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Marine Strategy Framework Directive- Descriptor 3 report

The report below is a result of a process undertaken by ICES to provide guidance to support EU Member States (MS) in the implementation of the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC). The document focuses on Descriptor 3 (D3), commercially exploited fish and shellfish, but fisheries-related information relevant for the other Descriptors is also identified and reported on.

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Core Group Report

Marine Strategy Framework Directive – Descriptor 3+

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 Introduction

This is a report of a process undertaken by ICES to provide guidance to support EU Member States (MS) in the implementation of the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC). The process focused on Descriptor 3 (D3), commercially exploited fish and shellfish, but fisheries-related information relevant for the other Descriptors is also identified and reported on.

The terms of Reference (ToRs) for the process were:

- Review how assessments, indicators and targets based on the best available science can be developed regarding MSFD Descriptor 3 on a regional seas basis:
    - Identify which fish stocks come under the scope of Descriptor 3
    - Select an assessment scale for each stock identified
    - For these stocks, prepare an initial assessment as described in Article 8 of the MSFD
    - Referring to the initial assessment propose a set of characteristics for good environmental status (GES) based on Descriptor 3 as described in Article 9 of the MSFD. This will include consideration and advice on how to aggregate indicators.
    - Referring to the initial assessment, propose a comprehensive set of environmental targets related to the indicators set out in the Commission Decision 2010/477/EU and as described in Article 10 of the MSFD
- Review how fisheries and fish community data such as those collected through the Data Collection Framework (DCF) including the fisheries ecosystem impact indicators of the DCF can contribute to assessments and indicators for other MSFD descriptors on a regional basis, notably Descriptors 1, 4 and 6.
- Propose a core set of indicators which other users could use to report on the impact of fisheries on the ecosystem. The set of indicators will be used by ICES for annual reporting, but may also serve the purpose of the DCF Appendix XIII, EEA and Eurostat.

The work was led by a small Core Group of experts supported by two workshops in which ICES Member Countries experts were invited along with experts from the Regional Seas Conventions, the European Environment Agency (EEA) and other stakeholders. The report of the first workshop, held during 4-8 July 2011, is available at http://www.ices.dk/reports/ACOM/2011/WKMSFD1-D3/WKMSFD1%20D3+%202011.pdf. A specific report of the second workshop, held during 5-7 October 2011, has not been prepared as the input of both workshops is compiled into this final process report prepared by the Core Group. Lists of participants and Core Group members at both the first and second Workshops are provided in Annex 1.

This final report, prepared by the Core Group, describes the process, assessment methodologies, the key issues and recommendations, as well as their implications for defining GES and environmental targets and indicators for D3. The participants of both workshops have been given the opportunity to comment on the report and the comments have been considered by the Core Group but it is not necessarily an agreed report of all the participants.

ICES has undertaken this work on its own initiative. The result is not ICES advice but provides technical/scientific support to the EU Member States and shows worked examples of how the requirements of the MSFD with respect to D3 can be fulfilled.

1.1 Background

Descriptor 3 for determining Good Environmental Status (GES) under the MSFD was defined as "Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock" (Directive 2008/56/EC, Annex I).

In the Commission Decision 2010/477/EU three criteria including methodological standards were described for this descriptor. Here methodological standards are defined in general terms as all methods developed and agreed in the framework of European or international conventions (Piha and Zampoukas, 2011). The three criteria and associated indicators are:

Criterion 3.1 Level of pressure of the fishing activity

- Primary indicator: Indicator 3.1.1 Fishing mortality (F)
- Secondary indicator (if analytical assessments yielding values for F are not available): Indicator 3.1.2 Ratio between catch and biomass index (hereinafter 'catch/biomass ratio')

Criterion 3.2 Reproductive capacity of the stock

- Primary indicator: Indicator 3.2.1 Spawning Stock Biomass (SSB)
- Secondary indicator (if analytical assessments yielding values for SSB are not available): Indicator 3.2.2 Biomass indices

Criterion 3.3 Population age and size distribution

- Primary indicator: Indicator 3.3.1 Proportion of fish larger than the mean size of first sexual maturation
- Primary indicator: Indicator 3.3.2 Mean maximum length across all species found in research vessel surveys
- Primary indicator: Indicator 3.3.3 95% percentile of the fish length distribution observed in research vessel surveys
- Secondary indicator: Indicator 3.3.4 Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation

1.2 Approach followed and structure of report

This report first describes the different criteria to use for the selection of "Populations of all commercially exploited fish and shellfish" and lists the relevant MSFD (sub)regions (chapter 2). Then chapter 3 focuses on the stocks for which analytical stock assessments are conducted, as these provide the indicators and reference levels that allow an assessment of current status in relation to GES based on criteria 3.1 and 3.2. As no reference levels have so far been defined for the indicators under Criterion 3.3, this criterion is not considered in this chapter. Chapter 4 considers the populations for which only information from monitoring programs is available. This information should provide the secondary indicators for criteria 3.1 and 3.2 as well as some or all of the indicators for criterion 3.3. Because no reference values are available when based on this source of information, the assessment against GES should be considered less robust. In chapter 5 we briefly consider how GES can be assessed for MSFD Descriptor 3.

Chapter 6 develops case studies covering several of the MSFD (sub)regions, namely, the Baltic Sea, North Sea, Celtic Seas, Bay of Biscay and Iberian Coast, and Mediterranean Sea (see Figure 1.2.1). Following the MSFD in that "Each Member State should therefore develop a marine strategy for its marine waters which, while being specific to its own waters, reflects the overall perspective of the marine region or subregion concerned.", we needed to apply a member state (MS) perspective in some of the case studies to reflect that in those (sub)regions it is likely that for at least some of the MSs their assessment will not be applied on a (sub)regional basis. Another point to note is that the case studies should *NOT* be considered to represent *THE* assessment of status in relation to GES of any specific MS but merely as applications of the approach developed by this group and applied by the regional experts within the group.

The outcomes of the case studies are then used in chapter 7 to show how the actual assessment of current status in relation to GES could be conducted based on the available information. Chapter 7 is the main chapter of this report. It provides a comprehensive structured summary of the potential approaches which emerged from the case studies presented in this report. The roadmap provided in this chapter should not be taken as prescriptive but is intended to provide a structured summary of potential approaches that could reasonably be used by MSs for developing their assessments and determining the current status of their marine waters in relation to GES for Descriptor 3.

Finally, we considered the potential ability of other fisheries related indicators collected under the Data Collection Framework (DCF) to report on the impacts of fishing on the environment as a whole. This was to support development of a core set of indicators that could be used to report on the wider impacts of fishing, and to monitor the impacts of fishing on MSFD descriptors other than descriptor 3. The merits of these indicators and requirements for further development are discussed in chapter 8.

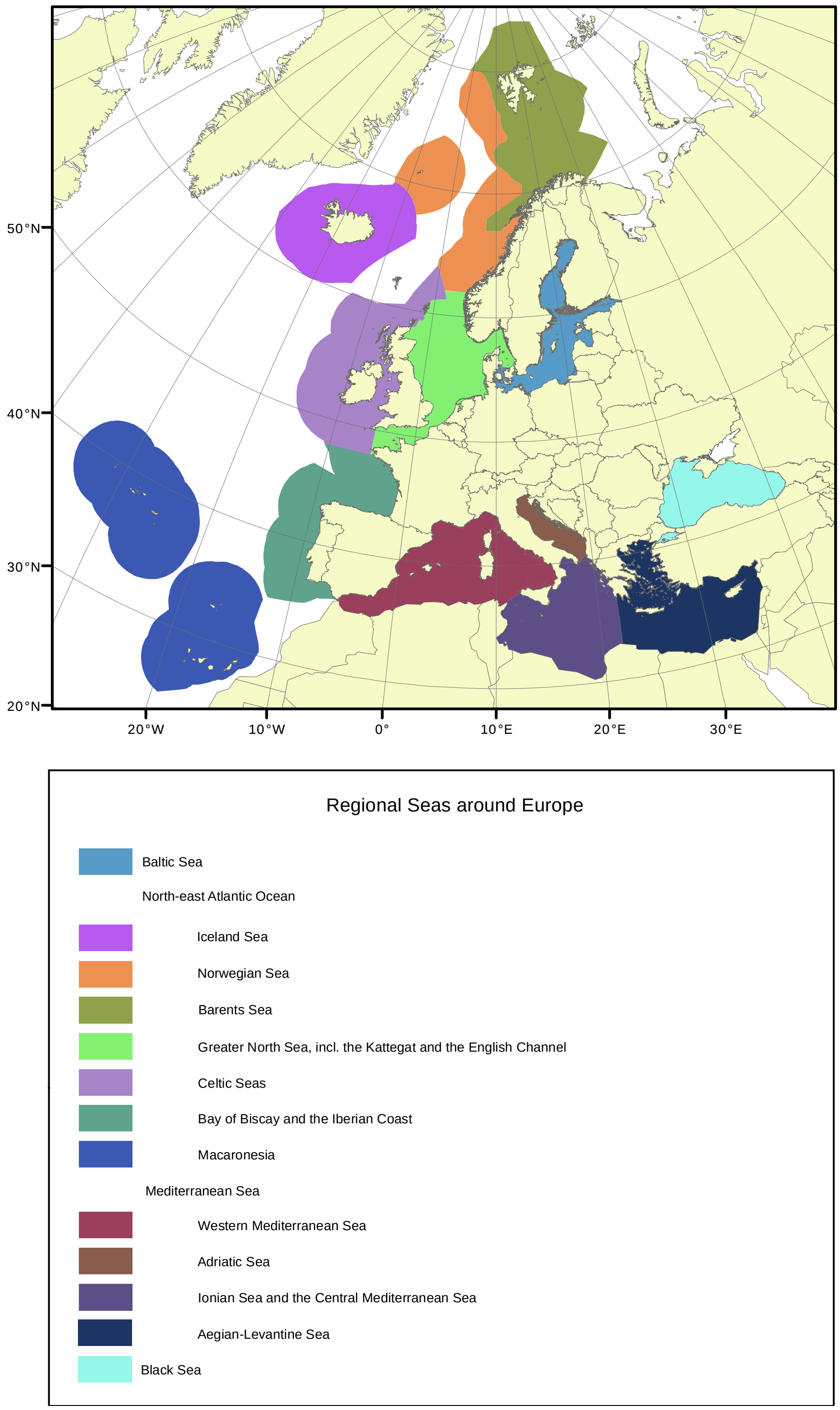


Figure 1.2.1. MSFD regions and subregions. Note this is still a draft figure which is currently under consultation with Member States, in the context of the MSFD Common Implementation Strategy WG DIKE (Data, Information and Knowledge Exchange)

2 Commercially exploited (shell)fish populations

The first issue to be addressed is what are considered the commercially exploited (shell)fish populations for each MSFD (sub)region. The main criterion for inclusion of populations should be based on their contribution to commercial landings by weight in each (sub)region (where the landings should, of course, come from all countries prosecuting the fisheries). For this several sources of information were considered, e.g. the FAO Fishstat database, which is based on actual logbook information, or the DCF (see Appendix VII Commission Decision 2008/949), where the following species groups are considered: 1) Species that drive the international management process including species under EU management plans or EU recovery plans; 2) Other internationally regulated species and major non-internationally regulated by-catch species; 3) All other by-catch (fish and shellfish) species.

The following issues need to be considered:

- Choosing the appropriate areas to extract data from the database for each MSFD marine region and sub-regions. The use of different regional boundaries is an issue since there is still no agreed map of the boundaries of the MSFD marine regions and sub-regions. Therefore EEA, supported by ICES (as part of the EEA European Topic Centre on Inland, Coastal and Marine waters) and in consultation with a few Member States, developed at the beginning of 2011 a draft map of the European Regional Seas as identified in the MSFD art.4. This draft map (Figure 1.2.1) is currently under consultation with MSs, in the context of the MSFD Common Implementation Strategy WG DIKE (Data, Information and Knowledge Exchange). The agreed version will be made available as soon as the consultation process ends (Spring 2012). This map should be the basis for the selection of stocks for assessment in each region and as such the Fishstat and ICES assessment areas need to be mapped against these MSFD marine regions and su-regions. Please notice that Member States have the option for identifying subdivisions, which are divisions of the subregion. These have not been discussed yet, but it might be useful for assessment of stocks to operate with subdivisions as long as the assessments can be compiled at the subregion or regional level at a later stage.
- The time period over which the landings data are considered determines the relative importance of species or species groups. This relative importance may change to the point that some species/taxa that decrease in their relative importance beyond some set threshold (based on some percentage of the total landings in the geographical area considered) drop from the suite of selected species. For example: species that may have been an important component of the overall landings in the 1950s may have become rare and hence exploitation has ceased. These species would not appear in the ranking based on only data from recent years.
- Threshold for inclusion of species.There was a discussion on how species could be selected for the assessment under MSFD descriptor 3. One suggestion was to consider all species that contributed more than a specific threshold of the overall landings. Initially 1% of the landings was suggested. However, for the Baltic it was decided to use 0.1% as the threshold in order to include salmon which is considered an important commercial species but which contributes less than 1% to the landings. It was also

pointed out that the relative contribution of pelagic/demersal/benthic species would change as you increase the number of species. Whatever the threshold chosen, it is important that the list of selected species is comprehensive and includes most of the landings in the region. Whether this should be >99%, > 95% or even 90% should be decided. In practice it may turn out that for part of those species no information is available. The minimum proportion of the landings that need to be covered by stocks for which information exists is another decision issue that needs to be considered.

- It could be relevant to distinguish different categories for which to determine the relative proportions, e.g. pelagic, demersal and benthic, so as to avoid important species of a relatively small category falling below the threshold due to high catches of species in another category.
- There is the possibility for other (e.g. socio-economic) considerations than the suggested weight of landings for inclusion of a particular species. The reason for only considering weight of landings in this report is that this information is readily and consistently available for all MSFD regions.
- The Fishstat database is not up-to-date. This needs to be considered as well as how many of the last years need to be included. In the ICES/JRC Task Group 3 report this was arbitrarily set at the last 5 years for which the database was up-to-date (i.e. 2003-2007) but for the initial assessment and future assessments against GES this is to be decided.
- As the MSFD states that MSs are responsible to assess whether GES is achieved in their national waters, a MS can decide to include one or more species/taxa that would not appear in the list of regionally important species but may be considered important from a MS perspective (e.g. a species that occurs almost exclusively in one MS's national waters or supports a national fishery). For these MS-specific species/taxa there is no need to agree with the other MSs bordering the same MSFD (sub)region on one consistent approach as applies for the "regional" stocks, i.e. those that fall under Common Fisheries Policy (CFP) or support international fisheries and which occur more or less throughout the region. The inclusion of such MS-specific species/taxa, however, may result in different outcomes in the GES assessment of bordering MSs belonging to the same MSFD (sub)region.

2.1 Sub-division of the (sub)region

According to the MSFD Article 4 on Marine regions or subregions:

1. Member States shall, when implementing their obligations under this Directive, take due account of the fact that marine waters covered by their sovereignty or jurisdiction form an integral part of the following marine regions:

(a) the Baltic Sea;

(b) the North-east Atlantic Ocean;

(c) the Mediterranean Sea;

(d) the Black Sea.

2. Member States may, in order to take into account the specificities of a particular area, implement this Directive by reference to subdivisions at the appropriate level of the marine wa-

ters referred to in paragraph 1, provided that such subdivisions are delimited in a manner compatible with the following marine subregions:

(a) in the North-east Atlantic Ocean:

(i) the Greater North Sea, including the Kattegat, and the English Channel;

(ii) the Celtic Seas;

(iii) the Bay of Biscay and the Iberian Coast;

(iv) in the Atlantic Ocean, the Macaronesian biogeographic region, being the waters surrounding the Azores, Madeira and the Canary Islands;

(b) in the Mediterranean Sea:

(i) the Western Mediterranean Sea;

(ii) the Adriatic Sea;

(iii) the Ionian Sea and the Central Mediterranean Sea;

(iv) the Aegean-Levantine Sea.

MSs may therefore define specific subdivisions within their MSFD (sub)region based on the specificities of that area and conduct separate assessments for each subdivision. These assessments, however, can follow the same approach as proposed in this report and applied to the different MSFD (sub)regions.

3 Species covered by stock assessments

3.1 Introduction

The main reason for distinguishing assessed from non-assessed stocks is that stock assessments usually calculate two primary indicators (F and SSB) for which often reference levels exist, thereby covering respectively the first two criteria of Descriptor 3:

- Criterion 3.1 Level of pressure of the fishing activity:
- Criterion 3.2 Reproductive capacity of the stock

However, applying the information from stock assessments to these two criteria is often not a straightforward exercise and several issues need to be considered:

What should be considered an "assessed" stock? Within ICES there is a continuum from analytical assessments providing estimates of F and SSB (with or without reference levels), to analytical assessments providing only indicative trends in F and SSB (normally without reference levels), to empirical indicators used as indicative of stock trends. The list will be either everything on which ICES gives advice or some subset of this depending on agreed criteria. Possible criteria for inclusion in this section are whether or not (and which) indicators are given (i.e. level of exploitation (F) and reproductive capacity (SSB)) and whether or not one (or more) reference levels are given (i.e. MSY-based, lim or pa, the latter two corresponding to the ICES precautionary approach).

Other bodies such as GFCM or ICCAT also conduct stock assessments that provide indicators and apply reference levels. Similar criteria to the above can be applied to use the information from these sources.

What stocks should be considered for the (sub)region? For this it is important to adopt a practical and common sense approach to the mapping of stocks to areas. This could involve 3 basic principles:

1) stocks entirely within an area map to that area,
2) straddling or highly migratory stocks appear within the areas they straddle or migrate and are fished through,
3) stocks which partially extend into another area will be placed in the area in which they are primarily distributed and fished.

Pertaining to the choice of reference levels it is important here to note that neither the ICES workshops WKMSFD nor anyone helping prepare the example assessments have put forward any Descriptor 3 reference levels which are not consistent with advice from ICES or similar bodies in the Mediterranean and Black Sea (e.g. GFCM, ICCAT) in order to avoid generating "noise" between the MSFD and the CFP.

Reference levels are supposed to be scientific (non-judgemental) values. The setting of MSY-based reference values for stocks can be based on clear and objective routines and where possible this approach should be followed. Stock status summary sheets provide a useful starting point to support this, but do not provide reference levels for all stocks. The use of the pristine concept to set reference levels is not useful for commercial (shell)fish, as these stocks are unlikely to ever return to such conditions, especially since the MSFD supports sustainable exploitation of resources. When making a comparison with the past care needs to be taken that exceptional historic conditions (e.g. the gadoid outburst) do not affect our perspective of what "good" conditions look like when working with trends and trying to choose a period of years as a reference.

3.2 Fishing mortality (F)

For the indicator on fishing mortality (F) the following reference levels may exist:

- F_{lim} - the fishing mortality level above which, over the long term, the stock will be reduced to levels at which it suffers severely reduced reproductive capacity
- F_{pa} - because of uncertainties in the assessment process, F_{pa} is defined as a precautionary fishing mortality (lower than F_{lim}) designed to result in avoidance of exceeding F_{lim} when F is estimated to be below F_{pa}
- F_{MSY} - the level of fishing mortality that achieves maximum sustainable yield (MSY) over the long term based on growth and natural mortality rates, the selection pattern of the fishery and recruitment changes associated with the level of adult biomass (stock-recruitment relationship)
- F_{max} - the level of fishing mortality that maximises the long term average yield per recruit; based on the same quantities as F_{MSY} but without using a stock-recruitment relationship
- $F_{0.1}$ - a more conservative (lower) fishing mortality reference level than F_{max}; as for F_{max}, $F_{0.1}$ is based on the long term average yield per recruit; $F_{0.1}$ is often used when F_{max} is not well defined or when a more conservative reference level than F_{max} is sought

Fishing mortality reference levels F_{lim} and F_{pa} have been used by ICES as indicators of stock status since the introduction of the Precautionary Approach in the late 1990s. In general terms, fishing mortality rates are specified as limits (e.g. F_{lim}, F_{pa}) which define "safe" levels of exploitation (below the threshold) and targets (e.g. F_{MSY}, $F_{0.1}$, F_{max}) for achieving a high long-term yield from the stock. Some issues may need to be resolved: e.g. DGMARE uses F_{MSY} as a target while Commission Decision 2010/477/EU states that F_{MSY} is a limit. For the Mediterranean Sea and Black Sea, the GFCM Scientific Advisory Committee agreed on adopting F_{max} as a limit reference point and $F_{0.1}$ as a technical target reference point, used as proxy for F_{MSY}, for demersal species (GFCM, 2011).

F_{MSY}, F_{max} and $F_{0.1}$ are defined on the basis of single species analysis which does not include predator-prey interactions or linkages to ecosystem productivity. The reference levels are also dependent on the selection pattern of the fishery (the distribution of fishing mortality at length or age); for example recent measures to reduce discarding of small fish, if successful, will change the selection pattern of the fishery and, hence, the F_{MSY} reference value. Consequently, the reference levels are unlikely to be stable in the long-term and will require recalculation as stocks rebuild and the balance of predators and preys changes over time.

Given the variability and uncertainty inherent in the estimation of fishing mortality reference levels and the difficulty (impossibility!) of simultaneously maintaining all stocks in a mixed fishery at their optimum exploitation rate, a range within which the exploitation rate is maintained (e.g. F_{MSY} +/- x%) may be considered appropriate rather than using the exact reference levels as limit or target values. It must be noted that the Commission Decision 2010/477/EU states that "in mixed fisheries and where ecosystem interactions are important, long term management plans may result in exploiting some stocks more lightly than at F_{MSY} levels in order not to compromise the exploitation at F_{MSY} of other species". The implications of allowing a range around the target reference values will be considered during the regional case studies and incorporated in the GES assessments.

For application of the above reference levels the following applies:

- In order to ensure a low risk of stock depletion fishing mortality should be maintained below the stock-specific Precautionary Approach fishing mortality limit F_{lim}. In practical terms, this means that estimates of fishing mortality should be below F_{pa}.
- To achieve sustainable levels of exploitation consistent with GES, fishing mortality should also be maintained at levels consistent with the stock-specific value of F_{MSY}.
- In the absence of the former, only the latter applies

3.3 Spawning stock biomass (SSB)

For the indicator on Spawning Stock Biomass (SSB) the following reference levels may apply:

- B_{lim} - A level of SSB defined such that below B_{lim} there is a high risk that the stock suffers from severely reduced reproductive capacity or the stock dynamics are unknown.
- B_{pa} - Because of uncertainties in the assessment process, a precautionary level of SSB (higher than B_{lim}) designed to result in avoidance of going below B_{lim} when SSB is estimated to be above B_{pa}.
- SSB_{MSY} (or B_{MSY}) - The level of SSB that would achieve maximum sustainable yield (MSY) under a fishing mortality equal to F_{MSY}. For a stock fished constantly at F_{MSY}, SSB_{MSY} is obtained in the long term. This value of SSB is not expected to be constant, but rather to fluctuate due to natural variability and species interaction.
- $B_{MSY\text{-}trigger}$ - A level of SSB below which the stock is outside the range of values associated with SSB_{MSY}. An appropriate choice of $B_{MSY\text{-}trigger}$ requires contemporary data with fishing at F_{MSY} to experience the normal range of fluctuations in SSB. Until this experience is gained, B_{pa} has, for the time being, been adopted for many stocks assessed by ICES as $B_{MSY\text{-}trigger}$ even though B_{pa} and $B_{MSY\text{-}trigger}$ formally correspond to different concepts.

These reference levels for SSB are only available for the ICES areas as GFCM and ICCAT usually do not provide them.

The reference level for SSB given by the Commission Decision 2010/447/EU is SSB_{MSY}. As explained above, due to natural variability and species interaction a fixed point is difficult to attain and highly theoretical.

B_{lim} and B_{pa} have been used by ICES to define stock status in terms of reproductive capacity since the introduction of the Precautionary Approach. SSB reference levels are often used to define change points at which fishing mortality is reduced if SSB falls below them or increased if SSB recovers, within harvest control rules that form the basis of stock management plans.

Even stronger than with the fishing mortality reference levels, a problem of SSB reference levels is that they have been defined on the basis of single species stock theory, without including predator-prey interactions or linkages to ecosystem productivity.

As a consequence they are unlikely to be stable in the long term and will require re-calculation as stocks rebuild and the balance of predators and prey changes over time. This is also implicit in the Commission Decision 2010/477/EU, which states that "Further research is needed to address the fact that a SSB corresponding to MSY may not be achieved for all stocks simultaneously due to possible interactions between them".

There is a direct linkage between the fishing mortality targets defined previously and the SSB targets described in this section. They must be estimated and applied simultaneously, if used together to manage the fisheries towards GES.

The lack of SSB reference levels should not prevent the definition of GES for a stock. If fishing mortality is at a level consistent with F_{MSY} over the long term, then that should be sufficient to define GES for stocks where SSB estimates are impractical, for instance the less abundant but commercially important finfish species and the majority of shellfish stocks. This approach, however, relies strongly on getting appropriate estimates of F_{MSY} and ensuring that fishing exploitation is consistent with F_{MSY} in the long term.

For application of the above SSB reference levels the following applies:

- In order to avoid a reduced reproductive capacity and, thus, ensure a low risk of stock depletion SSB should be maintained above the stock specific Precautionary Approach limit B_{lim}. In practical terms, this means that SSB estimates should be above B_{pa}.
- To achieve sustainable levels of exploitation consistent with GES, SSB should be maintained at or above the stock specific reference level $B_{MSY\text{-}trigger}$. If SSB falls below the $B_{MSY\text{-}trigger}$, the current ICES MSY harvest control rule proposes that fishing mortality be reduced proportionately below F_{MSY} to allow the stock to rebuild.

4 Species covered by monitoring programs

4.1 Introduction

For those species that are relevant from a commercial perspective but for which no stock assessments are available the first two criteria need to be assessed by two secondary indicators:

- 3.1.2 Ratio between catch and biomass index
- 3.2.2 Biomass indices

that require data from monitoring programs for their calculation. Additionally, the indicators for the third criterion (Criterion 3.3 Population age and size distribution) also require data from monitoring programs for their calculation. These indicators are:

- Primary indicator: 3.3.1 Proportion of fish larger than the mean size of first sexual maturation
- Primary indicator: 3.3.2 Mean maximum length across all species found in research vessel surveys
- Primary indicator: 3.3.3 95% percentile of the fish length distribution observed in research vessel surveys
- Secondary indicator: 3.3.4 Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation

Each of those indicators is discussed below in some more detail and with background information.

4.2 Ratio between catch and biomass index

Calculation of this indicator for each specific species requires catch information and a biomass index (i.e. CPUE of a research vessel survey or an appropriately standardized CPUE of the commercial fishery, see WKCPUEFFORT 2011 for insights on this issue). It is worth noting that for many commercial species only landings data are available, while catches (landings + discards + IUU catches) are lacking. Where discards and IUU catches are unknown, landings can be considered as a proxy for catches.). The main requirement is that the catch (landings) data and biomass index need to match as closely as possible in terms of area covered, the definition of the species (e.g. sometimes the landings are reported for higher taxa) and possibly other criteria.

4.3 Biomass indices

Calculation of biomass indices is described above. Applying some transformation (e.g. log) to improve the signal-to-noise ratio can be considered. It should be noted that the Commission Decision 2010/477/EU states that for biomass indices to be appropriate indicators of stock reproductive capacity they must refer to the fraction of the population that is sexually mature. Hence, the biomass index used as Indicator 3.2.2 under Criterion 3.2 would normally refer to a different fraction of the population than the biomass index used in Indicator 3.1.2 under Criterion 3.1. In order to make that distinction, however, some indication of size at maturity should be available. If this is not available, we propose that total biomass be used as a proxy of the stock reproductive capacity (i.e. as Indicator 3.2.2).

4.4 Proportion of fish larger than the mean size of first sexual maturation

This indicator can be calculated at a population and community/assemblage level: To address criterion 3.3 it should be calculated at the population level:

At the population level it can be calculated as proportion of biomass > mean size of first sexual maturation. This mean size should be based on an agreed list that may differ between (sub)regions. Using biomass instead of numbers has the advantage that this puts a larger weighting on the older size-classes improving the signal-to-noise ratio.

4.5 Mean maximum length across all species found in research vessel surveys

This indicator is part of the DCF indicators to measure the effects of fisheries on marine ecosystems. According to (EC 2008) the Mean maximum length indicator (MMLI) can be calculated for the entire assemblage that is caught by a particular gear or a subset based on morphology, behaviour or habitat preferences (e.g. bottom-dwelling species only). Mean maximum length is calculated as: $\overline{L_{\max}} = \sum_j (L_{\max j} N_j) \Big/ N$, where $L_{\max j}$ is the maximum length obtained by species j, N_j is the number of individuals of species j and N is the total number of individuals. Asymptotic total length ($L_{\infty,j}$) is preferred to maximum recorded total length if an estimate is available, but it is recognised that such data may not be available for many species. This indicator describes the fish community species composition and does not reflect any change in size structure of individual populations. Therefore the indicator is inappropriate for criterion 3.3, although it could be applied as a metric of fish community species composition under descriptor 1 (Biodiversity), see section 8.1.

4.6 95% percentile of the fish length distribution observed in research vessel surveys

According to Rochet *et al.* (2007), this indicator provides a good summary of the size distribution of fish with an emphasis on the large fish and is expected to be sensitive to fishing and other human impacts. For a species i and percentile q=0.95, the indicator is calculated as $L_{q,i} = l_{q,i} \left| \frac{\sum_{l=1}^{l_q} y_{l,i}}{y_i} = q \right.$, where $y_{l,i}$ = numbers caught in length class l, y_i = total numbers caught, $l_{q,i}$ = length corresponding to length class l_q for species i.

This indicator (L95) can be based on any standard survey that provides a length-frequency distribution. However, if more surveys are available it is recommended to choose the survey that samples the larger sizes best. Even though commercial catches (landings) in general sample the larger sizes better than surveys (that often target the smaller sizes), there is an issue with consistency because the fishery is more likely to have changed over time (e.g. changes in spatial distribution, technological creeping, etc.).

4.7 Size at first sexual maturation

This indicator is supposed to reflect the extent of undesirable genetic effects of exploitation. The most likely candidate for this is the so-called probabilistic maturation reaction norm indicator (PMRNI). According to (EC 2008) this indicator reflects the probability of maturing at age *a* and length *s* and is calculated as:

$m(a,s) = [o(a,s) - o(a\text{-}1, s - \Delta s(a))] / [1 - o(a\text{-}1, s - \Delta s(a))]$,

where $o(a,s)$ is the maturity ogive (i.e. the probability of being mature) and $\Delta s(a)$ is the length gained from age a-1 to a. Estimation of the probabilistic maturation reaction norm thus requires (i) estimation of maturity ogives, (ii) estimation of growth rates (from length at age), (iii) estimation of the probabilities of maturing, and (iv) estimation of confidence intervals around the obtained maturation probabilities. However, pertaining to the latter two points: (iii) is "$m(a,s)$" derived from (i) and (ii), while confidence intervals are still required and are typically calculated from bootstrapping.

This indicator is also part of the DCF indicators to measure the effects of fisheries on the marine ecosystem. A major disadvantage is that it requires large sample sizes (at least 100 specimen per age class). A recent paper in press by Wright *et al.* (2011), however, shows that a sample size of 50 fish per age class can be sufficient for calculation of the probabilistic maturation reaction norm.

5 Good Environmental Status

5.1 Introduction

The combination of the different indicators across attributes into an overall assessment of GES for this descriptor is not a straightforward task. Current practice under the Water Framework Directive (Directive 2000/60/EC), for provision of fisheries advice, and in environmental impact assessments was considered and provided some useful insights, but none was considered to exactly parallel the requirements of the MSFD (Borja, Elliott *et al.* 2010; Van Hoey, Borja *et al.* 2010). Depending on the selection of species, choice of indicators, application of reference levels and method of aggregation (involving e.g. the weighting of the various indicators or attributes) a different assessment of current status in relation to GES may emerge.

In Cardoso *et al.* (2010) two approaches were recommended: (i) integrative assessments combining indicators and/or attributes appropriate to local conditions and; (ii) assessment by worst case. An example of the former came from the Descriptor 6 (Seafloor integrity) where, according to (Rice, Arvanitidis *et al.* 2012), it may not even be desirable to focus on some weighted combination of all indicators to provide a single number as it is neither feasible nor ecologically appropriate to specify prescriptive algorithms for evaluating GES at regional, sub-regional or even sub-divisional scales. For Descriptor 3 the latter was suggested in Cardoso *et al.* (2010) where, in this context, \`worst case´ does not mean the full area of concern is assumed to be at the status of the worst part of the area. Rather, it means that the evaluation of GES will be set at the environmental status of the indicator and/or attribute assessed at the poorest state for the area of concern.

5.2 How to aggregate information into GES

Aggregation is required at several levels, e.g. across assessed stocks (primary indicators for F and/or SSB), across non-assessed stocks (secondary indicators for F and/or SSB) and across criteria (i.e. based on criteria 3.1, 3.2 and 3.3).

Here we will provide a first attempt at such a (partial) aggregation where we show how the information across assessed stocks may be aggregated in different MSFD regions and how the results could be used to determine whether or not GES is achieved.

Following Cardoso *et al.* (2010) we applied the "assessment by worst case" as an example in the North Sea case study (section 6.4). However, as the information is presented at the level of stocks, criteria and overall, a more "integrative assessment" would be possible. This was explored in the Bay of Biscay and Iberian Coast case study (section 6.3), where an overall assessment of Descriptor 3 based on giving different weights to criteria 3.1 and 3.2 was presented.

6 Case studies

6.1 Baltic Sea

This section presents a case study concerning the Baltic Sea. The purpose of this case study is to present ideas that could be useful for implementation of the MSFD Descriptor 3 in the whole Baltic Sea. During the ICES MSFD D3+ workshops, the Baltic Sea subgroup was attended by experts from Finland, Sweden, Germany and the Helsinki Commission (HELCOM). Therefore the vision and discussion provided in this Baltic Sea part of the report is based on the expertise of those persons only. They represented about 3/5 of the Baltic Sea area and only 3 out of 8 MSs around the Baltic Sea. Thus the following paragraphs represent the vision and ideas of those experts only, and should not be considered to reflect the position of any particular MS around the Baltic Sea and it is not at all the official position of their MSs.

6.1.1 Identification of the appropriate area

According to the MSFD, each MS should "develop a marine strategy for its marine waters", "in respect of each marine (sub-)region concerned". Therefore, as a first step for the Baltic Sea we identified the MSFD sub-regions for shellfish and fish stocks.

It is in general rather difficult to determine appropriate borderlines between any of the fish stocks for assessment purposes and for the MSFD. Any selection and combination of stock borders have their advantages and pitfalls. Fish populations do not respect our artificial borders and there will always be leakages between borders and difficulties to allocate information in agreed divisions and sub-divisions.

Over the years, especially in the 1980s, there was a tendency to split some of the Baltic fish stocks in smaller units and then in the 1990s many of the smaller units were merged into bigger units. All this splitting and merging has been a compromise between using a larger number of stocks/populations that have been identified on biological grounds and practical constraints, such as in what units catch figures are available and possibilities for correctly allocating individual fish to particular stocks. These allocations seem to be appropriate for single species assessment and management, especially regarding differences in population dynamics of various stock components.

The present ICES combination of assessment units for the main Baltic Sea commercial fish stocks, even though it will always be a compromise between different views and the intermixing of various components is unpreventable, may be the best one for aggregating the information of the main commercial fish species information into various units (Fig. 6.1.1. left panel). Thus we recommend that for the evaluation of the state of shellfish and fish stocks the most appropriate geographical areas are the ICES Baltic Sea divisions and sub-divisions as presented in Fig. 6.1.1 (left panel). This partition of the Baltic Sea has been used for several decades to allocate fisheries data (total catches, catch composition and effort) for stock assessment and there is no need to change this allocation for the MSFD. However, ICES Divisions and Sub-divisions for the Baltic Sea should be integrated with the 19 sub-basins used in HELCOM integrated assessments (Figure 6.1.1, right panel, blue lines) and water types of the EU Water Framework Directive in coastal and transitional waters (coloured areas) in the Baltic Sea. This integration should include coastal commercial and non-commercial fish stocks, which are not considered in detail here.

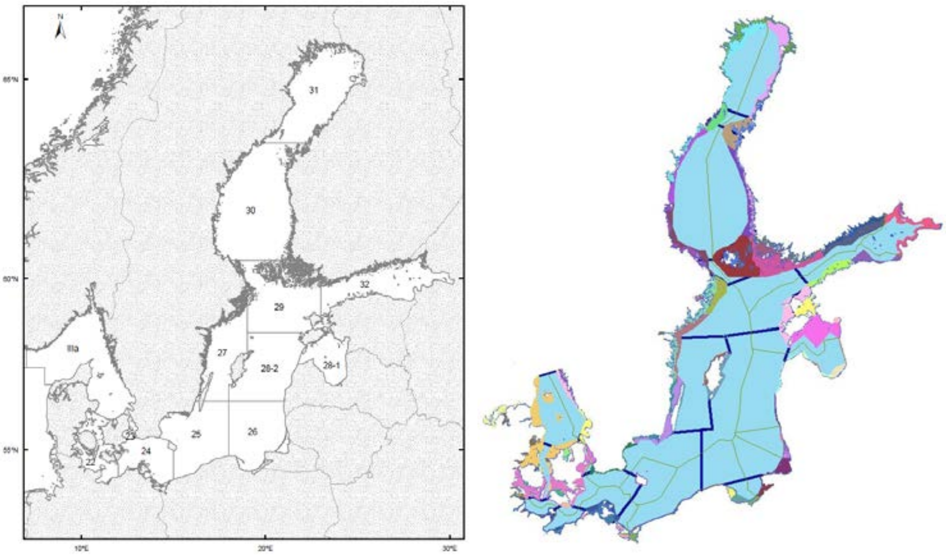


Figure 6.1.1 ICES Divisions and Sub-divisions in the Baltic Sea (left panel) and the 19 sub-basins used in HELCOM integrated assessments (right panel, blue lines). Exclusive Economic Zones are marked by thin brown lines.

6.1.2 Identification of commercially exploited (shell)fish populations per MSFD region and possible sub-regions

There are two potential data sources to identify exploited (shell)fish populations per MSFD region and possible sub-regions. Firstly the FAO Fishstat database, which is based on actual logbook information, and then the DCF (see Appendix VII Commission Decision 2008/949), where the following species groups are considered:

- Species that drive the international management process including species under EU management plans or EU recovery plans;
- Other internationally regulated species and major non-internationally regulated by-catch species;
- All other by-catch (fish and shellfish) species and nationally important commercial fish species.

In order to assess the representativeness of the MSFD assessment for commercially exploited fish stocks in the Baltic Sea, we used the estimate of what proportion of all landings of fish and shellfish consisted of assessed stocks. For this we updated the data from previous MSFD Descriptor 3 reports (Piet *et al.* 2010, ICES 2011b) and used the ICES catch statistics in the Baltic from 1983 to 2009 as they occur in the FAO Fishstat database. ICES sub-divisions 22-32 were used, except for western Baltic herring where Division IIIa (i.e. Kattegat) was also included to get full stock coverage (Fig. 6.1.1, left panel). Over the most recent 5 year period (2005-2009) there were about 70 different species or species-groups landed and reported. The exact number is difficult to determine from the database as there was overlap between groups and some overlapping of areas, as well as different species aggregated into one group (e.g. freshwater species). In the period 2005-2009 there were 21 species (20 fish, 1 invertebrate) that contributed at least 0.1% of the total landings, which was used as a threshold for the selection of species (Table 6.1.2.1). Together these species made up 99% of the total landings and consisted of approximately 98% fish and 2% invertebrates. About 95%

of the landings consist of assessed species (Table 6.1.2.1), being almost entirely sprat, herring and cod.

Several regions in the Baltic underwent a structural change in the mid-1980s and early 1990s (ICES 2008). These regime shifts have been observed in all sub-basins/sub-systems and there have been pronounced structural changes in the last two decades, related mainly to climate, fisheries and eutrophication. These changes have influenced the primary and secondary production capacity of the Baltic Sea and, thus, its fish production. Table 6.1.2.1 summarizes also species relative contributions to total landings before and after the regime shift, to show possible changes.

The effect of the time period on which the selection of species is based was also explored between 1983 and 2009. In the Baltic Sea three species are totally dominating the fishery and catches (Baltic cod, herring and sprat). The number of selected species using the 0.1% contribution to total annual landings threshold varied very little between various periods. The number of species varied between 21 and 23. This shows that the time period for selecting the species to be included in the GES assessment is not very important. However, it was agreed to use the most recent period, i.e. 2005-2009.

6.1.3 Species covered by stock assessments

In the Baltic, the assessment of commercially exploited species is mainly at the stock level, so all indicators are considered at the stock level here. Three main species (Baltic cod, herring and sprat) constitute about 95% of the landings and their stock geographical areas cover around 65% of the whole Baltic Sea for cod, 80% for sprat and 100% for herring.

Depending on national requirements and considerations, and the relative importance of various commercial fish species, the Baltic Sea could/should be divided into smaller MSFD units using ICES Sub-divisions or the HELCOM division system, as shown in Figure 6.1.1, for final assessment. However, how to allocate information for the MSFD should be decided by MSs, so as to be coherent with other descriptors as well, for example with Descriptor 4 (Food webs).

From Table 6.1.2.1 it follows that from the 21 selected species, 9 species' stocks are assessed (annually, every second year or irregularly) and they consist of 2 cod stocks, 5 herring stocks, 1 sprat stock, 2 salmon stocks, several local perch, pike-perch, bream, sea trout stocks and several flatfish stocks. The total number of possible stocks for assessments is roughly 30 or more depending on national data sources.

The summary of stocks and their present reference levels is given in Table 6.1.3.1.

Table 6.1.2.1. All major fish and shellfish species in the Baltic (≥0.1% of the total landings, period 2005-2009, green) and their relative contributions (percentage of total landings). For comparison, the table summarizes also the whole observation period 1983-2009 (yellow), the periods "before" (1983-1989) and "after" (1990-2009) the Baltic Sea regime shift which took place mainly in the mid-1980s, and the last 10 years period (2000-2009). Indicated is whether the species are assessed (A) or non-assessed (NA) as well as fish (F) or invertebrate (I) (in green columns)

Species	Relative to years 1983-2009	Species	Before regime shift 1983-1989	Species	After regime shift 1990-2009	Species	Relative to last 10 years 2000-2009	Species	Assessed	Type	Relative to last 5 years 2005-2009
Baltic herring	42.4	Baltic herring	49.0	Baltic sprat	44.5	Baltic sprat	44.6	Baltic sprat	A	F	51.9
Baltic sprat	37.5	Baltic sprat	28.4	Baltic herring	38.6	Baltic herring	38.6	Baltic herring	A	F	31.8
Baltic cod	12.0	Baltic cod	15.0	Baltic cod	8.7	Baltic cod	8.5	Baltic cod	A	F	8.1
Blue mussel	3.4	Blue mussel	3.3	Blue mussel	3.0	Blue mussel	2.9	Flounder	A	F	2.2
Flounder	1.2	Flounder	0.9	Flounder	1.5	Flounder	1.6	Blue mussel	NA	I	2.0
Perch	0.4	Atlantic horse mackerel	0.4	Perch	0.7	Perch	0.7	Perch	A	F	0.8
Baltic salmon	0.3	Baltic salmon	0.4	Roach	0.3	Roach	0.3	Bream	NA	F	0.4
Common dab	0.2	Common dab	0.4	Northern pike	0.3	Northern pike	0.3	Roach	NA	F	0.4
Roach	0.2	Perch	0.2	Pike-perch	0.2	Bream	0.3	Plaice	NA	F	0.3
Atlantic horse mackerel	0.2	European eel	0.2	Bream	0.2	Pike-perch	0.3	Northern pike	NA	F	0.3
European whitefish	0.2	European whitefish	0.2	European whitefish	0.2	European whitefish	0.2	European whitefish	NA	F	0.2
Plaice	0.2	Roach	0.2	Plaice	0.2	Plaice	0.2	Pike-perch	A	F	0.2
Northern pike	0.2	Plaice	0.2	Baltic salmon	0.2	Baltic salmon	0.2	Common dab	NA	F	0.2
European eel	0.2	Smelt	0.2	Common dab	0.2	Common dab	0.2	Vendace	A	F	0.2
Bream	0.2	Pike-perch	0.1	Vendace	0.2	Vendace	0.2	Smelt	NA	F	0.1
Pike-perch	0.2	Garfish	0.1	Smelt	0.1	Smelt	0.1	European eel	NA	F	0.1
Smelt	0.1	Sticklebacks	0.1	European eel	0.1	European eel	0.1	Whiting	NA	F	0.1
Vendace	0.1	Bream	0.1	Atlantic horse mackerel	0.1	Atlantic horse mackerel	0.1	Atlantic horse mackerel	NA	F	0.1
Garfish	0.1	Whiting	0.1	Garfish	0.1	Whiting	0.1	Baltic salmon	A	F	0.1
Whiting	0.1	Lumpfish	0.1	Whiting	0.1	Garfish	0.1	Garfish	NA	F	0.1
Sticklebacks	0.1	Northern pike	0.1	Sea trout	0.1	Sea trout	0.1	Sea trout	A	F	0.1
Sea trout	0.1	Turbot	0.1								
Lumpfish	0.1										

Table 6.1.3.1. Summary of Baltic Sea commercial fish stocks, their reference levels and availability of indicators.

