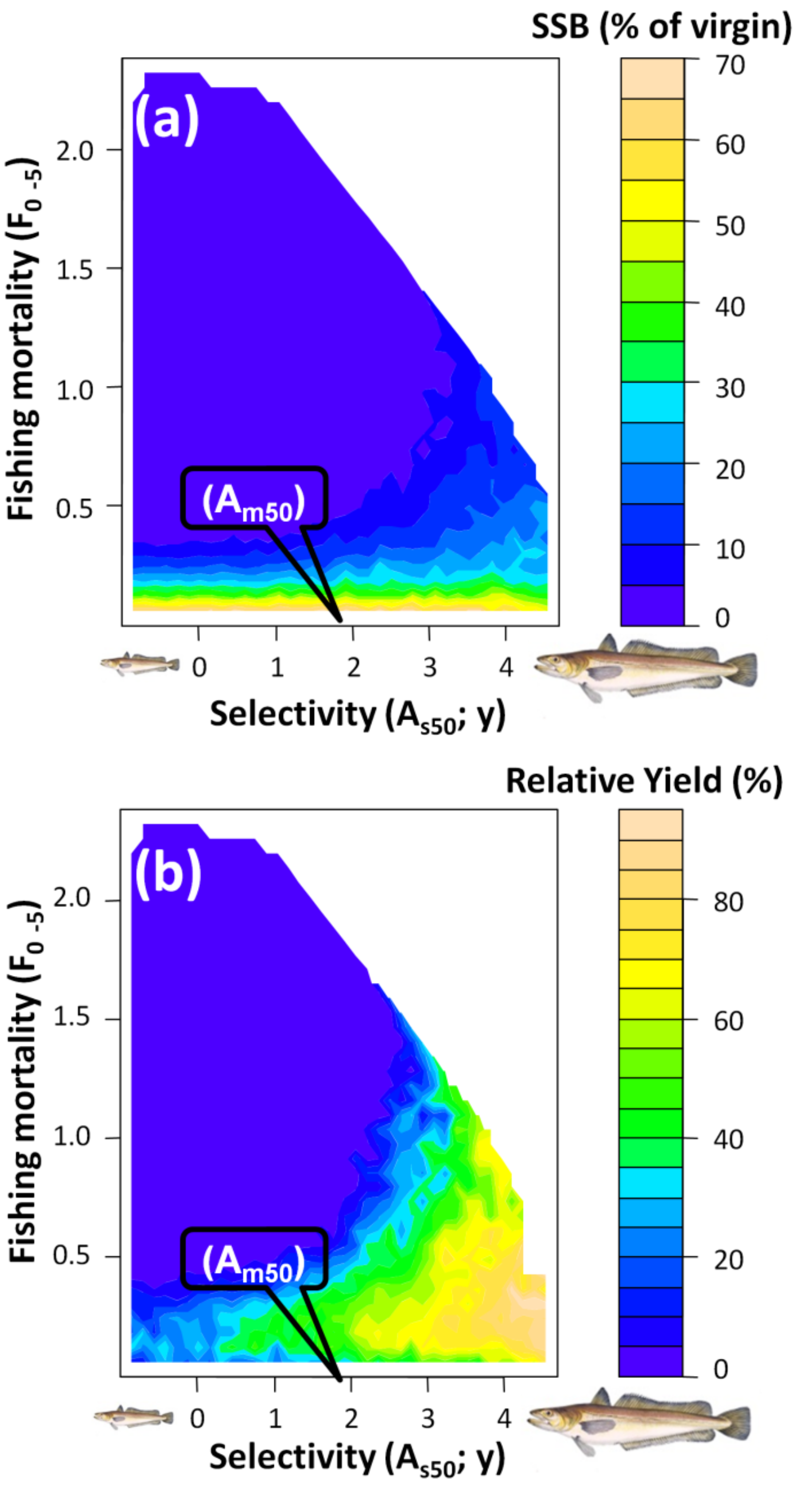


Figure 3-23 Effect of different combinations of exploitation rate and selectivity on the long-term SSB (a) and yield (b) of a simulated age-structured population of Mediterranean hake (*Merluccius merluccius*). A_{m50}: age at which 50% of fish mature, A_{s50} age at which 50% of fish are selected. Modified from Vasilakopoulos *et al.*, 2014.