				Precautionary				MSY Approach		Target	Management	Primary Indicators					Secondary Indicators		
Species	Stock	ICES SD	Descriptor	B_{lim}	B_{pa}	F_{lim}	F_{pa}	Fmsy	MSY Btrigger	SSB $_{MGT}$	F_{mgt}	3.1.1. F	3.2.1 SSB	3.3.1	3.3.2	3.3.3	C/B 3.1.2	B ind. 3.2.2	3.3.4
Cod	Western Baltic	22 - 24	D3		23 000			0.25	23 000		0.60	x	x	x	x	x	x	x	x
Cod	Eastern Baltic	25 - 32	D3			0.96	0.60	0.30	Undefined		0.30	x	x	x	x	x	x	x	x
Baltic herring	Western Baltic, spring spawners	22 - 24	D3					0.25	110 000			x	x	x	x	x	x	x	x
Baltic herring	Baltic Main Basin	25 - 29 & 32 excluding GoR	D3				0.19	0.16	Not defined			x	x	x	x	x	x	x	x
Baltic herring	Gulf of Riga	28.1	D3				0.40	0.35	60 000			x	x	x	x	x	x	x	x
Baltic herring	Bothnian Sea	30	D3	290 000		0.30	0.21	0.19	200 000			x	x	x	x	x	x	x	x
Baltic herring	Bothnian Bay	31	D3																
Sprat	Whole Baltic	22 - 32	D3				0.40	0.35				x	x	x	x	x	x	x	x
European flounder	Whole Baltic	22-32	D3																
Salmon	Baltic Main Basin and Gulf of Bothnia	22 - 31	D3					75% of PSPC				x	x						
Salmon	Gulf of Finland	32	D3					75% of PSPC				x	x						
Sea trout	Whole Baltic	22-32	D3																
European plaice	Western Baltic	22-24	D3																
Common dab	Western Baltic	22-24	D3																
Whiting	Western Baltic	22-24	D3																
Vendace	Bothnian Bay	31	D3									x	x						
Pike-perch	Northern Baltic	28, 29,32	D3									x	x						
Turbot	Whole Baltic	22-32	D3									x	x						
European whitefish	Northern Baltic	29, 30	D3									x	x						
Atlantic horse mackerel	Western Baltic	22	D1, D4																
Blue mussel	Western Baltic	22-24	D3, D5																
Cyprinids (others)	Northern Baltic	29, 32	D4																
European smelt	Northern Baltic	29, 30, 32	D1, D4																
Freshwater bream	Northern Baltic	29, 32	D1, D4, D5																
Freshwater fishes (others)	Northern Baltic	29-32	D1, D4																
Northern pike	Northern Baltic	32	D4																
Roach	Northern Baltic	29, 32	D1, D4, D5																
Perch	Northern Baltic	28, 29-32	D1, D4, D5									x							

X = available

6.1.4 Baltic Sea fish stocks, which are assessed annually and for which indicators and reference levels are available and/or under development

In this section we give more detailed information about those internationally assessed and managed stocks, which can be considered representative for the MSs in the Baltic Sea. ICES produces annual assessments for a number of stocks, for which one or more indicators including reference levels are available. These assessments allow a more robust assessment of stock status in relation to GES.

From the 21 species presented in Table 6.1.2.1, which contributed at least 0.1% to the total landings in 2005-2009, ICES gives advice on 16 stocks or stock complexes. Table 6.1.4.1 shows the species by stock units where reference points are estimated or under development by ICES expert groups. In addition it lists reference points in relation to the MSY framework (F_{MSY} and $B_{MSY\text{-}trigger}$) and/or the Precautionary Approach framework (F_{pa}, F_{lim}, B_{pa} and B_{lim}). The information was taken from the most up to date ICES advice summaries (ICES 2011 advice, available under the "Advice" link of the ICES webpage). It is not always easy to make a clear distinction between full analytical stock assessments and trends based assessments, as there is a range of different stock assessment methodologies currently used by ICES expert groups assessing Baltic Sea stocks, but in general stocks are considered to be fully assessed if an accepted analytical stock assessment was carried out with an evaluation of fishing mortality and spawning stock biomass against MSY reference points.

Table 6.1.4.1. The present biological reference points in use for the main commercial fish stocks in the Baltic.

	Precautionary				MSY Approach		Target	Management
Stock	B_{lim}	B_{pa}	F_{lim}	F_{pa}	Fmsy	MSY Btrigger	SSB $_{MGT}$	F_{mgt}
cod-2224	Not defined	23 000 t MBAL	Not defined	Not defined	0.25	23 000	Undefined	0.6 EU management plan 2007
cod-2532	Undefined	Undefined	0.96 Fmed estimated in 1998	0.6 5th percentile of Fmed	0.3	Undefined	Undefined	0.3 EU management plan 2007
Her3a22	Not defined	Not defined	Not defined	Not defined	0.25	110 000	Not defined	Not defined
Her-2532-Ex-Go	Not defined	Not defined	Not defined	0.19 F_{med} (assessment 2000)	0.16	Not defined	Not defined	Not defined
her-riga	Not defined	Not defined	Not defined	0.4 Medium term projections	0.35	60 000	Not defined	Not defined
her-30	290 000	Not defined	0.3 Floss (in 2000)	0.21 Fmed (in 2000)	0.19	200 000	Not defined	Not defined
her-31 *)	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Not defined	Not defined
spr-22-32	Not defined	Not defined	Not defined	0.4	0.35	Not defined	Not defined	Not defined
sal-2231	Not defined	Not defined	Not defined	Not defined	75% of PSPC	Not defined	Not defined	Not defined
sal-32	Not defined	Not defined	Not defined	Not defined	75% of PSPC	Not defined	Not defined	Not defined

*) assessment available, under development

Among the remaining stocks/species there is a range of different assessments ranging from exploratory analytical assessments which evaluate F and SSB in relation to reference points to situations with no information available. Some of the nationally and locally important fish species have trends based analytical assessments with qualitative evaluation of F (or Z) and SSB against reference points, trend based analytical assessments with an evaluation of F (or Z) and SSB without reference points, or assessments that use biomass trends from surveys or commercial CPUEs as the basis for advice. Some of the stocks are the so-called non-assessed stocks, or stocks with limited amount of information or no information at all.

6.1.5 Assesment of GES at the stock level

The assessment of the current status of the Baltic main stocks is conducted on the basis of the 10 stocks presented in Table 6.1.4.1. These stocks have been assessed by ICES and their most recent assessments are used here (see reports of the working groups WGBFAS 2011, WGBAST 2011). The latest version of ICES advice is available on the web address http://www.ices.dk/advice/icesadvice.asp.

The Commission Decision of September 2010 establishes 3 criteria that must be considered in order to assess the current status with respect to GES:

Criterion 3.1 (level of pressure of fishing activity),
Criterion 3.2 (reproductive capacity of the stock),
Criterion 3.3 (population age and size distribution).

The Commission Decision states that achieving or maintaining GES requires that $F \leq F_{MSY}$ in Criterion 3.1, whereas for Criterion 3.2 full reproductive capacity corresponds to $SSB \geq SSB_{MSY}$. However, due to possible interactions between species, SSB_{MSY} may not be attained for all stocks simultaneously and further research is needed to address this fact (like Baltic cod-Baltic herring-sprat interactions). The Commission Decision also states that if SSB_{MSY} cannot be reliably estimated, a precautionary biomass value could be used instead.

For long-lived stocks with population size estimates, ICES bases its MSY approach on attaining a fishing mortality rate at or below F_{MSY}. In this approach, both fishing mortality and biomass reference points are used; these reference points are F_{MSY} and $B_{MSY\text{-}trigger}$. The approach does not use an SSB_{MSY} estimate. SSB_{MSY} is a notional value around which stock size fluctuates when $F=F_{MSY}$. Recent stock size trends may not be informative about SSB_{MSY}, e.g. when F has exceeded F_{MSY} for many years or when current ecosystem conditions and spatial stock structure are or could be substantially different from those in the past. This is the case in the Baltic Sea because of past overfishing of various stocks and observed regime shift as pointed out in section 6.1.2. Thus, we have used $B_{MSY\text{-}trigger}$ instead of SSB_{MSY}. Table 6.1.5.1 summarizes the present status of the 10 assessed Baltic Sea stocks. In the Baltic Sea case $B_{MSY\text{-}trigger}$ is thus (as in other areas) a biomass reference point that triggers a cautious response; the cautious response is to reduce fishing mortality to reinforce the tendency for a stock to rebuild and fluctuate around a notional value of SSB_{MSY} (even though the notional value is not specified in the ICES MSY framework). The concept of $B_{MSY\text{-}trigger}$ evolves from the Precautionary Approach reference point B_{pa} (see Table 6.1.4.1), which ICES has used as a basis for fisheries advice since the late 1990s. B_{pa} is a biomass designed to avoid reaching B_{lim}, in the sense that if SSB is estimated to be above B_{pa} the probability of impaired recruitment should be low. The evolution in the determination of $B_{MSY\text{-}trigger}$ requires contemporary data with fishing at F_{MSY} to experience the normal range of fluctuations in biomass under that fishing mortality rate.

Table 6.1.5.1. Assessed stocks and their current status in relation to criteria 3.1, 3.2 and management plans in force in 2011

		Reference points			State of the stock		
		MSY Approach		Management	State of the stock in relation to MSY		State of the stock in relation to F_{mgt}
Species	Stock	Fmsy	MSY Btrigger	F_{mgt}	F/F_{MSY}	$B/B_{trigger}$	F_{mgt}
Baltic cod	cod-2224	0.25	23 000	0.6 EU management plan 2007			
Baltic cod	cod-2532	0.3	Undefined	0.3 EU management plan 2007			
Baltic herring	Her3a22	0.25	110 000	Not defined			No mgt plan
Baltic herring	Her-2532-Ex-Go	0.16	Not defined	Not defined			No mgt plan No mgt plan No mgt plan
Baltic herring	her-riga	0.35	60 000	Not defined			No mgt plan No mgt plan
Baltic herring	her-30	0.19	200 000	Not defined			No mgt plan No mgt plan
Baltic herring	her-31	Unknown	Unknown	Not defined	Under development	Under development	No mgt plan
Baltic sprat	spr-22-32	0.35	Not defined	Not defined		Under development	No mgt plan
Baltic salmon	sal-2231	75% of PSPC	Not defined	Not defined			Under development
Baltic salmon	sal-32	75% of PSPC	Not defined	Not defined			Under development

(red)	= F status quo > F_{MSY} or F_{mgt}; B < $B_{trigger}$
(green)	= F status quo < F_{MSY} or F_{mgt}; B > $B_{trigger}$

According to Table 6.1.4.1, of the 10 commercial stocks assessed, 7 have F status quo (the expected value of F in 2011) above F_{MSY} and 2 below; 4 stocks are below $B_{MSY\text{-}trigger}$ and 4 above according to qualitative evaluation by ACOM in 2011. F_{MSY} is not defined for the herring stock in the northern Baltic (ICES subdivision 31) owing to accepted assessment and $B_{MSY\text{-}trigger}$ values have only been defined for 4 stocks. However, ICES assessment working groups (WGBFAS and WGBAST) have been tasked with evaluating and updating those values if appropriate in their next round of meetings in spring 2012 and, thus, we may expect to have more or updated reference points for all stocks assessed on annual basis. All other marine and freshwater species listed in Table 6.1.3.1 need to be assessed based on monitoring programs delivering only secondary indicators for criteria 3.1 and 3.2 and the indicators for criterion 3.3.

As in other MSFD areas, in the Baltic there are at least three different interpretations of GES, when aggregating across stocks, which could be considered:

1. Firstly using a strict interpretation of the Commission Decision, GES would require that F≤F_{MSY} for all the stocks. This definition of GES treats F_{MSY} as a limit for F. However, taking into account the strong linkage between cod-herring-sprat stocks, this interpretation is not very realistic and the outcome with high probability is that GES is never achieved just because of predator-prey relationships.

2. When F_{MSY} is treated as a target rather than a limit, this allows fishing mortality to fluctuate around F_{MSY} for each of the stocks. In addition, this GES interpretation requires that no stock is exploited outside safe limits (precautionary limits). In the Baltic Sea this limit has been F_{pa}.

3. A third possible interpretation of GES could be that the average value of F/F_{MSY} across all stocks is ≤ 1. As this definition works with an average across stocks, GES would not ensure that all stocks are within safe exploitation limits.

6.1.6 The need for international and/or bilateral cooperation in the Baltic

In the Baltic there are number of fish stocks outside international cooperation, assessment and management. In Table 6.1.3.1 we have listed more than 20 stocks beyond those explained in Table 6.1.4.1, which in fact may be good candidates for GES evaluation in D3, but are perhaps more useful for D1 (Biological diversity) or D4 (Food web). Most of them are under international or national monitoring programs, especially under the DCF. They are usually distributed across two or more national fishing zones and stock components are managed nationally. Some of the stocks are local, coastal stocks, which should, therefore, be treated on a national basis only.

Coastal fish monitoring is performed annually in many areas of the Baltic Sea. The available data include monitoring information from Finland, Estonia, Latvia, Lithuania and Sweden (HELCOM 2011). Coastal fish communities in the Baltic Sea areas of Denmark, Germany, Poland and Russia are also monitored, but they have not usually been included in evaluations of the state of the stocks or fish communities. The longest time series is 22 years long, but several time series are much shorter and have been initiated in the 2000s.

To ensure proper data availability from national laboratories and research institutions, cooperation between MSs is necessary. Eight MSs share about 97% of the Baltic Sea area and possibilities for useful cooperation are present (Fig. 6.1.6.1). Usually stock status is evaluated with a simple analysis of biomass trends and, at best, age composition analysis from national and/or bilateral surveys. The current monitoring program on commercial coastal fish stocks does not provide good spatial coverage and mainly targets areas with relatively low levels of direct anthropogenic influence (baseline areas). Currently, methods for extrapolating the results to areas without monitoring are under development by HELCOM.

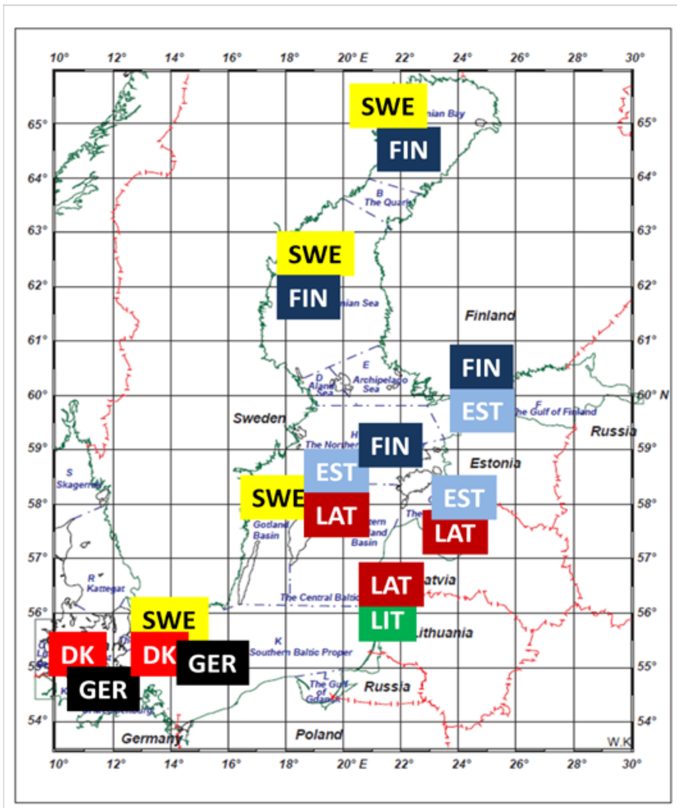


Figure 6.1.6.1. EU member countries and how they share geographical areas in the Baltic Sea.

6.2 Mediterranean Sea

6.2.1 Selection of commercially exploited (shell)fish populations

The Mediterranean case study was developed from an Italian geographic perspective. In the context of the MSFD the Italian National waters fall within the Mediterranean Region, and specifically in three Mediterranean sub-regions, namely the Western Mediterranean Sea, the Ionian Sea and the Central Mediterranean, and the Adriatic Sea (Fig. 6.2.1.1). Each sub-region is shared between different MSs and third (non-EU) Countries (Tab. 6.2.1.1).

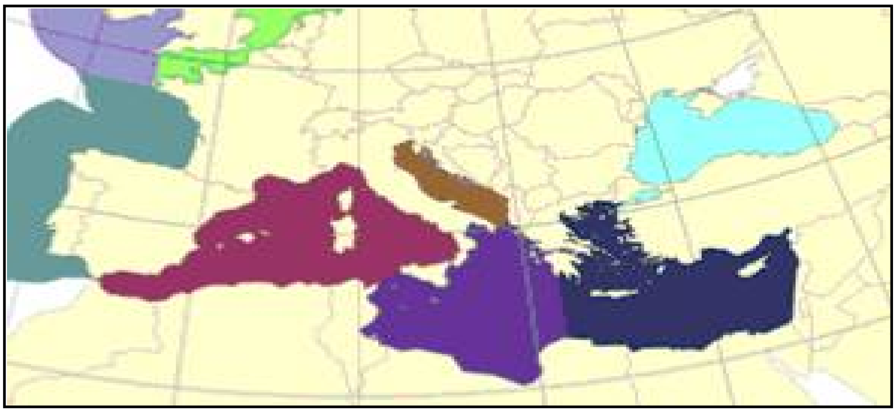


Figure 6.2.1.1: Mediterranean sub-regions according to MSFD; Magenta = Western Mediterranean; Violet = Ionian Sea and the Central Mediterranean; Brown = Adriatic Sea; Dark Blue = Aegean-Levantine Sea.

Table 6.2.1.1: List of EU MSs and third Countries (non-EU) whose Mediterranean waters fall within MSFD sub-regions and are shared with Italian National waters.

MSFD Sub-regions	EU Member States	Third Countries (non-EU Members)
Western Mediterranean	France, Italy, Spain	Algeria, Morocco, Tunisia
Ionian Sea and the Central Mediterranean	Greece, Italy, Malta	Egypt, Lybia, Tunisia, Albania
Adriatic Sea	Italy, Slovenia	Croatia, Bosnia-Ertzegovina, Montenegro, Albania

In Italy, as well as in the other EU Mediterranean countries, fisheries data are collected in the context of the DCF according to the FAO Geographical Sub-Areas (GSA), which represent the General Fisheries Commission of the Mediterranean (GFCM) management units (Fig. 6.2.1.2). Consisting of 23 Member countries along with the European Union, the GFCM's objectives are to promote the development, conservation, rational management and best utilization of living marine resources, as well as the sustainable development of aquaculture in the Mediterranean, Black Sea and connecting waters. Membership is open to both Mediterranean coastal states and regional economic organizations as well as to United Nations member states whose vessels engage in fishing in Mediterranean waters.

In cooperation with other Regional Fisheries Management Organizations (RFMOs), the GFCM is instrumental in coordinating efforts by governments to effectively manage fisheries at regional level following the Code of Conduct for Responsible Fisheries. The GFCM has the authority to adopt binding recommendations for fisheries conservation and management in its Convention Area and plays a critical role in fisheries governance in the region.

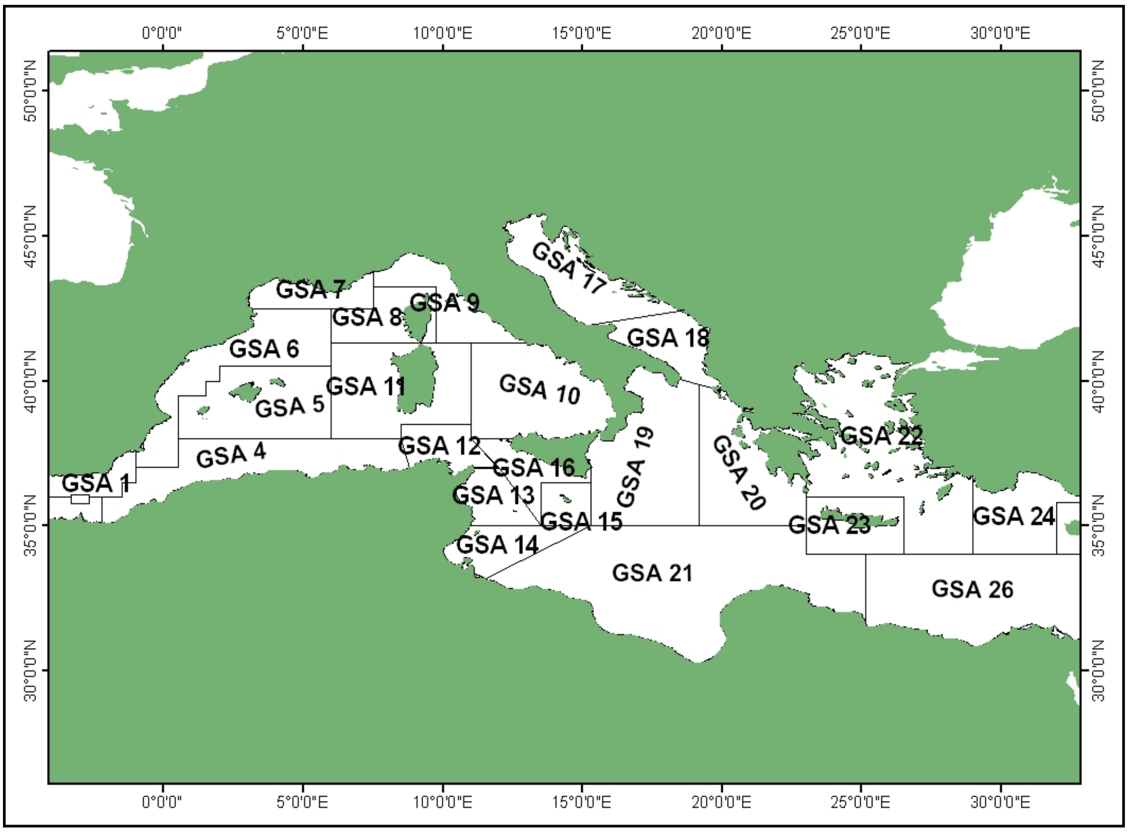


Figure 6.2.1.2. Mediterranean Geographical Sub-Areas according to the FAO General Fisheries Commission for the Mediterranean.

In what can be considered Italian waters a good match between the boundaries of MSFD sub-regions and GSAs can be seen:

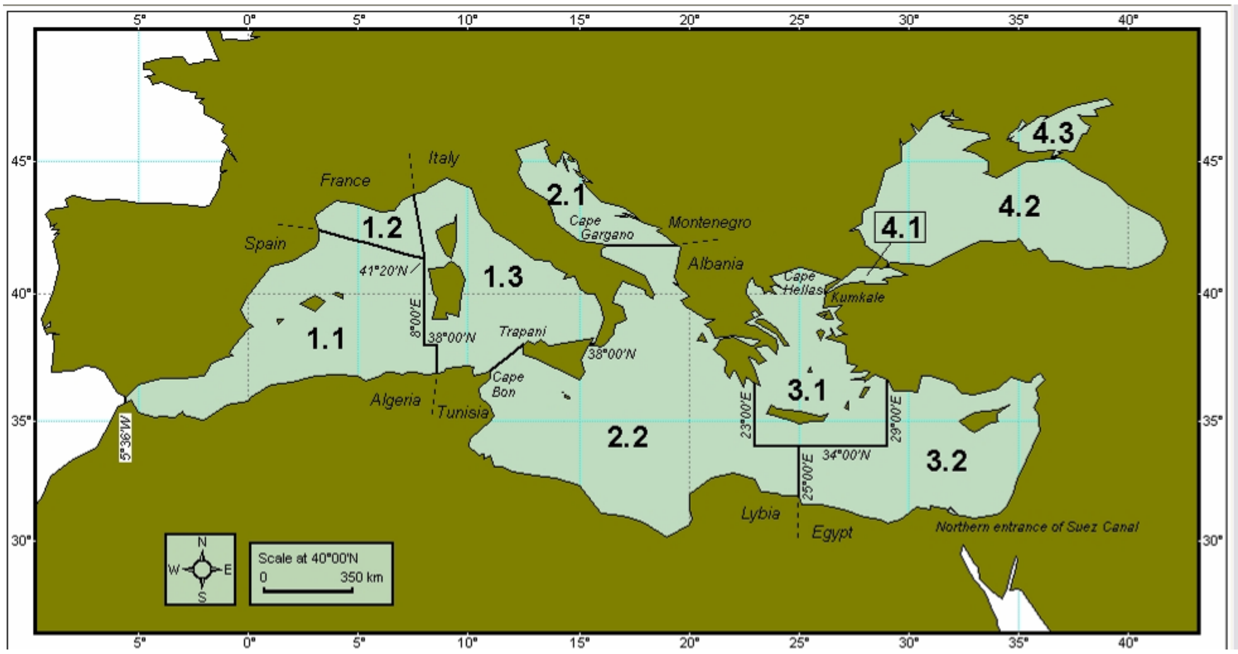
- Western Mediterranean: GSA 9 (Ligurian and North Tyrrhenian Sea), 10 (South Tyrrhenian Sea), 11 (Sardinia);
- Ionian Sea and the Central Mediterranean: GSA 16 (South of Sicily), 19 (Western Ionian Sea);
- Adriatic Sea: GSA 17 (Northern Adriatic), GSA 18 (Southern Adriatic Sea).

However, it is worth noting that the GSA 16 (South of Sicily) covers two sub-regions: the Western Mediterranean and the Ionian Sea/Central Mediterranean, of which the latter dominates.

Landings statistics and species' identification in the context of Descriptor 3 indicators

Official landings statistics for the Mediterranean countries are available from the FAO Fishstat Database. However, often the spatial units used in this database do not match the MSFD sub-regions, in particular the Ionian/Central Mediterranean Sea, and the Adriatic Sea sub-regions (Fig. 6.2.1.3). Moreover, being stocks assessed at a GSA level (at lower spatial scale compared to that provided by the Fishstat data), the use of FAO Fishstat data to estimate the coverage for primary and secondary indicators in terms of landings percentage is not straightforward.

Figure 6.2.1.3. Fishstat (FAO) General Fisheries Commission for the Mediterranean Sea spatial areas for landings data statistics.



In contrast, the DCF landings dataset, consisting of the official landings statistics provided by each EU Member State to the European Commission, are defined for the Mediterranean Sea at GSA level. Therefore this dataset was considered more appropriate and used for the purposes of this report. The dataset was kindly provided by the Italian Ministry of Fisheries and Aquaculture.

The dataset included Italian landings statistics per species/*taxa* in the last 5 years (2006-2010), by GSA, and represented the basis for the identification of the potential coverage of landed species in terms of the application of primary and secondary indicators.

Overall, landings data on 65 *taxa* (49 at species level; 16 at lower taxonomic resolution, *e.g.* genus/family) were available in the Italian DCF database (Tab. 6.2.1.2).

Table 6.2.1.2. Species list included in the DCF Italian official landing statistics.

Group	Species/taxon	Common name
Bony Fish	*Atherina* spp.	Mediterranean sand smelt
	Boops boops	Bogue
	Coryphaena hippurus	Common dolphinfish
	Dicentrarchus labrax	European seabass
	Diplodus spp.	Seabreams
	Engraulis encrasicolus	European anchovy
	Eutrigla gurnardus	Grey gurnard
	Katsuwonus pelamis	Skipjack tuna
	Lepidopus caudatus	Silver scabbardfish
	Lophius budegassa	Black-bellied angler
	Lophius budegassa/L. piscatorius	Anglers
	Lophius piscatorius	Angler
	Merlangius merlangus	Whiting
	Merluccius merluccius	European hake
	Micromesistius poutassou	Blue whiting
	Mugilidae	Mullets
	Mullus barbatus	Red mullet
	Mullus surmuletus	Striped red mullet
	Pagellus erythrinus	Common pandora
	Sarda sarda	Atlantic bonito
	Sardina pilchardus	European pilchard
	Sardina pilchardus (juv.)	Sardina pilchardus (juv.)
	Scomber japonicus	Chub mackerel
	Scomber scombrus	Atlantic mackerel
	Scorpaena scrofa / S. porcus	Scorpionfish
	Sepia officinalis	Common cuttlefish
	Seriola dumerili	Greater amberjack
	Solea solea	Common sole
	Spicara maena / S. smaris / S. flexuosa	Picarels
	Tetrapturus belone	Mediterranean spearfish
	Thunnidae	Other tunas
	Thunnus alalunga	Albacore
	Thunnus thynnus	Northern bluefin tuna
	Trachurus mediterraneus	Mediterranean horse mackerel
	Trachurus picturatus	Blue jack mackerel
	Trachurus trachurus	Atlantic horse mackerel
	Triglidae	Gurnards
	Trisopterus minutus capelanus	Poor cod
	Xiphias gladius	Swordfish
	Other Fish	Other Fish
Selachians	*Raja clavata*	Thornback ray
	Raja miraletus	Brown ray
	Raja spp.	Rays
	Selachia	Selachians
Bivalvia	*Callista chione*	Smooth callista
	Chamelea gallina	Striped venus

Group	Species/taxon	Common name
	Other Clams	Other Clams
Cephalo-poda	*Eledone cirrhosa*	Horned octopus
	Eledone moschata	Musky octopus
	Illex coindetii	Shortfin squid
	Loligo vulgaris	European squid
	Murex brandaris	Purple dye murex
	Nassarius mutabilis	Changeable nassa
	Octopus vulgaris	Common octopus
	Other Molluscs	Other Mollusco
Crustaceans	*Aristeomorpha foliacea*	Giant red shrimp
	Aristeus antennatus	Blue and red shrimp
	Melicertus kerathurus	Caramote prawn
	Nephrops norvegicus	Norway lobster
	Palinurus elephas	Common spiny lobster
	Pandalidae	Other shrimps
	Parapenaeus longirostris	Deep-water rose shrimp
	Portunidae	Swimming crabs
	Squilla mantis	Spottail mantis shrimp
	Other crustaceans	Other crustaceans

Temporal and spatial variability in species' cumulative percentage landings

The variability in species' cumulative landings according to different spatial units (i.e., GSAs versus MSFD sub-regions), as average values for the period 2006-2010, was explored.

The comparison of cumulative percentages of Italian landings within each MSDF sub-region with the percentage of landings for each GSA (as average, for the 2006-2010 period in both the cases) shows that large variability can be found for some species when comparing their percentage value in landings between different GSAs belonging to the same MSFD sub-region (Figures 6.2.1.4, 6.2.1.5, 6.2.1.6).

Figure 6.2.1.4. Variability in species/*taxa* percentage landings (average % of the 2006-2010 period) in the Italian waters estimated for the Western Mediterranean Sea sub-region (red square) and in GSA 9,10,11 (blue, violet and green lines, respectively). Only the most important species/*taxa* in the landings are shown.

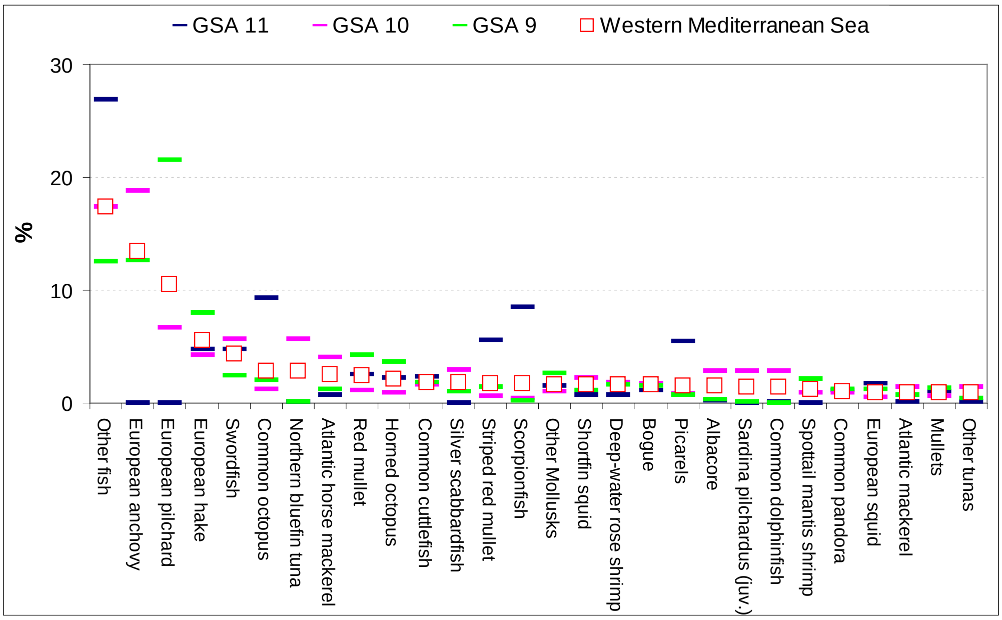


Figure 6.2.1.5. Variability in species/*taxa* percentage landings (average % of the 2006-2010 period) in the Italian waters estimated for the Ionian Sea and the Central Mediterranean Sea sub-region (red square) and in GSA 16 and 19 (violet and blue lines, respectively). Only the most important species/*taxa* in the landings are shown.

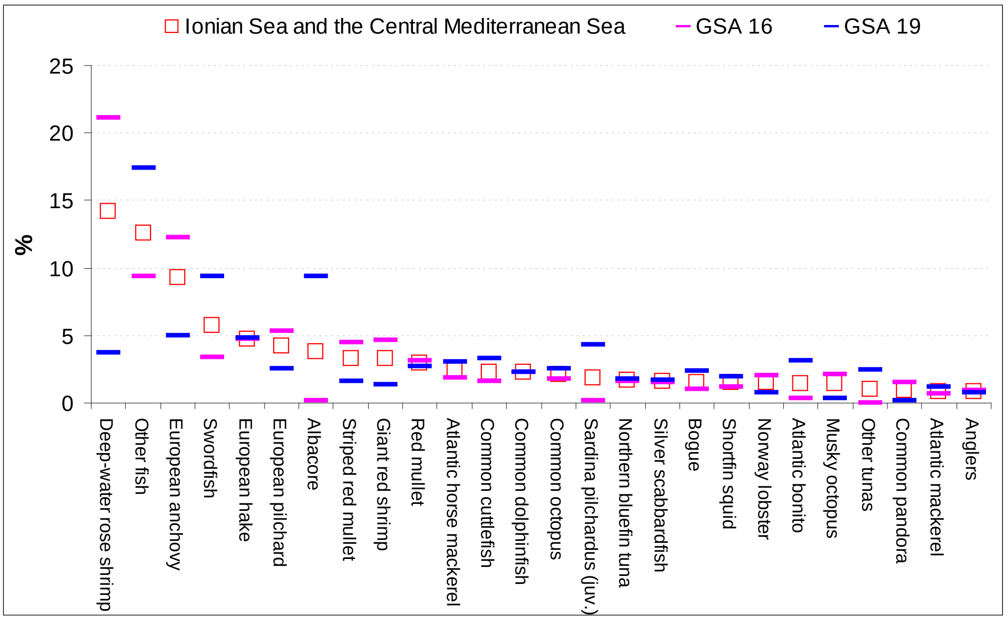
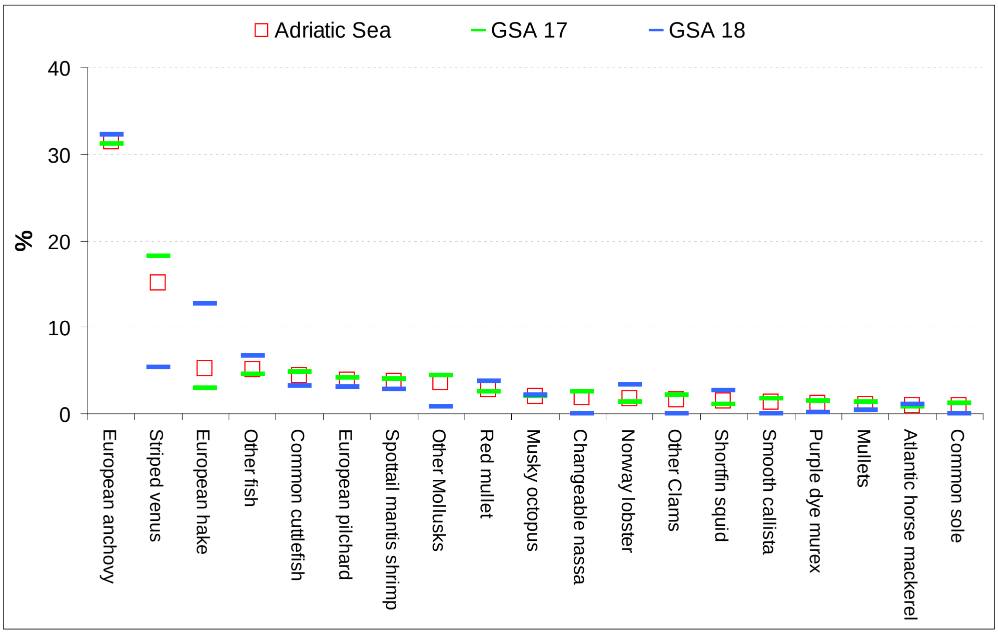
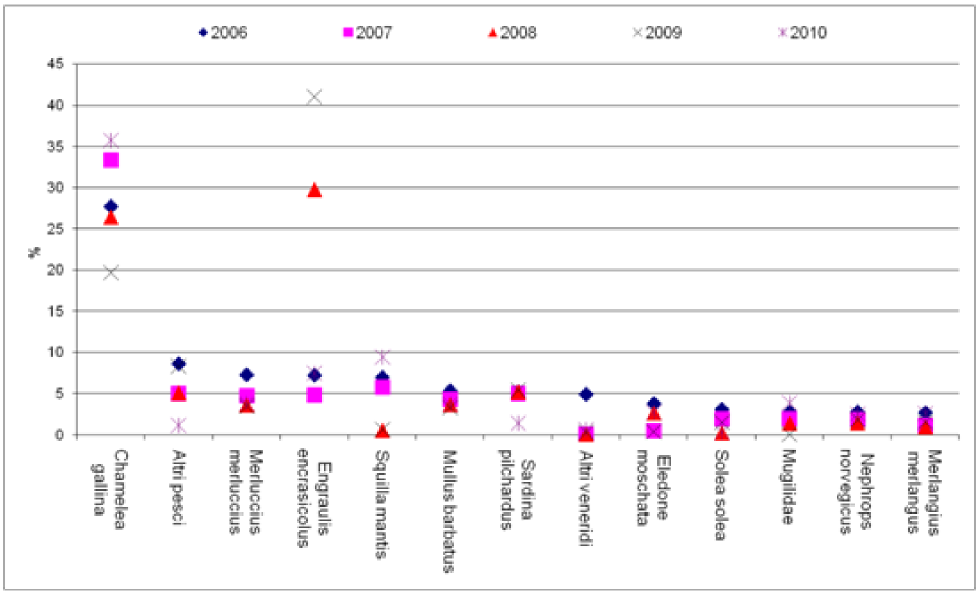


Figure 6.2.1.6. Variability in species/*taxa* percentage landings values (average % of the 2006-2010 period) in the Italian waters estimated for the Adriatic Sea sub-region (red square) and GSA 17 and 18 (green and blue line, respectively). Only the most important species/*taxa* in the landings are shown.



A further analysis showed that within each GSA some species/*taxa* display high temporal fluctuations (from 2006 to 2010) in their percentage contribution to the total landings (see the example reported for the GSA 17 – Northern Adriatic Sea, in Fig. 6.2.1.7).

Figure 6.2.1.7. Yearly variability in species/*taxa* percentage values of Italian landings in the GSA 17 (Northern and Central Adriatic Sea, 2006-2010). Only the most important species/*taxa* in the landings are shown.



Spatial subdivision with (sub)regions

The Mediterranean GSA management unit system adopted by the GFCM is seen as the most applicable in the context of this region since the DCF program is based on such spatial level and, in general, stock assessments are provided per GSA. This approach does not create any particular problem for the Initial Assessment of the MSFD since GSA mostly fall within the MSFD (sub)regional boundaries. Only in the case of GSA16 there is overlap with two sub-regions. In this case our recommendation will be to include it in the MSFD sub-region that covers most of its area (i.e. Ionian Sea/Central Mediterranean).

Database selection

The DCF database providing data at GSA level is the most appropriate for the Mediterranean region since the spatial units in the GFCM database (Fishstat) are too coarse to provide landings composition at the sub-regional level. Specific problems arising from the categorization of landings exists for some species which are grouped at higher taxonomic levels (e.g. Selachians, other fish)

Selection of species for GES assessment

According to the DCF database national landings were explored per GSA/national (sub)region.

Species were sorted and ranked according to their contribution to the overall landings; then information from stock assessments from the GFCM Sub-Committee on Stock Assessment (GFCM-SCSA) and the Scientific, Technical and Economic Committee for Fisheries – Study Group on Mediterranean stocks (STECF-SGMED) as well as research surveys (e.g. MEDITS, MEDIAS) and biological sampling within the DCF was gathered. According to that, our advice for species selection is to focus mainly on those species/groups listed in MEDITS, MEDIAS (and other surveys) and DCF sampling activities (see tables 6.2.1.3, 6.2.1.4, 6.2.1.5); details on the sources that were used can be found in paragraphs 6.2.2 and 6.2.3. Indeed these species are also included in the stocks assessed in the framework of GFCM-SCSA working groups and STECF-SGMED.

Table 6.2.1.3: Species list of Italian landings from the Western Mediterranean Sea sub-region (GSA 9, 10, 11), their relative contribution to the total landings for the period 2006-2010 according to the DCF database. Indicated whether the species is fish (F) or invertebrate (I), assessed (A = stocks whose assessment were considered to be completed -i.e., not preliminary or to be agreed on- by GFCM-SCSA or STECF-SGMED or ICCAT) or non-assessed (NA), key species in the context of surveys (e.g. MEDITS, MEDIAS), included in the DCF biological sampling (X). *: Not all species are subject to regular sampling.

Species/Group	Fish / Invertebrates	Assessed / Non-assessed			Fraction (2006-2010)	Surveys	DCF
		GSA 9	GSA 10	GSA 11	GSA 9 + GSA 10 + GSA 11		
Other fish	F	NA	NA	NA	0.1741		
Engraulis encrasicolus	F	A	NA	NA	0.1347		X
Sardina pilchardus	F	NA	NA	NA	0.1052		X
Merluccius merluccius	F	A	A	NA	0.0560	Y	X
Xiphias gladius	F	A	A	A	0.0439		X
Octopus vulgaris	I	NA	NA	NA	0.0287	Y	X

Species/Group	Fish / Invertebrates	Assessed / Non-assessed			Fraction (2006-2010)	Surveys	DCF
		GSA 9	GSA 10	GSA 11	GSA 9 + GSA 10 + GSA 11		
Thunnus thynnus	F	A	A	A	0.0280		X
Trachurus trachurus	F	NA	NA	NA	0.0254	Y	X
Mullus barbatus	F	A	A	A	0.0241	Y	X
Eledone cirrhosa	I	NA	NA	NA	0.0208	Y	X
Sepia officinalis	I	NA	NA	NA	0.0178	Y	X
Lepidopus caudatus	F	NA	NA	NA	0.0177		
Mullus surmuletus	F	A	NA	NA	0.0174	Y	X
Scorpaena scrofa/S. porcus	F	NA	NA	NA	0.0171		
Other Mollusks	I	NA	NA	NA	0.0163		
Illex coindetii	I	NA	NA	NA	0.0159	Y	X
Parapenaeus longirostris	I	A	A	NA	0.0159	Y	X
Boops boops	F	NA	NA	NA	0.0157	Y	X
Spicara maena/S. smaris/S. flexuosa	F	NA	NA	NA	0.0155	Y*	
Thunnus alalunga	F	NA	NA	NA	0.0155		X
Sardina pilchardus (juv.)	F	NA	NA	NA	0.0143		X
Coryphaena hippurus	F	NA	NA	NA	0.0141		X
Squilla mantis	I	A	NA	NA	0.0117		X
Pagellus erythrinus	F	A	NA	NA	0.0103	Y	X
Loligo vulgaris	I	NA	NA	NA	0.0095	Y	X
Scomber scombrus	F	NA	NA	NA	0.0093		X
Mugilidae	F	NA	NA	NA	0.0092		X
Thunnidi	F	NA	NA	NA	0.0087		
Diplodus spp.	F	NA	NA	NA	0.0081		
Aristeomorpha foliacea	I	A	NA	A	0.0072	Y	X
Solea solea	F	NA	NA	NA	0.0069	Y	
Micromesistius poutassou	F	NA	NA	NA	0.0063	Y	
Eledone moschata	I	NA	NA	NA	0.0062	Y	X
Selachians	F	NA	NA	NA	0.0061	Y	X*
Raja spp.	F	NA	NA	NA	0.0061	Y	X*
Sarda sarda	F	NA	NA	NA	0.0059		X
Lophius budegassa/L. piscatorius	F	NA	NA	NA	0.0057	Y	X
Nephrops norvegicus	F	A	NA	NA	0.0054	Y	X
Aristeus antennatus	I	A	NA	NA	0.0045	Y	X
Trachurus mediterraneus	F	NA	NA	NA	0.0043	Y	X
Seriola dumerili	F	NA	NA	NA	0.0039		
Lophius piscatorius	F	NA	NA	NA	0.0037	Y	X
Scomber japonicus	F	NA	NA	NA	0.0037		X
Other crustaceans	I	NA	NA	NA	0.0037		
Chamelea gallina	I	NA	NA	NA	0.0026		
Raja clavata	F	NA	NA	NA	0.0025	Y	X
Trisopterus minutus capelanus	F	NA	NA	NA	0.0025	Y	
Lophius budegassa	F	NA	NA	NA	0.0024	Y	X
Melicertus kerathurus	I	NA	NA	NA	0.0020		
Palinurus elephas	I	NA	NA	NA	0.0018		
Triglidae	F	NA	NA	NA	0.0017		X*
Dicentrarchus labrax	F	NA	NA	NA	0.0010		
Murex brandaris	I	NA	NA	NA	0.0006		
Trachurus picturatus	F	NA	NA	NA	0.0006		
Nassarius mutabilis	I	NA	NA	NA	0.0006		
Other *Veneridae*	I	NA	NA	NA	0.0005		
Pandalidae	I	NA	NA	NA	0.0004		
Eutrigla gurnardus	F	NA	NA	NA	0.0004	Y	
Tetrapturus belone	F	NA	NA	NA	0.0002		
Portunidae	I	NA	NA	NA	0.0001		

Species/Group	Fish / Inverte-brates	Assessed / Non-assessed			Fraction (2006-2010)	Sur-veys	DCF
		GSA 9	GSA 10	GSA 11	GSA 9 + GSA 10 + GSA 11		
Merlangius merlangus	F	NA	NA	NA	<0.0001		
Katsuwonus pelamis	F	NA	NA	NA	<0.0001		
Raja miraletus	F	NA	NA	NA	<0.0001	Y	X

Table 6.2.1.4: Species list of Italian landings from the Central/Ionian Mediterranean sub-region (GSA 16, 19), their relative contribution to the total landings for the period 2006-2010 according to the DCF database. Indicated whether the species is fish (F) or invertebrate (I), assessed (A= stocks whose assessment were considered to be completed -i.e., not preliminary or to be agreed on- by GFCM-SCSA or STECF-SGMED or ICCAT) or non-assessed (NA), key species in the context of surveys (e.g. MEDITS, MEDIAS), included in the DCF biological sampling (X). *: Not all species are subject to regular sampling.