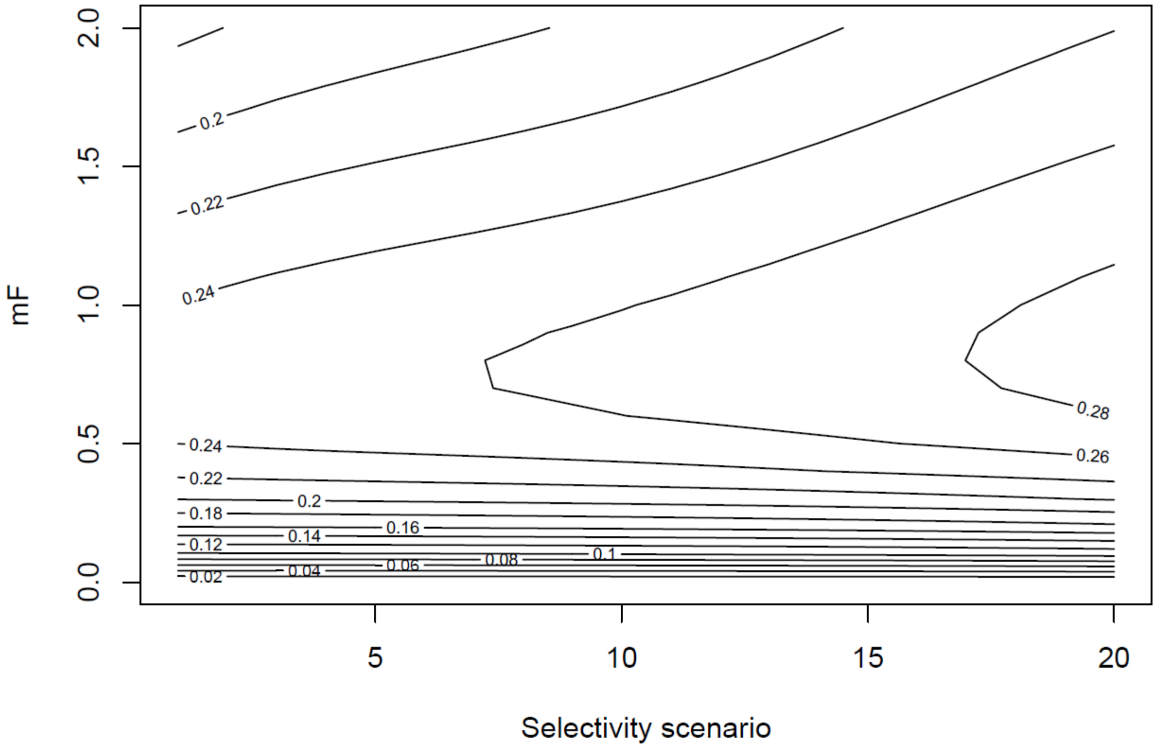


Figure 3-24 Effect of different combinations of exploitation rate (mF) and selectivity pattern on the equilibrium yield per recruit for northern hake (Atlantic hake). mF corresponds to fishing mortality multipliers applied to current level estimated by ICES (ICES, 2014). The selectivity scenarios (20 scenarios were tested) correspond to progressive 1cm shifts in the L_{50} of the main trawler fleets catching hake: scenario 1 corresponds to the current selectivity pattern while scenario 20 correspond to a shift of 19cm in L50.

Besides MCRS, the establishment of a maximum conservation reference size (MaxCRS) could also biologically sensible for certain species (e.g. long-lived demersal species such as cod, haddock, hake). This would allow big old fecund females (BOFFS) to survive. Such fish are particularly valuable as they tend to produce more, larger, and qualitatively superior eggs compared to younger spawners. This has obvious benefits for recruitment (e.g. Froese 2004; Trippel and Neill 2004; Carr and Kaufman 2009).

Despite this, protection of juveniles appears to be more effective for yield than protection of BOFFS (Brunel and Piet 2013), and the contribution of BOFFS to recruitment can be highly variable (Brunel 2010). Therefore, setting sound MCRS should be given priority over setting maximum CRS. Just like MCRS, the potential introduction of maximum CRS and its exact level should be examined on a stock-by-stock basis, taking into consideration local priorities and needs.