Species/Group	Fish / Inverte-brates	Assessed / Non-assessed		Fraction (2006-2010)	Sur-veys	DCF
		GSA 16	GSA 19	GSA 16 + GSA 19		
Parapenaeus longirostris	I	A	NA	0.1418	Y	X
Other fish	F	NA	NA	0.1259		
Engraulis encrasicolus	F	A	NA	0.0933		X
Xiphias gladius	F	A	A	0.0575		X
Merluccius merluccius	F	A	NA	0.0474	Y	X
Sardina pilchardus	F	A	NA	0.0422	Y	X
Thunnus alalunga	F	NA	NA	0.0384		X
Mullus surmuletus	F	NA	NA	0.0333	Y	X
Aristeomorpha foliacea	I	A	NA	0.0329	Y	X
Mullus barbatus	F	A	NA	0.0295	Y	X
Trachurus trachurus	F	NA	NA	0.0234	Y	X
Sepia officinalis	I	NA	NA	0.0227	Y	X
Coryphaena hippurus	F	NA	NA	0.0226		X
Octopus vulgaris	I	NA	NA	0.0210	Y	X
Sardina pilchardus (juv.)	F	NA	NA	0.0182	Y	X
Thunnus thynnus	F	A	A	0.0169		X
Lepidopus caudatus	F	NA	NA	0.0160		
Boops boops	F	NA	NA	0.0153	Y	X
Illex coindetii	I	NA	NA	0.0152	Y	X
Nephrops norvegicus	F	NA	NA	0.0152	Y	X
Sarda sarda	F	NA	NA	0.0148		X
Eledone moschata	I	NA	NA	0.0143	Y	X
Thunnidi	F	NA	NA	0.0099		
Pagellus erythrinus	F	A	NA	0.0096	Y	X
Scomber scombrus	F	NA	NA	0.0087		X
Lophius budegassa/L. piscatorius	F	NA	NA	0.0086	Y	X
Spicara maena/S. smaris/S. flexuosa	F	NA	NA	0.0080	Y*	
Other Mollusks	I	NA	NA	0.0077		
Eledone cirrhosa	I	NA	NA	0.0069	Y	X
Lophius piscatorius	F	NA	NA	0.0067	Y	X
Aristeus antennatus	I	NA	NA	0.0066	Y	X
Raja spp.	F	NA	NA	0.0064		X*
Seriola dumerili	F	NA	NA	0.0060		
Loligo vulgaris	I	NA	NA	0.0058	Y	X
Other crustaceans	I	NA	NA	0.0056		
Squilla mantis	I	NA	NA	0.0049		X
Diplodus spp.	F	NA	NA	0.0047		
Tetrapturus belone	F	NA	NA	0.0046		
Scorpaena scrofa/S. porcus	F	NA	NA	0.0045		
Selachians	F	NA	NA	0.0044	Y	X*

Species/Group	Fish / Inverte-brates	Assessed / Non-assessed		Fraction (2006-2010)	Sur-veys	DC F
		GSA 16	GSA 19	GSA 16 + GSA 19		
Raja clavata	F	NA	NA	0.0032	Y	X
Palinurus elephas	I	NA	NA	0.0031		
Micromesistius poutassou	F	NA	NA	0.0031	Y	
Trachurus mediterraneus	F	NA	NA	0,0020	Y	X
Lophius budegassa	F	NA	NA	0,0019	Y	X
Scomber japonicus	F	NA	NA	0,0016		X
Solea solea	F	NA	NA	0,0013	Y	
Mugilidae	F	NA	NA	0,0012		X
Atherina spp.	F	NA	NA	0,0011		
Triglidae	F	NA	NA	0,0008		X*
Melicertus kerathurus	I	NA	NA	0,0008		
Katsuwonus pelamis	F	NA	NA	0,0006		
Trisopterus minutus capelanus	F	NA	NA	0,0005	Y	
Trachurus picturatus	F	NA	NA	0,0005		
Raja miraletus	F	NA	NA	0,0003	Y	X
Murex brandaris	I	NA	NA	0,0002		
Dicentrarchus labrax	F	NA	NA	0,0002		
Eutrigla gurnardus	F	NA	NA	0,0001	Y	
Portunidae	I	NA	NA	0,0001		
Nassarius mutabilis	I	NA	NA	<0,0001		
Pandalidae	I	NA	NA	<0,0001		
Merlangius merlangus	F	NA	NA	<0,0001		

Table 6.2.1.5: Species list of Italian landings from the Adriatic Sea sub-region (GSA 17, 18), their relative contribution to the total landings for the period 2006-2010 according to the DCF database. Indicated whether the species is fish (F) or invertebrate (I), assessed (A= stocks whose assessment were considered to be completed -i.e., not preliminary or to be agreed on- by GFCM-SCSA or STECF-SGMED or ICCAT) or non-assessed (NA), key species in the context of surveys (e.g. MEDITS, MEDIAS), included in the DCF biological sampling (X). *: Not all species are subject to regular sampling.

Species/Group	Fish / Inverte-brates	Assessed / Non-assessed		Fraction (2006-2010)	Sur-veys	DC F
		GSA 17	GSA 18	GSA17+GSA18		
Engraulis encrasicolus	F	A	NA	0.3141	Y	X
Chamelea gallina	I	NA	NA	0.1513		X
Merluccius merluccius	F	NA	A	0.0526	Y	X
Other fish	F	NA	NA	0.0509		
Sepia officinalis	F	NA	NA	0.0447	Y	X
Sardina pilchardus	F	A	NA	0.0389	Y	X
Squilla mantis	I	NA	NA	0.0374		X
Other Mollusks	I	NA	NA	0.0359		
Mullus barbatus	F	NA	NA	0.0286	Y	X
Eledone moschata	I	NA	NA	0.0207	Y	X
Nassarius mutabilis	I	NA	NA	0.0189		
Nephrops norvegicus	I	NA	NA	0.0180	Y	X
Other Veneridae	I	NA	NA	0.0163		
Illex coindetii	I	NA	NA	0.0143	Y	X
Callista chione	I	NA	NA	0.0129		
Murex brandaris	F	NA	NA	0.0118		
Mugilidae	F	NA	NA	0.0112		X
Trachurus trachurus	F	NA	NA	0.0092	Y	X
Solea solea	F	A	NA	0.0092	Y	X
Merlangius merlangus	F	NA	NA	0.0083		
Eledone cirrhosa	I	NA	NA	0.0073	Y	X
Parapenaeus longirostris	F	NA	NA	0.0073	Y	X
Lophius budegassa/L. piscatorius	F	NA	NA	0.0062	Y	X

Species/Group	Fish / Invertebrates	Assessed / Non-assessed		Fraction (2006-2010)	Surveys	DCF
		GSA 17	GSA 18	GSA17+GSA18		
Atherina spp.	F	NA	NA	0.0059		
Loligo vulgaris	I	NA	NA	0.0048	Y	X
Scomber japonicus	F	NA	NA	0.0047		X
Lophius piscatorius	F	NA	NA	0.0045	Y	X
Scomber scombrus	F	NA	NA	0.0043		X
Boops boops	F	NA	NA	0.0043	Y	X
Melicertus kerathurus	I	NA	NA	0.0037		
Micromesistius poutassou	F	NA	NA	0.0037	Y	
Selachians	F	NA	NA	0.0036	Y	X*
Octopus vulgaris	I	NA	NA	0.0036	Y	X
Other crustaceans	I	NA	NA	0.0035		
Portunidae	I	NA	NA	0.0033		
Trisopterus minutus capelanus	F	NA	NA	0.0029	Y	
Triglidae	F	NA	NA	0.0029		
Eutrigla gurnardus	F	NA	NA	0.0026	Y	X
Sarda sarda	F	NA	NA	0.0016		X
Mullus surmuletus	F	NA	NA	0.0016	Y	X
Lophius budegassa	F	NA	NA	0.0013	Y	X
Lepidopus caudatus	F	NA	NA	0.0012		
Aristeomorpha foliacea	I	NA	NA	0.0012	Y	X
Raja spp.	F	NA	NA	0.0011	Y	
Pagellus erythrinus	F	NA	NA	0.0011	Y	X
Thunnus thynnus	F	A	A	0.0010		X
Xiphias gladius	F	A	A	0.0008		X
Trachurus mediterraneus	F	NA	NA	0.0007	Y	X
Thunnidae	F	NA	NA	0.0007		
Scorpaena scrofa/S. porcus	F	NA	NA	0.0007		
Diplodus spp.	F	NA	NA	0.0006		
Dicentrarchus labrax	F	NA	NA	0.0006		
Spicara maena/S. smaris/S. flexuosa	F	NA	NA	0.0005	Y*	X*
Raja clavata	F	NA	NA	0.0003	Y	X
Katsuwonus pelamis	F	NA	NA	0.0003		
Trachurus picturatus	F	NA	NA	0.0002		
Seriola dumerili	F	NA	NA	0.0002		
Aristeus antennatus	I	NA	NA	0.0001	Y	X
Thunnus alalunga	F	NA	NA	0.0001		X
Palinurus elephas	I	NA	NA	0.0001		
Coryphaena hippurus	F	NA	NA	<0.0001		X
Raja miraletus	F	NA	NA	<0.0001	Y	X
Sardina pilchardus (juv.)	F	NA	NA	<0.0001		X
Pandalidae	I	NA	NA	<0.0001		

Selection of indicators

Existing efforts/literature on stock assessments as well as on quantified fishery indicators in different Mediterranean regions was evaluated. For the two most important small pelagics (anchovy and sardine) there are stock assessments, although they often lack reference values; stock assessments have been carried out for an increasing number of demersal species in the last years (both in the context of GFCM-SCSA and STECF-SGMED). Most of the formal stock assessments provide reference levels for the F based primary indicator (3.1.1) while SSB limits definitions are lacking. For those species where stock assessments are lacking, secondary indicators quantified through MEDITS and the DCF can be used as the basis for GES assessments, ensuring at the same time consistency across EU Mediterranean MSs.

The use of data collected in further trawl-surveys (e.g. SoleMON) or national sampling frameworks is envisaged in the case of species that are not fully represented in the MEDITS program (e.g. species with low catchability or not monitored). For large pelagics, there are stock assessments provided by ICCAT in the context of international agreements; these stocks are assessed on a large spatial scale (Eastern Atlantic and Mediterranean Sea).

GES evaluation

The percentage of stocks fulfilling specific criteria should be reported. In cases where reference levels exist, comparisons should refer to discrepancies from these levels, while for secondary indicators significant trends need to be reported. Particular attention should also be paid to developing methods that allow to merge information/GES assessment from GSA level to MSFD sub-regional scale.

6.2.2 Species covered by stock assessments

The availability of stock assessments that provide reference levels for primary indicators based on F and SSB (3.1.1 and 3.2.1 indicators, respectively) was reviewed. Three different sources were considered: the reports of the GFCM-SCSA Working Group on Small Pelagic Species (FAO 2011a, in press), the GFCM-SCSA Working Group on Demersal Species (FAO 2011b, in press) and the STECF Review of scientific advice for 2012 (Casey *et al.*, 2011) that includes the work carried out by SGMED, with the aim of providing the best information.

The two reports based on GFCM-SCSA activities summarize the results of stock assessments for 30 demersal stocks (mainly carried out at single GSA level, except for 7 stocks that were assessed for a combination of several GSAs; Tab. 6.2.2.1) and 11 small pelagics stocks (all stock assessments carried out at GSA level; Tab. 6.2.2.2) in the whole Mediterranean Sea.

In total, 18 stock assessments (14 demersal species; 4 pelagics) were accepted by the GFCM-SCSA working groups in relation to Italian GSAs, plus 3 whose results were considered as preliminary (1 demersal species, 2 pelagic species). For the demersal species, reference values based on fishing mortality F were available ($F_{0.1}$ and, to a lesser extent, F_{max}). In a small number of cases (small pelagics) only the exploitation rate was given. In contrast, while estimates of SSB are available for some stocks, SSB_{MSY} was available only for red mullet in GSA 9 and anchovy and sardine stocks in GSA 16. It is worth noting that the Scientific Advisory Committee (SAC) of GFCM agreed on the use of $F_{0.1}$ as a proxy for F_{MSY} in demersal stocks, to be considered as technical target reference value, while F_{max} is used as a limit (SAC GFCM, 2011).

Table 6.2.2.1. Synthesis of available stock assessment for Mediterranean stocks according to the GFCM SCSA Working Group on Demersal Species (FAO 2011a, in press).

No	Stock	GSA	Method & Software	Stock Status	Advice & Recommendation
1	*Merluccius merluccius*	1	VPA, XSA, Y/R	In overfishing status	Reduction of F of trawling 80%. Use of 40 mm square or 50mm diamond mesh size in the bottom trawl cod-end
2	*Merluccius merluccius*	5	XSA, retrospective analysis, Y/R	In overfishing status	Reduction of F.
3	*Merluccius merluccius*	7	VPA, XSA, Y/R, FLR	In overfishing status, low abudance	Reduction of growth overfishing
4	*Merluccius merluccius*	9	VPA, XSA, SURBA, Y/R	In overfishing status	Reduction of F
5	*Merluccius merluccius*	12, 15, 16	LCA, Y/R	The assessment was considered preliminary	
6	*Merluccius merluccius*	18	SURBA, ALADYM, VIT, R	In overfishing status	Reduction of F
7	*Mullus barbatus*	6	VPA, XSA, Y/R	in overfishing status low abudance	Reduction of F by 70%
8	*Mullus barbatus*	7	XSA, Y/R	In overfishing status, intermediate abudance	Reduction of F
9	*Mullus barbatus*	9	ASPIC.5.3, LCA	In overfishing status	Reduction of F
10	*Mullus barbatus*	15-16	LCA, Y/R, VIT4win	In overfishing status	Reduction of F by about 45%
11	*Mullus barbatus*	25	VPA, VPA-Pseudocohort, Y/R	In overfishing status, low abudance	Reduction of F
12	*Mullus surmuletus*	5	VPA, XSA, Y/R	In overfishing status	Reduction of F. Increase of selectivity.

No	Stock	GSA	Method & Software	Stock Status	Advice & Recommendation
13	*Mullus surmuletus*	9	VIT, Y/R	In overfishing status	Reduction of F
14	*Mullus surmuletus*	25	VPA-Pseudocohort, Y/R	In overfishing status	Reduction of F
15	*Pagellus erythrinus*	26	Y/R, FISAT	In overfishing status	Reduction of F. Use of 40 mm square or 50 mm diamond mesh size in the bottom trawl cod-end
16	*Pagellus erythrinus*	15-16	VIT4win, Y/R, VPA, LFDA	In overfishing status	Reduction of F by about 50%
17	*Solea solea*	17	XSA, SURBA, LCA, VIT, Y/R	In overfishing status	Reduction of F
18	*Sphyraena sphyraena*	12-13	VPA,VIT	In overfishing status	Reduction of F
19	*Galeus melastomus*	9	Thompson-Bell model, Leslie matrix, LCA	In overfishing status	Reduction of F
20	*Spicara smaris*	25	VPA, VIT	2005-2007: Fully exploited, intermediate abundance. 2008-2010: in overfishing status, intermediate abudance	Reduction of F by 15%
21	*Boops boops*	25	VPA, VIT	2005-2007: Fully exploited and intermediate abundance. 2008-2010: Overfishing status and intermediate abudance	Reduction of F by 15%
22	*Parapenaeus longirostris*	1 to 3	LCA, VPA, Y/R, VIT	In overfishing status	Avoid increasing F even though the stock seems at an overexploitation status. This advice is necessary considering the uncertainty and the lack of knowledge of the real effect of environmental issues on the assessement in order to be consistent with the precautionary
23	*Parapenaeus longirostris*	6	VPA, XSA, FLR	In overfishing status, low abudance	Reduction of F of trawling by 70%. Use of 40 mm square or 50mm diamond mesh size in the bottom trawl cod-end
24	*Parapenaeus longirostris*	9	VPA, XSA, SURBA,Y/R	Under-exploited	

No	Stock	GSA	Method & Software	Stock Status	Advice & Recommendation
25	*Parapenaeus longirostris*	12 to 16	Y/R, SSB/R, VIT, ANALEN, YIELD	In overfishing status	Reduction of F by 20%.
26	*Aristaeus antennatus*	5	Y/R, VIT, VPA, LCA, XSA	In overfishing status	Reduction of F.
27	*Aristaeus antennatus*	6	LCA, Y/R, VPA, XSA	In overfishing status, low abudance	Reduction of F by 72%
28	*Aristaeus antennatus*	9	LCA, VIT	In overfishing status	Reduction of F
29	*Nephrops norvegicus*	9	LCA, VIT, SURBA, Y/R	In overfishing status	Reduction of F
30	*Aristaemorpha foliacea*	15-16	SURBA, VPA, Y/R, VIT4win, VIT	In overfishing status	Reduction of F by 50-60%

Table 6.2.2.2. Synthesis of available stock assessment for Mediterranean stocks according to the GFCM SCSA Working Group on Small Pelagic Species (FAO 2011b, in press).

GSA	Species	Assessed by	Exploitation rate	Biomass level	Status	Recommendation
3	Sardine	VIT	Moderate in East, high in west	Lower than previous years	Fully exploited	Maintain current F, protect spawners (temporal ban)
6	Sardine	XSA tuned with acoustic	High	The lowest value in the time series	Overexploited	Reduce fishing effort until recruitment levels increase
7	Sardine	Acoustic and CPUE	Very Low	Low, decreasing trend. Close to collapse	Fully exploited, without room for potential expansion	The system is not controlled by human activity. Not to increase fishing effort until the system stabilizes or show signals of recovery.
16	Sardine	Surplus production model, BIODYN	Moderate	Lower than BMSY	Fully exploited with low abundance and moderate fishing	Not to increase fishing effort
17	Sardine	VPA, ICA and acoustic survey	Moderate	Low	Fully exploited	Not to increase fishing effort
18	Sardine	Acoustic survey	Moderate	Low	Considered Moderately exploited, but exploitation rate is uncertain	An exploitation rate for the whole area should be estimated. Not to increase fishing effort in the western part.
6	Anchovy	XSA tuned with acoustic	It is difficult to assess. (between moderate to high) It is constant.	Intermediate but within a low range for the area	Fully exploited	Not to increase fishing effort. Despite F has been constant, there are fluctuations in biomass.
7	Anchovy	Acoustic and CPUE	Moderate	Low	Fully exploited	Not to increase fishing effort.

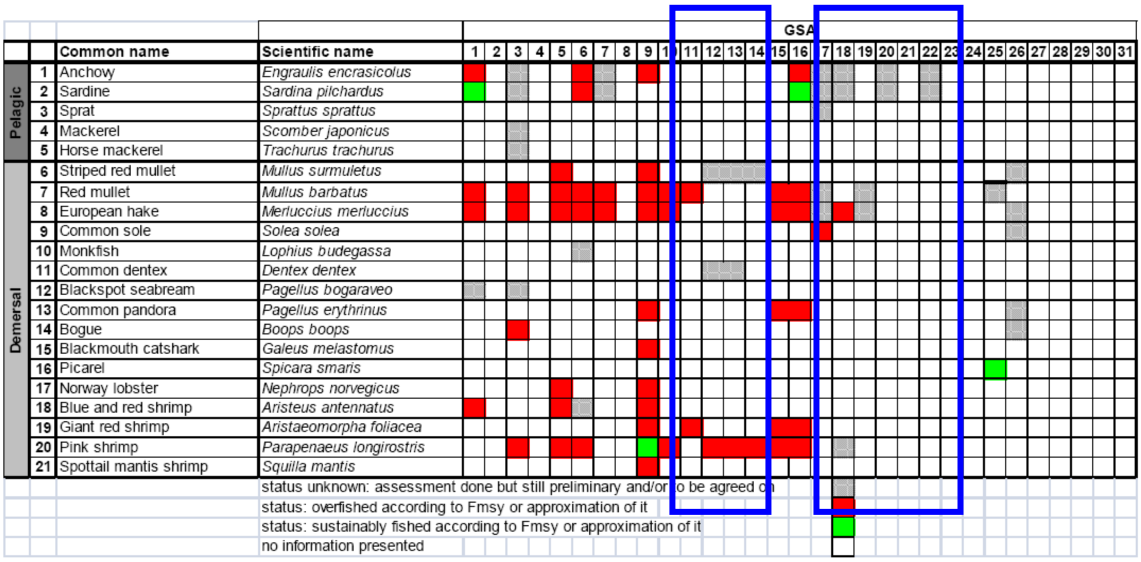
GSA	Species	Assessed by	Exploitation rate	Biomass level	Status	Recommendation
16	Anchovy	Surplus production model, BIODYN	High	Intermediate	Overexploited	Fishing effort should be reduced by means of a multi-annual management plan until there is evidence for stock recovery
17	Anchovy	VPA tuned with echosurvey	Moderate	Intermediate	Fully exploited	Not to increase fishing effort
18	Anchovy	Acoustic and DEPM	Moderate	Intermediate	Unknown but biomass in a decreasing trend	Not to increase fishing effort, especially in the West

The source based on SGMED activities (STECF Review of scientific advice for 2012. Part 3; Casey *et al.*, 2011) shows the results of 80 stock assessment conducted by this Study group on Mediterranean stocks. Overall 48 stock assessments met the criteria for the classification and provision of reference values (Tab. 6.2.2.3). Among the 35 stocks assessed for Italian GSAs, 25 met the SGMED criteria for achieving a proper assessment while another 10 stocks were assessed but the results were considered as preliminary and/or to be agreed on (Tab. 6.2.2.4). Almost all the assessments provide $F_{0.1}$ as proxy for F_{MSY} and, to a lesser extent, F_{max} reference levels, while for a limited number of stocks (3) only E_{MSY} (i.e. Exploitation rate at MSY) and E_{curr} are given. Reference levels based on SSB are usually not available.

Table 6.2.2.3. Summary overview of Mediterranean stocks as assessed by SGMED (Casey *et al.*, 2011).

Scientific advice about the state of the stock exploitation	no.	%	
Stocks classified according to criteria	48	60.0	
Other stocks not included for very poor data	32	40.0	
Stocks taken into account	80	100	
Classified stocks:			
The stock is overfished (above Fmsy)	44	91.7	
The stock is fished at or below the Fmsy	4	8.3	
Total stocks (21 species)	48	100	

Table 6.2.2.4. Mediterranean stocks assessed by SGMED by GSA (1-31). Stocks related to Italian GSAs (9, 10, 11, 16, 17, 18, 19) are shown in the blue rectangles (Casey *et al.*, 2011).



Regarding bluefin tuna (*Thunnus thynnus*) and swordfish (*Xyphias gladius*), stock assessments are carried out by the ICCAT at an international level. The former species is managed according to a TAC set each year by this international committee. Precautionary reference values have been proposed for both species according to different simulations, although the STECF did not endorse them (Casey *et al.*, 2011).

6.2.3 Species covered by monitoring programs

Secondary indicators mainly rely on data collected in the framework of trawl-surveys and biological sampling under the DCF. These activities are established at GSA level for Mediterranean EU countries waters. The main sources of data are the following:

MEDITS: **Mediterranean International Bottom Trawl Survey:** this trawl survey is carried out in the Mediterranean since 1994 in late spring-early summer with a random-stratified approach (Bertrand *et al.*, 2002). Overall 30 fish species, 4 crustaceans and 6 cephalopods are monitored, providing data on indices of abundance and biomass, length frequency distribution by sex and maturity stage (Tab. 6.2.3.1).

Table 6.2.3.1. MEDITS (Mediterranean International Bottom Trawl Survey) reference species list.

Scientific name	Date[1]	CODE	Common name	
			Français	English
Aspitrigla cuculus	1998	ASPI CUC	Grondin rouge	Red gurnard
Boops boops	2006	BOOPBOO	Bogue	Bogue
Citharus linguatula	1994	CITH MAC	Feuille	Spotted flounder
Eutrigla gurnardus	1994	EUTR GUR	Grondin gris	Grey gurnard
Galeus melastomus	1998	GALU MEL	Chien espagnol	Blackmouth catshark
Helicolenus dactylopterus	1994	HELI DAC	Rascasse de fond	Rockfish
Lepidorhombus boscii	1994	LEPM BOS	Cardine à quatre taches	Four-spotted megrim
Lophius budegassa	1994	LOPH BUD	Baudroie rousse	Black-bellied angler
Lophius piscatorius	1994	LOPH PIS	Baudroie commune	Angler
Merluccius merluccius	1994	MERL MER	Merlu commun	European hake
Micromesistius poutassou	1994	MICM POU	Merlan bleu	Blue whiting
Mullus barbatus	1994	MULL BAR	Rouget-barbet de vase	Red mullet
Mullus surmuletus	1994	MULL SUR	Rouget-barbet de roche	Striped red mullet
Pagellus acarne	1994	PAGE ACA	Pageot acarné	Axillary seabream
Pagellus bogaraveo	1994	PAGE BOG	Dorade rose	Blackspot seabream
Pagellus erythrinus	1994	PAGE ERY	Pageot commun	Common pandora
Sparus pagrus	> 1996	SPAR PAG	Pagre commun	Common seabream
Phycis blennoides	1994	PHYI BLE	Phycis de fond	Greater forkbeard
Raja clavata	1994	RAJA CLA	Raie bouclée	Thornback ray
Scyliorhinus canicula	1998	SCYO CAN	Petite roussette	Smallspotted catshark
Solea vulgaris	1994	SOLE VUL	Sole commune	Common sole
Spicara flexuosa	1994	SPIC FLE	Gerle	Picarel
Spicara smaris	1998	SPIC SMA	Picarel	Picarel
Trachurus mediterraneus	1994	TRAC MED	Chinchard à queue jaune	Mediterranean horse mackerel
Trachurus trachurus	1994	TRAC TRA	Chinchard d'Europe	Atlantic horse mackerel
Trigla lucerna	2006	TRIGLUC	Grondin-perlon	Tub gurnard
Trigloporus lastoviza	1998	TRIP LAS	Grondin camard	Streaked gurnard
Trisopterus minutus capelanus	1994	TRIS CAP	Capelan	Poor-cod
Zeus faber	1994	ZEUS FAB	Saint-Pierre	John dory
Selacians[2]	2006			
Aristaeomorpha foliacea	1994	ARIS FOL	Gambon rouge	Giant red shrimp
Aristeus antennatus	1994	ARIT ANT	Crevette rouge	Blue and red shrimp
Nephrops norvegicus	1994	NEPR NOR	Langoustine	Norway lobster
Parapenaeus longirostris	1994	PAPE LON	Crevette rose du large	Deep-water pink shrimp
Eledone cirrhosa	1994	ELED CIR	Poulpe blanc	Horned octopus
Eledone moschata	1997	ELED MOS	Elédone musquée	Musky octopus
Illex coindetti	1994	ILLE COI	Encornet rouge	Broadtail squid
Loligo vulgaris	1994	LOLI VUL	Encornet	European squid
Octopus vulgaris	1994	OCTO VUL	Pieuvre	Common octopus
Sepia officinalis	1994	SEPI OFF	Seiche commune	Common cuttlefish

Data Collection Framework (DCF) Biological sampling: under the DCF, the following biological data are collected: length-class distribution, maturity, age, for the most important species caught in several fishing metiers. These data can be used to estimate the secondary indicators for many species for which no stock assessments are conducted. Overall, in Italy, 28 fish species, 6 crustaceans and 7 molluscs are monitored under the DCF biological sampling program since 2002. It is worth noting that some biological parameters are not calculated each year, but with lower frequency (e.g. every three years). The reference list of species currently included in the DCF is given in table 6.2.3.2.

Table 6.2.3.2. DCF species list for biological sampling.

Table III.E.1 Stocks to be sampled and derogations

Stocks that will NOT be sampled for any of the parameters are highligthed in grey					
Species	**Area / Stock**		**Species Group**	**Average landings --- tons**	**Share in EU TAC --- %**
Raja miraletus	Mediterranean	1.3, 2.1, 2.2, 3.1	G1	< 200	
Istiophoridae[1]	Mediterranean	all areas	G1	< 200	
Raja clavata	Mediterranean	1.3, 2.1, 2.2, 3.1	G1	271,5	
Aristeus antennatus	Mediterranean	all areas	G1	795,0	
Shark-like Selachii	Mediterranean	all areas	G1	1944,6	
Aristeomorpha foliacea	Mediterranean	all areas	G1	2167,6	
Solea vulgaris	Mediterranean	1.2, 2.1, 3.1	G1	2266,3	
Mullus surmuletus	Mediterranean	all areas	G1	4037,7	
Nephrops norvegicus	Mediterranean	all areas	G1	4290,5	
Thunnus thynnus	Mediterranean	all areas	G1	5173,8	14,43
Xiphias gladius	Mediterranean	all areas	G1	7346,4	
Mullus barbatus	Mediterranean	all areas	G1	9307,4	
Parapenaeus longirostris	Mediterranean	all areas	G1	12239,9	
Merluccius merluccius	Mediterranean	all areas	G1	15341,5	
Sardina pilchardus	Mediterranean	all areas	G1	15889,5	
Engraulis encrasicolus	Mediterranean	all areas	G1	65858,0	
Anguilla anguilla	Mediterranean	all areas	G1	< 200	
Sparus aurata	Mediterranean	1.2, 3.1	G2	0,0	
Dicentrarchus labrax	Mediterranean	all areas	G2	44,3	
Trigla lucerna	Mediterranean	1.3, 2.2, 3.1	G2	305,6	
Penaeus kerathurus	Mediterranean	3,1	G2	374,1	
Eutrigla gurnardus	Mediterranean	2.2, 3.1	G2	614,6	
Lophius piscatorius [4]	Mediterranean	1.1, 1.2, 1.3, 2.2, 3.1	G2	823,4	
Trachurus mediterraneus	Mediterranean	all areas	G2	926,6	
Lophius budegassa [4]	Mediterranean	1.1, 1.2, 1.3, 2.2, 3.1	G2	1333,5	
Sarda sarda	Mediterranean	all areas	G2	1386,2	
Micromesistius poutassou	Mediterranean	1.1, 3.1	G2	1707,9	
Pagellus erythrinus	Mediterranean	all areas	G2	1753,8	
Loligo vulgaris	Mediterranean	all areas	G2	1955,9	
Coryphaena hippurus	Mediterranean	all areas	G2	2087,6	
Eledone cirrhosa [3]	Mediterranean	1.1, 1.3, 2.1, 2.2, 3.1	G2	2597,9	
Spicara smaris	Mediterranean	2.1, 3.1, 3.2	G2	2623,9	
Mugilidae	Mediterranean	1.3, 2.1, 2.2, 3.1	G2	3098,2	
Thunnus alalunga	Mediterranean	all areas	G2	3571,0	
Boops boops	Mediterranean	1.3, 2.1, 2.2, 3.1, 3.2	G2	3830,7	
Eledone moschata [3]	Mediterranean	1.3, 2.1, 2.2, 3.1	G2	3900,2	
Trachurus trachurus	Mediterranean	all areas	G2	4086,6	
Scomber spp .	Mediterranean	all areas	G2	4145,1	
Illex spp., Todarodes spp.	Mediterranean	all areas	G2	4260,3	
Octopus vulgaris	Mediterranean	all areas	G2	4400,1	
Squilla mantis	Mediterranean	1.3, 2.1, 2.2	G2	7202,0	
Sepia officinalis	Mediterranean	all areas1	G2	8668,2	
Veneridae[2]	Mediterranean	2.1, 2.2	G2	22698,4	
Coryphaena equiselis	Mediterranean	all areas	G2	0	

SoleMON: Adriatic Sea rapido trawl-survey. This survey is carried out yearly since 2005 in the Adriatic Sea (GSA 17) for the assessment of the common sole during late fall. The survey uses a rapido trawl as sampling gear (an iron-toothed dredge, similar to a beam trawl) with a random stratified approach (up to 100 m of depth). All commercial fish and non-commercial fish are sampled and measured for the estimation of indices of abundance and biomass, as well as length distributions. Length distributions in all commercial cephalopods and crustaceans are recorded as well, along with sex ratio and maturity stages in the most important flatfish, crustaceans and cephalopods. Data on mega-epifauna composition are also collected in the framework of SoleMON (FAO - Adriamed Technical Document, in prep.).

Pan-Mediterranean pelagic survey (MEDIAS): this acoustic survey is carried out in the Adriatic Sea (GSA 17 and 18) and the Strait of Sicily (GSA 16) since 2009 and targets small pelagics (i.e. sardine and anchovy) (V.A., 2010). The survey provides spatial distribution as well as indices of abundance and biomass, plus additional biological data on length-distribution and maturity. Earlier data are available from the projects ANCHOVETA and SARDONE, that were carried out before the start of MEDIAS.

It is worth noting that additional data could be derived from other sources, e.g. the GRUND trawl-survey, carried out from 1982 to 2008; the HVAR expedition, carried out in the Adriatic Sea in 1948-1949. However, differences in methodologies, fishing gear, technical configuration and spatial distribution of sampling stations need to be carefully considered before these datasets can be used.

6.2.4 Quality assurance

Evaluation of the quality of the assessment depends on proportion species/taxa for which information that fulfils certain quality standards is available. For this we distinguish between species/*taxa* for which indicators with reference values are available, those for which indicators but no reference values are available and those for which no information is available.

According to the cumulative landings composition of each species/*taxon* (by Italian GSA), the information gained from stock assessment from GFCM-SCSA and STECF-SGMED reports as well as the analysis of other data sources (see above), the potential coverage of Descriptor 3 indicators (both primary and secondary) was evaluated.

It is worth noting that this assessment provides only the “potential coverage” for these indicators, and it is necessary to test if their inherent properties (e.g., number of individuals caught during trawl-surveys, length of the time-series) fulfil the statistical requirement needed for robust estimation of each indicator. For the purpose of this exercise large pelagics (bluefin tuna and swordfish) were considered as assessed in each GSA although their stock assessment is carried out at a larger geographical scale (Eastern Atlantic and Mediterranean Sea).

Moreover, only the stocks whose assessment was considered to be completed (i.e., not preliminary or to be agreed on) by GFCM SCSA (FAO 2011a, 2011b) and STECF-SGMED (Casey *et al.* 2011) were taken into account.

Italian species/*taxa* cumulative landings data per each MSFD sub-region, as well as data availability from accepted stock assessments, surveys and DCF biological sampling are summarized in section 6.2.1 (Tables 6.2.1.3, 6.2.1.4 and 6.2.1.5).

The potential coverage was first examined for each GSA separately (in order to show inter-GSA variability) and later for each of the Italian MSFD sub-regions (thus merging the data of GSAs into larger geographical areas).

As stated previously, the primary indicators for criteria 3.1 and 3.2 can only be estimated for a limited proportion of the stocks in terms of number of species/*taxa* (5-20 % depending on the GSA), and only for Indicator 3.1.1 (based on F) as SSB reference levels (Indicator 3.2.1) are available for a very limited number of stocks (about 5%), in particular those assessed by ICCAT. The secondary indicators for criteria 3.1 and 3.2, could be estimated in about 45-50 % of the number of species/*taxa* in all GSAs, while the indicators for criterion 3.3 show a higher coverage, of around 65% of species/*taxa* (Figure 6.2.4.1).

These percentages are similar when merging data at MSFD sub-regional level (Figure 6.2.4.2). The Western Mediterranean sub-region has the highest percentage of assessed stocks in Italian waters providing data for estimating F related reference levels while the Adriatic Sea the lowest.

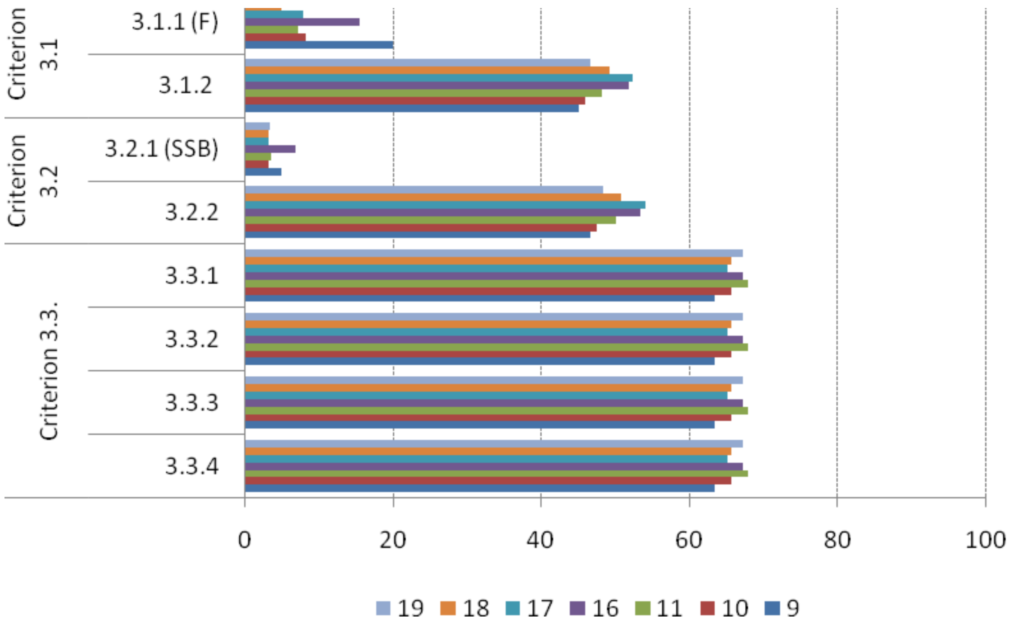


Figure 6.2.4.1. Potential percentage coverage of Descriptor 3 indicators in terms of number of species/*taxa* in Italian GSAs (9, 10, 11, 16, 17, 18, 19).

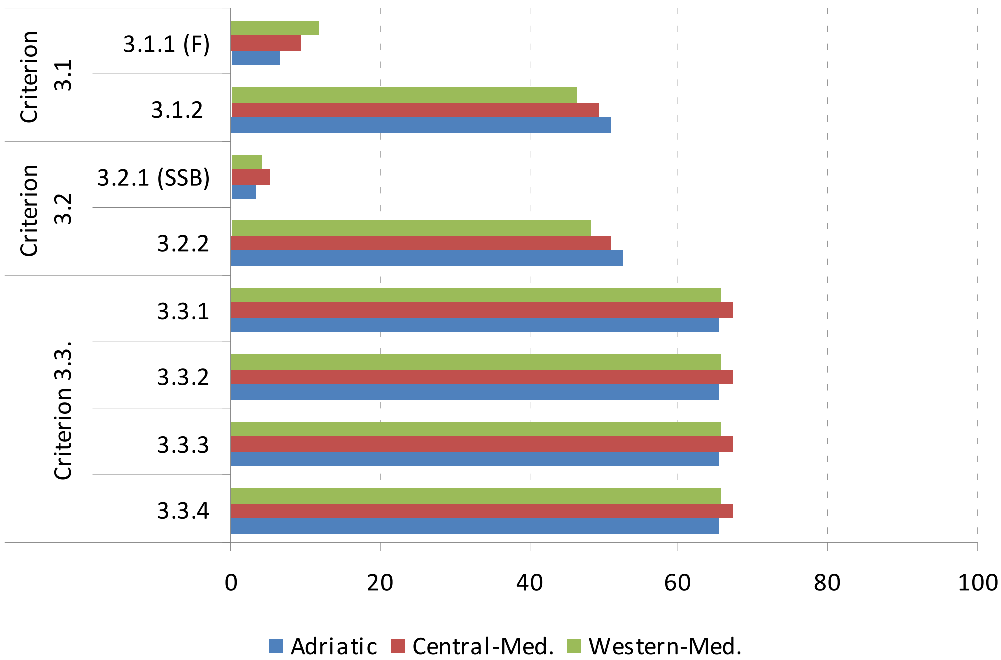


Figure 6.2.4.2. Potential percentage coverage of Descriptor 3 indicators in terms of number of species/*taxa* for Italian MSFD sub-regions. Percentages are standardized in relation to the total number of stocks per MSFD sub-region.

When considering the potential percentage coverage in terms of landings (as opposed to number of species), the potential coverage of Descriptor 3 indicators increases, although a considerable variability can be observed between GSAs and also between MSFD sub-regions (Fig. 6.2.4.3, 6.2.4.4). The 3.1.1 indicator could be established for up to the 50% of landed biomass when considering the GSA geographical level, although this percentage is usually markedly lower in most of the GSAs showing, as already observed, high variability between GSAs (Fig. 6.2.4.3). Lower percentages are found when the primary indicator for biomass (3.2.1) is taken into account. Percentage coverage of secondary indicators for F and SSB vary between 25 to 80% according to different GSAs. Indicators for the criterion 3.3 are potentially available for stocks covering 45 to 85% of the landings. When considering the MSFD sub-regional level (Fig. 6.2.4.4) the percentage of landings where the primary indicator 3.1.1 could be established ranges between 20% to 40%, with the Ionian/Central Mediterranean Sea and the Adriatic Sea sub-regions showing the highest coverage (around 40% and 30%, respectively). Indicator 3.2.1 (SSB) reference levels could be established for nearly 20% of the landings in the Ionian/Central Mediterranean and 10% in the Western Mediterranean, while in the Adriatic the percentage of landings coverage is negligible. However this picture might be overestimated since it is partially influenced by stock assessments on large pelagics (bluefin tuna and swordfish) whose SSB reference levels are not generally accepted and are assessed only at a large spatial scale (Eastern Atlantic and Mediterranean Sea). Regarding the secondary indicators for F and SSB, the percentage coverage of species/*taxa* in terms of landings shows a clear distinction between MSFD sub-regions, where coverage in the Western Mediterranean is lower (30%) compared to the Ionian/Central Mediterranean (60%), and the Adriatic Sea (65%) (Fig. 6.2.4.4). Around 70 to 80 % of landings can be potentially described with 3.3 related indicators in Italian MSFD subregions.

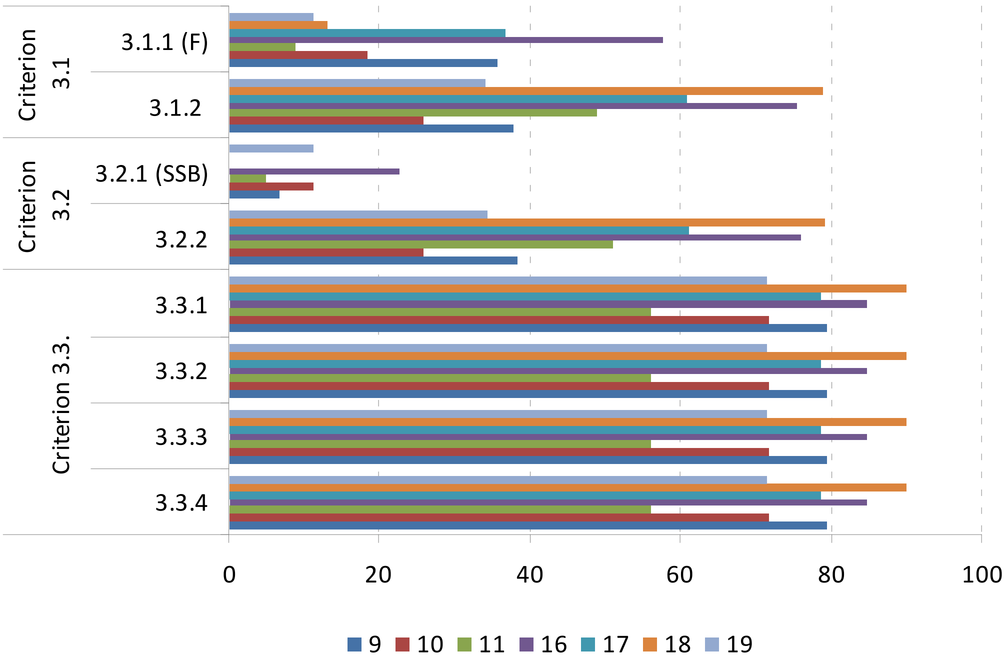


Figure 6.2.4.3. Potential percentage coverage of Descriptor 3 indicators in terms of species/*taxa* landings in Italian GSAs (9, 10, 11, 16, 17, 18, 19).

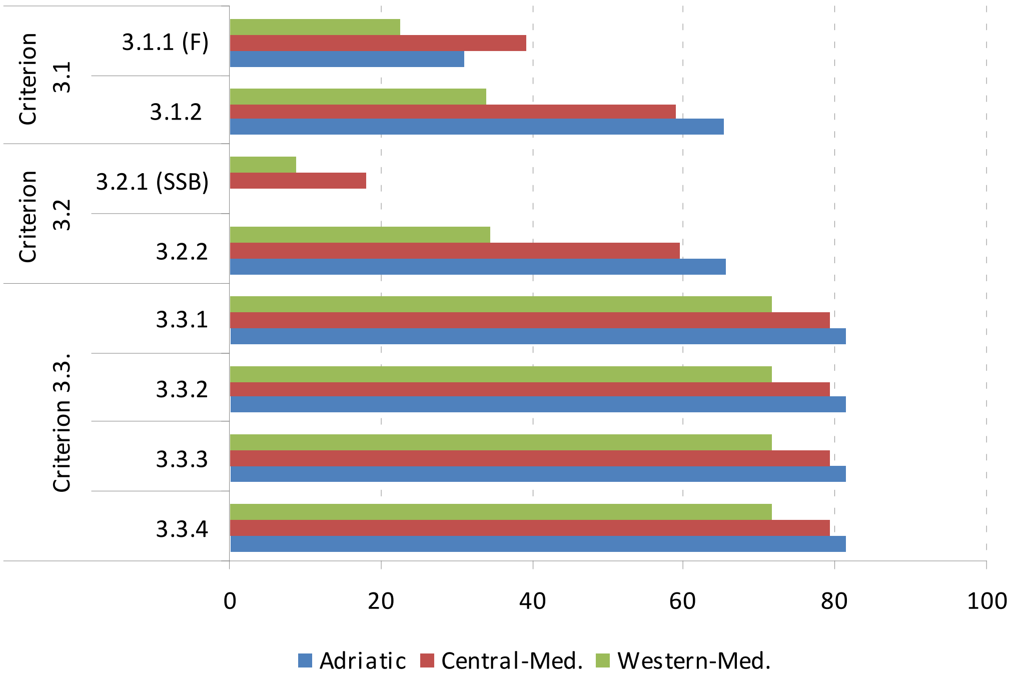


Figure 6.2.4.4. Potential percentage coverage of Descriptor 3 indicators in terms of species/*taxa* landings in Italian MSFD sub-regions.

6.2.5 Other indicators

In relation to the DCF environmental indicators listed in Annex XIII of Commission Decision 2008/949/EC, estimates for some species are available at GSA level (SIBM, 2010). For the LFI indicators, several length thresholds have been used and compared in each GSA, although final agreement on the best thresholds per single GSA or MSFD sub-region needs to be reached. Regarding spatial indicators (5, 6, and 7) that summarize the area impacted by fishing, they have been estimated using VMS data; moreover, several procedures tailored for the Italian fleets have been so far developed (Russo *et al*. 2011a, 2011b) and discussed in the framework of the WKCPUEFFORT ICES Workshop (WKCPUEFFORT 2011). An R package for facilitating the use of such routines in the context of the Mediterranean Sea (where fishing is multi-target and characterised by small-scale activities, as in Italy) will be delivered at the beginning of 2012.

6.3 North-east Atlantic Ocean – Bay of Biscay and Iberian Coast

This section presents a case study concerning the Spanish North Atlantic marine waters (*i.e.* within 200 nautical miles of the coast and under Spanish jurisdiction). The purpose of this case study is to present ideas that could be useful for implementation of the MSFD pertaining to Descriptor 3 in this or other regions and should in no way be interpreted as reflecting the position of Spain as a Member State. Three key aspects are examined in this case study: the way to select the species to be included in the analysis, potential ways in which GES could be meaningfully determined, discussing the differences between them, and the development of some simple mathematical formulations to measure the current status with respect to GES on a 0 to 1 scale, where 0 reflects the worst outcome and 1 means GES.

Point 2 of Article 4 of the MSFD states that MSs may implement the directive by reference to subdivisions, provided that such subdivisions are delimited in a manner compatible with the subregions defined in the directive. It also states that MSs may revise the subdivisions upon completion of the initial assessment due in July 2012. When the MSFD was transposed to Spanish legislation, five subdivisions were defined, in which the MSFD will, in principle, be separately implemented. The five subdivisions are displayed with different colours in Figure 6.3.1. This case study focuses on the so-called *Spanish North-Atlantic subdivision*, shown in green.

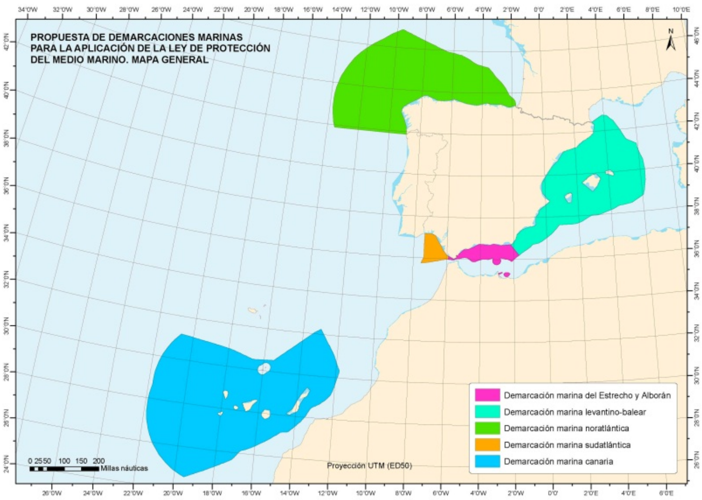


Figure 6.3.1: Spanish subdivisions defined for the MSFD (each subdivision in a different colour)

6.3.1 Selection of commercially exploited (shell)fish populations

The Commission Decision on criteria and methodological standards on good environmental status (2010/477/EU) indicates that Descriptor 3 applies to all the stocks covered by the DCF and similar obligations under the Common Fisheries Policy. Additionally, it says that for these and for other stocks, its application depends on the data available, which will determine the most appropriate indicators to be used.

Accordingly, the selection of species for this case study started from the information contained in the table in Annex VII of the Spanish proposal for the DCF (which is the relevant subset of the tables in Appendix VII of Commission Decision 2008/949/EC). This is a very extensive list of species covering several ICES areas (at different levels of spatial resolution) and the Atlantic Region of ICCAT (without any spatial disaggregation).

The Spanish North-Atlantic subdivision comprises almost the entire ICES Division VIIIc and part of ICES Divisions VIIIb, VIIId, VIIIe, IXa and IXb (see Figure 6.3.1.1). Almost all of the catches in these waters can be attributed to the Spanish fleet and, for this reason, focusing only on Spanish landings for the selection of commercially exploited species is considered a sensible approach in this case study. The Spanish landings (averaged over 2006-2008) from the DCF table corresponding to regions that have substantial overlap with the Spanish North-Atlantic subdivision were used for the selection of species. Even though there are mismatches between the regions in the

DCF table and the Spanish North-Atlantic subdivision, this procedure is considered to provide a reasonable approximation and, hence, to be appropriate for the selection of species to be considered under Descriptor 3. In some cases where the DCF region is much larger than the Spanish North-Atlantic subdivision and certain species are known not to occur in the Spanish North-Atlantic subdivision, the species were excluded (this applied to *e.g.* certain tropical and oceanic tuna species).

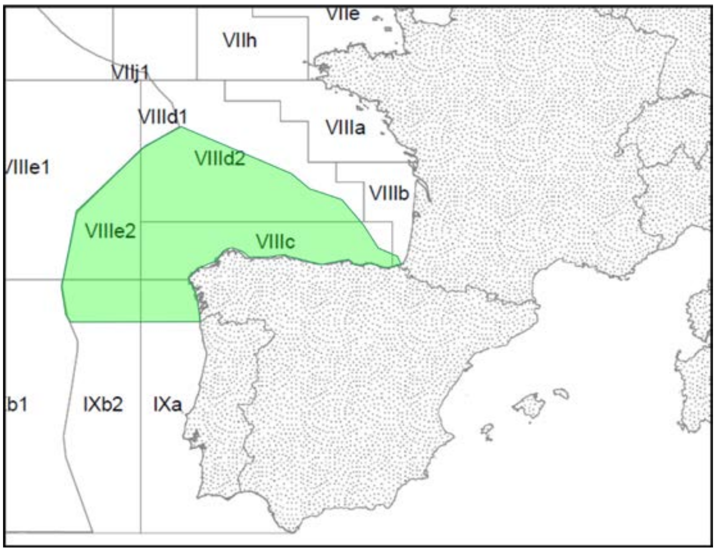


Figure 6.3.1.1: Overlap between Spanish North-Atlantic subdivision (green) and ICES areas

The DCF list relevant for the Spanish North-Atlantic subdivision contains more than 100 species. The species were ordered from larger to smaller landings (average landings of 2006-2008, except for anchovy, for which the 2010 Spanish quota was used because the fishery was closed during the entire 2006-2008 period). There are 11 species (mackerel, sardine, horse mackerel, albacore tuna, blue whiting, hake, chub mackerel, anchovy, octopus, bluefin tuna and white anglerfish) that each contributes more than 1% of the total landings and together they constitute 93% of the total landings. If the landings threshold for the species is lowered from 1% to 0.1%, then 19 species are added and the 30 species together constitute 99% of the total landings. However, there is no information available for most of the 19 additional species. Rather than lowering the landings threshold to 0.1% it seemed more useful to select the species from the DCF list that satisfy at least one of the following 4 criteria:

- Landings ≥ 1%.
- Regularly assessed by ICES: these species are, or have been, commercially important, either because of high catch levels or due to their socio-economic value.
- "New ICES species": species for which ICES gave advice for the first time in 2011 and for which there is a higher chance that assessments may be developed in the not too distant future.
- WFD: species that were selected for this area under the Water Framework Directive (2000/60/EC). This introduces coherence with related European legislation.

  This procedure led to 28 selected species (see Table 6.3.1.1), which together represent 97% of the total landings.

Species / Stock	Common name	%landings	Selection criterion	Indicators
Scomber scombrus	*mackerel*	29.57	landings ≥ 1%	P3
Sardina pilchardus	*sardine*	15.89	landings ≥ 1%	P4
Trachurus trachurus (western stock)	*horse mackerel*	13.66	landings ≥ 1%	P1
Trachurus trachurus (southern stock)				P4
Thunnus alalunga	*albacore tuna*	8.77	landings ≥ 1%	P3
Micromesistius poutassou	*blue whiting*	7.08	landings ≥ 1%	P3
Merluccius merluccius	*hake*	5.88	landings ≥ 1%	P1
Scomber colias	*chub mackerel*	5.27	landings ≥ 1%	None
Engraulis encrasicolus (ICES Subarea VIII)	*anchovy*	3.07	landings ≥ 1% + WFD	P2
Octopus vulgaris	*octopus*	1.78	landings ≥ 1%	None
Thunnus thynnus	*bluefin tuna*	1.34	landings ≥ 1%	P3
Lophius piscatorious	*white anglerfish*	1.18	landings ≥ 1%	P1
Conger conger	*conger*	0.76	WFD	None
Sepia officinalis	*cuttlefish*	0.53	WFD	None
Lophius budegassa	*black anglerfish*	0.49	Regularly assessed by ICES	P1
Trisopterus spp. (taxon)	*poutings*	0.43	WFD	None
Lepidorhombus boscii	*4-spot megrim*	0.42	Regularly assessed by ICES	P1
Mullus surmuletus	*red mullet*	0.16	WFD	None
Nephrops norvegicus (FU 31)	*Norway lobster*	0.13	Regularly assessed by ICES	S
Nephrops norvegicus (FU 25)			Regularly assessed by ICES	S
Nephrops norvegicus (FU 26-27)			Regularly assessed by ICES	S
Pollachius pollachius (all areas)	*pollack*	0.13	New ICES species + WFD	None
Dicentrarchus labrax	*seabass*	0.13	WFD	None
Lepidorhombus whiffiagonis	*megrim*	0.08	Regularly assessed by ICES	P1
Pollachius pollachius (ICES Subareas IX, X)	*pollack*	0.05	New ICES species	None
Solea solea	*sole*	0.05	New ICES species + WFD	None
Pleuronectes platessa	*plaice*	0.03	New ICES species	None
Sparidae (taxon)	*sparids*	0.03	WFD	None
Psetta maxima	*turbot*	0.02	WFD	None
Anguilla Anguilla	*eel*	0.00	WFD	None
Merlangius merlangus	*whiting*	0.00	New ICES species	None
Salmo salar	*salmon*	0.00	WFD	None

Table 6.3.1.1: Selected species for Descriptor 3 in the Spanish North-Atlantic subdivision case study

6.3.2 Species covered by stock assessments

Since the assessment of commercially exploited species is at the stock level, all indicators are considered at the stock level. The stock distribution boundaries used by ICES or ICCAT do not coincide with the Spanish North-Atlantic subdivision. In particular, 3 species from Table 6.3.1.1 belong to more than 1 stock:

- Horse mackerel: 2 ICES stocks (western and southern).

- Norway lobster: 3 ICES assessment units (Functional Unit FU 31 --Cantabrian Sea--, FU 25 --Northern Galicia--, and FU 26-27 --Western Galicia and Northern Portugal--).
- Pollack: 2 entries in the DCF table ("all areas" and "ICES Subareas IX-X").

For the species in Table 6.3.1.1, stocks that do not cover at least one of ICES Divisions VIIIc or IXa are not considered, because even though they may have some overlap with the Spanish North-Atlantic subdivision, this overlap is very minor and not considered sufficiently representative for the area examined in this case study. Hence, the so-called ICES northern stock of hake and the ICES stocks of anglerfish and megrim in ICES Divisions VIIb-k and VIIIabd are not considered in this case study.

From all of the above it follows that the 28 selected species correspond to 32 stocks. The last column of Table 6.3.1.1 shows the type of indicators available for the assessment of each stock. For 16 stocks no indicators are available, whereas 13 and 3 stocks have, respectively, "primary" and "secondary" indicators, according to the definitions in the Commission Decision 2010/477/EU. The stocks with primary indicators are classified into 4 categories:

- P1: F_{MSY} defined
- P2: reference level coherent with SSB_{MSY} defined (for stocks assessed by ICES, this point is called $B_{MSY\text{-trigger}}$ and corresponds to the *minimum* value of SSB considered consistent with SSB_{MSY}; for the two tuna stocks, assessed by ICCAT, estimates of SSB_{MSY} are provided)
- P3: F_{MSY} and reference level coherent with SSB_{MSY} both defined
- P4: no reference levels defined

The 3 stocks with secondary indicators (denoted as "S" in the last column of Table 6.3.1.1) do not have reference levels defined.

The 16 stocks for which primary or secondary indicators exist constitute 88% of the total landings.

6.3.3 Assessment of current status in relation to GES at the stock level

The assessment of the current status is conducted on the basis of the 16 stocks for which primary or secondary indicators exist. These stocks have been assessed by ICES or ICCAT and the results of their most recent assessments are used in this case study. Some of these stocks (mackerel, blue whiting, western horse mackerel and the two tuna species) are widely distributed and cover a much wider distribution area than the Spanish North-Atlantic subdivision. However, since they are assessed by ICES or ICCAT as single units it seems appropriate to use the results of their assessments in the analysis of the Spanish North-Atlantic subdivision. The latest ICES results are available on the web address http://www.ices.dk/advice/icesadvice.asp, whereas the results of the tuna assessments are in the latest ICCAT report at http://www.iccat.es/Documents/Meetings/Docs/SCRC2011-Report-ENG.pdf.

The Commission Decision 2010/477/EU establishes 3 criteria that must be considered in Descriptor 3 to assess the current status with respect to GES: Criterion 3.1 (level of pressure of fishing activity), Criterion 3.2 (reproductive capacity of the stock) and Criterion 3.3 (population age and size distribution). The same Commission Decision establishes primary and secondary indicators for the analysis of each criterion. It also states that achieving or maintaining GES requires that $F \leq F_{MSY}$ in Criterion 3.1, whereas for Criterion 3.2 full reproductive capacity corresponds to $SSB \geq SSB_{MSY}$. It notes, however, that due to possible interactions between species, SSB_{MSY} may not be attained for all stocks simultaneously and that further research is needed to address this fact. It also states that if SSB_{MSY} cannot be reliably estimated, a precautionary biomass value could be used instead. In terms of Criterion 3.3, the Commission Decision says that healthy stocks are characterised by a high proportion of old, large individuals and that expert judgement is required for determining whether there is a high probability that the intrinsic genetic diversity of the stock will not be undermined. It does not give any further indication about possible reference values consistent with GES for the indicators of this criterion.

The approach followed to assess the current status of Descriptor 3 in this case study focuses mainly on criteria 3.1 and 3.2, for which the assessments conducted by ICES and ICCAT provide indicator values (although not always with reference levels). For Norway lobster Functional Units only secondary indicators are available. The most representative biomass indices for Indicator 3.2.2 for this species were considered to be the CPUEs of the following commercial bottom trawl fleets: Santander fleet for FU31, A Coruña fleet for FU25 and Marín fleet for FU 26-27. Indicator 3.1.2 was computed as the ratio of the Norway lobster catch in the corresponding FU divided by the chosen biomass index.

The interpretation of the Criterion 3.3 indicators is much less straightforward and it is not even clear in some cases in which direction the indicators should go to in order to achieve GES. Available indicators under Criterion 3.3, based on the Spanish bottom trawl survey in quarter 4 (a DCF-supported survey), are presented as a form of additional monitoring for the stocks for which this survey is believed to be representative, but it is proposed that these indicators not be analysed in detail unless any of them showed a clear trend, in which case the reasons should be investigated.

Results for Criterion 3.1:

		CRITERION 3.1 Level of pressure of fishing activity				
Stock	**Indicator Type**	**F(2010) / F_{MSY}**	**Fmean(2008-2010) / F_{MSY}**	**[F(2010) - Fmean(1992-2010)] / Fstdev(1992-2010)**	**[Fmean(2008-2010) - Fmean(1992-2010)] / Fstdev(1992-2010)**	**Fmean(2009-2010) / Fmean(2006-2008)**
Mackerel	P3	1.2	1.2	-0.9	-0.9	1.0
Sardine	P4			2.0	1.0	1.7
Horse mackerel (western stock)	P1	1.0	0.7	0.6	-0.2	2.3
Horse mackerel (southern stock)	P4			0.1	0.3	1.1
Albacore tuna	P3	1.0	1.4	-1.6	-0.3	1.0
Blue whiting	P3	1.0	1.3	-1.4	-0.9	0.5
Hake	P1	2.2	3.0	-2.0	-0.7	0.8
Anchovy (ICES Subarea VIII)	P2			-0.6	-1.2	4.7
Bluefin tuna	P3	2.9	3.0	-0.2	-0.2	0.9
White anglerfish	P1	0.9	1.3	-1.4	-0.7	0.6
Black anglerfish	P1	0.4	0.7	-2.3	-1.8	0.4
Four-spot megrim	P1	1.9	1.6	0.1	-0.7	1.0
Megrim	P1	0.4	0.8	-1.8	-1.1	0.4
Norway lobster (FU 31)	S			-1.1	-1.1	0.5
Norway lobster (FU 25)	S			-0.8	-0.8	0.9
Norway lobster (FU 26-27)	S			-0.4	-1.2	0.9

Table 6.3.3.1: Results for Criterion 3.1

Table 6.3.3.1 contains 5 columns concerning results for Criterion 3.1.

The first 2 columns refer to the current stock status of F (where "current" is taken to mean the most recent year in column 1 and the average of the 3 most recent years in column 2) in relation to F_{MSY}.

Columns 1 and 2 display in green colour all cells with values ≤ 1.0, yellow colour the cells with values > 1.0 and ≤ 1.6, and in red the cells with values > 1.6. The cut-off value of 1.6 between yellow and red colours was chosen on the basis of a report on the ICES MSY approach (ICES, 2011a) which shows that for the ICES stocks for which F_{MSY} and F_{pa} are both defined (where F_{pa} is the maximum value of the F estimates consistent with biological sustainability of the stock), $F_{pa} \approx 1.57\ F_{MSY}$ on average, so the cut-off value of 1.6 is consistent with this result. The cut-off value for F between yellow and red could have been chosen at F_{pa} instead of at 1.6 F_{MSY}, but as F_{pa} is not defined for many of these stocks the approach used here is considered to be more inclusive and coherent across this suite of stocks.

As F_{MSY} is not defined for all stocks, a more comprehensive assessment could be made on the basis of the mean value of the F estimates for 1992-2010 instead of F_{MSY}. The historic period was chosen starting from 1992 because this is the first year which is common to all the 16 stocks considered. Additionally, for coherence across stocks, only point estimates of F will be used, even though for a few stocks the assessments also provide the uncertainty associated with the annual estimates of F. The advantage of using this historic mean value of F instead of F_{MSY} is that calculations can be performed for all stocks, including also those for which only secondary indicators exist (Norway lobster), using in such cases the secondary instead of the primary indicator. Note, however, that this mean value of F cannot be considered as a proxy for F_{MSY}, as it is just an average value over a historic period, which is likely to be higher (although it could also be lower) than F_{MSY}. The same calculations as performed in columns 1 and 2 could be made dividing by the mean F during 1992-2010 instead of F_{MSY}. However, when using the historic time series of F estimates it seems more appropriate also to take into account its historic variability in addition to the average value. Therefore, columns 3 and 4 display (Fcurrent – Fmean)/Fstdev, where Fcurrent is defined as F in the most recent year in column 3 (*i.e.* as in the numerator in column 1) and as the average F of the 3 most recent years in column 4 (*i.e.* as in the numerator in column 2), and Fmean and Fstdev are the mean and standard deviation of the F values over the historic period from 1992 to the most recent year.

Columns 3 and 4 of Table 6.3.3.1 cannot be directly used to measure the current status in relation to GES, since they are based on historic values of F rather than on F_{MSY}, but they are at least helpful to ascertain the current situation in relation to the historic period since 1992 and, hence, the direction in which progress is occurring.

Columns 3 and 4 display in green the cells with values ≤ 0.0 (*i.e.* values corresponding to Fcurrent ≤ Fmean), in yellow the cells with values > 0.0 and ≤ 1.6, and in red the cells with values > 1.6. The cut-off value 1.6 between yellow and red was chosen as it corresponds to the 95th percentile of the standard Normal distribution. If there were no trends in the historic time series of F, the standard Normal distribution might be considered as an approximation to the values of (Fcurrent – Fmean)/Fstdev, and there would then be a 5% probability that the actual value was > 1.6 due to chance alone. Hence, a value > 1.6 can be considered a clear indication that Fcurrent is larger than historic F values and is, consequently, marked in red in the table.

Column 5 of the table shows the trend in F in the most recent 5 years, for which the value Fmean(2009-2010)/Fmean(2006-2008) is computed. Only values > 1.2 are marked (in red) as indicative of an increasing trend in recent F values. The cut-off value 1.2 was chosen arbitrarily as there was no clear reason to choose a certain value over another. It is just a very simple rule similar to what the European Commission used to implement regarding SSB in their so-called "Policy Paper" for the stocks without analytical assessments (see COM(2010) 241 final, point 5 of Annex IV). The very high value obtained for anchovy in this column arises from the fact that this fishery was closed during 2006-2009, which must be taken into account to avoid mis-interpretation.

The latest ICCAT assessment of albacore tuna only provides values of F until 2007, so the values in Table 6.3.3.1 are modified as follows for this stock: first column is F(2007)/F_{MSY}, second column Fmean(2005-2007)/F_{MSY}, third column [F(2007)-Fmean(1992-2007)]/Fstdev(1992-2007), fourth column [Fmean(2005-2007)-Fmean(1992-2007)]/Fstdev(1992-2007), fifth column Fmean(2006-2007)/Fmean(2003-2005). Similarly, the latest ICCAT assessment of bluefin tuna provides values of F until 2009, so appropriate modifications are also applied to the columns of Table 6.3.3.1 for this stock.

Results for Criterion 3.2:

		CRITERION 3.2: Reproductive capacity of the stock				
Stock	**Indicator Type**	**SSB(2011) / SSB_{MSY}**	**SSBmean (2009-2011) / SSB_{MSY}**	**[SSB(2011) - SSBmean(1992-2011)] / SSBstdev(1992-2011)**	**[SSBmean (2009-2011) – SSBmean(1992-2011)] / SSBstdev(1992-2011)**	**SSBmean(2010-2011) / SSBmean(2007-2009)**
Mackerel	P3	1.3	1.4	1.4	1.7	1.0
Sardine	P4			-1.7	-1.5	0.4
Horse mackerel (western stock)	P1			-0.4	0.5	0.8
Horse mackerel (southern stock)	P4			-2.0	-1.8	0.9
Albacore tuna	P3	0.6	0.7	-0.1	0.2	0.9
Blue whiting	P3	1.1	1.3	-1.0	-0.7	0.6
Hake	P1			3.1	1.8	1.5
Anchovy (ICES Subarea VIII)	P2	3.0	1.8	1.3	-0.1	2.4
Bluefin tuna	P3	0.3	0.3	-0.7	-0.9	1.1
White anglerfish	P1			2.2	1.1	1.3
Black anglerfish	P1			3.0	1.5	2.2
Four-spot megrim	P1			0.8	0.6	1.0
Megrim	P1			-0.2	-0.9	1.2
Norway lobster (FU 31)	S			-0.2	-1.0	0.9
Norway lobster (FU 25)	S			-1.2	-1.2	0.6
Norway lobster (FU 26-27)	S			-1.1	-0.9	0.7

Table 6.3.3.2: Results for Criterion 3.2

Table 6.3.3.2 also contains 5 columns, all very similar to the corresponding columns of Table 6.3.3.1, but relating to SSB instead of F.

Columns 1 and 2 display current SSB divided by a reference level coherent with SSB_{MSY}, where "current" is interpreted as the most recent year in column 1 and the average of the 3 most recent years in column 2. Only 5 stocks have a reference level coherent with SSB_{MSY} defined. It must also be noted that for the 3 stocks assessed by ICES (mackerel, blue whiting and anchovy) the denominator in columns 1 and 2 is

$B_{MSY-trigger}$ (in principle defined as a lower percentile of the distribution of SSB_{MSY} values and, at present, simply taken as a precautionary biomass until the latter distribution is better known), whereas for the 2 stocks assessed by ICCAT (albacore tuna and bluefin tuna) the denominator is meant to represent SSB_{MSY}. As a consequence, the interpretation of the values in columns 1 and 2 is not entirely coherent between ICES and ICCAT stocks (being, by definition, more optimistic when the denominator is $B_{MSY-trigger}$ instead of an SSB_{MSY} estimate), posing difficulties for their use in the context of Descriptor 3.

Columns 1 and 2 display in green colour all cells with values ≥ 1.0, yellow colour the cells with values < 1.0 and ≥ 0.6, and in red the cells with values < 0.6. The cut-off value 0.6 between yellow and red colours corresponds to 1/1.6, remembering that 1.6 was the cut-off value for F/F_{MSY} used in columns 1 and 2 of Table 6.3.3.1. The underlying idea for this choice of cut-off value for SSB/SSB_{MSY} is that multiplying F or dividing SSB by the same constant should ascertain a certain level of consistency.

Given the difficulties with columns 1 and 2 in Table 6.3.3.2 explained above, a more comprehensive (as well as coherent across stocks) assessment could be made on the basis of the mean value of the SSB estimates for 1992-2011 instead of SSB_{MSY}. As was the case for Criterion 3.1, only point estimates of SSB will be used, to enhance coherence across stocks, even though a few of the stock assessments also provide the uncertainty associated with the annual SSB estimates (this explains the apparent discrepancy for the southern horse mackerel stock between the results obtained here and the ICES assessment: large negative values are obtained here because the ICES stock assessment indicates rather limited historic variability in the point estimates of SSB across years but very wide confidence limits in each year, and the confidence limits are not used here). It must be noted that the mean value of SSB cannot be considered as a proxy for SSB_{MSY}, as it is just an average value over a historic period. Similarly to what was done for F, columns 3 and 4 of Table 6.3.3.2 display (SSBcurrent – SSBmean)/SSBstdev, where SSBcurrent is defined as SSB in the most recent year in column 3 (*i.e.* as in the numerator in column 1) and as the average SSB of the 3 most recent years in column 4 (*i.e.* as in the numerator in column 2), and SSBmean and SSBstdev are the mean and standard deviation of the SSB values over the historic period from 1992 to the most recent year.

Columns 3 and 4 of Table 6.3.3.2 cannot be directly used to measure the current status in relation to GES, but at least they are useful to ascertain the current status in relation to the historic period from 1992 to present and the direction in which progress is being made.

Columns 3 and 4 display in green the cells with values ≥ 0.0 (*i.e.* values corresponding to SSBcurrent ≥ SSBmean), in yellow the cells with values < 0.0 and ≥ -1.6, and in red the cells with values < -1.6. Similarly to what was done for columns 3 and 4 of Table 6.3.3.1 (pertaining to F), the cut-off value -1.6 between yellow and red was chosen as it corresponds to the 5th percentile of the standard Normal distribution. If there were no trends in the historic time series of SSB, the standard Normal distribution might be considered as an approximation to the values of (SSBcurrent – SSBmean)/SSBstdev, and there would then be a 5% probability that the actual value was < -1.6 due to chance alone. Hence, a value < -1.6 can be considered as a clear indication that SSBcurrent is smaller than historic SSB values and is, consequently, marked in red in the table.

Column 5 shows the trend in SSB in the last 5 years, for which SSBmean(2010-2011)/SSBmean(2007-2009) was computed. Only values < 0.8 are marked (in red), as indicative of a decreasing trend in recent SSB values. This is just a very simple rule along the lines of what the European Commission used to implement regarding SSB in their so-called "Policy Paper" for the stocks without analytical assessments (see COM(2010) 241 final, point 5 of Annex IV).

The most recent ICCAT assessment give values of SSB only up to 2007 for albacore tuna and up to 2009 for bluefin tuna, whereas the secondary biomass indicators for Norway lobster stocks only go to 2010. The years used for these stocks in Table 6.3.3.2 have been modified accordingly, similarly to the procedure applied in Table 6.3.3.1 for the tuna stocks.

Results for Criterion 3.3:

	Indicator 3.3.1: Prop of biomass > L50			Indicator 3.3.2: Mean maximum length			Indicator 3.3.3: 95 percentile of fish length distribution		
Stock	[I(2010) - Imean(1990-2010)] / Istdev(1990-2010)	[Imean(2008-2010) - Imean(1990-2010)] / Istdev(1990-2010)	Imean(2009-2010)/ Imean (2006-2008)	[I(2010) - Imean(1990-2010)] / Istdev(1990-2010)	[Imean(2008-2010) - Imean(1990-2010)] / Istdev(1990-2010)	Imean(2009-2010) / Imean(2006-2008)	[I(2010) - Imean(1990-2010)] / Istdev(1990-2010)	[Imean(2008-2010) - Imean(1990-2010)] / Istdev(1990-2010)	Imean(2009-2010) / Imean(2006-2008)
H. mackerel (western)	-1.2	-1.2	0.7	0.0	0.3	0.9	0.8	-0.3	1.0
H. mackerel (southern)	0.5	-0.3	1.0	0.0	0.3	0.9	0.8	-0.3	1.0
Blue whiting	-0.5	0.1	0.5	0.0	0.3	0.9	-0.3	0.4	0.8
Hake	0.5	0.2	1.0	0.0	0.3	0.9	0.2	-0.1	0.9
White anglerfish	-0.1	-0.1	0.8	0.0	0.3	0.9	-0.3	-0.3	0.9
Black anglerfish	-0.3	0.5	1.0	0.0	0.3	0.9	-0.6	0.1	1.0
Four-spot megrim	-0.8	0.2	1.0	0.0	0.3	0.9	-0.6	0.4	1.0
Megrim	-3.1	-0.9	0.9	0.0	0.3	0.9	0.9	1.4	1.0

Table 6.3.3.3: Results for Criterion 3.3

The Spanish bottom trawl survey conducted in quarter 4 is considered to provide relevant indicators for the 8 stocks shown in Table 6.3.3.3. A complete time series between 1990 and 2010 is available for this survey. Table 6.3.3.3 displays results for the 3 primary indicators of Criterion 3.3. By definition, Indicator 3.3.2 has the same value for all the stocks.

As there is no reference level set for any of the indicators, the first 2 columns presented for each indicator measure current levels in relation to the values during the period 1990-2010. Similarly to what was done for Criteria 3.1 and 3.2, the formula used is (Icurrent – Imean)/Istdev, where Icurrent is the value of the indicator in 2010 (column 1) or the average of 2008-2010 (column 2), and Imean and Istdev are the mean and standard deviation of the indicator values over the historic period 1990-2010. On the basis of the percentiles of the standard Normal distribution, values smaller than -1.6 or larger than 1.6 in these columns may be considered as signalling that current values are not in line with the historic period. Using this reasoning, only the first column of Indicator 3.3.1 for megrim stands out (value -3.1), but upon examination of the ICES assessment results for this stock and the survey index, this large negative value is likely to be more reflective of the good incoming recruitment (age 1 individuals) detected by the survey in 2010 than to a decrease in the mature biomass of the stock.

The third column under each indicator in Table 6.3.3.3 reflects potential trends in the last 5 years. Most values are very close to 1. The most extreme value is for Indicator 3.3.1 for blue whiting (value 0.5), but an examination of the entire historic series of this indicator showed wide inter-annual fluctuations for this stock without any strong trend in the last 5 years. The same examination for the western horse mackerel stock revealed that the value 0.7 is signalling a mild decreasing trend in the last 5 years.

The overall conclusion is that no strong changes or trends in the indicators are apparent from Table 6.3.3.3, and these indicators will not be analysed in any further detail.

6.3.4 Assessment of current status in relation to GES at the criterion level

As already explained, the Commission Decision states that achieving or maintaining GES requires that $F \leq F_{MSY}$ in Criterion 3.1, whereas full reproductive capacity corresponds to $SSB \geq SSB_{MSY}$ in Criterion 3.2 (although a precautionary biomass may be used in place of SSB_{MSY} if no reference level coherent with SSB_{MSY} can be reliably estimated). Hence, the definition of GES in relation to these criteria is already implicitly stated in the Commission Decision. The same definition of GES could also be considered as the environmental target.

<u>Criterion 3.1:</u>

Three possible interpretations of GES are considered/proposed in this case study:

1) Using a strict interpretation of the Commission Decision, GES would require that $F \leq F_{MSY}$ for all the stocks. This definition of GES treats F_{MSY} as a limit for F.

2) However, one might also consider that F_{MSY} could be a target rather than a limit, in which case F would be expected to fluctuate randomly over time around F_{MSY} for each stock. At any point in time 50% of the stocks would be expected to be above F_{MSY} and 50% below F_{MSY}. With this in mind, a possible alternative interpretation of GES could be that F/F_{MSY} is ≤ 1.0 for at least 50% of the stocks and that it is not > 1.6 for any stock (*i.e.* no stock is outside “precautionary” exploitation limits).

3) A third possible interpretation of GES could be that the average value of F/F_{MSY} across all stocks is ≤ 1. In this case, achieving GES would not ensure that all stocks are within safe exploitation limits. Problems with individual stocks would have to be detected in the assessments regularly performed for the stocks under such an obligation in the Common Fisheries Policy.

The first of the 3 possible GES interpretations for Criterion 3.1 is the most strict (if GES is reached according to it then it is also reached according to the other 2 interpretations), whereas there is no order between the second and third interpretations (GES may be reached according to any one of them and not the other).

Note that all 3 possible interpretations of GES suggested above treat all the stocks in the same way (*i.e.* the same weight is given to all stocks). Since all the selected stocks in this case study are of commercial importance, no clear reason was found to give different weights to them in the context of Descriptor 3.

Using Table 6.3.3.1, the assessment of the current status in relation to GES would be based on the first or the second column of the table. Using one of these columns and any of the 3 possible interpretations of GES, the current status in relation to GES could be measured on a 0 to 1 scale (with 0 corresponding to the worst situation and 1 to GES) as follows:

- **First interpretation of GES**: GES corresponds to all stocks being in green.

Current status in relation to GES is:

proportion of stocks in green.

- **Second interpretation of GES**: GES corresponds to at least 50% of the stocks in green and no stock in red.

Current status in relation to GES on a 0 to 1 scale could be measured by the formula:

max[0 , 1 – proportion of stocks in red – max{0, 0.5 – proportion of stocks in green}].

- **Third interpretation of GES:** GES corresponds to the average of the column values (*i.e.* average across all stocks) being in green.

Current status in relation to GES on a 0 to 1 scale could be measured by the formula:

0 if average of the column values across all stocks is > c_{red}

1 if average of the column values across all stocks is < c_{green}

[c_{red} – (average of the column values across all stocks)] / (c_{red} – c_{green}) in all other cases

where c_{green} = 1 and c_{red} = 1.6 are the cut-off values chosen to separate green from yellow (c_{green}) and red from yellow (c_{red}) in the first two columns of Table 6.3.3.1.

When no reference level F_{MSY} exists, it is not possible to work on the basis of columns 1 and 2 of Table 6.3.3.1. In this case, it is possible to do exactly the same calculations shown above but based on the values in columns 3 and 4 of the table. Using the values in columns 3 and 4 the cut-off points to measure current status in relation to the third interpretation of GES are c_{green} = 0 (between green and yellow) and c_{red} = 1.6 (between yellow and red). Working on the basis of columns 3 and 4 has the advantage that all stocks with primary or secondary indicators can be included. It is, however, very important to remark that the value 1 in this case would not necessarily correspond to GES, since the analysis is based on historic F values rather than on F_{MSY}.

Table 6.3.4.1 calculates the current status on the 0 to 1 scale according to the 3 GES interpretations mentioned above. As just said, for columns 1 and 2 of Table 6.3.4.1, the value 1 would correspond to GES, but this does not apply to columns 3 and 4 of the table. Regarding columns 1 and 2, although the strictest interpretation of GES is the first one, because of the way current status in relation to GES has been defined it turns out to lead to lower values of the current status under GES Interpretation 3. This is because even though 60% of the stocks are in green (see column 1) the mean value of F(2010)/F_{MSY} across stocks is not far from 1.6, the cut-off point at which current status is taken to be 0 when Interpretation 3 is used. A similar situation happens in column 2 of the table. Columns 3 and 4 give higher values of the current status (in a 0 to 1 scale) than columns 1 and 2, but note that the value 1 in columns 3 or 4 does not correspond to GES.

		CRITERION 3.1 Level of pressure of fishing activity				
		$F(2010) / F_{MSY}$	$Fmean(2008\text{-}2010) / F_{MSY}$		[F(2010) - Fmean(1992-2010)] / Fstdev(1992-2010)	[Fmean(2008-2010) - Fmean(1992-2010)] / Fstdev(1992-2010)
Proportion of stocks in green		0.60	0.30		0.75	0.88
Current status in relation to GES Interpretation 1		0.60	0.30		0.75	0.88
Proportion of stocks in red		0.30	0.20		0.06	0.00
Current status in relation to GES Interpretation 2		0.70	0.60		0.94	1.00
Mean value across stocks		1.30	1.49		-0.74	-0.67
Current status in relation to GES Interpretation 3		0.51	0.19		1.00	1.00

Table 6.3.4.1: Current status of Criterion 3.1 measured on a 0 to 1 scale.

Criterion 3.2:

According to the Commission Decision, $SSB \geq SSB_{MSY}$ corresponds to full reproductive capacity. A precautionary biomass may be used instead of SSB_{MSY} if no reference level coherent with SSB_{MSY} can be reliably estimated. As already indicated, the Commission Decision states that further research is needed to address the fact that SSB_{MSY} may not be achieved for all stocks simultaneously due to possible interactions between them. It is therefore less clear what would correspond to GES for Criterion 3.2 and how to combine the stocks to measure the current status in relation to GES. For the Spanish North-Atlantic subdivision it should also be taken into account that SSB_{MSY} or precautionary biomass levels are defined for only 5 stocks (see columns 1 and 2 of Table 6.3.3.2), of which the 3 ICES stocks (mackerel, blue whiting, anchovy) are using $B_{MSY\text{-}trigger}$ (currently an SSB level closer to a precautionary biomass than to SSB_{MSY}) instead of SSB_{MSY}, whereas the two ICCAT tuna stocks use SSB_{MSY} estimates. As a consequence, the values in columns 1 and 2 of Table 6.3.3.2 do not seem entirely comparable across stocks.

Nevertheless, GES interpretations could be considered in the context of Criterion 3.2, similarly to how it was done for Criterion 3.1. In all interpretations below, "SSB_{MSY}" should be understood to mean an SSB_{MSY} estimate or a precautionary biomass level in the absence of such an estimate ($B_{MSY\text{-}trigger}$ is used instead of SSB_{MSY} for ICES stocks, as explained above).

1) A first interpretation of GES would be $SSB \geq SSB_{MSY}$ for all stocks.

2) A second interpretation of GES could be that SSB/SSB_{MSY} is ≥ 1.0 for at least 50% of the stocks and that it is not < 0.6 for any stock. The value 0.6 is 1/1.6, where 1.6 is the value used for the second interpretation of GES under Criterion 3.1.

3) A third possible interpretation of GES could be that the average value of SSB/SSB_{MSY} across all stocks is ≥ 1. Similarly to what happened under the third GES interpretation for Criterion 3.1, this does not prevent very low SSB values for some stocks, a problem which should then be detected

when the stocks are individually assessed under Common Fishery Policy obligations.

As was the case for the 3 possible interpretations of GES in Criterion 3.1, the first interpretation here is the strictest, whilst there is no order between the other 2 interpretations.

Using either the first or the second column of Table 6.3.3.2, current status in relation to GES can be measured on a 0 to 1 scale, with 0 corresponding to the worst situation and 1 to GES as follows:

- **First interpretation of GES**: GES corresponds to all stocks being in green.

Current status in relation to GES is:

proportion of stocks in green.

- **Second interpretation of GES**: GES corresponds to at least 50% of the stocks in green and none in red.

Current status in relation to GES could be measured on a 0 to 1 scale using the formula:

max[0 , 1 – proportion of stocks in red – max{0, 0.5 – proportion of stocks in green}].

- **Third interpretation of GES:** GES corresponds to the average of the column values (*i.e.* average across all stocks) being in green.

Current status in relation to GES could be measured on a 0 to 1 scale using the formula:

0 if average of the column values across all stocks is < c_{red}

1 if average of the column values across all stocks is > c_{green}

[(average of the column values across all stocks) – c_{red}]/(c_{green}- c_{red}) in all other cases

where c_{green} = 1 and c_{red} = 0.6 are the cut-off values chosen to separate green from yellow (c_{green}) and red from yellow (c_{red}) in the first two columns of Table 6.3.3.2.

When no reference level SSB$_{MSY}$ exists, it is not possible to work on the basis of columns 1 and 2 of Table 6.3.3.2. In this case, it is possible to perform exactly the same calculations described above based on the values in columns 3 and 4 of the table. For the values in columns 3 and 4 the cut-off points to assess current status under the third GES interpretation are c_{green} = 0 (between green and yellow) and c_{red} = -1.6 (between yellow and red). Working on the basis of columns 3 and 4 has the advantage that all stocks with primary or secondary indicators can be included. It is, however, very important to remark that the value 1 in this case would not necessarily correspond to GES, since the analysis is based on historic SSB values rather than on SSB$_{MSY}$.

Table 6.3.4.2 calculates the current status on the 0 to 1 scale according to the 3 interpretations given above. As just said, for columns 1 and 2 of Table 6.3.4.2, the value 1 would correspond to GES, but this does not apply to columns 3 and 4 of the table. The lower values obtained in some cases in columns 3 and 4 (in relation to those obtained in columns 1 and 2) are in part due to the fact that all 16 stocks are considered in those columns, whereas columns 1 and 2 relate only to 5 stocks.

		CRITERION 3.2 Reproductive capacity of the stock				
		SSB (2011) / SSB_{MSY}	SSBmean(2009-2011) / SSB_{MSY}		[SSB(2011) - SSBmean(1992-2011)] / SSBstdev (1992-2011)	[SSBmean(2009-2011) - SSBmean(1992-2011)] / SSBstdev(1992-2011)
Proportion of stocks in green		0.60	0.60		0.38	0.44
Current status in relation to GES Interpretation 1		0.60	0.60		0.38	0.44
Proportion of stocks in red		0.20	0.20		0.13	0.06
Current status in relation to GES Interpretation 2		0.80	0.80		0.75	0.88
Mean value across stocks		1.27	1.09		0.20	-0.10
Current status in relation to GES Interpretation 3		1.00	1.00		1.00	0.94

Table 6.3.4.2: Current status of Criterion 3.2 measured on a 0 to 1 scale.

6.3.5 Overall assessment of current status in relation to GES for Descriptor3

Once the current status (measured on a 0 to 1 scale) of Criteria 3.1 and 3.2 in relation to GES has been calculated according to any of the 3 alternative interpretations of GES, the current status of the two criteria can be combined giving weights adding up to 1 to the two criteria. The same weight could be given to each criterion. However, Criterion 3.1 seems more important than Criterion 3.2 in order to attain GES for Descriptor 3 as a whole, given that maintaining fishing mortality at levels consistent with F_{MSY} should, after some time, lead to SSB values consistent with SSB_{MSY}. Additionally, as explained when the results of Criterion 3.2 were discussed, results based on the first 2 columns for this criterion contain only 5 stocks, with different ways of interpreting "SSB_{MSY}" for ICES stocks ($B_{MSY\text{-}trigger}$, which is often equal to the precautionary biomass) and ICCAT stocks (SSB_{MSY}).

All this suggests giving more weight to Criterion 3.1 when combining it with Criterion 3.2. Possible weighting options for the two criteria could be (1,0), (0.75,0.25), (0.67,0.33), (0.5,0.5), where the first option uses only Criterion 3.1 and ignores entirely Criterion 3.2 and the last option gives the same weight to both criteria.

Results from combining both criteria with the 4 weighting options mentioned above and based on each of the 4 columns of Tables 6.3.4.1 and 6.3.4.2 are presented in Table 6.3.5.1. Therefore, this table provides the current status of the whole Descriptor 3 in relation to GES on a 0 to 1 scale. It should, however, be remembered that results based on columns 3 and 4 do not relate to MSY reference levels (*i.e.* to GES) but to historic values from 1992 to present.

	Weight of Criterion 3.1	Weight of Criterion 3.2	Columns used from Tables 6.3.4.1 and 6.3.4.2			
			Column 1	Column 2	Column 3 (value 1 is not GES)	Column 4 (value 1 is not GES)
Current status of Descriptor 3 with respect to GES Interpretation 1	1	0	0.60	0.30	0.75	0.88
	0.75	0.25	0.60	0.38	0.66	0.77
	0.67	0.33	0.60	0.40	0.63	0.73
	0.5	0.5	0.60	0.45	0.56	0.66
Current status of Descriptor 3 with respect to GES Interpretation 2	1	0	0.70	0.60	0.94	1.00
	0.75	0.25	0.73	0.65	0.89	0.97
	0.67	0.33	0.73	0.67	0.88	0.96
	0.5	0.5	0.75	0.70	0.84	0.94
Current status of Descriptor 3 with respect to GES Interpretation 3	1	0	0.51	0.19	1.00	1.00
	0.75	0.25	0.63	0.39	1.00	0.98
	0.67	0.33	0.67	0.46	1.00	0.98
	0.5	0.5	0.75	0.59	1.00	0.97

Table 6.3.5.1: Current status of Descriptor 3 (combining Criteria 3.1 and 3.2) measured on a 0 to 1 scale.

6.4 North-east Atlantic Ocean - North Sea

The North Sea case study was approached from the perspective of the Netherlands but as all information is based on international stocks and an international survey and no subdivision was applied with the subregion these shouldn't differ from any other North Sea MS.

6.4.1 Selection of commercially exploited (shell)fish populations

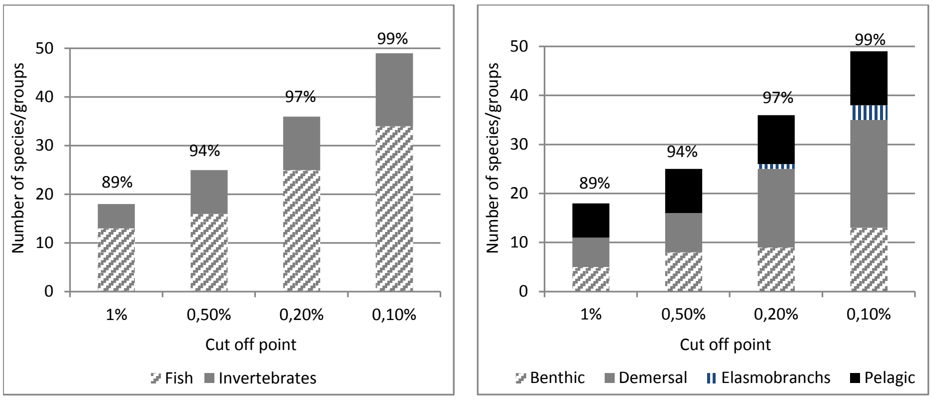
Based on the FAO Fishstat database, table 6.4.1.1 shows the 80 recorded commercial species/taxa for the North Sea, period 2005-2009. Figure 6.4.1.1 then shows how many species/taxa remain when applying a certain threshold fraction for the inclusion of the most important species/taxa and how these are distributed over various ecosystem (sub)components. As these (sub)components do not differ much in terms of their contribution to the overall landings, applying a threshold against these (sub)components as opposed to applying it against the total landings is not expected to make much difference.