4 CONCLUSIONS

The landing obligation, when fully implemented is likely to incentivise fishermen to deploy technical and tactical approaches that will minimise the retention of unwanted catches. In practice, linking MCRS with fishing opportunities (e.g. permissible sale of fish >MCRS and fish <MCRS being deducted from fishing opportunities) will introduce a “catch based” approach and therefore negate the need for detailed gear related TCMs. Fishermen will be strongly incentivised to develop and deploy technical and tactical approaches aimed at achieving a specific catch profile which minimises the retention of fish below MCRS. This (and other) catch based approaches is predicated on effective implementation. If there is a high degree of trust in the monitoring and documentation of catches, then there is little need for prescriptive TCMS for the protection of juveniles. It may still be necessary to implement TCMs for other purposes e.g. protection of vulnerable habitats, fishing methods that result in high levels of unaccounted mortality.

However, the shift to a results-based approach requires full confidence in the ability of management systems to adequately quantify catch. Until the Landing Obligation has been fully implemented it will not be possible to judge the success of accurate catch reporting. As a consequence, EWG 15-01 considers that some level of minimum selectivity standards as "backstop measures" will be required in the transition from the current situation to a full catch based management system and to ensure a drift towards less selective gears does not occur.

EWG 15-01 has assessed and identified the key cod-end design features that have been shown to have a significant influence on selectivity. These are mesh size; twine thickness/stiffness; presence or absence of lifting/strengthening bags; cod-end circumference; position and mesh size of square mesh/escape panels. EWG 15-01 consider that in order to maintain a minimum level of selectivity in demersal trawl fisheries then these factors will need to be considered in a legislative context. However, the introduction of the landing obligation effectively removes the current basis for defining minimum mesh sizes, (i.e the catch composition rules).

Currently, gear related minimum TCM requirements tend to be specified through a formal linkage with the retained catch. Catch composition determines the legally permissible mesh size. Neutralisation of catch composition rules as per the omnibus regulation means that in the immediate future, there will be no formal basis for the setting of minimum mesh sizes. Four possible alternative strategies have been identified as plausible replacements for the setting of minimum mesh size with the objective of ensuring that gear selectivity and exploitation patterns do not deviate further from current levels.

Option 1 would oblige individual businesses to use mesh sizes that they have previously used based on their historic track record. This would maintain the current status quo but would represent a significant limitation on future flexibility. For example, if a business had previously used a larger mesh size (e.g. >100mm) to target cod and haddock and wished in future to switch to the targeting of *Nephrops* using a smaller mesh size (e.g. 80mm), then this would not be permissible unless gear modifications were introduced that gave a similar or better selectivity than that of the larger mesh size. Additionally, this would also represent a significant administrative overhead through the need for individual authorisations. Where changes in gear (e.g. reductions in mesh size) were sought; there would be a significant burden in the provision of the necessary evidence to demonstrate equivalence in selectivity. Furthermore, in the case of demonstrating equivalence it would be necessary to select the species which would be used for such demonstration. In practice this may be difficult, given that modifications aimed at improved selectivity in smaller mesh fisheries (e.g. *Nephrops*) to have species specific efficiencies e.g. square mesh panels may be useful in improving selectivity for haddock and whiting, but have limited effectiveness for cod.

To permit more individual business flexibility, under option 2 current gear and mesh band effort levels (e.g. gear descriptors - TR1, BT2 - as defined under the cod plan for example) would be capped. In essence this would result in a similar approach to option 1 above, but switching between effort groups could be permitted either through penalties where business wish to switch between a “high” selectivity group (e.g. TR1) to a “lower” selectivity group (e.g. TR2). The penalties could be calculated on the ratio of old/new selectivity which is similar to the effort penalties currently used in the Long Term Management Plan for cod which are based on the average cod CPUE for the specific gear/mesh groupings. Similar equivalence rules could also be applied as under option 1. This approach will also represent similar issues in terms of administrative burden and choice of demonstration species as noted above.

The third option is to link mesh size to fishing opportunities. Under this approach, business will only be permitted to land (if not subject to the landing obligation) or to sell (if subject to the landing obligation) specific species, the principle being that the greater the selectivity, the more species can be sold. For example, if a business uses a mesh size >=120mm, then it would be permitted to sell it catches of all species. If however, a business opts to use a smaller mesh size (e.g. 80mm to target *Nephrops)* then it would only be permitted to sell a much narrower range of species unless equivalence in selectivity can be demonstrated (i.e. modifications would be required that give a selectivity profile equivalent to the higher mesh sizes). The rationale behind the proposed measures is to encourage fishermen to adapt their fishing tactics so that they can take advantage of all of their fishing opportunities and at the same time, avoid unwanted catches.