Table 6.4.1.1: Species list of landings from the North Sea (IV, IIIa, VIId,e), their relative contribution to the total landings for the period 2005-2009 according to the FAO Fishstat database. It is indicated whether the species is fish (F) or invertebrate (I), assessed (A, * may differ between stocks) or non-assessed (NA), included in the DCF (X). A species was considered assessed if in addition to one of the indicators (F, SSB) information on at least one of the reference points (B_{lim}, B_{pa}, $B_{MSY\text{-}trigger}$, F_{lim}, F_{pa}, F_{MSY}) was provided.

Species/groups	Fish/Invertebrate	Assessed/Non-assessed	Fraction 2005-2009	DCF species
Atlantic herring	F	A	21.38	X
Sandeel	F	A	14.98	X
Mackerels	F	A	11.38	X
European sprat	F	NA	8.58	X
Pollock/Saithe	F	A	5.78	X
Horse mackerels	F	A*	4.1	X
Blue whiting	F	A	3.84	X
European plaice	F	A*	3.34	X
Mytilus	I	NA	2.25	
Crangon/shrimps	I	NA	2.12	X
Great Atlantic scallop	I	NA	1.98	
Haddock	F	A*	1.78	X
Norway pout	F	A	1.61	X
Atlantic cod	F	A	1.55	X
Norway lobster/nephrops	I	A*	1.41	X
Sole	F	A	1.05	X
Whiting	F	NA	1.02	X
Whelks	I	NA	1	
Edible crab/Canger pagurus	I	NA	0.98	X
European pilchard	F	NA	0.95	
Monkfishes/Anglers	F	NA	0.84	X
Northern shrimp/pandalus	I	NA	0.66	X
Cuttlefish and bobtail squids	I	NA	0.65	X
Common dab	F	NA	0.54	X
Cockles	I	NA	0.51	
Gurnards/sea robins	F	NA	0.44	X
Ling	F	NA	0.4	X
Pouting	F	NA	0.29	X
Various squids	I	NA	0.26	X
Common European bittersweet	I	NA	0.26	
Lemon sole	F	NA	0.26	X
European hake	F	A	0.26	X
Rays and skates	F	NA	0.26	X
Mugil/mullets	F	NA	0.23	X
European flounder	F	NA	0.22	X
Turbot	F	NA	0.2	X
Catsharks and nursehounds	F	NA	0.2	
Queen scallop	I	NA	0.2	
Spinous spider crab	I	NA	0.19	
Seabreams	F	NA	0.18	X
Roundnose grenadier	F	NA	0.18	X
Dogfishes and hounds/triakidae	F	NA	0.17	X
Seabasses	F	NA	0.17	X
Witch flounder	F	NA	0.12	X
European lobster	I	NA	0.11	X

Species/groups	Fish/Invertebrate	Assessed/Non-assessed	Fraction 2005-2009	DCF species
Cusk/tusk	F	NA	0.11	X
Argentines	F	NA	0.11	X
Razor clam	I	NA	0.1	
Brill	F	NA	0.1	X
European conger	F	NA	0.09	X
Flat oysters	I	NA	0.09	
Megrims	F	NA	0.08	X
Silvery pout	F	NA	0.08	
Weevers	F	NA	0.05	
Velvet swimcrab	I	NA	0.05	
John dory	F	NA	0.03	X
Wolffishes	F	NA	0.03	X
Atlantic halibut	F	NA	0.02	
European eel	F	NA	0.02	X
European anchovy	F	NA	0.02	
Green crab	I	NA	0.02	
Carpet shells	I	NA	0.01	
Redfishes/sebastes	F	NA	0.01	X
European smelt	F	NA	0.01	
Greater forkbeard	F	NA	0.01	X
Wrasses	F	NA	0.01	
Lumpfish	F	NA	0.01	
Sand sole	F	NA	0.01	
Greenland halibut	F	NA	0.01	X
Blue ling	F	NA	0.01	
Octopuses	I	NA	<0.01	X
Garfish	F	NA	<0.01	
Periwinkels	I	NA	<0.01	
Paleamon/prawns	I	NA	<0.01	
Albacore	F	NA	<0.01	
Atlantic salmon	F	NA	<0.01	X
Porbeagle	F	NA	<0.01	X
Cupped oysters	I	NA	<0.01	
Spiny lobster/palinuridae	I	NA	<0.01	
American plaice	F	NA	<0.01	

Figure 6.4.1.1: Number of species and species groups for different percentage landings cut-off points, presented for fish and invertebrates (left), and benthic, demersal, elasmobranchs and pelagic species (right), and their aggregated percentage contribution to the total landings. Source: 2005-2009 FAO Fishstat dataset.



For this case study we assessed how the period of years over which the landing data were considered determined the relative importance of species/taxa and to what extent this affected the composition of the suite of selected species. To that end, data from the ICES catch statistic data base from 1950 until 2009 and for the entire North Sea were used to rank the relative contribution to the total landing biomass in six different time periods: from 1950 to 2009, from 1960 to 2009, from 1970 to 2009, from 1980 to 2009, from 1990 to 2009 and from 2000 to 2009 (Table 6.4.1.2). The cut-off value for including species/groups into the ranking list was a set at 0.1% of the total landings biomass. Any species/group which contributed less than this percentage was excluded from the ranking list.

The comparison of the ranking lists from the different periods will result in species/groups which are not included when considering a shorter period (these species/groups have become less important in recent years) and species/groups which will be included (these species/groups became more important in recent years). Hence the species/groups which became less important in recent years will be gained to the ranking list when considering a longer time span. On the other hand, species/groups which gained in relative importance in recent years will be lost when including data from longer time spans. Gained and lost species with respect to those corresponding to 2000-2009 for longer time spans are listed in Tables 6.4.1.3 & 6.4.1.4.

Number of included, gained and lost species/groups

The number of species/groups which contributed more than 0.1 % to the total catch biomass became smaller when more years were included in the ranking procedure (Fig. 6.4.1.2). In the period 2000-2009 47 species/groups were ranked, whereas in the period 1950-2009 only 38 species/groups were ranked. Compared to the ranking list of 2000-2009, less species/groups were gained than lost, meaning that a longer aggregation period of data will cause the exclusion of species that were not of sufficient relative importance in decades previous to 2000, but which contributed more than 0.1 % to the total landings of the recent ten years. Contrary, by extending the period of aggregated data backwards resulted only in the inclusion of oysters, for which landings peaked in the 1960s, 1970s and 1980s (Fig. 6.4.1.3).

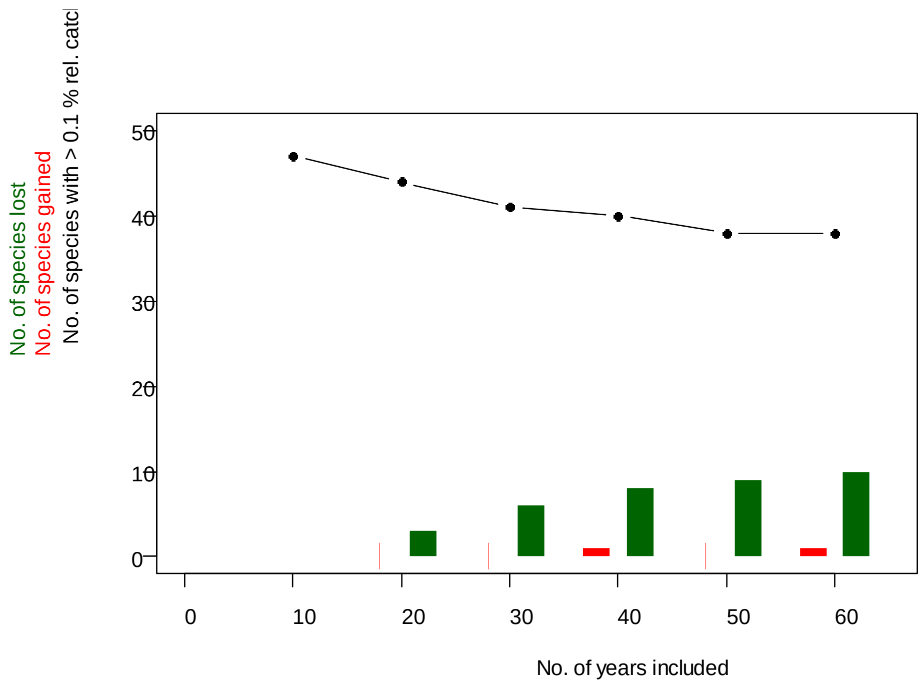


Fig.6.4.1.2: The number of ranked species/groups (black line), for different periods of years, always ending in 2009. Species/groups gained (red bars) and species/groups lost (green bars) when compared to the ranking list of 2000-2009. Species/groups were ranked by their contribution to the total landings biomass in a given period. Species/groups which contributed less than 0.1 % to the total landings biomass in a given period were excluded from the ranking in that period.

Changes in the landings composition

The composition of landings was rather stable between the different periods (Fig. 6.4.1.4). Sandeel was the most dominant group in time periods 1960-2009, 1970-2009, 1980-2009 and 1990-2009, while Atlantic herring was the most abundant species in time period 1950-2009. Other important species/groups were Atlantic cod, mackerels, Norway pout, plaice, saithe and sprat.

Implications for the selection of commercial species to be assessed under D3

The landings composition became more diverse because in the period from 2000-2009 more species were ranked than in the period 1950-2009 (Fig. 6.4.1.2; Table 6.4.1.2). This may reflect a true diversification in the targeted species/groups as well as an improved reporting and sampling system in recent years (e.g. by the implementation of the DCF).

The inclusion of landing data previous to 2000 did not result in a higher number of ranked species and only two groups of oysters were gained. Contrary, at least six species/groups which were relatively important in the period of 2000 to 2009 are not included in the ranking if landings from 1980 or earlier starting years were included. The results of this ranking comparisons are surprisingly clear and suggest to use the landings data from 2000-2009 for the North Sea. Because the reporting system has improved considerably with the advance of electronic information systems since the

1990s, the data of the recent 10 to 20 years are likely to be of higher quality than older landings data.

The DCF is constantly improving and will provide better estimation of true catches (i.e. landings + discards + IUU) for a wider array of species/groups in the near future. Once the estimation of true catches is sufficiently robust for many species and groups, the selection of relevant commercial species for the assessment under Descriptor 3 should be based on these data. Until then, official landing statistics are the preferred source on information to determine the commercially exploited species.

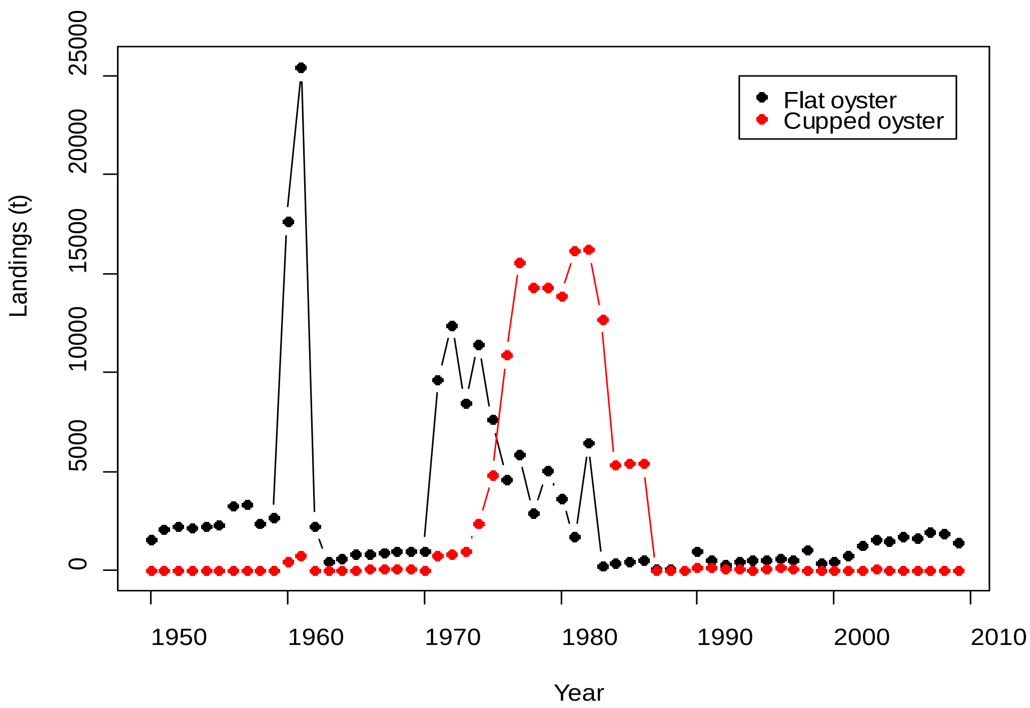


Fig.6.4.1.3: Annual landings of oysters in the North Sea between 1950 and 2009.

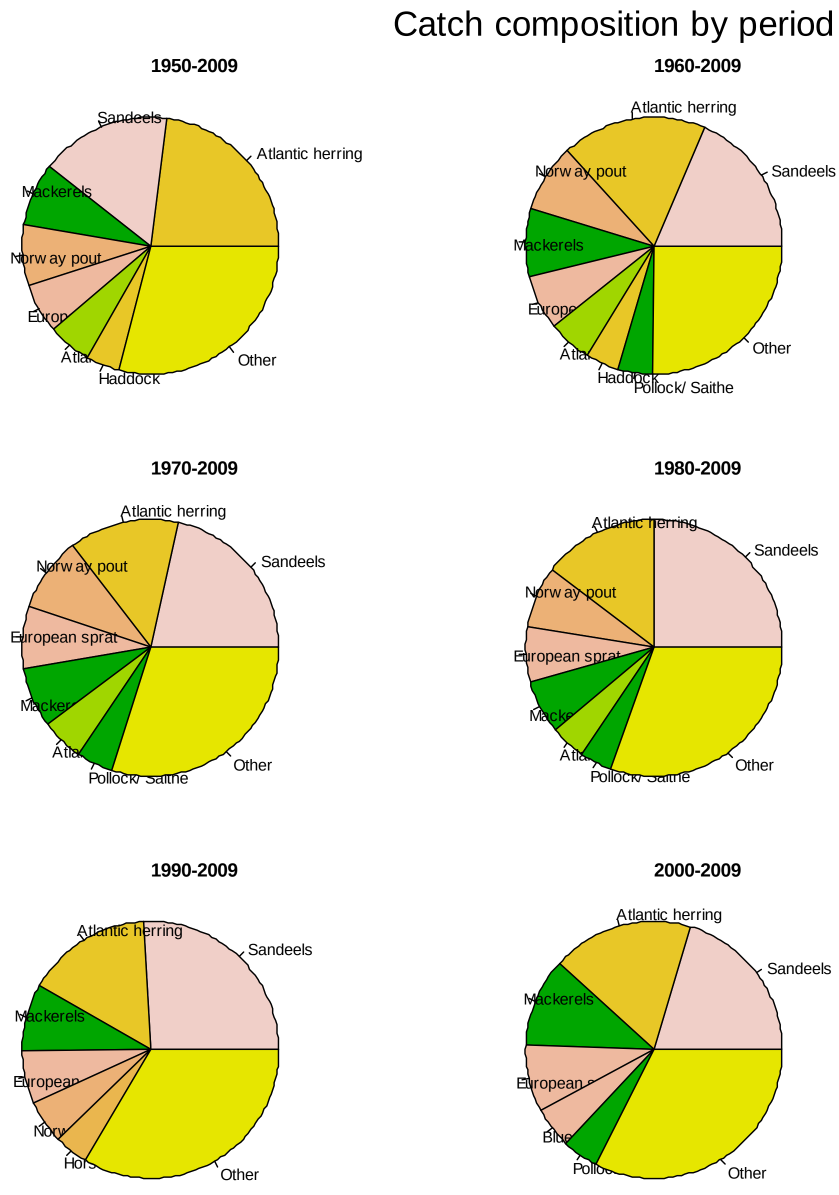


Fig. 6.4.1.4: Landings compositions (in biomass) in the North Sea from 1950 to 2009 grouped in six different time periods. Note that in order to improve clarity of the labelling for this graph, only species/groups contributing more than 4 % to the total landings biomass were included.

Table 6.4.1.2: Landings biomass in tons (L) ranked by species for different time periods. The cut-off point for inclusion in the ranking was 0.1 % of total landing biomass per period.

1950-2009		1960-2009		1970-2009		1980-2009		1990-2009		2000-2009	
Species	L(t)	Species	L(t)	Species	L(t)	Species	L(t)	Species	L(t)	Species	L(t)
Atlantic herring	40478559	Sandeels	28729476	Sandeels	27211014	Sandeels	22203938	Sandeels	14282619	Sandeels	4715278
Sandeels	28748856	Atlantic herring	28432709	Atlantic herring	17651876	Atlantic herring	13078104	Atlantic herring	8718243	Atlantic herring	4108776
Mackerels	14065355	Norway pout	13271571	Norway pout	11757703	Norway pout	6856765	Mackerels	4675065	Mackerels	2577109
Norway pout	13290339	Mackerels	13269637	European sprat	9901458	European sprat	6206617	European sprat	3724778	European sprat	1966037
European sprat	11030165	European sprat	10582548	Mackerels	9522487	Mackerels	6015124	Norway pout	3024051	Blue whiting	1164775
Atlantic cod	9683748	Atlantic cod	8670113	Atlantic cod	6807929	Atlantic cod	4045248	Horse mackerels	2316095	Pollock/ Saithe	1080397
Haddock	7480413	Haddock	6704190	Pollock/ Saithe	5860886	Pollock/ Saithe	3604382	Blue whiting	2105853	Horse mackerels	763766
Pollock/ Saithe	6957871	Pollock/ Saithe	6533037	European plaice	4807036	European plaice	3425957	Pollock/ Saithe	2062919	European plaice	757533
European plaice	6787349	European plaice	5993628	Haddock	4806650	Blue whiting	2974255	European plaice	1983937	Mytilus	670949
Mytilus	6566267	Mytilus	5726547	Mytilus	4495856	Horse mackerels	2924575	Atlantic cod	1649989	Norway pout	577187
Whiting	5612539	Whiting	4741243	Whiting	3375064	Mytilus	2831313	Mytilus	1520399	Haddock	415853
Horse mackerels	3368615	Horse mackerels	3363985	Horse mackerels	3323935	Haddock	2513112	Haddock	1112871	Atlantic cod	409332
Blue whiting	3198654	Blue whiting	3198654	Blue whiting	3196786	Whiting	1653859	Cockles	724885	Crangon/ shrimps	377045
Crangon/ shrimps	2207480	Crangon/ shrimps	1704067	Cockles	1331534	Cockles	1164636	Crangon/ shrimps	665896	Great atlantic scallop	300751
Cockles	1490952	Cockles	1438304	Crangon/ shrimps	1221146	Crangon/ shrimps	884383	Whiting	664181	Norway lobster/ Nephrops	238840
Sole	1338172	Sole	1169600	Sole	923609	Sole	731906	Sole	521446	Sole	222528
Dogfishes and hounds/ triakidae	1182366	Dogfishes and hounds/ triakidae	945839	Great atlantic scallop	775913	European pilchard	574599	European pilchard	493916	Whiting	219190
Great atlantic scallop	806417	Great atlantic scallop	805633	European pilchard	664120	Great atlantic scallop	568331	Great atlantic scallop	445039	European pilchard	204528
European pilchard	779252	European pilchard	697610	Edible crab/ Cancer pangarus	624631	Norway lobster/ Nephrops	521152	Norway lobster/ Nephrops	409252	Whelks	196998

Edible crab/ Cancer pangarus	747730	Edible crab/ Cancer pangarus	687321	Dogfishes and hounds/ triakidae	603145	Edible crab/ Cancer pangarus	515094	Monkfishes/Anglers	368833	Edible crab/ Cancer pangarus	195171
Ling	735403	Norway lobster/ Nephrops	634267	Norway lobster/ Nephrops	585251	Monkfishes/Anglers	487946	Edible crab/ Cancer pangarus	365235	Monkfishes/Anglers	159553
Northern shrimp/ Pandalus	684410	Ling	633271	Monkfishes/Anglers	547838	Northern shrimp/ Pandalus	439550	Northern shrimp/ Pandalus	288708	Cockles	145820
Rays and skates	661021	Northern shrimp/ Pandalus	628193	Ling	544856	Ling	413757	Whelks	276013	Cuttlefish and bobtail squids	143136
Norway lobster/ Nephrops	660919	Seaweeds	590410	Northern shrimp/ Pandalus	512420	Gurnards/ Sea robins	359357	Cuttlefish and bobtail squids	242413	Northern shrimp/ Pandalus	131138
Monkfishes/Anglers	619694	Monkfishes/Anglers	580760	Seaweeds	471919	Whelks	337184	Ling	227936	Seaweeds	122020
Seaweeds	590410	Common dab	483507	Gurnards/ Sea robins	425871	Common dab	308507	Common dab	190805	Common dab	108047
Common dab	567100	Rays and skates	473343	Common dab	414891	Cuttlefish and bobtail squids	284082	Gurnards/ Sea robins	185529	Gurnards/ Sea robins	85284
Gurnards/ Sea robins	467952	Gurnards/ Sea robins	447139	Whelks	372268	Dogfishes and hounds/ triakidae	275830	Seaweeds	154545	Ling	84475
Whelks	415181	Whelks	393321	Rays and skates	330883	Seaweeds	238857	Lemon sole	139662	Pouting	60350
Lemon sole	379777	Lemon sole	335770	Cuttlefish and bobtail squids	298298	Rays and skates	235471	Rays and skates	132261	Various squids	57325
Turbot	309473	Cuttlefish and bobtail squids	298561	Lemon sole	283740	Lemon sole	226118	Dogfishes and hounds/ triakidae	117294	Lemon sole	57198
Cuttlefish and bobtail squids	298708	Pouting	250235	Pouting	248923	Pouting	180596	Pouting	112688	Rays and skates	56263
European Hake	287138	Turbot	242635	Turbot	190270	Turbot	137684	Various squids	96606	Common european bittersweet	47766
Pouting	250235	European Hake	226018	European Hake	173823	Spinous spider crab	123266	Turbot	96269	European flounder	43462
European flounder	216560	Cusk/ tusk	176091	Spinous spider crab	161453	Various squids	122904	Spinous spider crab	77779	Mugil/ mullets	42961
Cusk/ tusk	194805	European flounder	172490	Cusk/ tusk	153519	Cusk/ tusk	122004	European flounder	75015	Turbot	41588
Flat oysters	178840	Spinous spider crab	161453	Various squids	146729	European Hake	119217	European Hake	73554	Roundnose grenadier	40904
Other	2247627	Other	2050661	European flounder	143278	European flounder	109116	Common european bittersweet	68408	Queen scallop	39210

				Cupped oysters	141673	Catsharks and Nursehounds	96891	Catsharks and Nursehounds	68026	Dogfishes and hounds/ triakidae	38043
				Other	1511747	Witch flounder	96158	Roundnose grenadier	64490	Catsharks and Nursehounds	37543
						Other	1096959	Witch flounder	62986	European Hake	37216
								Cusk/ tusk	62039	Spinous spider crab	37079
								Mugil/ mullets	59620	Seabreams	31206
								Other	564954	Witch flounder	29769
										Seabasses	27539
										Cusk/ tusk	24283
										Other	207165

Table 6.4.1.3: List of gained species with respect to those ranked for 2000-2009 when aggregating the landings data across longer periods

1950-2009		1960-2009		1970-2009		1980-2009		1990-2009	
Species	t	Species	t	Species	t	Species	t	Species	
Flat oysters	178840	none		Cupped oysters	141673	none		none	

Table 6.4.1.4: List of lost species with respect to those ranked for 2000-2009 when aggregating the landings data across longer periods

1950-2009		1960-2009		1970-2009		1980-2009		1990-2009	
Various squids	57325	Various squids	57325	Common european bittersweet	47766	Common european bittersweet	47766	Queen scallop	39210
Common european bittersweet	47766	Common european bittersweet	47766	Mugil/ mullets	42961	Mugil/ mullets	42961	Seabreams	31206
Mugil/ mullets	42961	Mugil/ mullets	42961	Roundnose grenadier	40904	Roundnose grenadier	40904	Seabasses	27539
Roundnose grenadier	40904	Roundnose grenadier	40904	Queen scallop	39210	Queen scallop	39210		
Queen scallop	39210	Queen scallop	39210	Catsharks and Nursehounds	37543	Seabreams	31206		
Catsharks and Nursehounds	37543	Catsharks and Nursehounds	37543	Seabreams	31206	Seabasses	27539		
Spinous spider crab	37079	Spinous spider crab	37079	Witch flounder	29769				
Seabreams	31206	Seabreams	31206	Seabasses	27539				
Witch flounder	29769	Witch flounder	29769						
Seabasses	27539	Seabasses	27539						

6.4.2 Stocks covered by assessments

Species	Area/ Stock	F 2009	SSB 2009 (tons)	B_{pa} (tons)	F_{pa}	F_{MSY}
Atlantic herring	her-47d3	0.099	1442422	1300000	0.25	0.25
Atlantic herring	her-3a22	0.5174	105222			0.25
Atlantic herring	her-noss	0.154	9871000	5000000	0.15	0.15
Sandeels	san-34	0.598	302830	215000		
Mackerels	mac-nea	0.2328	2978321	2300000	0.23	0.22
Pollock/ Saithe	sai-3a46	0.478	233900	200000	0.40	0.30
Horse mackerels	hom-west	0.087	2276680			0.13
Blue whiting	whb-comb	0.399	2097420	2250000	0.32	0.18
European plaice	ple-nsea	0.228	385900	230000	0.6	0.25
European plaice	ple-echw	0.4247	1868			0.19
Haddock	had-34	0.209	192276	140000	0.70	0.30
Norway pout	nop-34	0.259	175524	150000		
Atlantic cod	cod-kat			10500		
Atlantic cod	cod-7e-k	0.5493	6503	8800	0.68	0.4
Atlantic cod	cod-347	0.684	50767	150000	0.65	0.19
Sole	sol-nsea	0.345	34700	35000	0.40	0.22
Sole	sol-kask	0.323	2131		0.30	0.38
Sole	sol-eche	0.4033	12038	8000	0.40	0.29
sole	sol-echw	0.257	2600			0.27
European Hake	hke-nrth	0.4	85181			0.24

Table 6.4.2.1. North Sea stocks (second column gives ICES codes for the different stocks) and their reference levels. Note that widely distributed stocks (i.e. blue whiting and mackerel) or stocks of which their distribution area does not sufficiently overlap (e.g. cod-7e-k, sol-kask and sol-eche) are not included in further analysis in this case study.

The indicators fishing mortality and SSB for *Clupea harengus, Gadus morhua, Melanogrammus aeglefinus, Pleuronectes platessa, Pollachius virens, Solea solea,* and *Trisopterus esmarkii* are given in table 6.4.2.1 and depicted in Figure 6.4.2.1. The species were scored for both fisheries indicators according to the available reference points (Table 6.4.2.1). The results are shown in Table 6.4.4.2.

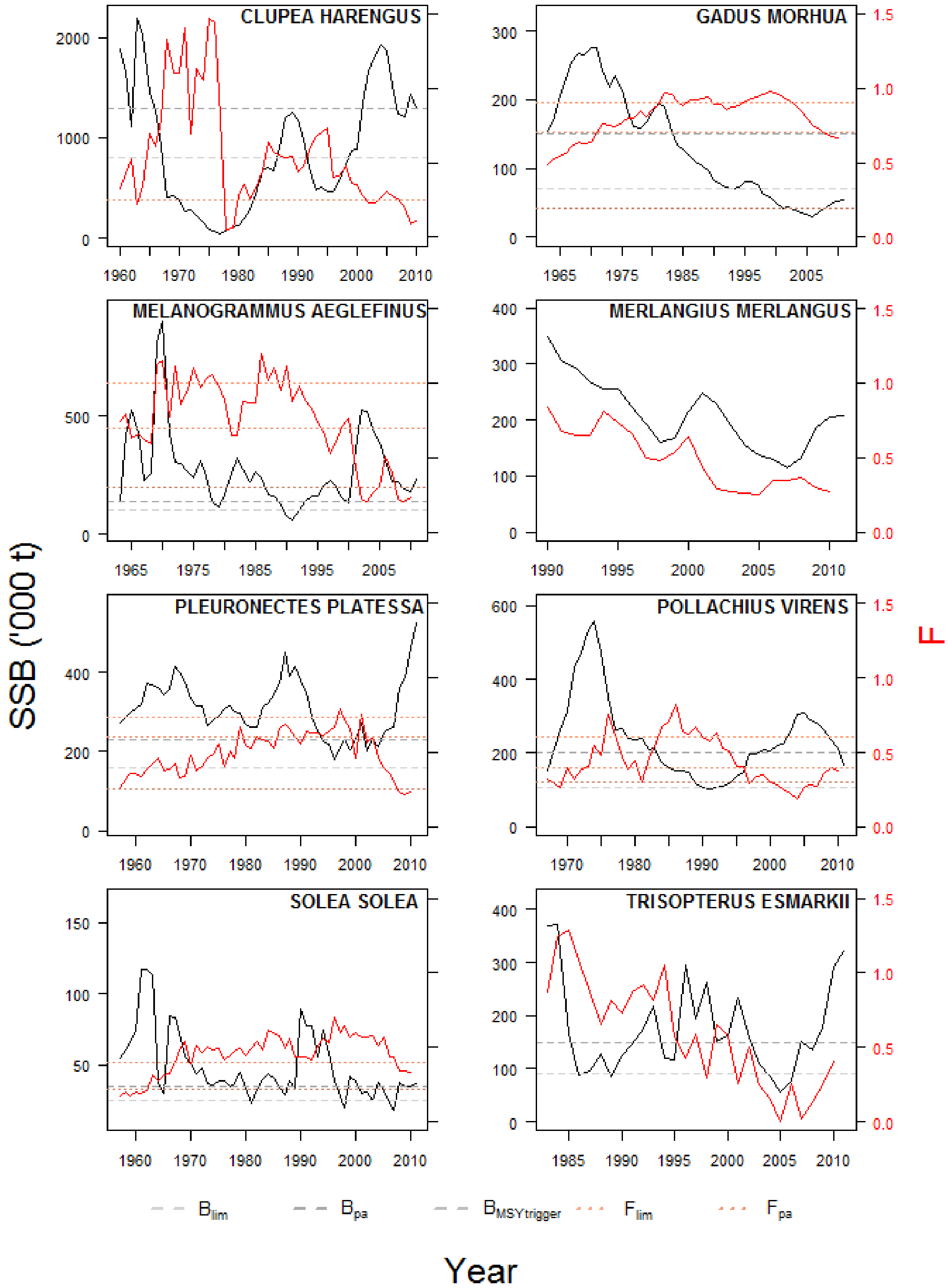


Figure 6.4.2.1: Stock information for eight assessed species in the North Sea. F_{MSY} is not displayed but can be derived from table 6.4.2.1.

6.4.3 Species covered by monitoring programs

The R-based function-bundle developed by Probst (2011) and presented in section 9.1 has been used to calculate a number of indicators from the North Sea IBTS Q1 survey (1985-2010) dataset. These indicators include:

- CPUE: Average number of caught individuals per haul in the survey
- L95: The length class in which 95% of the annual survey catch (by number) is achieved -- Indicator 3.3.3
- HR: Harvest rate (=landings/biomass ratio, a proxy for the catch/biomass ratio): the ratio between the annual commercial landings[1] and the annual catch weight per haul in the survey

For each indicator the long-term mean (+/- 1 standard deviation) for the entire time-series and the short-term mean (+/- 1 standard deviation) for the period 2006-2010 were calculated. The indicators of the species which contribute to 99.9% of the landings biomass between 2000-2009 (invertebrate species such as squids, crustaceans, and bivalves are not included) have been used to further investigate possible criteria in determining GES. It should be noted that as the data have not been validated, this assessment should be considered preliminary.

For each indicator, a comparison between the long-term and the short-term means for each species (in total 32 species) enabled us to classify the species in the following tables, where rows and columns have the following meanings:

- Above/Below: the short-term mean is above/below long-term mean
- Inside: the short-term mean is inside the long-term mean +/- 1 sd
- Outside: the short-term mean is outside the long-term mean +/- 1 sd

Table 6.4.3.1: CPUE – Classification of the 32 species according to the comparison between the long-term and short-term means (also illustrated in Figure 6.4.3.1)

	Above	Below
Inside	15	11
Outside	4	2

Table 6.4.3.2: L95 – Classification of the 32 species according to the comparison between the long-term and short-term means (also illustrated in Figure 6.4.3.2)

	Above	Below
Inside	17	10
Outside	3	2

[1]Commercial landings data have been taken from the ICES database. Note that for many relevant species the harvest ratio is not available, because landings data have been grouped on a different taxa level.

Table 6.4.3.3: HR – Classification of species according to the comparison between the long-term and short-term mean (also illustrated in Figure 6.4.3.3). Note that values for this indicator were only available for 17 species.

	Above	Below
Inside	3	13
Outside	0	1

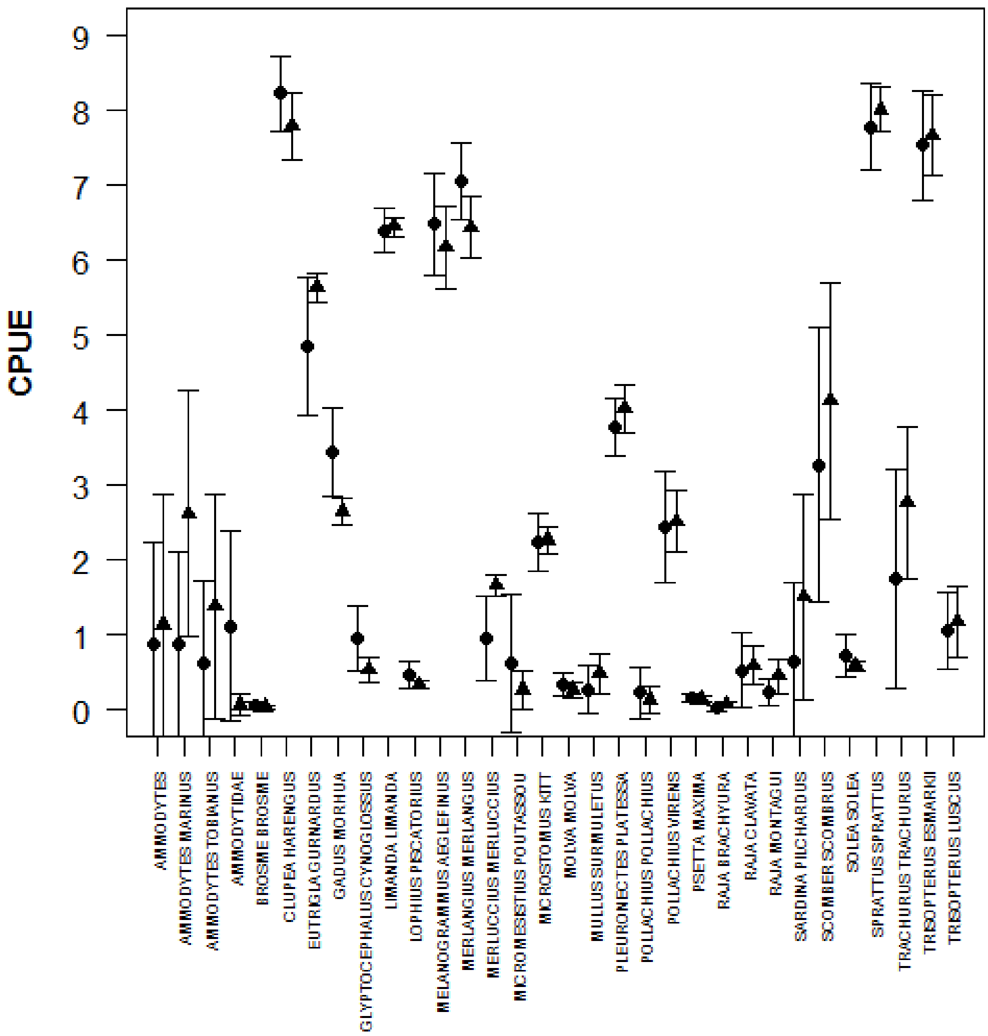


Figure 6.4.3.1: CPUE: Average number of individuals caught per haul in the North Sea IBTS Q1 (1985-2010) for the species which contribute to 99.9 % of the landings biomass between 2000 and 2009 (invertebrate species such as squids, crustaceans and bivalves are not included). Closed circles represent the long-term mean (+/- sd) and closed triangles represent the short-term mean (+/- sd).

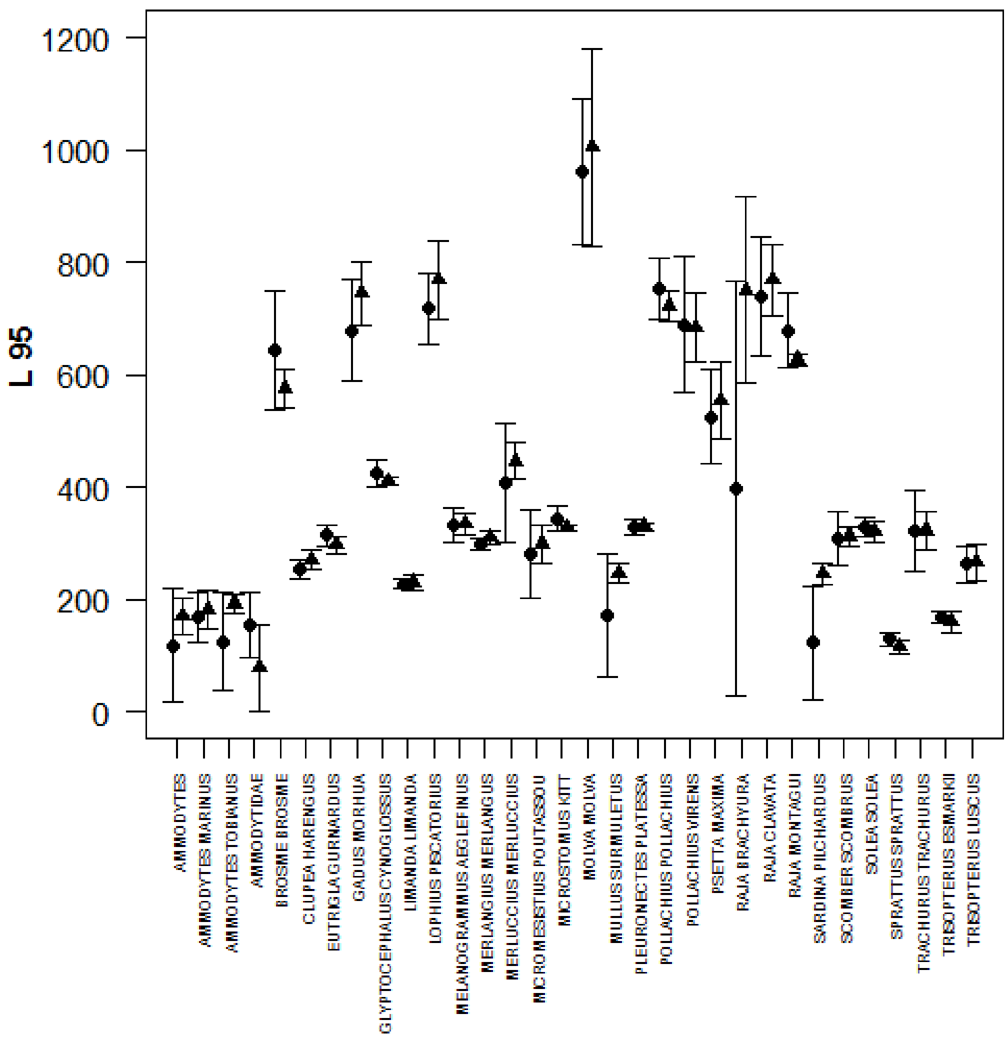


Figure 6.4.3.2: L95 (Indicator 3.3.3): Length class in which 95% of the annual survey catch (in number) is achieved for species caught in the North Sea IBTS Q1 (1985-2010) which contribute to 99.9 % of the landings biomass between 2000 and 2009 (invertebrate species such as squids, crustaceans and bivalves are not included). Closed circles represent the long-term mean (+/- sd) and closed triangles represent the short-term mean (+/- sd).

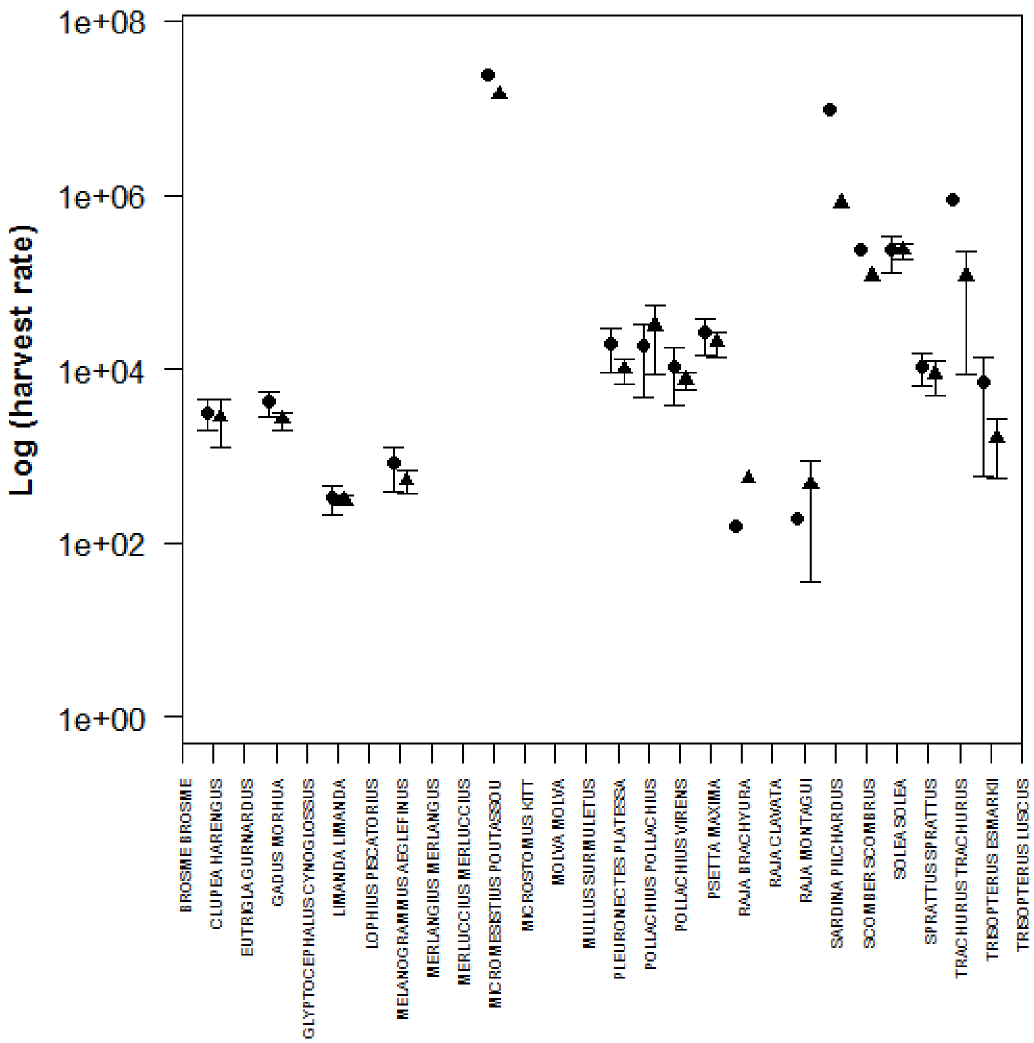


Figure 6.4.3.3: HR (ratio of annual commercial landings in t versus the annual average catch weight (in g) per haul in the survey) for the species caught in the North Sea IBTS Q1 (1985-2010) which contribute to 99.9 % of the landings biomass between 2000 and 2009 (invertebrate species such as squids, crustaceans and bivalves are not included). Closed circles represent the long-term mean (+/- sd) and closed triangles represent the short-term mean (+/- sd). While the harvest rate values have been depicted on a logarithmic scale, the means (+/- sd) have been computed from the original values.

6.4.4 Overall assessment of current status in relation to GES

For an assessment of the current status in relation to GES per species we considered three possible interpretations of GES:

1) According to a strict interpretation of the Commission Decision, MSY reference points are limits and GES would require that for criterion 3.1 all stocks $F \leq F_{MSY}$ and for criterion 3.2 all stocks $SSB \geq B_{MSY\text{-}trigger}$

2) Alternatively MSY reference points could be targets rather than limits, while precautionary reference points are limits. This would imply that the indicators fluctuate around MSY reference points while never going beyond precautionary reference points, which requires only 50% of the stocks to meet $F \leq F_{MSY}$ and $SSB \geq B_{MSY\text{-}trigger}$ (for criteria 3.1 and 3.2 respectively) while none of the stocks go beyond precautionary reference points.

3) Another alternative and even less strict definition of GES could be that at least 50% of the stocks fulfil the MSY condition (i.e. $F \leq F_{MSY}$ and $SSB \geq B_{MSY\text{-}trigger}$) and that for any stock that goes beyond precautionary reference points there is at least one additional (i.e. above the minimum 50% required) stock that fulfils the MSY condition. In this case, GES would allow some stocks to be outside safe limits as long as there are other stocks that compensate for them by fulfilling the MSY condition.

The consequences of these interpretations are reflected in the rules for the GES assessment given in tables 6.4.4.1 and 6.4.4.3, where table 6.4.4.1 shows the rules we applied for the stocks for which reference values are available and table 6.4.4.3 for the species without reference values.

GES Interpretation	criterion	stock status			GES at indicator level ("aggregating" across stocks)
		Green	Orange	Red	
1	Fishing pressure	$F \leq F_{MSY}$	$F_{MSY} < F$ and $F \leq F_{pa}$	$F > F_{pa}$	Y=100% stocks in Green
1	Reproductive capacity	$SSB >= B_{MSY\text{-}trigger}$		$SSB < B_{MSY\text{-}trigger}$	Y=100% stocks in Green
2	Fishing pressure	$F \leq F_{MSY}$	$F_{MSY} < F$ and $F \leq F_{pa}$	$F > F_{pa}$	Y= at least 50% stocks in Green, no stock in red
2	Reproductive capacity	$SSB >= B_{MSY\text{-}trigger}$		$SSB < B_{MSY\text{-}trigger}$	Y= at least 50% stocks in Green, no stock in red
3	Fishing pressure	$F \leq F_{MSY}$	$F_{MSY} < F$ and $F \leq F_{pa}$	$F > F_{pa}$	Y=at least 50% Green, but red stocks can be compensated by equivalent additional greens
3	Reproductive capacity	$SSB >= B_{MSY\text{-}trigger}$		$SSB < B_{MSY\text{-}trigger}$	Y=at least 50% Green, but red stocks can be compensated by equivalent additional greens

Table 6.4.4.1 Rules applied for GES assessment based on stocks and indicators for which reference levels are available. Assessment occurs both at the stock level and across stocks at the indicator level.

These rules can then be applied to determine the current status in relation to GES. We distinguish three levels in the GES assessment process:

- Stock/species: current status in relation to GES per stock or species based on a specific criterion and indicator
- Criterion: current status in relation to GES per indicator or criterion (thus aggregating across stocks)
- Overall: current status in relation to GES for Descriptor 3 (thus aggregating across stocks and criteria)

Application of the rules given in table 6.4.4.1 to the stocks covered by stock assessments for criteria 3.1 and 3.2 only shows that GES is only achieved in the last year and only for the most lenient interpretation of GES (table 6.4.4.2). Note that these results are linked to the graphs in Figure 6.4.2.1.

Table 6.4.4.2: Scoring results for indicators at the level of stocks (values in cells below "F" and "SSB" are number of stocks), across stocks per criterion and overall based on only two criteria (Y or N means GES achieved or not, respectively).

	GES per stock					GES across stocks per criteria and per interpretation						GES across two criteria per interpretation		
	F*			SSB**		F			SSB					
Year	Green	Orange	Red	Green	Red	1	2	3	1	2	3	1	2	3
1967		4	2	4	2	N	N	N	N	N	N	N	N	N
1968	1	3	2	5	1	N	N	N	N	N	N	N	N	N
1969	1	2	3	5	1	N	N	N	N	N	N	N	N	N
1970		3	3	5	1	N	N	N	N	N	N	N	N	N
1971		2	4	5	1	N	N	N	N	N	N	N	N	N
1972		2	4	5	1	N	N	N	N	N	N	N	N	N
1973		1	5	5	1	N	N	N	N	N	N	N	N	N
1974		1	5	5	1	N	N	N	N	N	N	N	N	N
1975		1	5	5	1	N	N	N	N	N	N	N	N	N
1976		1	5	5	1	N	N	N	N	N	N	N	N	N
1977		1	5	5	1	N	N	N	N	N	N	N	N	N
1978	1	1	4	4	2	N	N	N	N	N	N	N	N	N
1979	1	1	4	4	2	N	N	N	N	N	N	N	N	N
1980		1	5	4	2	N	N	N	N	N	N	N	N	N
1981		3	3	4	2	N	N	N	N	N	N	N	N	N
1982		1	5	4	2	N	N	N	N	N	N	N	N	N
1983		1	5	6	1	N	N	N	N	N	N	N	N	N
1984		1	5	4	3	N	N	N	N	N	N	N	N	N
1985		1	5	4	3	N	N	N	N	N	N	N	N	N
1986			6	2	5	N	N	N	N	N	N	N	N	N
1987			6	2	5	N	N	N	N	N	N	N	N	N
1988			6	3	4	N	N	N	N	N	N	N	N	N
1989			6	1	6	N	N	N	N	N	N	N	N	N
1990		1	5	2	5	N	N	N	N	N	N	N	N	N
1991			6	2	5	N	N	N	N	N	N	N	N	N
1992			6	3	4	N	N	N	N	N	N	N	N	N
1993			6	3	4	N	N	N	N	N	N	N	N	N
1994			6	2	5	N	N	N	N	N	N	N	N	N
1995			6	2	5	N	N	N	N	N	N	N	N	N
1996		1	5	3	4	N	N	N	N	N	N	N	N	N
1997	1	1	4	2	5	N	N	N	N	N	N	N	N	N
1998		2	4	2	5	N	N	N	N	N	N	N	N	N
1999		1	5	4	3	N	N	N	N	N	N	N	N	N
2000		2	4	4	3	N	N	N	N	N	N	N	N	N
2001	1	1	4	5	2	N	N	N	N	N	N	N	N	N
2002	3	1	2	4	3	N	N	N	N	N	N	N	N	N
2003	3		3	4	3	N	N	N	N	N	N	N	N	N

	GES per stock					GES across stocks per criteria and per interpretation						GES across two criteria per interpretation		
	F*			SSB**		F			SSB					
2004	2	1	3	4	3	N	N	N	N	N	N	N	N	N
2005	1	2	3	4	3	N	N	N	N	N	N	N	N	N
2006	1	2	3	4	3	N	N	N	N	N	N	N	N	N
2007	1	2	3	4	3	N	N	N	N	N	N	N	N	N
2008	3	3		4	3	N	Y	Y	N	N	N	N	N	N
2009	3	2	1	5	2	N	N	N	N	N	N	N	N	N
2010	3	3		6	1	N	Y	Y	N	N	Y	N	N	Y

*** Fish stocks include: C. harengus, G. morhua, M. aeglefinus, P. platessa, P. virens, S. solea**

**** Fish stocks include: C. harengus, G. morhua, M. aeglefinus, P. platessa, P. virens, S. solea, T. esmarkii (T. esmarkii only from 1983 onwards)**

GES Interpretation	criterion	stock/species status			GES at indicator level (“aggregating” across stocks)
		Green	Orange	Red	
1	Fishing pressure	Any at or “Below” category	Category “Above and Inside”	Category “Above and Outside”	Y= 100% of stocks in Green
1	Reproductive capacity	Any at or “Above” category	Category “Below and Inside”	Category “Below and Outside”	Y= 100% of stocks in Green
1	Structure	Any at or “Above” category	Category “Below and Inside”	Category “Below and Outside”	Y= 100% of stocks in Green
2	Fishing pressure	Any at or “Below” category	Category “Above and Inside”	Category “Above and Outside”	Y= at least 50% of stocks Green, no stock red
2	Reproductive capacity	Any at or “Above” category	Category “Below and Inside”	Category “Below and Outside”	Y= at least 50% of stocks Green, no stock red
2	Structure	Any at or “Above” category	Category “Below and Inside”	Category “Below and Outside”	Y= at least 50% of stocks Green, no stock red
3	Fishing pressure	Any at or “Below” category	Category “Above and Inside”	Category “Above and Outside”	Y=at least 50% Green, but red stocks can be compensated by equivalent additional greens
3	Reproductive capacity	Any at or “Above” category	Category “Below and Inside”	Category “Below and Outside”	Y=at least 50% Green, but red stocks can be compensated by equivalent additional greens
3	Structure	Any at or “Above” category	Category “Below and Inside”	Category “Below and Outside”	Y=at least 50% Green, but red stocks can be compensated by equivalent additional greens

Table 6.4.4.3 Rules applied for GES assessment based on species and indicators for which no reference levels are available. Categories are explained before Tables 6.4.3.1-6.4.3.3. Assessment occurs both at the species level and across stocks at the indicator level.

The species were scored based on the classification schemes (Tables 6.4.3.1-6.4.3.3) and according to the rules for GES assessment in Table 6.4.4.3. The results show that GES assessment based on all the 32 species for which indicators are available (Table 6.4.4.4) as well as the 26 non-assessed species only (Table 6.4.4.5) would indicate that GES is not achieved according to interpretations 1 and 2 (as there are always stocks in red for at least one of the 3 indicators) but is achieved in 2010 according to interpretation 3 (since for each of the 3 indicators, the number of stocks in red is compensated by at least as many additional stocks in green – where by “additional” it is meant above the minimum 50% required to be in green).

Table 6.4.4.4: Scoring results survey indicators. The cells under each indicator give the number of species per category (Green/Orange/Red).

	CPUE	L95	HR
Green	19	20	14
Orange	11	10	3
Red	2	2	

Table 6.4.4.5: Results scoring non-assessed stocks. The cells under each indicator give the number of species per category.

Ranking	CPUE	L95	HR
Green	17	16	8
Orange	8	8	3
Red	1	2	0

A comparison of the criteria based on primary indicators 3.1.1 and 3.2.1 (F and SSB) with reference values and equivalent secondary indicators 3.1.2 and 3.2.2 (HR and CPUE) shows some degree of consistency (Table 6.4.4.6). However, overall the non-assessed stocks with the criteria applied here appear less stringent when determining the status relative to GES than the assessed species and criteria applied here.

Table 6.4.4.6: Results scoring for assessed fish stocks

Species	ICES stock	Score	F*	SSB*	L95	CPUE	HR
Clupea harengus	her-47d3	Green	3	3	X		X
		Orange	0			X	
		Red	2	2			
Gadus morhua	cod-347d	Green	0		X		X
		Orange	3				
		Red	2	5		X	
Melanogrammus aeglefinus	had-34	Green	3	5	X		X
		Orange	2			X	
		Red	0				
Pleuronectes platessa	ple-nsea	Green	3	5	X	X	X
		Orange	2				
		Red	0				
Pollachius virens	sai-3a46	Green	2	5		X	X
		Orange	2		X		
		Red	1				
Solea solea	sol-nsea	Green	0	2			X
		Orange	3		X	X	
		Red	2	3			

* Information is taken for 2006-2010

6.5 North-east Atlantic Ocean - Celtic Seas

6.5.1 Selection of commercial (shell)fish populations

Data source for international catch data

The selection of commercial fish and shellfish species in the Celtic Seas is based on the average annual landings from the FAO Fishstat catch statistics database for ICES subareas VI and VII. Where there are distinctions made between EC and international waters within the catch data, the international part is subtracted from the total catches; this includes any catches from subdivisions VIb1, VIIc1 and VIIk1. Most of the catch data are, however, reported by ICES division and it is not possible to determine if the landings are from international waters or the European EEZ. In the subsequent sections, different scenarios are presented to examine how the area definition, the time period chosen and the landings percentage cut-off point affect the selection of commercial species in the Celtic Seas. In addition, the list of commercial species based on average annual catches is compared to the list of species as given in the DCF.

Comparison of commercial species between the Celtic Sea and West of Scotland ICES Ecoregion and the Celtic Seas MSFD subregion

The selection of commercial species depends on the spatial definition of the MSFD subregion, which at the time of this report was not finalised. Two scenarios are presented in this case study: the first scenario is based on the ICES Celtic Sea and West of Scotland ecoregion, which includes ICES subareas VI and VII without division VIId (Fig. 6.5.1.1). The second scenario is based on the most up to date definition of the MSFD Celtic Seas subregion, which covers the European waters of VI and VII without the channel VIId and VIIe. For the northern boundary of the MSFD subregion the boundary between ICES subareas VI and IV was used in this case study (even though the MSFD Celtic Seas subregion contains also part of Division IVa). The species selection was based on average annual catches from 2005 to 2009, as given in the Fishstat database. Species which contributed at least 0.1% to the total catches were ranked according to their average annual landings (table 6.5.1.1).

Blue whiting, mackerel and horse mackerel were the main contributing species to total landings and ranked highest in the catch table. All pelagic species including blue whiting, mackerel, horse mackerel, herring, boarfish, sprat and sardines made up over 75% the weight of total catches for the ICES Celtic Sea and West of Scotland ecoregion and over 82% for the MSFD subregion, which excluded both channel divisions VIId and VIIe (Fig. 6.5.1.2). Demersal fish stocks and shellfish stocks were both contributing in similar proportions to the overall landings (around 9%) for the ICES Ecoregion. The most important demersal species in terms of catches were monkfish, hake, haddock, megrims, whiting, saithe and ling. *Nephrops* was the most important shellfish species (circa 2% of total catches), with scallops, edible crab and whelk further contributing to over 1% to total catches. Many of the shellfish fisheries are concentrated in the channel and if both channel areas are excluded (i.e. VIId and VIIe) as in the MSFD subregion, the contribution of the shellfish landings decreases to just over 5% of total catches (Fig. 6.5.1.2).

For the Celtic Seas case study as presented in this report, commercial species were selected on the basis of the current definition of the MSFD subregion with ICES subareas VI and VII, excluding VIId and VIIe.

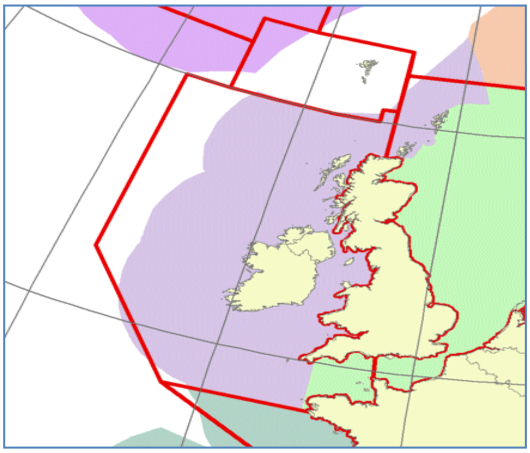
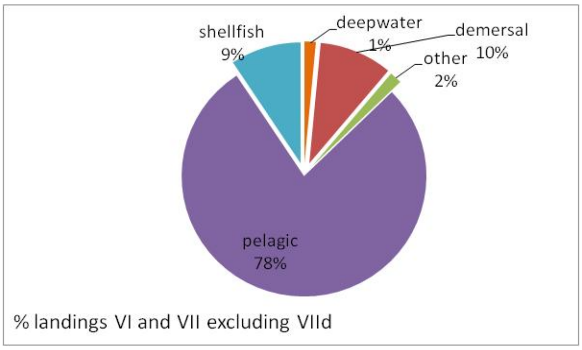


Fig 6.5.1.1.Spatial definition of the Celtic Seas assessment area: red boundary- Celtic Sea and West of Scotland ICES ecoregion, comprising ICES subareas VI and VII, except VIId; Purple Shading- current MSFD Celtic Seas subregion, comprising ICES subareas VI and VII, except VII d and e, as well as a section of Division IVa which does not correspond to any ICES boundary.

a)



b)

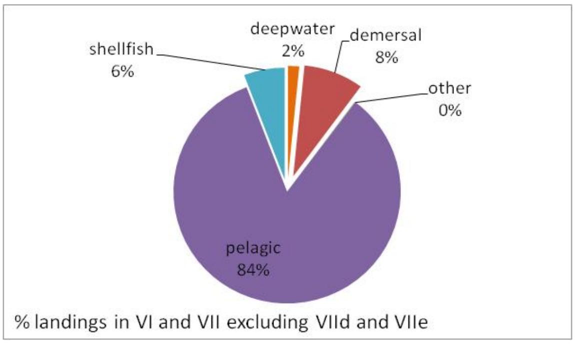


Fig 6.5.1.2. The proportion of annual average catches (Fishstat 2005-2009) by functional group as defined by the Celtic Sea and West of Scotland ICES Ecoregion (a) and the Celtic Seas MSFD subregion (b).

Rank	Species	Annual mean 2005-2009	Contribution to Landings
1	Blue whiting(=Poutassou)	884,338	54.3%
2	Atlantic mackerel	165,076	10.1%
3	Atlantic horse mackerel	93,881	5.76%
4	Atlantic herring	55,142	3.38%
5	Norway lobster	31,236	1.92%
6	Great Atlantic scallop	27,270	1.67%
7	Monkfishes	26,034	1.60%
8	Boarfish	25,485	1.56%
9	Edible crab	24,748	1.52%
10	European hake	21,776	1.34%
11	Whelk	20,924	1.28%
12	Tangle	15,755	0.97%
13	Haddock	15,016	0.92%
14	Megrims nei	12,132	0.74%
15	Queen scallop	9,857	0.61%
16	Whiting	9,471	0.58%
17	European pilchard(=Sardine)	9,269	0.57%
18	Saithe(=Pollock)	8,424	0.52%
19	Ling	8,204	0.50%
20	Cuttlefish,bobtail squids nei	7,379	0.45%
21	Blue mussel	7,090	0.44%
22	Raja rays nei	6,552	0.40%
23	European sprat	6,246	0.38%
24	Seaweeds nei	5,657	0.35%
25	Common European bittersweet	5,066	0.31%
26	Witch flounder	4,912	0.30%
27	Atlantic cod	4,822	0.30%
28	Spinous spider crab	4,315	0.26%
29	European conger	4,177	0.26%
30	Pollack	4,137	0.25%
31	Groundfishes nei	3,906	0.24%
32	Argentine	3,835	0.24%
33	Albacore	3,693	0.23%
34	Jack and horse mackerels nei	3,599	0.22%
35	North European kelp	3,483	0.21%
36	Red gurnard	3,281	0.20%
37	Pouting(=Bib)	3,201	0.20%
38	Lemon sole	3,083	0.19%
39	Blue ling	2,887	0.18%
40	Black scabbardfish	2,868	0.18%
41	Roundnose grenadier	2,766	0.17%
42	Small-spotted catshark	2,706	0.17%
43	Common sole	2,633	0.16%
44	European plaice	2,511	0.15%
45	John dory	2,328	0.14%
46	Greater argentine	2,230	0.14%
47	Scallops nei	1,815	0.11%
48	Greater forkbeard	1,789	0.11%
49	European lobster	1,755	0.11%
50	Tusk(=Cusk)	1,684	0.10%
51	Cuckoo ray	1,637	0.10%
52	Picked dogfish	1,590	0.10%

Rank	Species	Annual mean 2005-2009	Contribution to Landings
1	Blue whiting(=Poutassou)	884,326	59.50%
2	Atlantic mackerel	164,407	11.06%
3	Atlantic horse mackerel	83,494	5.62%
4	Atlantic herring	54,609	3.67%
5	Norway lobster	31,220	2.10%
6	Boarfish	25,485	1.71%
7	European hake	21,584	1.45%
8	Monkfishes	21,291	1.43%
9	Edible crab	18,168	1.22%
10	Haddock	14,170	0.95%
11	Megrims nei	12,041	0.81%
12	Great Atlantic scallop	10,432	0.70%
13	Saithe(=Pollock)	8,414	0.57%
14	Whelk	7,995	0.54%
15	Whiting	7,701	0.52%
16	Ling	7,571	0.51%
17	Queen scallop	6,456	0.43%
18	Raja rays nei	5,298	0.36%
19	Witch flounder	4,907	0.33%
20	Blue mussel	4,872	0.33%
21	Atlantic cod	4,231	0.28%
22	Groundfishes nei	3,875	0.26%
23	European sprat	3,766	0.25%
24	Albacore	3,671	0.25%
25	Jack and horse mackerels nei	3,000	0.20%
26	Blue ling	2,887	0.19%
27	Black scabbardfish	2,868	0.19%
28	European conger	2,803	0.19%
29	Roundnose grenadier	2,766	0.19%
30	Pollack	2,278	0.15%
31	Greater argentine	2,230	0.15%
32	Argentine	2,170	0.15%
33	Lemon sole	2,167	0.15%
34	John dory	1,817	0.12%
35	Greater forkbeard	1,788	0.12%
36	Common sole	1,739	0.12%
37	Tusk(=Cusk)	1,684	0.11%
38	Argentines	1,663	0.11%
39	European pilchard(=Sardine)	1,655	0.11%
40	Picked dogfish	1,484	0.10%
41	Cuckoo ray	1,479	0.10%
42	Tangle	1,477	0.10%
43	European plaice	1,470	0.10%
44	Northern shortfin squid	1,468	0.10%

Table 6.5.1.1. Commercial species sorted by the weight of their average annual landings (Fishstat 2005-2009) and their percentage contribution to total landings in the ICES Celtic Sea and West of Scotland ecoregion VI and VII excluding VIId (left) and the Celtic Seas MSFD subregion VI and VII excluding both VIId and VIIe (right).

Comparison of commercial species lists using different time series of commercial catches

In order to examine how species of commercial importance have proportionally changed over time, different time series of Fishstat catches were used as a basis to select commercial species. The selection of species was compared between the different lists. Fishstat catches for the Celtic Seas were averaged over five different time periods:

- 2005-2009
- 2000-2009
- 1990-2009
- 1970-2009
- 1950-2009

Species were ranked according to their contribution to total catches for the different periods (using a 0.1% cut-off point) and the ranked lists were compared to examine whether species either disappeared or appeared from the lists in the more recent periods. Overall, the number of species contributing ≥ 0.1% of total catches decreased gradually over time from 54 using 1950 or 1970 as the start of the time series to 48 species when 2005 was used as the initial year of the time series (Fig. 6.5.1.3).

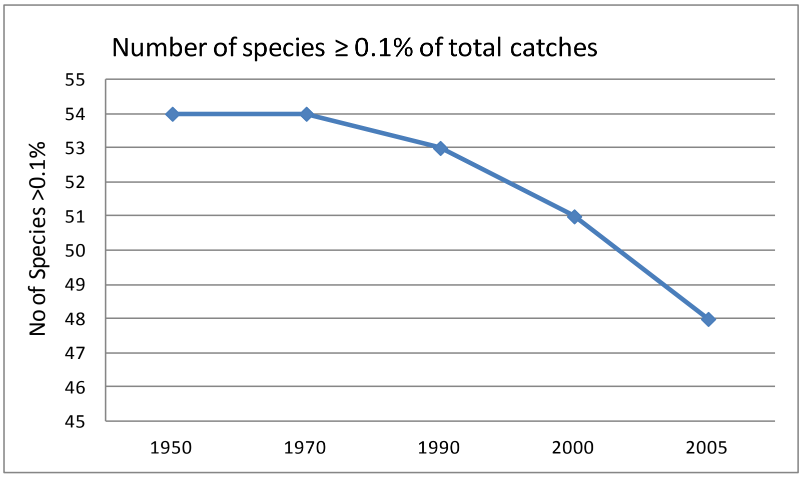


Figure 6.5.1.3.The number of species contributing ≥ 0.1% of total catches in the Celtic Seas using different historic time periods. The horizontal axis in the figure marks the start year, while the end year is always 2009.

Norway pout and sandeel are two species which were of commercial importance in the past. Both species contributed substantially to total catches in the ranked lists for 1950-2009 and 1970-2009 with annual catches ranging between 5 and 20 kt in the eighties and nineties, but now have only minor contributions as their annual landings decreased to almost zero for Norway Pout and to < 1 kt for sandeel. Other species that had minor contributions to overall catches throughout the time series and now contribute less than 0.1% are common dab, dogfishes, catsharks, grey gurnard, seabream and pouting, as well as the categories of "various sharks". In the shellfish category, periwinkles and cockles slowly declined in their overall contribution over time and now contribute less than 0.1% of total catches, while swimmer crabs and various squids contributed > 0.1% for some of the time periods with no time trends detectable. Boarfish is one of the main species that appeared above 0.1% of the catches in the more recent time series (1990+) as the fishery only developed in the last decade. Other species that appeared in the recent time series with only a minor overall contribution were John Dory and Greater Argentine.

Comparison of species selection based on Fishstat landings and the DCF sampling species list

Commission Decision 2010/477/EU states that Descriptor 3 applies to all commercial fish and shellfish stocks covered by Regulation (EC) No 199/2008 (within the geographical scope of Directive 2008/56/EC) and similar obligations under the common fisheries policy. The list of species based on Fishstat landings was compared with the DCF species listed in Appendix 7 of the most up to date DCF Commission Decision (2010/93/EU), to review which species would be selected based on the DCF criteria and which species would be included if the selection of commercial species was based on Fishstat catches (table 6.5.1.2). Within the fish category, the most commercially important species in terms of catches are also included in the DCF. The exceptions for this are boarfish, sprat or sardine, which are not listed in Appendix 7 of the DCF. For boarfish a new fishery has only emerged in very recent years, while sardines and sprat are not required to be sampled in the Celtic Seas MSFD subregion. For shellfish species the situation is different. There are seven shellfish species which contribute ≥ 0.1% of total catches, but only two of those species are included in Appendix 7 of the DCF. These are Norway lobster and edible crab (table 6.5.1.2).

Species	Rank	Contribution to Landings	functional group	DCF list
Blue whiting(=Poutassou)	1	59.50%	pelagic	y
Atlantic mackerel	2	11.06%	pelagic	y
Atlantic horse mackerel	3	5.62%	pelagic	y
Atlantic herring	4	3.67%	pelagic	y
Norway lobster	5	2.10%	shellfish	y
Boarfish	6	1.71%	pelagic	no
European hake	7	1.45%	demersal	y
Monkfishes	8	1.43%	demersal	y
Edible crab	9	1.22%	shellfish	y
Haddock	10	0.95%	demersal	y
Megrims nei	11	0.81%	demersal	y
Great Atlantic scallop	12	0.70%	shellfish	no
Saithe(=Pollock)	13	0.57%	demersal	y
Whelk	14	0.54%	shellfish	no
Whiting	15	0.52%	demersal	y
Ling	16	0.51%	demersal	y
Queen scallop	17	0.43%	shellfish	no
Raja rays nei	18	0.36%	demersal	y
Witch flounder	19	0.33%	demersal	y
Blue mussel	20	0.33%	shellfish	no
Atlantic cod	21	0.28%	demersal	y
Groundfishes nei	22	0.26%	demersal	na
European sprat	23	0.25%	pelagic	no
Albacore	24	0.25%	pelagic	y
Jack and horse mackerels nei	25	0.20%	pelagic	y
Blue ling	26	0.19%	deepwater	y
Black scabbardfish	27	0.19%	deepwater	y
European conger	28	0.19%	demersal	y
Roundnose grenadier	29	0.19%	deepwater	y
Pollack	30	0.15%	demersal	y
Greater argentine	31	0.15%	deepwater	y
Argentine	32	0.15%	pelagic	y
Lemon sole	33	0.15%	demersal	y
John dory	34	0.12%	demersal	y
Greater forkbeard	35	0.12%	deepwater	y
Common sole	36	0.12%	demersal	y
Tusk(=Cusk)	37	0.11%	deepwater	no
Argentines	38	0.11%	pelagic	y
European pilchard(=Sardine)	39	0.11%	pelagic	no
Picked dogfish	40	0.10%	demersal	y
Cuckoo ray	41	0.10%	demersal	y
Tangle	42	0.10%	other	na
European plaice	43	0.10%	demersal	y
Northern shortfin squid	44	0.10%	shellfish	no
Atlantic pomfret	45	0.09%	pelagic	no
Blackbelly rosefish	46	0.09%	deepwater	y
Common edible cockle	47	0.08%	shellfish	no
European lobster	48	0.08%	shellfish	y
Dogfish sharks nei	49	0.08%	demersal	y
Rays, stingrays, mantas nei	50	0.07%	demersal	y
Small-spotted catshark	51	0.07%	demersal	y
Forkbeard	52	0.07%	demersal	y
Spinous spider crab	53	0.06%	shellfish	no
Cuttlefish,bobtail squids nei	54	0.06%	shellfish	y
Gadiformes nei	55	0.06%	demersal	na
Red gurnard	56	0.05%	demersal	y
Velvet swimcrab	57	0.05%	shellfish	no
Various squids nei	58	0.05%	shellfish	y
Common squids nei	59	0.05%	shellfish	y
Cupped oysters nei	60	0.04%	shellfish	no
Baird's slickhead	61	0.04%	deepwater	y
Sandeels(=Sandlances) nei	62	0.04%	demersal	y
Octopuses, etc. nei	63	0.04%	shellfish	y
European flying squid	64	0.04%	shellfish	no
Thornback ray	65	0.04%	demersal	y
Grey gurnard	66	0.04%	demersal	no
Turbot	67	0.04%	demersal	y
Common periwinkle	68	0.04%	shellfish	no
Spotted ray	69	0.03%	demersal	y
Scallops nei	70	0.03%	shellfish	no
Portuguese dogfish	71	0.03%	deepwater	y
Atlantic redfishes nei	72	0.03%	pelagic	y
Flat oysters nei	73	0.03%	shellfish	no
Smooth-hounds nei	74	0.03%	demersal	y
Portunus swimcrabs nei	75	0.03%	shellfish	no
Dealfish	76	0.03%	pelagic	no
Pouting(=Bib)	77	0.02%	demersal	y
Ratfishes nei	78	0.02%	deepwater	no
Brill	79	0.02%	demersal	y
Marine fishes nei	80	0.02%	na	na
Silvery lightfish	81	0.02%	pelagic	no
Gurnards, searobins nei	82	0.02%	demersal	y
Orange roughy	83	0.02%	deepwater	y
Squids nei	84	0.02%	shellfish	y
Razor clams nei	85	0.02%	shellfish	no
Inshore squids nei	86	0.02%	shellfish	y
European seabass	87	0.02%	demersal	y
European flat oyster	88	0.02%	shellfish	no
Roughsnout grenadier	89	0.02%	deepwater	no
Periwinkles nei	90	0.02%	shellfish	no
Red crab	91	0.02%	shellfish	no
Green crab	92	0.02%	shellfish	no
Cardinalfishes, etc. nei	93	0.02%	deepwater	no
Rays and skates nei	94	0.02%	demersal	y
Common cuttlefish	95	0.01%	shellfish	y
Palaemonid shrimps nei	96	0.01%	shellfish	no
Finfishes nei	97	0.01%	na	na
Catsharks, etc. nei	98	0.01%	demersal	no
Red mullet	99	0.01%	demersal	y
Blue skate	100	0.01%	demersal	y

Table 6.5.1.2. Commercial species ranked by the weight of their average annual catches (Fishstat 2005-2009) and their percentage contribution to total catches in the Celtic Seas MSFD subregion and their sampling requirements under the DCF (Commission Decision 2010/93/EU, Appendix 7).

Species selection based on different percentage cut-off points using Fishstat catch data

If the selection of commercial species is to be based on catch statistics, then the number of species that are included in the MSFD assessment will depend on the percentage cut-off point used (Fig 6.5.1.4). The number of species increases from 9 using a 1% cut-off point to 44 when 0.1% is used as a cut-off point. The 0.01% level would require 126 species to be assessed. The number of species per functional group does not increase proportionally, as most pelagic species are in the higher percentages (>0.5%), while there is a sharp increase in the number of demersal species when the cut-off point is moved to 0.1% and a high increase in species in the deepwater group and the shellfish group at the 0.01% level (Fig 6.5.1.4).

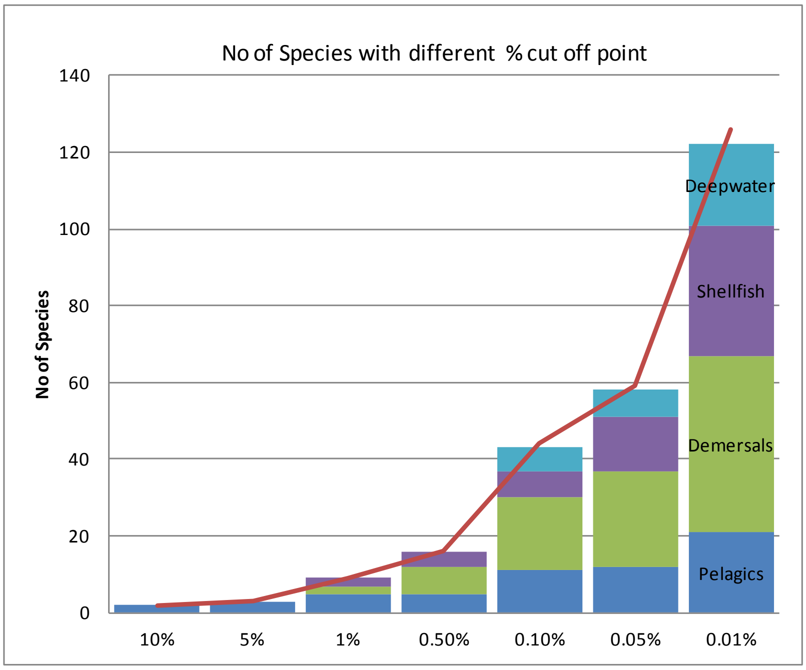


Figure 6.5.1.4. Number of species per functional group with different cut-off points of contribution to total landings of the Fishstat database.

For the Celtic Seas case study as presented in this report, a final cut-off point of 0.1% was chosen; this includes 11 pelagic species groups, 19 demersal species, 7 shellfish species, 6 deepwater species and one other.

6.5.2 Species covered by stock assessments

The proportion of assessed stocks

The 44 Fishstat species (or species groupings) which contributed at least 0.1% to the total Fishstat landings in the Celtic Seas can be divided into 72 stocks or functional units. ICES gives advice on 59 of those stocks, while ICCAT gives advice on albacore tuna. Within the shellfish group, ICES only gives advice on *Nephrops*. Other shellfish species that contribute > 0.1% of the catches are edible crab, two scallop species, whelk, blue mussel and squid.

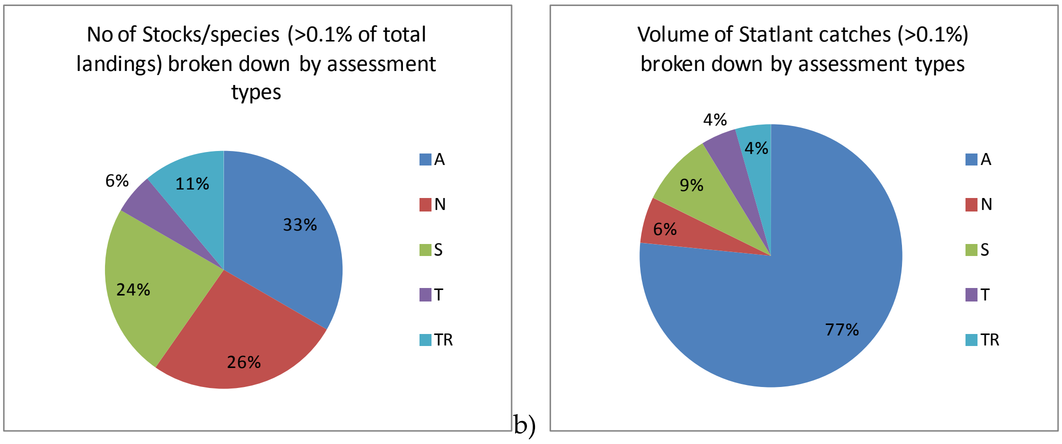
Table 6.5.2.1 shows the species ranked by landings and broken down by stock units where these are known and described by ICES. In addition it lists whether the stocks are assessed and if reference levels are given in relation to the MSY framework (F_{MSY} and $B_{MSY\text{-}trigger}$) and/or the Precautionary Approach framework (F_{pa}, F_{lim}, B_{pa} and B_{lim}). The information was taken from the most up to date ICES advice summaries (ICES 2011 advice, available online under the "Advice" link of the ICES webpage). In terms of stock assessments, it is not always easy to make a clear distinction between full analytical stock assessment and trends based assessment as there is a wide range of different stock assessment methodologies currently being used by ICES expert groups. Stocks are considered to be fully assessed (category A in table 6.5.2.1), if an accepted analytical stock assessment was carried out with an evaluation of F and/or SSB against MSY reference levels.

There are 24 stocks which are fully assessed and all of them have F evaluated in relation to F_{MSY}. For most of these stocks, SSB is also assessed in relation to $B_{MSY\text{-}trigger}$. These 24 stocks correspond to 77 % of the Fishstat landings (fig. 6.5.2.1).

Among the 48 remaining stocks/species there is a range of different assessments from exploratory analytical assessments which evaluate F and SSB in relation to reference levels to no information available. Hence the remaining stocks were divided into 4 further categories:

- Stocks that have analytical assessments but only have a qualitative evaluation of F (or Z) and SSB against reference levels (category TR in table),
- analytical assessment with an evaluation of F (or Z) and SSB without reference levels (category T);
- assessments that use only abundance or biomass trends from surveys or commercial CPUEs as the basis for advice (category S);
- Stocks/species that are not assessed or with no information (category N).

Within these categories there are some stocks that only have an evaluation of F and not of SSB. For some stocks it is not possible to evaluate fishing mortality F, but total mortality Z is estimated. Shellfish stocks other than *Nephrops* were categorised as non-assessed, but it has to be noted that for a number of these shellfish species there are defined stock units which are assessed at a national level.



a) b)

Fig. 6.5.2.1. The proportions of different assessment types in relation to a) total number of stocks/functional units and b) total Statlant (Fishstat) landings.

Rank	FG	Species	Stocks/Functional Unit	ICES advice	Assessed	F_{MSY}	Fpa	Flim	$B_{MSY\ trigger}$	Bpa	Blim
1	pelagic	Blue whiting	NEA	yes	A	y	y	y	y	y	y
2	pelagic	Atlantic mackerel	NEA	yes	A	y	y	y	y	y	y
3	pelagic	Atlantic horse mackerel	Western	yes	A	y					
4	pelagic	Atlantic herring	VIaN	yes	A	y					y
4	pelagic	Atlantic herring	VIaS VIIbc	yes	TR	y		y		y	y
4	pelagic	Atlantic herring	VIIaN	yes	T					y	y
4	pelagic	Atlantic herring	VIIaS VIIg,j	yes	A	y				y	y
5	shellfish	Norway lobster	VIa FU11	yes	A	y			y		
5	shellfish	Norway lobster	VIa FU12	yes	A	y			y		
5	shellfish	Norway lobster	VIa FU13 (F. Clyde)	yes	A	y			y		
5	shellfish	Norway lobster	VIa FU13 (S. Jura)	yes	A	y					
5	shellfish	Norway lobster	VIIaE FU14	yes	A	y					
5	shellfish	Norway lobster	VIIaW FU15	yes	A	y			y		
5	shellfish	Norway lobster	VIIb,c,j,k FU16	yes	S						
5	shellfish	Norway lobster	VIIb FU17	yes	A	y					
5	shellfish	Norway lobster	VIIa,g,j FU19	yes	N						
5	shellfish	Norway lobster	VIIg,h FU20-21	yes	S						
5	shellfish	Norway lobster	VIIg,h FU22	yes	A	y					
6	pelagic	Boarfish	not defined	yes	S						
7	demersal	European hake	Northern (VI,VII,VIII)	yes	A	y					
8	demersal	Monkfishes	VIIb–k, VIIIa,b,d	yes	S						
8	demersal	Monkfishes	IIa, IIIa, IV and VI	yes	S						
9	shellfish	Edible crab		no	N						
10	demersal	Haddock	VIa	yes	A	y	y		y	y	y
10	demersal	Haddock	VIIa	yes	TR		y				
10	demersal	Haddock	VIIb-k	yes	T						
10	demersal	Haddock	VIb	yes	A	y	y		y	y	y
11	demersal	Megrims nei	IVa and VIa	yes	T						
11	demersal	Megrims nei	VIb	yes	S						
11	demersal	Megrims nei	VIIb,c,e-k & VIIIabd	yes	S		y	y		y	
12	shellfish	Great Atlantic scallop		no	N						
13	demersal	Saithe(=Pollock)	IV & VI and IIIa	yes	A	y	y	y	y	y	y
14	shellfish	Whelk		no	N						
15	demersal	Whiting	VIa	yes	TR		y	y		y	y
15	demersal	Whiting	VIb	yes	N						
15	demersal	Whiting	VIIa	yes	TR		y	y		y	y
15	demersal	Whiting	VIIe-k	yes	T					y	y
16	demersal	Ling	IIIa, IVa, VI,VII,VIII,IX,XII,XIV	yes	S						
17	shellfish	Queen scallop		no	N						
18	demersal	Raja rays nei	VI and VII	yes	S						
19	demersal	Witch flounder	only NS(VI,IIIa,VIId)	only VIId as part of NS	N						
20	shellfish	Blue mussel		no	N						
21	demersal	Atlantic cod	VIIa	yes	A	y	y	y	y	y	y
21	demersal	Atlantic cod	VIa	yes	A	y	y	y	y	y	y
21	demersal	Atlantic cod	VIb	yes	N						
21	demersal	Atlantic cod	VIIe-k	yes	A	y	y	y	y	y	y
23	pelagic	European sprat	VI, VII a-c,f-k	yes	N						
24	pelagic	Albacore	North Atlantic	ICCAT	A	y			Bmsy		
26	deepwater	Blue ling	Vb, VI, VII	yes	S						
27	deepwater	Black scabbardfish	VI, VII, Vb,XIIb	yes	S						
28	demersal	European conger	no stock def	no	N						
29	deepwater	Roundnose grenadier	VI, VII, Vb,XIIb	yes	S						
30	demersal	Pollack	VI and VII	yes	N						
31	deepwater	Greater argentine	I, II,IIIa, IV, Vb,VI, VII, VIII,IX, X, XII and XIV	yes	S						
33	demersal	Lemon sole	no stock def in VI,VII	no (only NS and VIId)	N						
34	demersal	John dory	no stock def	no	N						
35	deepwater	Greater forkbeard	NEA	yes	S						
36	demersal	Common sole	VIIa	yes	A	y	y	y	y	y	y
36	demersal	Common sole	VIIfg	yes	A	y	y	y	y	y	
36	demersal	Common sole	VIIbc	yes	N						
36	demersal	Common sole	VIIhjk	yes	TR	y					
37	deepwater	Tusk(=Cusk)	VIb	yes	S						
37	deepwater	Tusk(=Cusk)	IIIa, IV,Vb, VIa, VII, VIII, IX,XIIb	yes	S						
39	pelagic	European pilchard(=Sardine)	no stock def in VI,VII	No advice by ICES, catches presented in WG	N						
40	demersal	Picked dogfish	NEA	yes	A	y					
41	demersal	Cuckoo ray	VI, VII	yes	S						
42	other	Tangle			N						
43	demersal	European plaice	VIIa	yes	TR						
43	demersal	European plaice	VIIfg	yes	TR						
43	demersal	European plaice	VIIbc	yes	N						
43	demersal	European plaice	VIIhjk	yes	TR	y					
44	shellfish	Northern shortfin squid		no	N						

Table 6.5.2.1. Fishstat species broken into stocks or functional units with details on their assessment and reference levels available.

Evaluation of stock status in relation to GES

Stocks which have an estimation of F and SSB in relation to MSY reference levels, either quantitative or qualitative, can be directly evaluated against criteria 3.1 and 3.2. These include stocks of categories A and TR. For category T stocks, the primary indicators F (or Z) and SSB are available, but only trends can be determined. For stocks under category S and N, secondary indicators have to be calculated which are generally based on survey data. Category S and N stocks are dealt with in the following section on stocks covered by monitoring programmes.

Criterion 3.1 of the Commission Decision 2010/477/EU relates to fishing pressure and states that "achieving or maintaining good environmental status requires that F values are equal to or lower than F_{MSY}". Criterion 3.2 relates to the reproductive capacity of the stock and states that any observed SSB value equal to or greater than SSB_{MSY} is considered to meet this criterion. With the exception of albacore tuna, none of the Celtic Seas stocks currently have an evaluation of SSB_{MSY}. Instead, if anything, they have a reference value of $B_{MSY\text{-}trigger}$, which is a lower bound on the expected range of fluctuation in SSB_{MSY} (and it is currently closer to a precautionary biomass level for most stocks). Table 6.5.2.2 lists the assessed stocks and their current stock status in relation to F_{MSY} and $B_{MSY\text{-}trigger}$ (for stocks assessed by ICES) or SSB_{MSY} (for the albacore tuna stock, assessed by ICCAT). There are 14 out of 24 stocks/functional units that currently have an F equal to or below F_{MSY}. This represents 58 % of the assessed stocks. Not all assessed stocks have SSB estimates in relation to $B_{MSY\text{-}trigger}$. There are ten assessed stocks for which SSB is currently equal or above $B_{MSY\text{-}trigger}$, while for seven stocks SSB is below $B_{MSY\text{-}trigger}$.

Rank	FG	Species	Stocks	ICES advice	Assessed	F/Fmsy	B/Btrigger
1	pelagic	Blue whiting(=Poutassou)	NEA	yes	A	≤	≥
2	pelagic	Atlantic mackerel	NEA	yes	A	>	≥
3	pelagic	Atlantic horse mackerel	Western	yes	A	≤	?
4	pelagic	Atlantic herring	VIaN	yes	A	>	?
4	pelagic	Atlantic herring	VIIaS VIIg,j	yes	A	≤	?
5	shellfish	Norway lobster	VIa FU11	yes	A	≤	≥
5	shellfish	Norway lobster	VIa FU12	yes	A	≤	≥
5	shellfish	Norway lobster	VIa FU13 (F. Clyde)	yes	A	>	≥
5	shellfish	Norway lobster	VIa FU13 (S. Jura)	yes	A	≤	?
5	shellfish	Norway lobster	VIIaE FU14	yes	A	≤	?
5	shellfish	Norway lobster	VIIaW FU15	yes	A	≤	≥
5	shellfish	Norway lobster	VIIb FU17	yes	A	≤	?
5	shellfish	Norway lobster	VIIg,h FU22	yes	A	≤	→
7	demersal	European hake	Northern (VI,VII,VIII)	yes	A	>	≥?
10	demersal	Haddock	VIa	yes	A	≤	<
10	demersal	Haddock	VIb	yes	A	≤	≥
13	demersal	Saithe(=Pollock)	IV & VI and IIIa	yes	A	>	<
21	demersal	Atlantic cod	VIIa	yes	A	>	<
21	demersal	Atlantic cod	VIa	yes	A	>?	<
21	demersal	Atlantic cod	VIIe-k	yes	A	>	≥
24	pelagic	Albacore	North Atlantic	ICCAT	A	>	<
36	demersal	Common sole	VIIa	yes	A	>	<
36	demersal	Common sole	VIIfg	yes	A	≤	≥
40	demersal	Picked dogfish	NEA	yes	A	≤	<?

Table 6.5.2.2. Assessed stocks /functional units and their current stock status in relation to criteria 3.1 and 3.2. Colours represent the following: green is F ≤ F_{MSY} and B ≥ $B_{MSY\text{-}trigger}$, red is F > F_{MSY} and B < $B_{MSY\text{-}trigger}$, a lighter shade with ? is applied where qualitative reference levels were used in advice and F > F_{MSY} or B< $B_{MSY\ trigger}$ (orange), or F ≤ F_{MSY} or B ≥ $B_{MSY\ trigger}$ (light green), white= unknown.

The status of stocks which have assessments with qualitative evaluation of their fishing pressure against F_{MSY} and biomass against $B_{MSY\text{-}trigger}$ (i.e. category TR stocks), is summarised in table 6.5.2.3. While more than 50% of the stocks are estimated to be fished above F_{MSY}, spawning stock biomass of all of them is below $B_{MSY\text{-}trigger}$ with the exception of one plaice stock. For the four category T stocks (Herring in VIIaN, West of Scotland Megrim, Celtic Sea Haddock and Whiting), only trends of F and SSB can be evaluated. While current fishing mortality is believed to be stable or decreasing, biomass is estimated to increase in all four cases (see table 6.5.2.4.).