There is a danger that in the transitional period leading up to full implementation of the landing obligation, skippers may choose to use a gear category that is not appropriate for all of their fishing opportunities. Such a decision may result in increased discarding of fish that cannot legitimately be sold if caught using the gear category deployed. This will particularly be true if fishermen are unable to devise and implement technical or tactical adaptations that can deliver equivalent selectivity.

Option 4 would see minimum mesh sizes based on spatial considerations. Analysis of current spatial distribution of gear and mesh size shows in most areas that the current mesh size and catch composition rules have led to the deployment of mesh sizes that are spatially explicit. For example large mesh (120mm) is used in areas in the Northern North Sea and West of Scotland to target gadoids. It may therefore be possible to apply the current mesh sizes based on specific areas. Such an approach could be further refined where there is a strong linkage between species and well defined habitat (e.g. *Nephrops*), where it could therefore be possible to specify mesh sizes based on the species distribution. This approach has the benefit of being closely aligned with existing practices and therefore minimising the impact on existing business. However, in areas where there is no clear spatial (or temporal) delineation between species such an approach may not be appropriate without additional measures otherwise mesh sizes would need to be set in line with the current lowest selectivity (e.g. *Nephrops*). This could result in a deterioration in selectivity overall, otherwise larger mesh size would be required which would result in loses of yield.

There are few examples where the efficacy of technical measures has been evaluated post-introduction. EWG 15-01 has identified several metrics that could be used to monitor, and identify fleets where adjustments to catch profiles may be warranted (i.e. identify fleets that are considered to have undesirable levels of age specific catches). Population dependent metrics (Catch and CPUE at age) can enable a direct comparison between fleets while population independent metrics (partial fishing mortality and catchability at age) provide a standardised means of comparing changes in exploitation pattern both between and within fleets over time.

EWG 15-01 has provided a comparison of the variability (CV) across both population dependent (catch and CPUE) and population independent (partial fishing mortality and catchability) which shows that in one of the examples provided (Celtic Sea Haddock) that both partial fishing mortality and catchability indicators are more stable in comparison to either of the fishery dependent indicators (catch and CPUE) while an alternative example (North Sea plaice) shows much lower variability between metrics.

Further stock specific analysis is required to assess variability between metrics and therefore determine ability to detect changes in selectivity between and within fleets. It is important to note that both of the population independent metrics require quantification of the stock biomass which means that there would typically be a two year time lag between the analysis and the fishing year as this would require full analytical assessments. The population dependent indicators of catch and CPUE could be collated within a much shorter time frame, but still require age based sampling of catch. The precision of all of the metrics is predicated on reliable catch at age data.

Comparisons between minimum size (currently MLS), the length at 50% maturity (L_{mat}) and selectivity of demersal towed gears, shows that although the MLS matches closely with mean length at maturity in most cases, the towed gears examined here catch substantial numbers of fish below the MLS e.g. L_{50}/ L_{25} is below MLS. In general, the analysis shows that where larger mesh sizes are deployed, then there is a better correlation between selectivity, MLS and L_{mat}. Because there is a close correlation between maturity and MLS, this indicates that the selectivity of the gears should be improved, rather than MLS/MCRS lowered, to minimise catches of unwanted fish as this will result in sub-optimal yields from the stocks. In complex multi-gear/multi-species fisheries which will have a range of selectivities and catch a range of species with differing L_{mat}/L_{opt} values, the choice of selectivity and minimum size will be a compromise as it is not possible to optimise all species and gears simultaneously. However, it is concluded that when deciding on MCRS and gear selectivity options, priority should be given where possible to aligning MCRS with the species biological characteristics rather than with current selectivity, particularly in settings where the current ratio between selectivity and maturity is shown to be sub-optimal. This would be more consistent with the objective of protecting juveniles.

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6 CONTACT DETAILS OF STECF MEMBERS AND EWG-15-01 LIST OF PARTICIPANTS

1 - Information on STECF members and invited experts' affiliations is displayed for information only. In some instances the details given below for STECF members may differ from that provided in Commission COMMISSION DECISION of 27 October 2010 on the appointment of members of the STECF (2010/C 292/04) as some members' employment details may have changed or have been subject to organisational changes in their main place of employment. In any case, as outlined in Article 13 of the Commission Decision (2005/629/EU and 2010/74/EU) on STECF, Members of the STECF, invited experts, and JRC experts shall act independently of Member States or stakeholders. In the context of the STECF work, the committee members and other experts do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members and invited experts make declarations of commitment (yearly for STECF members) to act independently in the public interest of the European Union. STECF members and experts also declare at each meeting of the STECF and of its Expert Working Groups any specific interest which might be considered prejudicial to their independence in relation to specific items on the agenda. These declarations are displayed on the public meeting's website if experts explicitly authorized the JRC to do so in accordance with EU legislation on the protection of personnel data. For more information: http://stecf.jrc.ec.europa.eu/adm-declarations

STECF members:

Name	**Address**[1]	**Tel.**	Email
STECF members			
Abella, J. Alvaro (vice-chair)	ARPAT – AREA MARE Agenzia Regionale per la Protezione Ambientale della Toscana Articolazione Funzionale RIBM Risorse Ittiche e Biodiversità Marina Via Marradi 114, 57126 Livorno – Italia	Tel. 0039-0555-3206956	alvarojuan.abella@arpat.toscana.it
Andersen, Jesper Levring (vice-chair)	Department of Food and Resource Economics (IFRO) Section for Environment and Natural Resources University of Copenhagen Rolighedsvej 25 1958 Frederiksberg Denmark	Tel.dir.: +45 35 28 68 92	jla@ifro.ku.dk
Bailey, Nicholas	Fisheries Research Services Marine Laboratory, P.O Box 101 375 Victoria Road, Torry Aberdeen AB11 9DB UK	Tel: +44 (0)1224 876544 Direct: +44 (0)1224 295398 Fax: +44 (0)1224 295511	N.Bailey@MARLAB.AC.UK
Bertignac, Michel	Laboratoire de Biologie Halieutique IFREMER Centre de Brest BP 70 - 29280 Plouzane, France	tel : +33 (0)2 98 22 45 25 - fax : +33 (0)2 98 22 46 53	michel.bertignac@ifremer.fr
Cardinale, Massimiliano	Föreningsgatan 45, 330 Lysekil, Sweden	Tel: +46 523 18750	massimiliano.cardinale@slu.se

Name	**Address**[1]	**Tel.**	Email
STECF members			
Curtis, Hazel	Sea Fish Industry Authority 18 Logie Mill Logie Green Road Edinburgh EH7 4HS	Tel: +44 (0)131 558 3331 Fax: +44 (0)131 558 1442	H_Curtis@seafish.co.uk
Delaney, Alyne	Innovative Fisheries Management, -an Aalborg University Research Centre, Postboks 104, 9850 Hirtshals, Denmark	Tel.: +45 9940 3694	ad@ifm.aau.dk
Daskalov, Georgi	Laboratory of Marine Ecology, Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences	Tel.: +359 52 646892	gmdaskalov@yahoo.co.uk
Döring, Ralf	Thünen Bundesforschungsinstitut, für Ländliche Räume, Wald und Fischerei, Institut für Seefischerei - AG Fischereiökonomie, Palmaille 9, D-22767 Hamburg, Germany	Tel.: 040 38905-185 Fax.: 040 38905-263	ralf.doering@ti.bund.de
Gascuel, Didier	AGROCAMPUS OUEST 65 Route de Saint Brieuc, bat.4 CS 84215, F-35042 RENNES Cedex France	Tel:+33(0)2.23.48.55.34 Fax: +33(0)2.23.48.55.35	Didier.Gascuel@agrocampus-ouest.fr
Graham, Norman (chair)	Marine Institute, Fisheries Science Services (FSS), Rinville, Oranmore, Co. Galway, Ireland	Tel: + 353(0) 91 87200	norman.graham@marine.ie
Garcia Rodriguez, Mariano	Instituto Español de Oceanografía, Servicios Centrales, Corazón de María 8, 28002, Madrid, Spain		Mariano.Garcia@md.ieo.es
Gustavsson, Tore Karl-Erik	Independent Consultant, Göteborg, Sweden		tore.gustavsson@hotmail.com
Jennings, Simon	CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft Suffolk, UK NR33 0HT	Tel.: +44 1502562244 Fax: +44 1502513865	simon.jennings@cefas.co.uk
Kenny, Andrew	CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft Suffolk, UK NR33 0HT	Tel.: +44 1502562244 Fax: +44 1502513865	andrew.kenny@cefas.co.uk
Kraak, Sarah	University College Cork Based at: Marine Institute, Rinville, Oranmore, Co Galway, Ireland	Tel: +353 (0)91 387392 Fax +353 (0)91 387201	Sarah.kraak@marine.ie
Kuikka, Sakari	University of Helsinki, Department of Environmental Sciences, P.O. Box 65 (Viikinkaari 1), FI-00014 University of Helsinki, FINLAND	Tel.: +358 50 3309233 Fax. +358-9-191 58754	skuikka@mappi.helsinki.fi