Rank	FG	Species	Stocks	ICES advice	Assessed	GES 3.1	GES 3.2
4	pelagic	Atlantic herring	VIaS VIIbc	yes	TR	>?	<?
10	demersal	Haddock	VIIa	yes	TR	?	<?
15	demersal	Whiting	VIa	yes	TR	≤?	<?
15	demersal	Whiting	VIIa	yes	TR	>?	<?
36	demersal	Common sole	VIIhjk	yes	TR	≤?	?
43	demersal	European plaice	VIIa	yes	TR	≤?	≥?
43	demersal	European plaice	VIIfg	yes	TR	>?	<?
43	demersal	European plaice	VIIhjk	yes	TR	>?	?

Table 6.5.2.3. Stocks /functional units which have qualitative evaluation of F and SSB and their current stock status in relation to criteria 3.1 and 3.2. Light green with ? is F ≤ possible reference levels and B ≥ possible reference levels, orange with ? is used where F > possible reference levels and B < possible ref points, white = unknown.

Rank	FG	Species	Stocks	ICES advice	Assessed	GES 3.1	GES 3.2
4	pelagic	Atlantic herring	VIIaN	yes	T	↘	↗
10	demersal	Haddock	VIIb-k	yes	T	→	↗
11	demersal	Megrims nei	IVa and VIa	yes	T	→	↗
15	demersal	Whiting	VIIe-k	yes	T	?	↗

Table 6.5.2.4. Stocks /functional units which have trends based assessments and their current stock status in relation to criteria 3.1 and 3.2- directions of arrows indicate directions of trends.

6.5.3 Stocks covered by monitoring programmes

This section covers demersal fish, and their stocks where known, in subareas VI and VII for which ICES either uses abundance or biomass trends as a basis of advice (category S stocks) or for which there is insufficient information to conclude on their status and exploitation (category N stocks). There are 14 demersal species which fall into this category and contribute ≥ 0.1% to overall catches. The pelagic species boarfish is also included in this section, as demersal groundfish surveys are currently used as a basis of advice for this species. For the species covered in this section it was first assessed whether they were adequately covered by monitoring programmes. If this was the case, the secondary indicators of mature biomass (Indicator 3.2.2) and catch to biomass ratio (Indicator 3.1.2) were calculated as detailed in the Commission Decision. In addition, the population indicators proportion of fish larger than the mean size of first sexual maturation (Indicator 3.3.1) and the "95 percentile length distribution" (Indicator 3.3.3) were calculated as described in section 4.

Choice of surveys

There are a number of different groundfish surveys which cover the Celtic Sea assessment area (fig. 6.5.3.1). Most of the surveys are part of the western international bottom trawl surveys but differences in sampling gear and sampling methodology exists between surveys (ICES 2010). The time series are also of different durations (Table 6.5.3.1, which lists the surveys used in this case study). As a consequence, the indicators had to be calculated for individual surveys. The Irish ground fish survey (IGFS) has the most extensive spatial coverage in the Celtic Seas, covering divisions VIaS, VIIb, VIIg and VIIj. This survey was chosen for the calculation of secondary and population indicators for stocks that cover ICES subareas VI and VII and for species which had no spatial stock definition. For stocks, where there is a spatial definition restricted to certain ICES divisions, the most appropriate survey in terms of spatial coverage was selected, prioritising longer time series. Monkfish in division VIa is assessed as part of combined North Sea - west of Scotland stocks. Traditional groundfish surveys are ineffective at catching anglerfish in this area and biomass trends were derived from a dedicated monkfish survey which was initiated in 2005 (SCO-IV-VI-AMISS). The same survey was used for the estimation of megrim biomass in division VIb.

Country	Survey	Acronym as given in IBTS	Time series
Ireland	Irish groundfish survey (Divisions VIa-VIIbgj)	IGFS	2003+
Scotland/Ireland	Anglerfish survey in VI and IVa	SCO-IV-VI-AMISS	2005+
France	French Groundfish Survey in the Celtic Sea and Bay of Biscay (Divisions VIIfghj; VIIIab)	FR-EVHOE	1997+

Table 6.5.3.1. List of surveys used in this case study for the calculation of indicators for the Celtic Seas

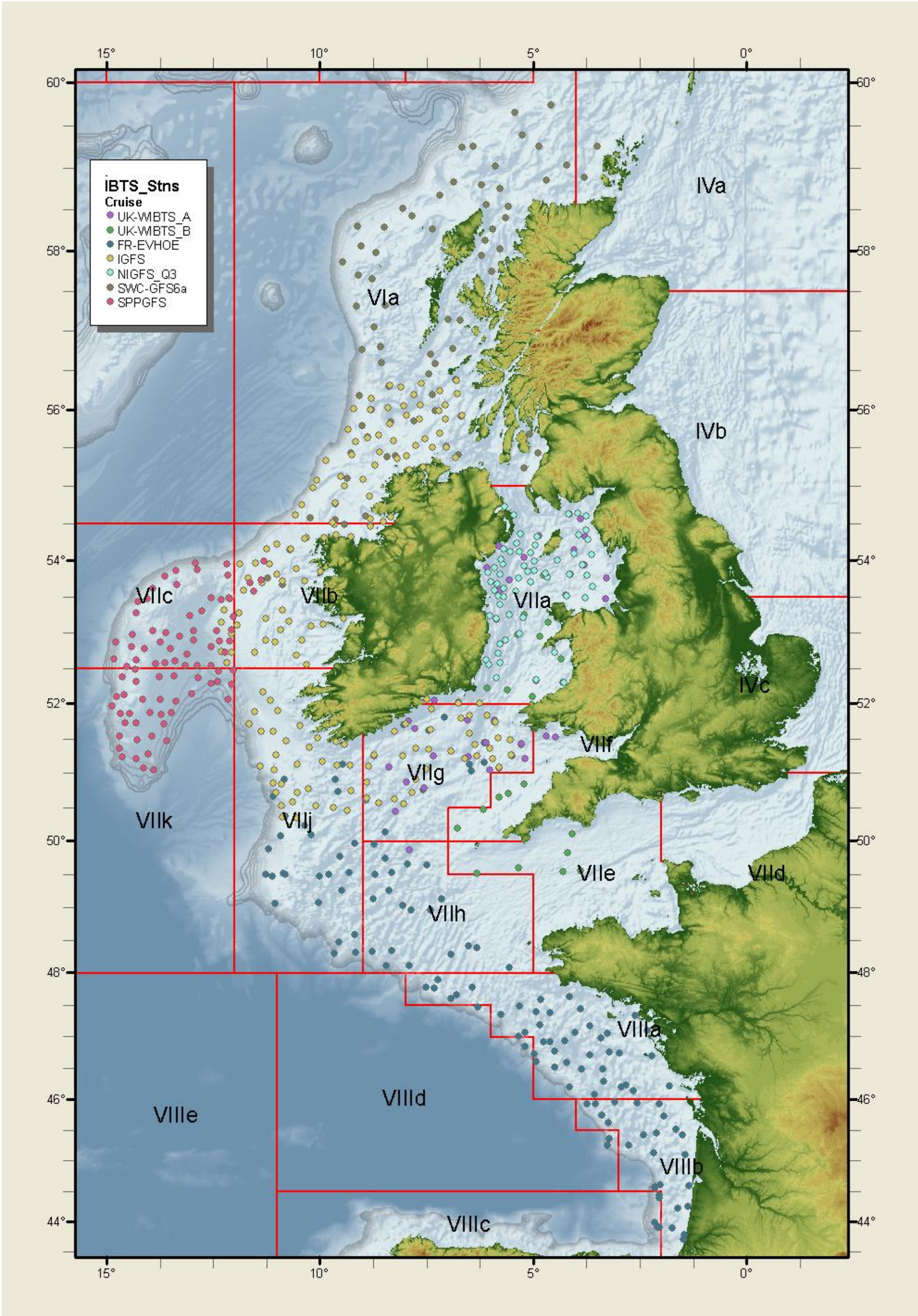


Fig. 6.5.3.1 Survey coverage of western IBTS in the Celtic Seas, broken down by individual surveys.

Calculation of indicators

For the calculation of the secondary indicators, several biological parameters are required. The conversion from numbers to weight requires the *a* and *b* parameters of the length weight relationship ($w = a\ l^b$). For the stocks that are routinely sampled for length and weight, survey-specific *a* and *b* parameters were used. For the other stocks, values were obtained from Fishbase, selecting references that related to the Celtic Seas region where available. The biomass of the mature proportion of the population (Indicator 3.2.2 in the Commission Decision) was calculated using maturity ogives where the data was readily available. Otherwise the mean size at first maturity was used as a size cut off point and numbers above this size were converted to mature biomass using the length weight relationship. The calculation of the population indicator "proportion of fish larger than the mean size of first sexual maturity" (Indicator 3.3.1 in the Commission Decision) requires the mean size at first maturity. Survey data were used where available, otherwise values were taken from Fishbase. In the rare cases where there was no published data for size at first maturity, the calculation for the estimation of biological parameters suggested by (Froese *et al.* 2008) was used.

Detection of significant trends

Time series of the secondary and population indicators were calculated as described above. Details of the species, their stock units if known and the survey that was used to calculate the indicator are given in table 6.5.3.2. An intersection union test as developed by Trenkel and Rochet (2009) was used to detect recent trends (increasing or decreasing) in the time series. In this method, first the indicator time series is smoothed using a generalised additive model with optimal selection of the degree of smoothness. Second an intersection-union test is carried out using two test statistics which are the occurrence of the global maximum (or minimum) within the most recent years and the signs of the estimated annual first derivatives of the smoothed indicator time series during the same period, including years with missing data. The output of the time series calculation for the five indicators is shown for cuckoo ray and ling as an example in fig 6.5.3.2 and 6.5.3.3.

In summary, the majority of stocks have no detectable trend in biomass and/or mature biomass (table 6.5.3.2). For stocks with detectable trends in biomass using the intersection union test, such as for megrim in subarea VII and cuckoo ray in subareas VI and VII, an increasing trend was observed. Catch/biomass ratios had no detectable trend for most stocks, while for cuckoo ray and witch flounder there was a negative trend. Population indicators exhibited no trends with the exception of 3.3.1 (i.e. the proportion of fish larger than mean size of first sexual maturation) for ling, which showed a negative trend. It has to be noted that these are preliminary results.

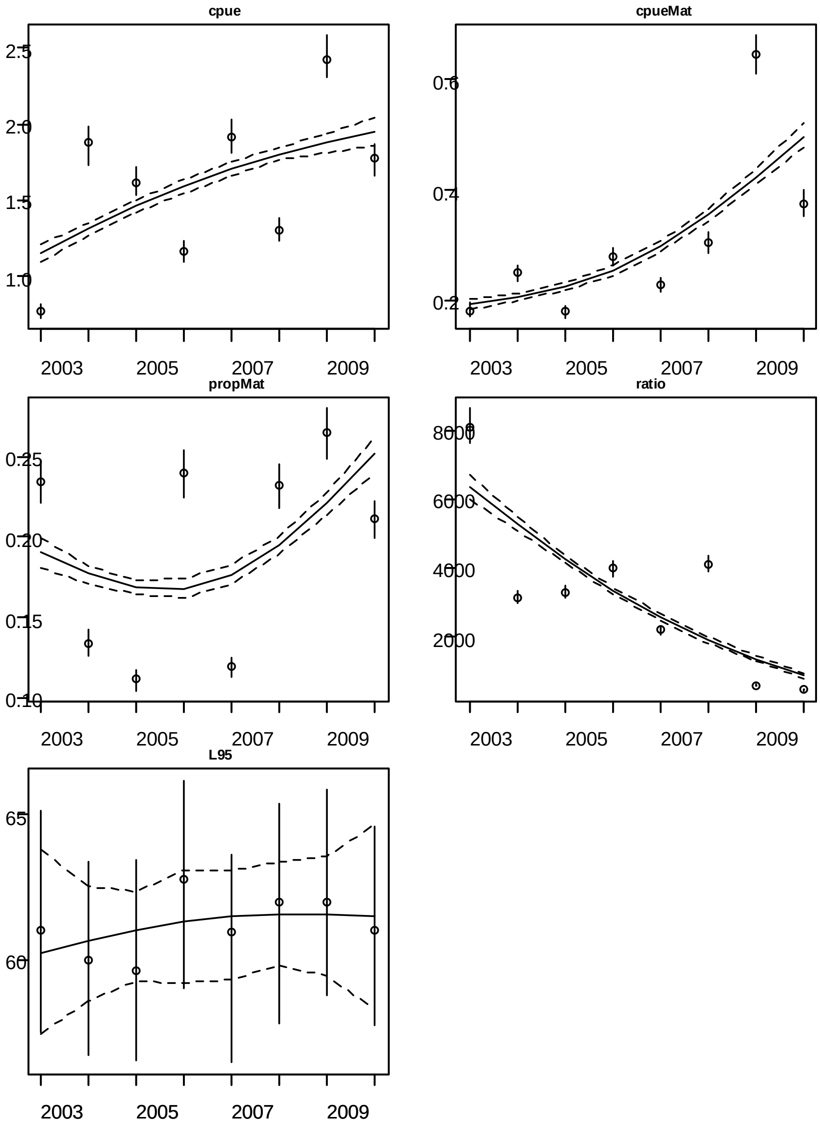


Fig. 6.5.3.2. Secondary and population indicator time series for Cuckoo Ray in subareas VI and VII with smoothing function as used in the intersection union test by Trenkel and Rochet (2009). The following indicators are presented in the diagram- cpue: survey biomass (kg h^{-1}); cpue mat: survey biomass (kg h^{-1}) of the mature proportion (Indicator 3.2.2); prop Mat: percentage of biomass above the mean size at first maturity (Indicator 3.3.1); ratio: catch to biomass ratio (Indicator 3.1.2); L95: 95 percentile length distribution (cm) (Indicator 3.3.3)

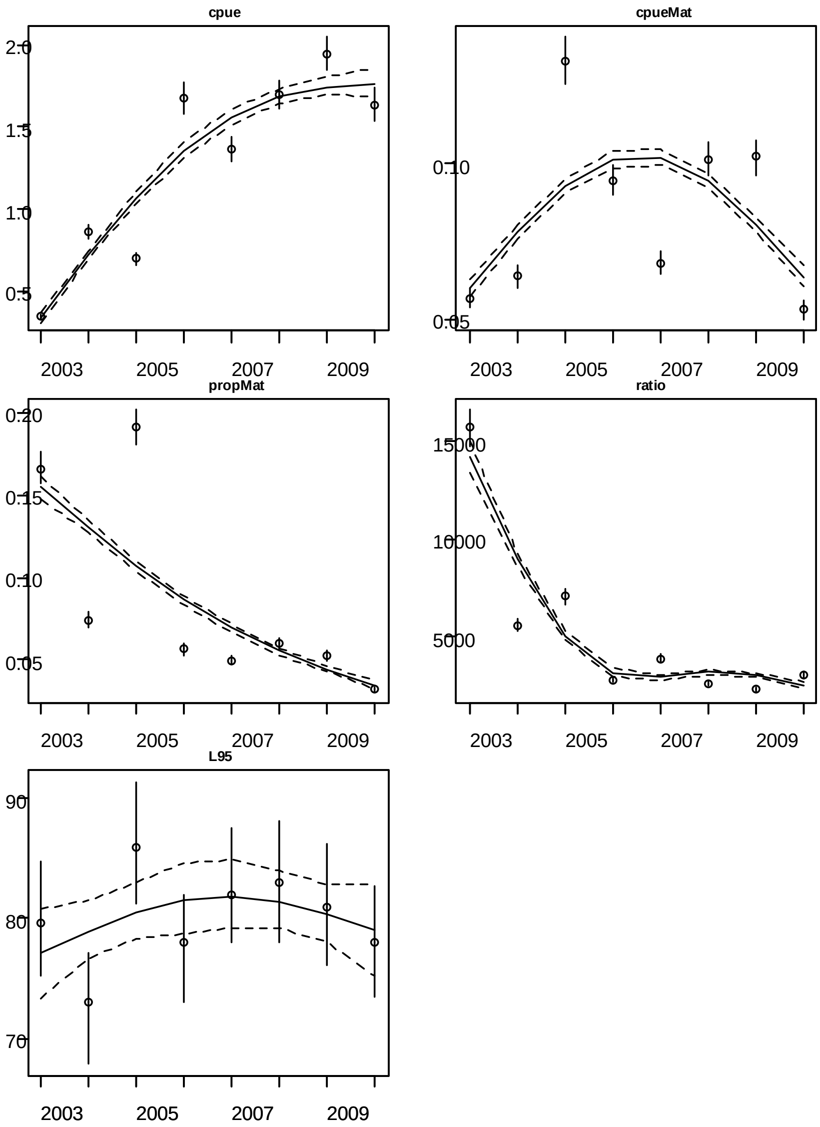


Fig. 6.5.3.3. Secondary and population indicator time series for Ling in subareas VI and VII with smoothing function as used in the intersection union test by Trenkel and Rochet (2009). The following indicators are presented in the diagram- cpue: survey biomass (kg h^{-1}); cpue mat: survey biomass (kg h^{-1}) of the mature proportion (Indicator 3.2.2); prop Mat: percentage of biomass above the mean size at first maturity (Indicator 3.3.1); ratio: catch to biomass ratio (Indicator 3.1.2); L95: 95 percentile length distribution (cm) (Indicator 3.3.3).

Rank	FG	Species	Stocks	ICES advice	Assessed	Survey used for indicator	Survey biomass	Survey biomass (mature)	Catch ratio	% mature	0.95%
6	pelagic	Boarfish	NEA	yes	S	IGFS	→	→	→	→	→
8	demersal	Monkfishes:	VIIb–k, VIIIa,b,d								
		L. Piscatorius		yes	S	FR EVOE	→		→		→
		L. budegassa			S	FR EVOE	→		→		→
8	demersal	Monkfishes	VI	yes	S	SCO-IV-VI-AMISS	→		→		
11	demersal	Megrims nei	VIb	yes	S	SCO-IV-VI-AMISS	↗		→		
11	demersal	Megrims nei	VIIb,c,e-k & VIIIabd	yes	S	IGFS	↗	↗	→	→	→
15	demersal	Whiting	VIb	yes	N						
16	demersal	Ling	IIIa, IVa, VI,VII,VIII,IX,XII, XIV	yes	S	IGFS	→	→	→	↘	→
18	demersal	Raja rays nei:	VI and VII	yes	S						
	demersal	Cookoo Ray		yes	S	IGFS	↗	↗	↘	→	→
	demersal	Thornback Ray		yes	S	IGFS	→	→	→	→	→
	demersal	spotted Ray		yes	S	IGFS	→	→	→	→	→
	demersal	Blonde Ray		yes	S	IGFS	→		→		→
19	demersal	Witch flounder	no stock def in VI,VII exct channel	no	N	IGFS	→	→	↘	→	→
21	demersal	Atlantic cod	VIb	yes	N						
28	demersal	European conger	no stock def	no	N	IGFS	→		→		→
30	demersal	Pollack	VI and VII	yes	N	IGFS	→	→	→	→	→
33	demersal	Lemon sole	no stock def in VI,VII	no (only NS and VIId)	N	IGFS	→	→	→	→	→
34	demersal	John dory	no stock def in VI,VII	no	N	IGFS	→	→	→	→	→
36	demersal	Common sole	VIIbc	yes	N	IGFS	→	→	→	→	→
41	demersal	Cuckoo ray	VI, VII	yes	S	*given above under Raja nei*					
43	demersal	European plaice	VIIbc	yes	N	IGFS	→	→	↘	→	→

Table 6.5.3.2. Demersal species in category S and N and boarfish, their stocks units where known and the trends of their secondary and population indicators as detected by the intersection union test described by Trenkel and Rochet (2009). The 5 right-most columns of the table correspond to the same 5 indicators displayed in detail for two species in figures 7 and 8.

6.5.4 Overall assessment of current status in relation to GES

What is good environmental status:

Specification of what GES is for descriptor 3 is given in the Commission Decision (see section 1.1), as it states that stocks should be exploited ≤ F_{MSY} and their biomass should be ≥ B_{MSY} (or B_{pa} where B_{MSY} is not evaluated). Moreover populations should exhibit age and size distribution that is indicative of a healthy stock. The Commission Decision further states that within mixed fisheries and where there are ecosystem interactions, species might have to be exploited more lightly than F_{MSY}, in order not to compromise the exploitation at F_{MSY} of other species. Operational implementation of this approach needs further development as species interactions are not yet fully understood and the consequences of fishing at MSY on the overall fish community and the ecosystem in the medium to longer term are not yet known. F_{MSY} is regarded as a target for the CFP for 2015 (COM(2006) 360 final) and the thinking will need to be further developed of how it will be operationally possible to achieve and maintain the CFP target, while also maintaining good environmental status under the MSFD. From this perspective, consideration will need to be given to a buffer or *implementation boundary* around the theoretical determination of MSY which would take scientific uncertainty, species interaction and environmental variability into account.

Summary of current status:

The following information from Celtic Sea Stocks can be summarised in relation to the three GES criteria 3.1, 3.2 and 3.3:

F in relation to F_{MSY} for all stocks in the A and TR category, trends in F and catch/biomass ratio for stocks in the T, S and N category to address criterion 3.1.

SSB in relation to $B_{MSY\text{-}trigger}$ for stocks in the A and TR category (B_{MSY} for Albacore tuna), trends in biomass for stocks in the T, S and N category to address criterion 3.2.

Population indicators for stocks in the S and N category to address criterion 3.3.

For the fully assessed stocks, there are 14 out of 24 stocks/functional units that currently have an F equal to or below F_{MSY} (Fig 6.5.4.1). In addition there are 3 out of 8 stocks fished ≤ F_{MSY} based on qualitative assessments. Thus for the 32 stocks, for which an estimation of F against MSY is possible, 53% are fished ≤ F_{MSY}. This comprises approximately 68% of the total weight of landings. Within the functional groups there are some differences of the proportion of stock fished in relation to MSY. For demersal and pelagic species, the ratio of stocks fished ≤ and > MSY is ca. 0.8, while for the shellfish stocks the ratio is seven to one (*Nephrops* only). The results of the trends based evaluation of F for stocks which have no assessment against reference levels can be summarised as follows: For the four stocks which have relative estimations of F (category T), one stock has a significantly decreasing trend in F, while the remaining three stocks have a stable or no trend. For the 16 stocks covered by monitoring programmes the catch/biomass ratio is stable or without detectable trends for 14 stocks, while it is decreasing for two stocks.

For criterion 3.2, GES is defined as SSB ≥ SSB_{MSY} and if this cannot be evaluated, then SSB > B_{pa} can be used instead. With the exception of Albacore Tuna, none of the Celtic Seas stocks currently have an evaluation of SSB_{MSY}. Instead, they have a reference value of $B_{MSY\text{-}trigger}$, which is used in the ICES MSY framework as a lower percentile of the range of SSB values consistent with the fluctuations that might be expected around SSB_{MSY}. In most cases, the precautionary reference level B_{pa} is being used as

$B_{MSY\text{-}trigger}$ for the time being (until knowledge is gained on the range of SSB fluctuations observed when fishing at F_{MSY}). For demersal stocks, two thirds of the stocks are below $B_{MSY\text{-}trigger}$. For the pelagic stocks, there are two stocks below and two above $B_{MSY\text{-}trigger}$, while for shellfish, all functional units, where known, have their biomass above $B_{MSY\text{-}trigger}$ (Fig. 6.5.4.2). Overall, eleven of the assessed stocks including stocks with qualitative assessment in category TR, are at or above $B_{MSY\text{-}trigger}$, while 12 stocks are below $B_{MSY\text{-}trigger}$. The assessed stocks with SSB above $B_{MSY\text{-}trigger}$ represent 74% of the total landings according to the Fishstat database. The comparison between the outcome of the number of stocks versus the volume of catches shows the strong weighting for stocks with high volume catches such as blue whiting, which currently have a biomass above $B_{MSY\text{-}trigger}$.

For stocks which only have a trends based evaluation of SSB or survey biomass (category T, S and N), seven stocks exhibited an increasing trend of biomass while the remaining 13 stocks had a stable or no detectable trend.

In relation to criterion 3.3, Population age and size distribution, the Commission Decision states that healthy stocks are characterised by high proportion of old, large individuals. The indicators, used to evaluate the population structure, were the proportion of mature fish in the population (Indicator 3.3.1) and the 95% of the length distribution in the population (Indicator 3.3.3). Indicators were calculated for stocks/species for which secondary indicators were calculated as detailed in section 6.5.3. There was no significant increasing or decreasing trends in population diagnostics detected with the methods applied, with the exception of Ling, for which a significant decline in the proportion of mature fish was detected.

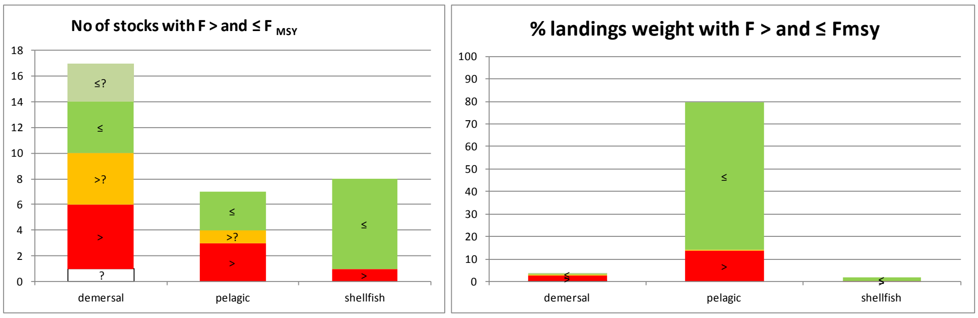


Fig. 6.5.4.1.The number of assessed stocks (category A and TR) with F > or ≤ F_{MSY} in numbers (left) and weighted by landings (right).

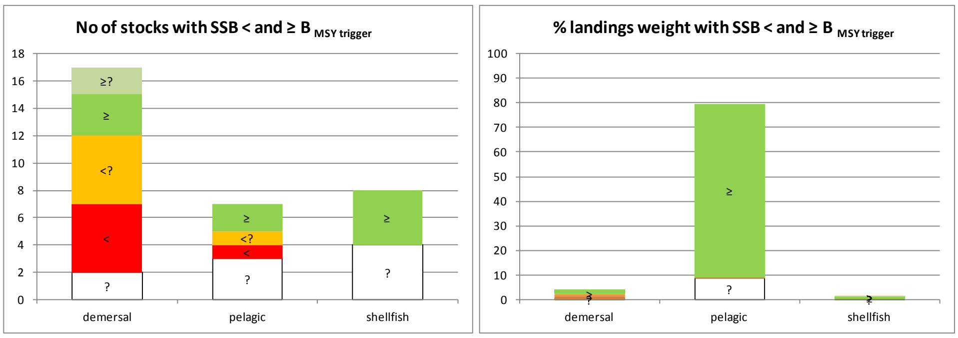


Fig. 6.5.4.2.The number of assessed stocks (category A and TR) with SSB < or ≥ $B_{MSY\text{-}trigger}$ in numbers (left) and weighted by landings (right).

How far are stocks from GES?

As a next step it is important to see how close the current Fs and SSBs are to their reference levels. In Fig. 11 the ratios of F_{curr}/F_{MSY} are plotted against $SSB_{curr}/B_{MSY\text{-}trigger}$ ratios for stocks with quantitative assessments (category A) based on 2011 ICES assessments (ICES 2011). The plot highlights the number of stocks that are currently fished very close to the MSY reference level, such as blue whiting, and the stocks that are exploited at high Fs with depleted biomasses, such as the cod and sole stocks in the Irish Sea.

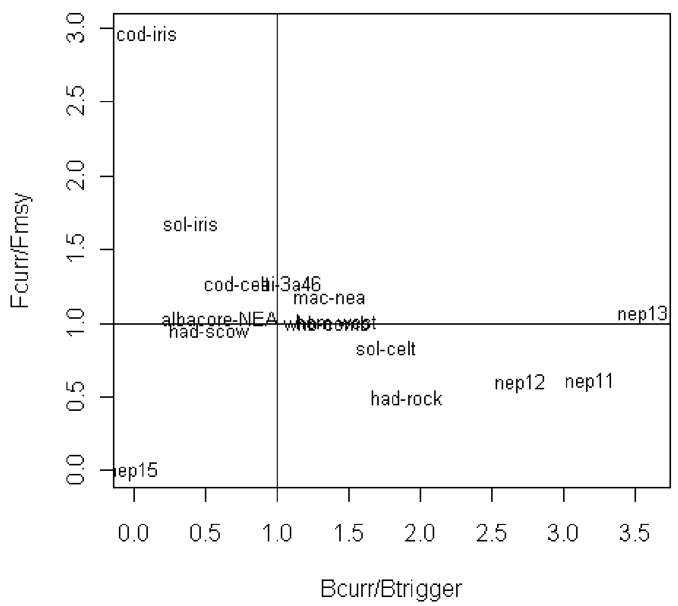


Fig. 6.5.4.3 The ratio of current F/F_{MSY} against the ratio of current SSB/$B_{MSY\text{-}trigger}$ for assessed stocks in the Celtic Seas MFSD subregion.

Are we moving towards GES?

Trajectories of fishing mortality and biomass in relation to the MSY reference levels can help to evaluate whether there is an improvement or deterioration in the state of the Celtic Seas fish stocks over time. Time series of F and SSB are available for stocks with analytical stock assessments and the longest time series of F and SSB for assessed stocks in the Celtic Seas commence in the late 1950 (Fig. 6.5.4.4). Most pelagic and demersal stocks have time series of F and SSB extending back to the late eighties while for the *Nephrops* stocks time series of F and SSB is have been available for the last decade (fig 6.5.4.4). For an evaluation of F and SSB in relation to MSY over time, 1990 was chosen as a starting point. Species were firstly evaluated separately on a stock by stock basis, then aggregated within their functional group and then combined into a total mean F and SSB ratio.

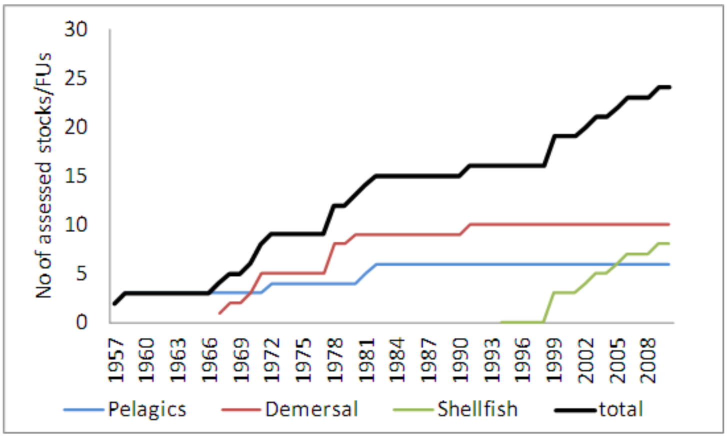


Fig. 6.5.4.4. Time series availability of assessed stocks in the Celtic Seas MSFD subregion (category A) with F and/or SSB defined in relation to MSY reference levels.

For pelagic stocks, fishing mortality was high for all stocks in the late nineties with some F to F_{MSY} ratios above 3. Relative F then followed a strong decline in the last decade and now current Fs are either below or very close to F_{MSY} for all assessed stocks. Time series for SSB in relation to $B_{MSY\text{-trigger}}$ indicate that two stocks are currently above $B_{MSY\text{-trigger}}$. While the biomass of mackerel is recovering with biomass above $B_{MSY\text{-trigger}}$ and increasing in the last 5 years, blue whiting is exhibiting a strong decline (Figure 6.5.4.5, top row). Albacore tuna is below the reference line, but note that for Albacore the reference level is B_{MSY} and not $B_{MSY\text{-trigger}}$.

For demersal species an improvement in the state of their stocks in the last twenty years is less apparent. While the number of stocks fished below or at F_{MSY} has increased in the last four years, there are still a number of stocks which are still fished well above F_{MSY}. Biomass continues to decline for the majority of stocks especially the ones that are already in a severely depleted state such as cod in VIIa and in VIa, haddock in VIa and sole in VIIa (Fig 6.5.4.5, second row).

Nephrops stocks show a strong overall reduction in their relative Fs in the last few years. While nearly all functional units were overfished in 2007/2008, current Fs are now below or close to F_{MSY} and all SSBs are above $B_{MSY\text{-trigger}}$ (Fig 6.5.4.5, third row).

The information on relative Fs and SSBs has been aggregated by functional group and overall to examine whether a directional change towards GES is detectable for all stocks in the Celtic Sea combined. For this purpose F/F_{MSY} ratios and SSB/$B_{MSY\text{-trigger}}$ ratios were averaged by functional group and overall (Fig 6.5.4.5, bottom row), whereby every individual stock/functional unit was given equal weighting. The relative F trajectories for both demersal and pelagic stocks show a declining trend since around 2000, while for *Nephrops* the trend is declining in the last few years. When all functional groups are combined, mean relative F shows a declining trend since around 2000 and is now around 1, which corresponds to the F_{MSY} reference level. The Biomass to $B_{MSY\text{-trigger}}$ ratio has also shown an improving trend for pelagic and *Nephrops* stocks and for all stocks combined, with a ratio above 1 and an increase since the late nineties.

The biomass ratio has however deteriorated for demersal stocks and is below $B_{MSY\text{-}trigger}$ since about 2005 with no indication of an improvement visible.

In summary, relative fishing mortality seems to have declined significantly in the last decade and there has been some increase in spawning stock biomasses. However there are still a number of severely depleted stocks present and there is no indication of their recovery.

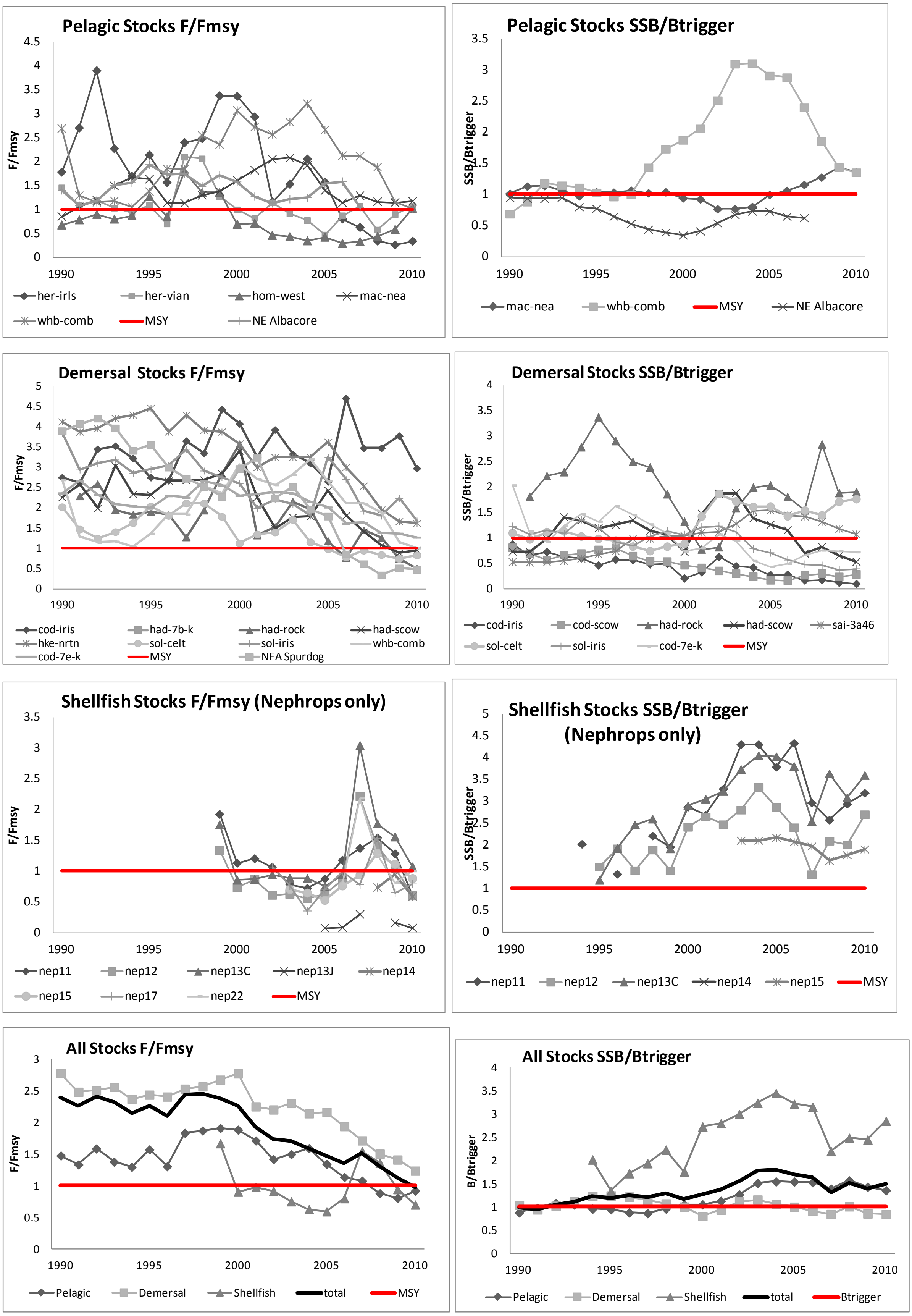


Fig. 6.5.4.5. Time series of F and SSB in relation to MSY reference levels of assessed stocks in the Celtic Seas MSFD subregion.

7 Roadmap to a GES assessment

The preliminary analyses conducted as part of our case studies revealed many of the issues that need to be considered for an assessment of current status in relation to GES for Descriptor 3 (Commercial fish and shellfish). Below we refer to examples in our case studies that illustrate these issues, provide possible approaches for how to deal with them, and present some of the consequences of these choices. Following the MSFD in that "Each Member State should therefore develop a marine strategy for its marine waters which, while being specific to its own waters, reflects the overall perspective of the marine region or sub-region concerned.", we have approached this from a member state (MS) perspective but the case studies provided should *NOT* be considered to represent *THE* assessment of status in relation to GES of any specific MS in that (sub)region, but rather as applications of the approach developed by this group and applied by the regional experts within the group.

Following the outline of this report we distinguish 5 major steps in the GES assessment process:

1) Selection of commercially exploited (shell)fish populations (i.e. which populations are considered relevant for Descriptor 3 in that MSFD sub-region or MS-specific sub-division of the sub-region)
2) Stocks for which indicators and reference levels are available (i.e. those covered by stock assessments)
3) Species for which no reference levels are available (i.e. those covered by monitoring programs)
4) Interpretation of what is GES
5) The assessment of current status in relation to GES (i.e. the synthesis or aggregation of available information)

7.1 Selection of commercially exploited (shell)fish populations

In the report we identified the following issues that need to be considered in this step of the process:

- Identification of the appropriate area
- Match of existing spatial units to that area
- Choice of data source
- Choice of time period
- Selection criteria

7.1.1 Identification of the appropriate area

According to the MSFD (Article 5, paragraph 1) "each MS shall, in respect to each marine region or subregion concerned, develop a marine strategy for its marine waters". Therefore as a first step we identified the MSFD sub-regions (see section 1.2) assuming that MSs would then need to agree on a common approach for the MSFD (sub)region to which the "marine waters covered by their sovereignty or jurisdiction form an integral part". However, the MSFD also states in its Article 4, paragraph 2, that MSs may, in order to take into account the specificities of a particular area, implement the directive by reference to subdivisions, provided that such subdivisions are compatible with the MSFD subregions. Such subdivisions may be revised by the MSs upon completion of the initial assessment. Several experts from different MSs also indicated that because in several MSFD (sub-)regions at least some of the stocks occurring in that (sub-)region are not relevant from their MS perspective, there is a need to apply subdivisions within the (sub-)regions to accommodate this. In this report we show what such subdivisions could look like from a Spanish perspective in the Bay of Biscay/Iberian coast (section 6.3), in several of the Mediterranean subregions from an Italian perspective (section 6.2) and in the Baltic from a Finnish perspective (section 6.1). An important point to consider, however, is that the application of subdivisions in a specific MSFD (sub-)region is likely to result in different outcomes of the GES assessment within that (sub-)region.

7.1.2 Match of existing spatial units to that area

Organisations such as ICES (covering North-east Atlantic Ocean and Baltic Sea), GFCM (Mediterranean and Black Sea) or ICCAT (Atlantic tunas) apply specific spatial units (ICES areas, GSAs in GFCM, …) when collecting and reporting on much of the information relevant for this descriptor. Therefore, in order to apply this information to the MSFD (sub-)regions or MS-specific subdivisions these spatial units need to be matched to these areas. This is often not a straightforward exercise and is likely to have consequences for the selection process. For example, section 6.2.1 shows how the GSA belonging to the different Mediterranean sub-regions differ in terms of their species composition so that the selection of matching spatial units is certain to determine the relative importance of the species in the table and is even very likely to influence the overall suite of populations of commercially exploited fish and shellfish considered for this Descriptor. How this could actually work out is shown in an example of the Celtic Seas (section 6.5.1) where the exclusion of ICES division VIIe resulted in 8 less species/taxa being selected and some (minor) changes in the relative importance of species. However, the main purpose for which this selection is used, i.e. to show how representative the species for which information is available are for the overall GES assessment in that area (i.e. MSFD (sub-)region or MS-specific subdivision), appears to be fairly robust against this choice.

7.1.3 Choice of data source

Two potential data sources were identified in this exercise: the FAO Fishstat database, which is based on actual logbook information, and the DCF (see Appendix VII of Commission Decision 2008/949/EC) where the following species groups are considered: 1) Species that drive the international management process including species under EU management plans or EU recovery plans; 2) Other internationally regulated species and major non-internationally regulated by-catch species; 3) All other by-catch (fish and shellfish) species. In two North-east Atlantic Ocean (sub-)regions the difference between applying these datasets was explored: in the Celtic Seas we found that 9 species/taxa contributing to 4% of the landings that occurred in the FAO Fishstat database did not occur in the DCF database, in the North Sea this was 5%. These examples show that the FAO database is more comprehensive and based on actual logbook information whereas the DCF data may be subject to political decisions on the inclusion of species based on the criteria above. As such, the FAO database is likely to provide a more consistent and longer-term source of information than the DCF database. There are, however, issues with the FAO database pertaining to the ability to provide up-to-date information. An issue that applies specifically for the Mediterranean is that the DCF database provides data at GSA level which is more appropriate for the Mediterranean region since the spatial units in the GFCM database (Fishstat) are in some cases too coarse to provide landings composition at the sub-regional level. Another issue related to the Fishstat database is that there often occur higher-order taxa or groups of species for which no straightforward link exists with the stocks or species as they occur in the stock assessments or monitoring programs. This could hamper e.g. the estimation of the secondary indicator for fishing mortality in non-assessed stocks (indicator 3.1.2; ratio between catch and biomass index) where landings data are only available at some coarse taxonomic category, while the biomass index from monitoring programs is at species level.

The choice of what is deemed the most appropriate data source depends on several considerations and can be decided by the experts. Our analysis shows that the main species are covered by both sources of information and as the two data sources only differ for some of the less important species for which often no information is available, it appears unlikely that the choice of data source would affect the outcome of the GES assessment. The outcome of the quality assessment (section 7.5), however, may be slightly affected.

7.1.4 Choice of time period

The effect of the time period on which the selection of species is based was explored in several of the case studies. In the Celtic Seas the number of selected species was observed to decrease from 54 when based on the period 1950-2009 to 48 when based on the period 2005-2009. The opposite occurred in the North Sea, where an increase was observed over the same periods from 38 to 47 species/taxa because the longer aggregation period caused the exclusion of species/taxa that were not of sufficient relative importance in decades previous to 2000, but contributed more than 0.1 % to the total landings of the recent years. This shows that it is important to consider the time period when selecting the species to be included in the GES assessment as the failure to include a species because the fishery moves to another stock after fishing one down may result in a shifting baseline. The case studies considered, however, showed the chosen time period had no major implications on the composition of THE selection of “populations of commercial fish and shellfish” which is the basis for the remainder of the process. It is, however, important to identify whenever species that have been exploited in the past and are not fished anymore either due to depletion or because of a change in demand are not included in descriptor 3. This can be done by comparison to a historic reference period or the type of exercises done in sections 6.4.1 and 6.5.1. Such excluded species should then be covered by the biodiversity Descriptor 1 of the MSFD.

7.1.5 Selection criteria

The number of species/taxa occurring in the case study databases prior to selection varied from 65 in the Mediterranean to more than 100 in the Celtic Seas and Bay of Biscay and Iberian Coast. The distribution of the landings is strongly skewed with few species/taxa contributing to most of the landings and many species/taxa with negligible landings. Therefore we applied selection criteria resulting in a final list that was considered sufficiently comprehensive to be representative for the commercial (shell)fish in the marine waters being assessed, while at the same time avoiding inclusion of insignificant species that would hamper the assessment process because of lack of information. The most common criterion applied was a threshold proportion of the total landings (e.g. ≥1%, ≥0.1% or ≥0.01%), while also taking into account the proportion of the total landings covered by the suite of species/taxa resulting from the chosen threshold. In some case studies additional criteria were applied to complement this. For example in the Bay of Biscay and Iberian Coast case study (section

6.3) a 1% threshold was applied but, in addition, some species/taxa which contributed less than the 1% threshold were included based on other criteria (these were the stocks regularly assessed by ICES, species/stocks for which ICES started to give advice in 2011, and species/stocks included in both the DCF and the Water Framework Directive). Similarly, salmon was included in the Baltic Sea case study. Another criterion that was explored was to apply the landings threshold per functional group (i.e. Fish/Invertebrates or Benthic/ Demersal/ Elasmobranch/ Pelagic) but the North Sea and Celtic Seas case studies showed this did not result in a better representation of the main species belonging to different functional groups. Thus, while applying a threshold across all species/taxa to determine the selection of species to be considered for the GES assessment appears valid, some flexibility allowing MSs to include species with specific relevance is recommended. Exclusion, however, of species/taxa that would fulfil the criteria of inclusion should be avoided.

7.2 Species for which indicators and reference levels are available

This section is specifically about assessed stocks for which one or more indicators including reference levels are available, as these allow a more robust assessment of current status in relation to GES. For these stocks we identified the following issues that need to be considered in this step of the process:

- Which stocks can be considered representative for a MS's marine waters?
- Which (other) criteria apply for the selection of stocks.

Which stocks can be considered representative for a MS's marine waters?