Name	Address[1]	Tel.	Email
STECF members			
Martin, Paloma	CSIC Instituto de Ciencias del Mar PasseigMarítim, 37-49 08003 Barcelona Spain	Tel: 34.93.2309500 direct line : 34.93.2309552 Fax: 34.93.2309555	paloma@icm.csic.es
Malvarosa, Loretta	NISEA S.c.a.r.l.		malvarosa@nisea.eu
Murua, Hilario	AZTI - Tecnalia / Unidad de Investigación Marina, Herrera kaia portualdea z/g 20110 Pasaia (Gipuzkoa), Spain	Tel: 0034 667174433 Fax: 94 6572555	hmurua@azti.es
Nord, Jenny	The Swedish Agency of Marine and Water Management (SwAM)	Tel. 0046 76 140 140 3	Jenny.nord@havochvatten.se
Nowakowski, Piotr	Maritime University of Szczecin. – Faculty of Food Science and Fisheries, Department of Fishing Technique, Szczecin		npfgd@poczta.onet.pl
Prelezzo, Raul	AZTI - Tecnalia / Unidad de Investigación Marina Txatxarramendi Ugartea z/g 48395 Sukarrieta (Bizkaia), Spain	Tel: 94 6029400 Ext: 406- Fax: 94 6870006	rprellezo@suk.azti.es
Sala, Antonello	Fishing Technology Unit National Research Council (CNR) Institute of Marine Sciences (ISMAR) - Fisheries Section Largo Fiera della Pesca, 1 60125 Ancona - Italy	Tel: +39 071 2078841 Fax: +39 071 55313	a.sala@ismar.cnr.it
Scarcella, Giuseppe	Environmental Management Unit National Research Council (CNR) Institute of Marine Sciences (ISMAR) - Fisheries Section Largo Fiera della Pesca, 1 60125 Ancona - ITaly	Tel: +39 071 2078846 Fax: +39 071 55313	g.scarcella@ismar.cnr.it
Somarakis, Stylianos	Department of Biology University of Crete VassilikaVouton P.O. Box 2208 71409 Heraklion Crete Greece	Tel.: +30 2610 394065, +30 6936566764	somarak@biology.uoc.gr
Stransky, Christoph	Thünen Institute [TI-SF] Federal Research Institute for Rural Areas, Forestry and Fisheries, Institute of Sea Fisheries, Palmaille 9, D-22767 Hamburg, Germany	Tel. +49 40 38905-228 Fax: +49 40 38905-263	christoph.stransky@ti.bund.de
Theret, Francois	Scapêche 17 Bd Abbé Le Cam 56100 Lorient France		ftheret@comata.com
Ulrich, Clara	DTU Aqua, National Institute of Aquatic Resources, Technical University of Denmark, Charlottenlund Slot, JægersborgAllé 1, 2920 Charlottenlund, Denmark		cu@aqua.dtu.dk
Vanhee, Willy	ILVO - Institute for Agricultural and Fisheries Research Unit Animal Sciences - Fisheries Ankerstraat 1, B-8400 Oostende, Belgium	Tel 00-32-59-34-22-55 Fax 00-32-59-33-06-29	willy.vanhee@ilvo.vlaanderen.be

Name	Address[1]	Tel.	Email
STECF members			
van Oostenbrugge, Hans	LandbouwEconomishInstituut-LEI, Fisheries Section, Burg. Patijnlaan 19 P.O.Box 29703 2502 LS The Hague The Netherlands	Tel:+31 (0)70 3358239 Fax: +31 (0)70 3615624	Hans.vanOostenbrugge@wur.Nl

EWG-15-01 participants:

STECF members		
Name	**Address[1]**	**Email**
Graham, Norman (chair)	Marine Institute, Fisheries Science Services (FSS), Rinville, Oranmore, Co. Galway, Ireland	norman.graham@marine.ie
Bailey, Nicholas	Fisheries Research Services Marine Laboratory, P.O Box 101 375 Victoria Road, Torry Aberdeen AB11 9DB UK	N.Bailey@MARLAB.AC.UK
Bertignac, Michel	Laboratoire de Biologie Halieutique IFREMER Centre de Brest BP 70 - 29280 Plouzane, France	michel.bertignac@ifremer.fr
Sala, Antonello	Fishing Technology Unit National Research Council (CNR) Institute of Marine Sciences (ISMAR) - Fisheries Section Largo Fiera della Pesca, 1 60125 Ancona - Italy	a.sala@ismar.cnr.it
Ulrich, Clara	DTU Aqua, National Institute of Aquatic Resources, Technical University of Denmark, Charlottenlund, Denmark	cu@aqua.dtu.dk

Invited experts		
Name	**Address[1]**	**Email**
Catchpole, Thomas	CEFAS Laboratory, Pakefield Road, Lowestoft Suffolk, UK NR33 0HT Lowestoft	thomas.catchpole@cefas.co.uk
McDonald, Daniel	Bord Iascaigh Mhara Irish Sea Fisheries Board, Ireland	dmcdonald@bim.ie

Minto, Coilin	Galway-Mayo Institute of Technology, Ireland	Coilin.Minto@gmit.ie
O'Neill Barry	Fisheries Research Services Marine Laboratory, P.O Box 101 375 Victoria Road, Torry Aberdeen AB11 9DB UK	oneillb@marlab.ac.uk
Valentinsson, Daniel	Swedish University of Agricultural Sciences, Sweden	daniel.valentinsson@slu.s
Vasilakopoulos, Paraskevas	Institute of Marine Biological Resources (IMBR), Hellenic Centre for Marine Research (HCMR), 46.7km Athens-Sounio ave. 19013, Anavyssos, Attiki, Greece	pvasilakopoulos@hcmr.gr

JRC expert		
Name	**Address**[1]	**Email**
Casey, John	Joint Research Centre JRC	John.casey@jrc.ec.europa.eu

European Fisheries Control Agency		
Name	**Address**	**Email**
Stewart, William	European Fisheries Control Agency, Garcia Barbon, 4, 36201 Vigo, Spain	william.stewart@efca.europa.eu

European Commission		
Name	**Address**	**Email**
Doerner, Hendrik	Joint Research Centre JRC, STECF secretariat	Stecf-secretariat@ jrc.ec.europa.eu
Rihan, Dominic	DG MARE, A2	Dominic.RIHAN@ec.europa.eu
Griffin, Robert	DG MARE, C2	robert.griffin@ec.europa.eu

7 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg1501

List of background documents:

1. EWG-15-01 – Doc 1 - Declarations of invited and JRC experts (see also section 6 of this report – List of participants)

European Commission

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Authors:

STECF members:
Graham, N., J., Abella, J. A., Andersen, J., Bailey, N., Bertignac, M., Cardinale, M., Curtis, H., Daskalov, G., Delaney, A., Döring, R., Garcia Rodriguez, M., Gascuel, D., Gustavsson, T., Jennings, S., Kenny, A., Kraak, S., Kuikka, S., Malvarosa, L., Martin, P., Murua, H., Nord, J., Nowakowski, P., Prellezo, R., Sala, A., Scarcella, G., Somarakis, S., Stransky, C., Theret, F., Ulrich, C., Vanhee, W. & Van Oostenbrugge, H.

EWG-15-01 members:
Graham, N., Bailey, N., Bertignac, M., Sala, A., Ulrich, C., Catchpole, T., McDonald, D., Minto, C., O'Neill B., Vasilakopoulos, P., Valentinsson, D. & Casey, J.

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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.

JRC Mission

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.

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