For every stock the boundaries of the assessment area are known. In the North-east Atlantic Ocean and Baltic Sea these are based on ICES areas, in the Mediterranean and Black Sea on GSAs. The boundaries for tuna stocks assessments are defined by ICCAT. Similar to the process of identification of the appropriate area (section 7.1.1) a stock can be included if it is considered sufficiently representative for that MS's marine waters based on the overlap of the stocks assessment area and the (sub-)region or subdivision of which these marine waters "form an integral part". Sometimes there may be several stocks for one of the species/taxa considered part of the "populations of commercially exploited fish and shellfish". In that case we included all stocks that fulfilled the criteria. In each case study issues were identified and how these were resolved can provide guidance on how to deal with this whenever similar problems arise.

For example, in the case study concerning the Spanish North-Atlantic subdivision (section 6.3), it was noted that the geographical area comprises almost the entire ICES Division VIIIc and parts of ICES Divisions VIIIb, VIIId, VIIIe, IXa and IXb. Species were selected based on DCF information. Stocks that do not cover at least one of ICES Divisions VIIIc or IXa were not considered, because even though they have some geographical overlap with the case study area, this is very minor and not considered sufficiently representative. Hence, the ICES so-called northern stock of hake and the stocks of anglerfish and megrim in ICES Divisions VIIb-k and VIIIa,b,d were not considered in that case study. Additionally, in some cases where the DCF region is much larger than the case study area and experts knew that certain species do not to occur in the case study area, the species were not included (this applied to *e.g.* several tropical and oceanic tuna species). Three of the included species belong to several stocks whose area intersects sufficiently with the case study area, hence all stocks were considered: Horse mackerel, consisting of a western stock and a southern stock, Norway lobster, consisting of three stocks in different Functional Units (FU 31, FU 25 and FU 26-27) and Pollack, consisting of two areas in terms of the DCF table entries ("all areas" and "ICES Subareas IX-X").

Which (other) criteria apply for the selection of stocks?

Two primary indicators were identified that could potentially be calculated for the assessed stocks, *i.e.* F and SSB, and specific reference levels for each of the indicators, *i.e.* F_{pa} and F_{MSY} (or suitable proxy) for F, SSB_{MSY} (replaced by $B_{MSY\text{-}trigger}$ for ICES stocks) for SSB. All stocks for which at least one of the indicators and its reference values are known can be included. For a number of stocks assessed by ICES only one of the reference levels F_{MSY} and F_{pa} is defined. These stocks can still be included in the analysis by applying thne 1.6 factor for the ratio between F_{MSY} and F_{pa}. The 1.6 factor is a starting point, chosen on the basis of a report on the ICES MSY approach (ICES, 2011a) which shows that for the ICES stocks for which F_{MSY} and F_{pa} are both defined (where F_{pa} is the precautionary value of the F estimates, as explained in section 3.2 of this report), $F_{pa} \approx 1.6\ F_{MSY}$ on average. While this was considered the best practical solution to avoid excluding stocks from the assessment because of one missing reference level, it must be noted that F_{pa} should be derived from F_{lim} taking into account the uncertainty in F estimates obtained from stock assessments. Therefore, a high degree of assessment uncertainty could result in a low F_{pa} value, which could conceivably be even below F_{MSY}. Alternatively, the 1.6 factor may also be interpreted as providing an interval around F_{MSY}, chosen on an entirely pragmatic basis, and used to set the boundary between "orange" and "red" stock status (see Section 7.4 below). It is also possible to use proxies for F_{MSY} such as $F_{0.1}$ or F_{max}, if these are available and considered appropriate by the relevant stock assessment body.

In some of the case studies (e.g. the Celtic Seas, section 6.5) different criteria were applied, resulting in more than two stock assessment categories (namely, A: fully assessed stocks with quantitative evaluation of F and/or SSB against MSY reference points, TR: trends based assessed stocks with qualitative evaluation of current F and/or SSB against MSY reference points, and T: trends based assessments without evaluation of current status with respect to reference points). This finer categorisation was devised in order to

- reflect the variety of stock assessments in the Celtic Seas area,
- put the emphasis on the outcome of stock assessments that were done by the expert groups with their evaluation of Fs, SSBs and reference points, including when expert judgement was used to determine whether a stock was above or below possible reference points (category TR),
- use primary indicators for criteria 3.1 and 3.2 where available, even if there are no reference points, rather than applying secondary indicators (category T). The Bay of Biscay and Iberian Coast case study (section 6.3) also used primary indicators where available, even if there were no reference points, instead of using secondary indicators in such cases.

If only stocks in the assessment category A were used in the Celtic Seas case study, most stocks would have had to be covered in the section under monitoring programme. This means that important information from the expert groups would not have been utilized in this study.

7.3 Species for which no reference levels are available

This section is specifically about species only covered by monitoring programs. Each species for which an appropriate monitoring program provides indicators for one or more of criteria 3.1, 3.2 or 3.3 can be included. For a monitoring program to be suitable it needs to:

1) be sufficiently representative for what is considered the MS's marine waters,
2) provide a time-series for one or more of the selected indicators,
3) apply the appropriate sampling technique so that it can provide an adequate signal-to-noise ratio.

The degree to which the monitoring program is representative is largely determined by its overlap with the MS's marine waters, similar to what was also applied for the selection of species/taxa and assessed stocks based on existing spatial units. Pertaining to the provision of time-series the general rule applies that monitoring programs that provide longer time-series are preferred even if some years are missing. Surveys that provide a shorter time-series but with a better signal-to-noise ratio may be preferred to those where it is the other way around. This often relates to the sampling technique that is used but may also involve area, time of year, time of day, etc. For example demersal gears (e.g. bottom trawl) are not the most appropriate to sample pelagic species and, hence, surveys that apply these gears should not be the preferred monitoring program for these species/taxa.

In order to determine the current status from time-series without reference levels we explored two approaches in the case studies:

- comparing the recent period with the long-term average (see sections 6.3.3 and 6.4.3)
- detection of trends (section 6.5.3)

The performance of these two methods in determining whether or not GES was achieved was not assessed and therefore no advice can be given as to what is the preferred method.

7.4 The assessment of GES

According to the Commission Decision 2010/477/EU GES is determined by three criteria for which different sources of information are available:

Criterion 3.1 Level of pressure of the fishing activity

- Primary indicator: Indicator 3.1.1 Fishing mortality (F)
- Secondary indicator (if analytical assessments yielding values for F are not available): Indicator 3.1.2 Ratio between catch and biomass index (hereinafter catch/biomass ratio)

Criterion 3.2 Reproductive capacity of the stock

- Primary indicator: Indicator 3.2.1 Spawning Stock Biomass (SSB)
- Secondary indicator (if analytical assessments yielding values for SSB are not available): Indicator 3.2.2 Biomass indices

Criterion 3.3 Population age and size distribution (the first 3 indicators are primary, the fourth indicator is secondary).

- Indicator 3.3.1 Proportion of fish larger than the mean size of first sexual maturation
- Indicator 3.3.2 Mean maximum length across all species found in research vessel surveys
- Indicator 3.3.3 95% percentile of the fish length distribution observed in research vessel surveys
- Indicator 3.3.4 Size at first sexual maturation, which may reflect the extent of undesirable genetic effects of exploitation

Reference levels are available (at least in theory, even if they cannot be reliably estimated for certain stocks) for the primary indicators of criteria 3.1 and 3.2, but not for the other indicators. This necessitates application of different methods in order to distinguish GES from non-GES for each of the indicators belonging to different criteria. To what extent it is appropriate or even desirable to aggregate the different indicators into one digit or number reflecting whether or not GES is achieved (e.g. current status=GES Yes/No) for this descriptor and/or the current status relative to GES (e.g. current status= 80% of GES) remains unanswered. But our case studies provide various examples of what the outcome of a GES assessment will look like depending on the approach that is applied.

We distinguish three levels in the GES assessment process:

- Stock/species: current status in relation to GES per stock or species based on a specific criterion and indicator
- Criterion: current status in relation to GES per indicator or criterion (thus aggregating across stocks)
- Overall: current status in relation to GES for Descriptor 3 (thus aggregating across stocks and criteria)

For an assessment of the current status in relation to GES per stock or species we considered three possible interpretations of GES. In all possible interpretations (given below), (1) instead of F_{MSY} proxies such as $F_{0.1}$ or E_{MSY} (for "Exploitation" as sometimes used in the Mediterranean); (2) "SSB_{MSY}" should be understood to mean an SSB_{MSY} estimate or a precautionary biomass level in the absence of such an estimate, as indicated in the Commission Decision 2010/477/EU ($B_{MSY\text{-}trigger}$, whose meaning is explained in section 3.3 of this report, is used instead of SSB_{MSY} for ICES stocks).

- GES Interpretation 1: According to a strict interpretation of the Commission Decision, MSY reference levels are limits and GES would require according to criterion 3.1 that for all stocks $F \leq F_{MSY}$ and, according to criterion 3.2, $SSB \geq SSB_{MSY}$.
- GES Interpretation 2: Alternatively MSY reference levels could be targets rather than limits, while in order to be precautionary pa reference levels should be limits. This would imply that the indicators fluctuate around MSY reference levels while never going beyond precautionary reference levels, which requires at least 50% of the stocks to meet $F \leq F_{MSY}$ in criterion 3.1 and $SSB \geq SSB_{MSY}$ in criterion 3.2, while all stocks are within precautionary limits. For stocks that only have one of the MSY or precautionary reference levels for F, the ratio of $F_{pa}/F_{MSY} \approx 1.6$ as described in the ICES WKFRAME2 report (ICES, 2011a) could be used provisionally to estimate

the missing reference level. Whether this applies for the Mediterranean equivalent based on F_{max} and $F_{0.1}$ remains to be assessed.

- GES Interpretation 3: Another alternative and even less strict definition of GES could be that the previous interpretation is essentially achieved "on average" (for which different rules are provided in Tables 7.4.1 and 7.4.2 below). As this definition works with an average across stocks, GES would allow stocks to be outside safe exploitation limits as long as there are other stocks that compensate for them relative to MSY. In this case, achieving GES would not ensure that all stocks are within safe exploitation limits. Problems with individual stocks would have to be detected in the assessments regularly performed for the stocks under such an obligation in the Common Fisheries Policy.

Tables 7.4.1 and 7.4.2 show how these levels in the GES assessment process for different interpretations of GES may be translated into rules for an assessment of current status in relation to GES for criteria 3.1, 3.2 and 3.3. In these tables we provide rules for what can be considered complementary assessments.

Table 7.4.1 corresponds to the case where primary indicators for criteria 3.1 and 3.2 exist, together with corresponding reference levels. In this case, one rule provides a binary outcome (i.e. GES is Yes/No achieved, denoted as Y/N) and uses both F_{MSY} and F_{pa} for F, whereas the other rule provides the outcome as a continuum on a 0 to 1 scale, where 0 is the worst possible result and 1 corresponds to GES (an example of a potential outcome would be current status is 0.8 GES). A continuum assessment can be directly turned into a binary assessment, since the value 1 in the 0 to 1 scale corresponds to GES (Y) and any value < 1 to non-GES (N).

For the species for which no reference levels are available, three complementary assessment approaches termed C (Category), D (Distribution) and T (Trend) are given in table 7.4.2. In both the C and D approaches the current value was compared to the historic mean, whereas the T assessment applied what was considered the best method to detect trends.

For the C approach a reference was calculated from the entire time-series by taking the long-term mean (+/- 1 standard deviation) and comparing this to the short-term (last 5 years) mean. This allowed a comparison between the long-term and the short-term means for each species and classification into categories defined by combinations of the following two features:

- Above/Below: short-term mean above/below long-term mean
- Inside/Outside: short-term mean inside/outside the long-term mean +/- 1 sd

The D approach is quite similar to the C approach: it looks at the current value of the indicator in relation to the historic mean and standard deviation of the indicator values and chooses an appropriate percentile (5^{th} or 95^{th} depending on the indicator examined) of the Normal distribution (hence 1.6 standard deviations) to separate orange from red in a green/orange/red colour scheme.

The T assessment applied an intersection union test as developed by Trenkel and Rochet (2009) to detect recent trends (increasing or decreasing) in the time series. In this method, first the indicator time series is smoothed using a generalised additive model with optimal selection of the degree of smoothness. Second, an intersection-union test is carried out using two test statistics which are the occurrence of the global maximum (or minimum) within the most recent years and the signs of the estimated annual first derivatives of the smoothed indicator time series during the same period, including years with missing data. As the method is used to detect significant decreases or increases in the time series there is only a distinction between green and red possible, but not between green and orange or orange and red. As a consequence the method could be used for GES interpretation 1 or 3.

Any of these approaches can be used to assess the current status in relation to GES by applying the rules given in Table 7.4.2 to the secondary indicators for criteria 3.1 and 3.2 (or to the primary indicators of these criteria, when these indicators exist but reference levels are not available for them) as well as the indicators for criterion 3.3. Similar to Table 7.4.1, this table also allows the application of different rules depending on whether the outcome of the current status in relation to GES is expressed as binary (Y/N) or as a continuum 0 to 1 scale, where 1 means GES and any value below 1 is not GES.

In spite of the differences between the indicators based on stock assessments and those based on monitoring programs in terms of information available for the GES assessment, the aim is to achieve high consistency. To that end we applied similar rules to both types of indicators. However, an analysis comparing the outcomes of the GES assessments for the same species but based on the two types of indicators (section 6.4.4) showed some consistency but also revealed that the assessment based on primary indicators with reference values is more strict than one based on secondary indicators without them. This is because with a relatively short time series the historic mean may still be far from where GES would actually be (and which should be represented by the MSY-based reference levels).

Approach	Criterion	Stock level			GES Interpretation	Current status in relation to GES at criterion level (aggregating across stocks)
		Green	Orange	Red		
Binary	3.1	$F \leq F_{MSY}$	$F_{MSY} < F \leq F_{pa}$	$F > F_{pa}$	1	Y if 100% of stocks in Green
					2	Y if at least 50% of stocks in Green none in Red
	3.2	$SSB \geq B_{MSY\text{-}trigger}$		$SSB < B_{MSY\text{-}trigger}$	3	Y if at least 50% of stocks in Green and Red stocks are compensated by equivalent additional stocks in Green
Continuum	3.1	$m \leq 1.0$	$1.0 < m \leq 1.6$	$m > 1.6$	1	Proportion of stocks in Green (= 1 if 100% of stocks in Green)
					2	max[0 , 1-proportion of stocks in Red-max{0, 0.5-proportion of stocks in Green}] (= 1 if at least 50% of stocks in Green and none in Red)
	3.2	$m \geq 1.0$	$0.6 \leq m < 1.0$	$m < 0.6$	3	Criterion 3.1: min[max{[1.6-(average *m* across all stocks)]/0.6, 0 } , 1] (= 1 if average *m* across all stocks is ≤ 1) Criterion 3.2: min[max{[(average *m* across all stocks)-0.6]/0.4, 0 }, 1] (= 1 if average *m* across all stocks is ≥ 1)

Table 7.4.1. Rules applied in the GES assessment based on primary indicators of criteria 3.1 and 3.2 and their reference levels. In the continuum approach, $m = F/F_{MSY}$ for criterion 3.1 and $m = SSB/SSB_{MSY}$ for criterion 3.2. In this approach, the rationale for red stock classification when $F/F_{MSY}>1.6$ follows from ICES (2011a), which shows that for ICES stocks for which both F_{pa} and F_{MSY} are available, $F_{pa} \approx 1.6\ F_{MSY}$ on average. The rationale for red stock classification when $SSB/SSB_{MSY}<0.6$ follows from the fact that 0.6=1/1.6 and that multiplying F by 1.6 or dividing SSB by 1.6 is expected to lead approximately to the same yield. The rules in the table differ depending on the interpretation of GES (1, 2, 3) and the assessment approach chosen (Binary or Continuum). At the criterion level the result of the Binary assessment is Y/N, where Y means GES. The result of the Continuum assessment is a value between 0 and 1. The table indicates how to calculate this value and under which conditions it is equal to 1 (i.e. GES).

Approach	Criterion	Stock level			GES Interpretation	Current status in relation to GES at criterion level (aggregating across stocks)
		Green	Orange	Red		
Category "C"	3.1	Any at or "Below" category	Category "Above and Inside"	Category "Above and Outside"	1	Y if 100% of stocks in Green
	3.2	Any at or "Above" category	Category "Below and Inside"	Category "Below and Outside"	2	Y if at least 50% of stocks in Green and none in red

	3.3					3	Y if at least 50% of stocks in Green and red stocks are compensated by equivalent additional greens
Distribution "D"	3.1	$m \leq 0.0$	$0.0 < m \leq 1.6$	$m > 1.6$		1	Proportion of stocks in Green (= 1 if 100% of stocks in Green)
	3.2	$m \geq 0.0$	$-1.6 \leq m < 0.0$	$m < -1.6$		2	max[0 , 1-proportion of stocks in Red-max{0, 0.5- proportion of stocks in Green}] (= 1 if at least 50% of stocks in Green and none in Red)
	3.3					3	Criterion 3.1: min[max{[1.6-(average m across all stocks)]/1.6, 0 } , 1] (= 1 if average m across all stocks is ≤ 0) Criteria 3.2 and 3.3: min[max{[1.6 + (average m across all stocks)]/1.6, 0 }, 1] (= 1 if average m across all stocks is ≥ 0)
Trend "T"	3.1	significantly decreasing or no trend		increasing trend		1	Y if 100% of stocks in Green
	3.2	significantly increasing or no trend		decreasing trend		3	Y if at least 50% of stocks in Green and Red stocks are compensated by equivalent additional stocks in Green
	3.3						

Table 7.4.2 Rules applied in the GES assessment based on secondary indicators of criteria 3.1 and 3.2 (or on primary indicators but without reference levels) and indicators for criterion 3.3. The rules differ depending on the interpretation of GES (1,2,3) and the assessment approach (C=Category, D=Distribution and T=Trend). In the "D" approach $m = (I-Imean)/Isd$, where *I* is the value of an appropriate indicator for the criterion according to the Commission Decision and *Imean* and *Isd* denote, respectively, the mean and standard deviation of the indicator values over an appropriately chosen period of years. The cut-off values 1.6 (criterion 3.1) and -1.6 (criteria 3.2 and 3.3) for red stock classification are, respectively, the 95 and 5 percentiles of the standard Normal distribution. At the criterion level the result of the "C" or "T" assessments is Y/N, where Y means GES. The result of the "D" assessment is a value between 0 and 1. The table indicates how to calculate this value and under which conditions it is equal to 1 (i.e. GES).

7.5 Overall assessment of current status in relation to GES

Once the rules shown in tables 7.4.1 and 7.4.2 have been applied to determine GES per criterion three different approaches emerged from the case studies to report on the current status in relation to GES for descriptor 3 as a whole:

- No aggregation across criteria. Whether or not GES is achieved is reported per criterion. This follows (Rice, Arvanitidis *et al.* 2012) who claim that it may not even be desirable to focus on some weighted combination of all indicators to provide a single number as it is neither feasible nor ecologically appropriate to specify prescriptive algorithms for evaluating GES at regional, sub-regional or even sub-divisional scales. These results are essentially available for most of the case studies although not always for all criteria.
- Application of the one-out-all-out aggregation rule or "assessment by worst case" as it is phrased in Cardoso *et al.* (2010). This implies that if one (worst) criterion fails, GES is not achieved. This approach is followed in the North Sea case study.
- Application of weights for the different criteria. This can only be applied if the assessments at the criterion level result in numbers on a common scale across criteria (as is the case with the "Continuum" approach if reference levels are available and "Distribution" approach if reference levels are not available). Even though the weighting introduces an arbitrary element, the overall status of Descriptor 3 can then be expressed relative to the target of GES. This approach is followed in the Bay of Biscay and Iberian Coast case study.

Even though the focus in all case studies was on criteria 3.1 and 3.2, the overall assessment of current status should be based on all three criteria. However, in terms of the suitability of the suggested indicators there are some marked differences. The main distinction is that primary indicators for criteria 3.1 and 3.2 have reference levels, whereas the other indicators do not. Therefore, the latter are considered to be less informative when assessing the status against GES.

Within the indicators without reference levels we can distinguish between the secondary indicators for criteria 3.1 and 3.2 and the indicators for criterion 3.3. While the secondary indicators for criteria 3.1 and 3.2 are proxies for, respectively, F and SSB, which have a long history of application in fisheries management and have proven their usefulness to describe the status of fish stocks, this is not the case for the indicators for criterion 3.3. While several of these indicators are known to be sensitive to fishing pressure, it has not been shown that they present any additional information to the indicators for criteria 3.1 and 3.2. When considering how to incorporate criterion 3.3 and its indicators into the overall assessment of current status in relation to GES, it is recommended to determine if this criterion indeed provides information complementary to criteria 3.1 and 3.2.

Finally, within the indictors for criterion 3.3 there is one indicator (mean maximum length) that is not appropriate for this criterion or even this descriptor, as it reflects the species composition in the fish community and not the age- or size-distribution of "populations of commercially exploited fish".

7.6 Quality assurance

Evaluation of the quality of the assessment depends on the proportion of species/taxa for which information that fulfils certain quality standards is available. A higher proportion of assessed stocks increases the quality of the GES assessment. Similarly, a higher proportion of species/taxa for which no information is available decreases the quality. The quality also increases with increasing length of the time-series of indicators without reference levels, to the extent that sufficiently long time-series would result in an assessment that could perform equally well as one based on indicators with reference values.

For the Celtic Seas case study, section 6.5.4 shows how the quality over time has improved as more assessed stocks have become available.

What can be considered “acceptable quality” remains unresolved but the different case studies provide a range of varying quality.

8 Fishery related indicators

8.1 Applying DCF indicators in MSFD assessments

The move to the ecosystem approach to fisheries management requires extending the consideration of fishing impacts beyond solely considering the impacts on commercially exploited stocks to encompass consideration of fishing impacts on biodiversity and ecosystem functioning. In the context of the MSFD fishing impacts on biodiversity are considered under Descriptor 1 and associated criteria for species, habitats and ecosystem diversity. In relation to ecosystem functioning this is covered by Descriptor 4 and associated criteria for food web structure and flows, and Descriptor 6 and associated criteria for benthic community status and pressures.

Information collected under the Data Collection Framework (DCF) can support assessments of environmental status and fishing impacts on GES beyond just Descriptor 3. Appendix XIII of EC (2008) specifies 10 environmental indicators of the 'effects of fisheries on the marine ecosystem' (hereafter referred to as 'the DCF indicators'). The ability of the DCF indicators to be operationally applied for GES assessments of descriptors *other* than Descriptor 3 is discussed below. A summary of the potential relationship between MSFD criteria and DCF indicators is presented in table 8.1.1. Prior to discussion of the application of the DCF indicators it should be noted that the DCF indicators were proposed to integrate general environmental considerations into fisheries management, rather than the specific requirements of the MSFD, and were only specified with provisional reference levels or for use with reference trends, rather than specific reference levels.

Table 8.1.1: Relationship between the DCF indicators and MSFD criteria for GES.

	Indicator	Criteria	Fixed calculation method	Reference level
1	Conservation status of fish species	1.2.1	Modifications proposed	Proposed
2	Proportion of large fish	1.7.1, 4.2.1	Regionally specified	Proposed in regions
3	Mean maximum length of fish	1.7.1		No
4	Size at maturation of exploited fish species	3.3.4	Modifications proposed (see section 8.1.4)	No
5	Distribution of fishing activities			
6	Aggregation of fishing activities			
7	Areas not impacted by mobile bottom gears	1.6, 6.1.2	Options proposed	No
8	Discarding rates of commercially exploited species			
9	Discarding rates in relation to landed value			
10	Fuel efficiency of fish capture			

Ideally indicator based assessment of GES should involve linked pressure and state indicators in relation to specified target or limit reference levels so that pressure can be modified to achieve a given reference level for state (ICES 2005, Garcia & Staples 2000). Of the 5 DCF indicators identified for GES assessments 4 are state indicators and 1 is a pressure indicator, none of them provide linked pairs of pressure-state indicators. SEC (2008) only proposes a reference level for one of the DCF indicators, the conservation status of fish species (CSF) indicator. Applying the DCF indicators for GES assessments will require specification of reference levels. For some indicators single generic reference levels applicable to all data sets and regions can be defined, whereas in other cases specific reference levels will have to be specified for each data set or region where the indicator is applied.

The indicator calculations methods specified in SEC (2008) were developed prior to specification of the criteria for determining GES, and in some cases the protocols for indicator calculation had not been robustly tested against a wide range of datasets. Work under the EU FP7 MEFEPO project applied a selection of the DCF indicators across a wider range of datasets and geographical regions with the specific objective of assessing status with respect to criteria for GES. This work has informed the applicability of the DCF indicators for GES assessments and in places identified suggested modifications to the indicator calculation methods to allow the indicators to be more robustly applied across a broad range of data sets and geographical regions in support of GES assessments. Comments are made below in relation to each of the DCF indicators.

Before discussing the DCF indicators in more detail two general points are noted in relation to the use of indicators for GES assessments.

Firstly the MSFD specifies that, following the initial assessment, MS will need to define *monitoring programmes* and then programmes of measures to support *progress towards achieving GES* by 2020. However, should natural conditions prevent sufficiently timely improvement in the status of marine waters in response to the measures applied it is not necessary to achieve GES by 2020 as long as the appropriate management actions have been implemented (Article 14). Where such exemptions are invoked Member States are required to clearly identify the instances and substantiate their views to the European Commission. In relation to this it is noted that significant lags can occur between changes in pressure and a response in state metrics, and when responses in state metrics do occur surveys only have limited power to observe changes in state, thus necessitating long time series of observations to substantiate improvements in status. For example, in the case of large fish indicator (LFI) Greenstreet *et al.* (2011) and Shepherd *et al*. (2010) have noted a more than 10 year lag between changes in fishing pressure and response in the LFI for the North Sea and Celtic Sea respectively. An analysis of the North Sea IBTS indicated that more than 15 years of data are likely required to demonstrate a change in trend in the mean maximum length of fish indicator (Nicholson & Jennings 2004). From this, Nicholson & Jennings (2004) concluded that short term management actions should not be made on the basis of state indicators derived from current survey assessments. For these type of indicators the phrase "surveillance indicators" was introduced (ICES 2005). These are indicators that provide information on some relevant ecosystem- or environmental characteristic but fail against the Rice & Rochet (2005) "responsiveness" criterion (i.e. provide rapid and reliable feedback on the consequences of management actions) for good indicators.

Secondly when indicators are used for formal assessments it is highly desirable that independent workers should be able to repeat calculations and reach the same values. However it is often difficult for different groups to calculate identical indicator values even when working on the same dataset and when all groups are applying the same protocols. Inevitably divergent calculations come down to protocols not having been documented in sufficient detail to allow every last step to be accurately re-created by independent groups. An approach to avoid this is to specify 'pseudo-code', or flow diagrams, for each GES indicator that details every single step in calculating an indicator, and which should include, for example, defined lists of L_{max} per species (or defined methods to generate the list) and defined data clearing routines applied to central datasets such as ICES' DATRAS database. Similarly validated, agreed computer scripts to calculate indicators based on outputs from formal datasets and available from a central server could ensure consistency between independent workers. However computer scripts in themselves are no substitute for complete documentation.

8.1.1 Conservation status of fish species (CSF)

Species conservation is a key component of the maintenance of biological diversity. Fishing is one of the main threats to marine species conservation, and in particular marine fish species conservation (Dulvy *et al.* 2003). Metrics of absolute or relative population abundance can provide a primary measure of the conservation status of species. Following the work of Dulvy *et al.* (2006), SEC (2008) specified two different indicators under the CSF. Both indicators are based on following survey abundance trends for selected vulnerable fish species. The first indicator, CSFa, contrasts abundance trends with the International Union for Conservation of Nature (IUCN) decline criteria, whereas CSFb calculates the average abundance of the vulnerable fish relative to the start of the survey time series.

The 2 CSF indicators specified by SEC (2008) are population abundance indicators of species vulnerable to direct impacts of fishing and therefore can be applied as state indicators of the biodiversity of fish species with respect to the impacts of fishing. As abundance indicators they certainly apply to biodiversity criterion 1.2.1 but since these indicators probably do not reflect changes in "key trophic species" they may not be appropriate for foodweb criterion 4.3.1.

The first step in calculating both indicators is to develop a list of up to 20 of the most vulnerable species with an L_{inf}>40cm, where L_{inf} is assumed to provide an index of vulnerability. Species are excluded if the mean annual catch rate over the whole survey is less than 20 individuals.

CSFa scores each species on the list against IUCN decline criteria ranging from 0 (not considered vulnerable under IUCN decline criteria) to 3 (critically endangered). The composite indicator value is calculated as the average of all the species included in the analysis and similarly could range from 0 (no species considered vulnerable) to 3 (all species critically endangered). The extent of decline is calculated by comparing the catch rate in the first year with the catch rate in the latest year as long as this covers a period of 10 years or longer. An increase in the CSFa indicator value indicates a decline in conservation status.

CSFb is calculated as the geometric mean of relative abundance of species compared with the average abundance over the first 3 years, therefore a decline in the CSFb indicator value indicates a decline in conservation status, and if the value is less than 1 this indicates a decline in status compared with the start of the time series.

The CSFa indicator will not generate an indicator value until the time series has been running for 10 years. The CSFb indicator will not generate an indicator value until the time series has been running for 3 years.

Reference levels: SEC (2008) proposes reference directions or reference limits for the 2 indicators that could be applied generally across all survey time series.

The reference limit proposed for CSFa is to maintain the indicator value below 1 (equivalent to all species on the list considered 'vulnerable' on average). A reference direction is for a 'significant reduction in rate of increase of the indicator [assuming it is increasing] to be consistent with the [then Convention on Biological Diversity, CBD] target of reducing the rate of biodiversity loss'.

The proposed reference direction for CSFb is a significant reduction in the rate of decline of the indicator (assuming it is declining) to be consistent with the World Summit on Sustainable Development target of reducing the rate of biodiversity loss (by 2010).

Calculation development: Two modifications to the calculation procedure are proposed. The first modification is applicable to both CSFa and CSFb and is due to the vulnerability of the indicator to the shifting baseline syndrome. The second modification only applies to CSFa and relates to its sensitivity to abundance in the first year of the time series.

Development 1: One of the criteria for defining the species list used in the indicator calculations is that the species have to have an average minimum annual abundance of 20 individuals per year. When the indicator was calculated for the North Sea IBTS data set it was noted that the species list used to calculate the indicator changed over time. Some species that were declining over time became excluded from the list on the abundance criterion even though they were present in sufficient numbers at the start of the time series to be included. This leads to declining species being lost from the indicator calculations even though these are the very species that should be monitored. A proposed modification to avoid the shifting baseline effect is to fix the species list on average abundances over the first 5 years of the time series. Figures 8.1.1.1 and 8.1.1.2 show the CSFa and b indicators for the North Sea IBTS data based on a species list updated each year and based on the first 5 years of data. Basing the species list on the first 5 years of data leads not just to a quantitative change in the indicator values, but also a qualitative change in the indicator trajectory over time.

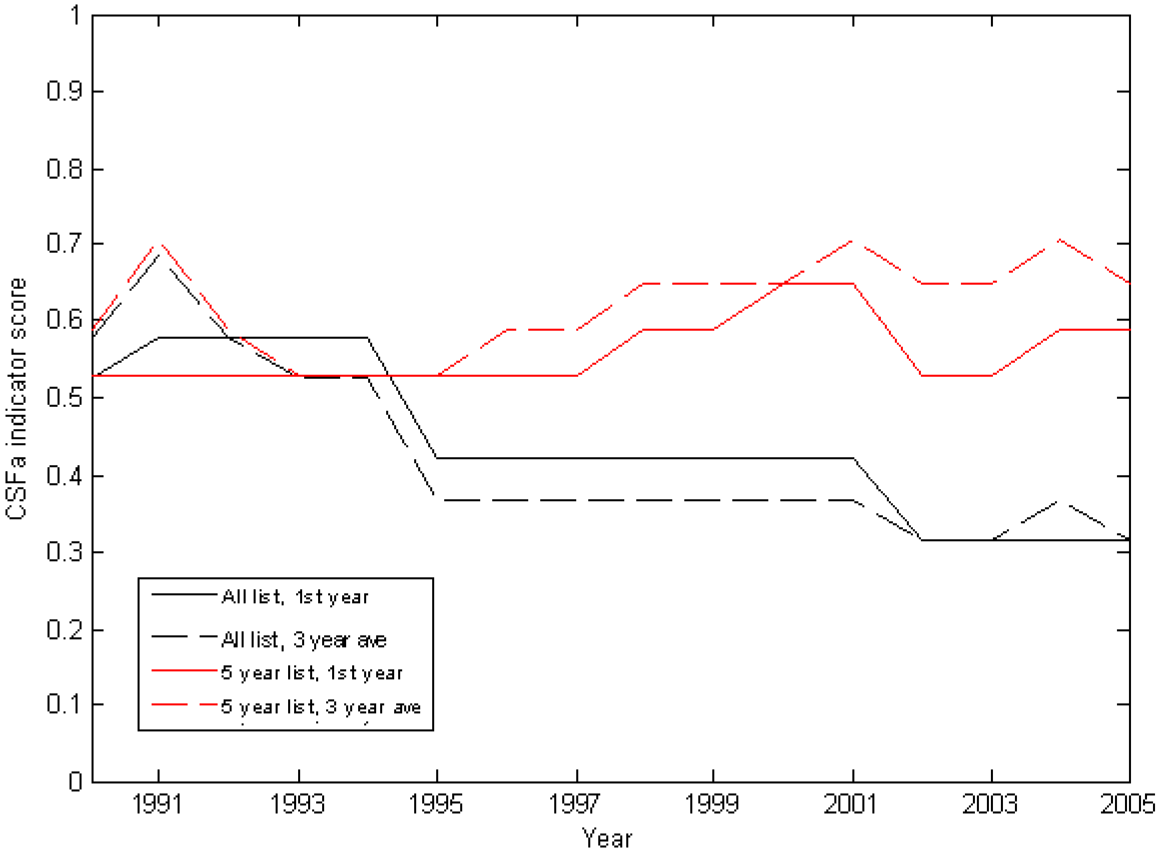


Figure 8.1.1.1: CSFa indicator for the North Sea IBTS calculated with and without the species list being fixed to the first 5 years data, and with the reference period as either the first or average of the first 3 years data. An increase in the indicator value indicates a decline in conservation status.

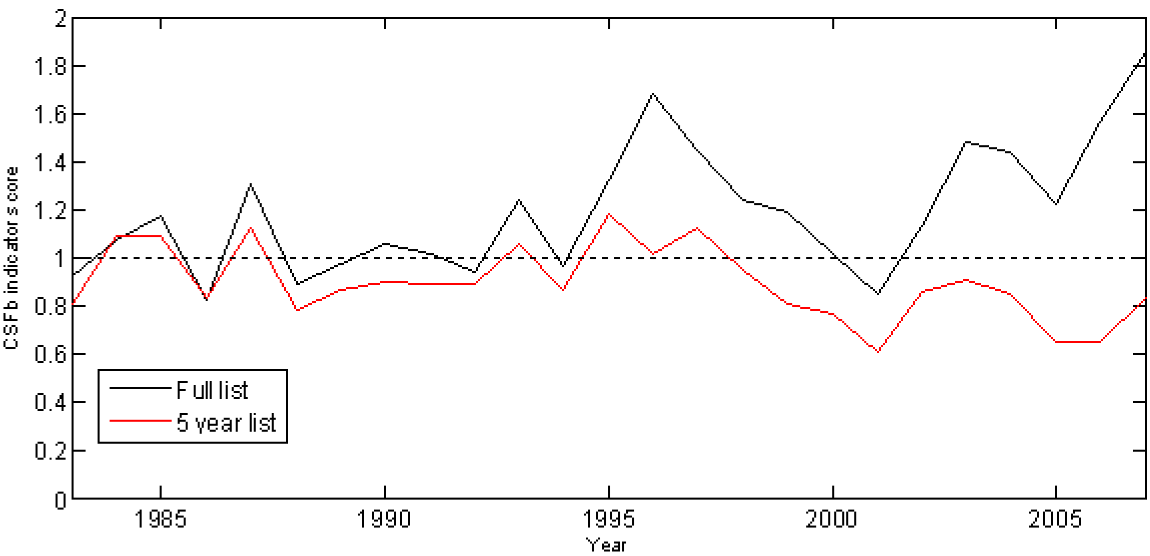


Figure 8.1.1.2: CSFb indicator for the North Sea IBTS calculated with and without the species list being fixed to the first 5 years data. A decrease in the indicator value indicates a decline in conservation status.

The main drawback in fixing the species list on the first 5 years of data is that the indicator could become anchored on a historic 'outdated' community description if climate change leads to a change in the 'natural' community inhabiting the area. In accordance with the MSFD the objectives for maintaining biodiversity are within prevailing climatic conditions. To 'protect' the indicator from being stuck on an outdated description of community composition the proposed modification is to define the species list on the basis of species abundances over the first 5 years of data, but to allow species to be removed from, or added to, the list if it is established that it is due to a climate related distribution shift.

Development 2: According to SEC (2008), CSFa is calculated with reference to the abundance in the first year of the time series, whereas CSFb is calculated with reference to the average abundance over the first three years. CSFa is therefore sensitive to abundance in the first year of the survey time series; to reduce this sensitivity and to align it with CSFb, the second proposed modification is to use the average abundance over the first three years as the reference level for CSFa. Figure 8.1.1.1 shows CSFa calculated with both just the first year, and the average of the first three years as the reference period for the indicator calculation. Although this is not expected to lead to the systematic bias associated with the shifting baseline issues identified for species selection it is expected to reduce the exposure of the indicator to stochastic effects of a single year's survey data.

Considerations: As the indicators are based on comparison with the start of the time series they do not take account of declines that occurred prior to the start of the time series. Also species which do not have sufficiently high annual catch rates at the start of the time series to qualify for the species list will not be considered in the indicator. Therefore in instances the indicators will not take account of some fish species at greatest risk of regional extirpation.

Both CSF indicators are based on averaging across several species, therefore if an individual species is declining whilst the rest of the species on the list are stable or improving it would be possible to lose a species from the system without the indicator exceeding the proposed reference limit for CSFa or without contravening the proposed reference direction for CSFa and CSFb. To allow for this the indicators could be calculated for the species showing the greatest decline, and similarly targets set in relation to the most declining species.

The species list is compiled on the basis of using L_{inf} as a proxy for vulnerability. Whilst L_{inf} may provide a good proxy for sensitivity to mortality (Jennings *et al.* 1999) it does not take account of systematic differences in vulnerability at length between taxa (Le Quesne & Jennings In press). Similarly a length based proxy for vulnerability does not account for species vulnerability due to restricted distribution or dependence on limited habitats. This specificity does mean the CSF indicators are good indicators for the state of fish biodiversity with respect to extraction of species due to fishing, but also means the CSF indicators are not appropriate as indicators for the state of fish biodiversity with respect to other pressures.

8.1.2 Proportion of large fish and Mean maximum length of fish

In addition to impacts on species conservation, fishing can cause impacts on community diversity, structure and composition (Bianchi *et al.* 2000; Piet & Jennings 2005), and thereby affecting food webs (Jennings *et al.* 2002). The MSFD has specified objectives for the maintenance of community composition and food web structure.

When considering community structure and species composition from the perspective of biological diversity, biodiversity is typically measured in terms of metrics of species richness or evenness. However the responses of such diversity metrics to fishing impacts can be inconsistent and are often not well understood (Bianchi *et al*. 2000; Piet & Jennings 2005; Trenkel & Rochet 2003). Therefore standard diversity metrics are not well suited to assess the impacts of fishing on marine biodiversity.

In response, indicators based on size, in terms of the size of individuals making up the community or the potential size of species making up the community (i.e. their species' L_{max}), have been proposed as an alternative framework to provide robust indicators of the effects of fishing on community structure. Species' L_{max} is a good proxy for life-history characteristics (Gislason *et al.* 2010) and therefore a species' sensitivity to mortality (Jennings *et al.* 1998; Reynolds *et al.* 2005), and fishing is a size selective process. Therefore the concept of size as a proxy for both exposure and sensitivity to fishing impacts is well grounded in theory, and comparative studies of the ability of indicators to show fishing signals have demonstrated that size-based indicators are responsive to the effects of fishing (Bianchi *et al.* 2000; Greenstreet & Rogers 2006; Jennings *et al*. 2002; Piet & Jennings 2005), even in the presence of confounding drivers (Blanchard *et al*. 2005).

Two of the DCF indicators, the LFI and the MML indicators (indicators 2 and 3 in table 8.1.1 respectively), are size based indicators of community status and can be applied as indicators for ecosystem structure in respect of biological diversity within assessments of GES. It should be noted that whilst both indicators are based on size, they reflect different aspects of the composition of the community and, therefore, have different applications.

The MML indicator is the average L_{inf} (or L_{max}) of fish making up the sampled community and provides a measure of the relative composition of *species* making up the community. On the other hand the LFI takes no account of species identity but rather that of individual size and is the proportion of fish by weight larger than a specified length threshold, and provides a measure of the relative composition in terms of size of *individuals* making up the community. The LFI was developed as an OSPAR EcoQO for fish community structure in relation to the impacts of fishing (Greenstreet *et al.* 2011). As indicators of community structure both indicators are applicable to criterion 1.7.1.

The MML indicator is calculated as the average maximum potential length of individuals making up a community and takes no account of length of individuals at the time of sampling. Or, in simple terms, the MML indicates what proportion of the community is made up of individuals from large species and what proportion of the community is made up of individuals from small species, and it does not matter if the individuals from the 'large species' are themselves large or small. Therefore the MML indicator is not appropriate as an indicator of size (or age) of individuals making up a population and should not be applied for this purpose as criterion 3.3.2 as specified in (EC 2010).

Since the work of Pauly *et al.* (1998) on fishing down food webs, the structural impacts of fishing on food webs have typically been examined in terms of trophic indicators such as the Marine Trophic Index (MTI, Pauly 2005). But more recent studies have found that neither average trophic level of landings, nor that of (parts of) the ecosystem, track fishing pressure (Branch *et al.* 2010). Furthermore, in the case of landings-based trophic measures such as the MTI, the indicator is sensitive to fisher's behaviour as well as ecosystem status (Essington *et al.* 2006).

However predator-prey relationships in aquatic environments are strongly size dependent (Jennings *et al.* 2001; Kerr & Dickie 2001), and therefore size-based indicators which are responsive to fishing impacts can be applied as indicators of food web structure. In the case of size-based trophic indicators it is the actual size individuals making up a food web that is important, rather than their potential size. Therefore the LFI can be used as a measure of food web structure for criterion 4.2.1 (although it is not yet completely clear in details what properties of the food web are captured by this indicator, WGECO 2011), but it is not appropriate to use the MML indicator as an indicator of food web structure.

Reference levels: Indicator values for the LFI and MML are survey specific as they depend on the geographic area covered by a survey and the catchability at size of species by the survey gear. Therefore individual reference levels have to be defined for each survey for each indicator. To date, there is no hard theoretical basis underpinning the selection of reference values for the indicators, where reference levels have been defined this was based on comparison with past baseline or reference periods and, thus, do not reflect an *a priori* definition of *Good* Environmental Status.

No reference levels have been specified for the MML indicator. Reference levels have been specified for the LFI for 2 surveys, the North Sea IBTS and the Celtic Sea UK West Coast Ground Fish Survey (WCGFS). The reference level for the North Sea IBTS is for 0.3 of the fish community by weight to be larger than 40cm (Greenstreet *et al.* 2011), and this has been adopted as the OSPAR EcoQO for the North Sea fish community. The reference level proposed for the Celtic Sea WCGFS is for 0.4 of the fish community by weight to be larger than 50cm (Shepherd *et al.* 2011), however the WCGFS was discontinued in 2004.

8.1.3 Areas not impacted by mobile bottom gears

Seafloor habitats are an important component of the marine biodiversity and a number of threatened or declining habitats have been identified in European waters. Furthermore, beyond biodiversity the seafloor and associated benthic communities play a key role in ecosystem processes including biogeochemical recycling and secondary production. Habitats of particular biodiversity concern are by definition rare and limited in their distribution, whereas it is the widespread abundant habitats that make the largest contribution to biogeochemical recycling and other sea floor ecosystem processes. These two aspects of GES in relation to habitats are recognised independently in the MSFD under descriptor 1 (biodiversity) and descriptor 6 (sea floor integrity). Fishing is the activity with most widespread direct impact on the sea-floor (Eastwood *et al.* 2007), therefore it is appropriate to monitor the impact of fishing on the seafloor as a pressure metric in relation to biodiversity and ecosystem processes.

Three DCF indicators, distribution of fishing activities, aggregation of fishing activities and areas not impact by mobile bottom gears are pressure indicators reflecting the spatial distribution of fishing activity. The first two cover all fishing activities and can be considered general indices of fishing activities on the marine environment that do not particularly match to any of the specific MSFD criteria. The third indicator, areas not impacted by mobile bottom gears (ANT), is computed for a series of bathymetric strata and is a specific measure of the extent of fishing impacts on the sea floor. It is directly applicable to criterion 6.1.2 (extent of the seabed significantly affected by human activities for different substrate types) and could be applied as a pressure indicator in relation to criterion 1.6 (habitat).

VMS systems and data were not specifically developed to describe fishing activity, or fishing impacts on the seafloor, and are not ideally suited to the purpose; however methods have been developed that allow VMS data to be used to describe patterns and intensity of fishing activities (e.g. Gerritsen & Lordan 2011, Hintzen *et al.* 2010, Lee *et al.* 2010; see also WKCPUEFFORT 2011 report) and which would allow clear and repeatable calculation of indicators of fishing impacts on the sea floor at the regional scale. In other words, whilst VMS data cannot be used to give a 'perfect' picture of fishing impacts on the seafloor, it can be used to give an objective and consistent measure. Obvious limitations relate to vessel coverage and spatial resolution. As of 1st January 2012 all vessels over 12m are required to carry VMS, and position records are reported every 2 hours. The absence of VMS coverage for vessels under 12m is of particular importance in inshore and coastal areas. Reporting of VMS data at 2 hourly intervals limits the spatial accuracy that can be achieved, which may not be significant for calculating impacts on widespread habitats although this problem can be mitigated by interpolation (Russo *et al.*, 2011a)(Hintzen, Piet *et al.* 2010); moreover it could be important for reporting fishing impacts on rare and vulnerable habitats. It is desirable for the vessel coverage to be extended and for the frequency of position records to be increased to half hourly or even quarter hourly records, especially if VMS is to be used to monitor fishing effort in relation to limited vulnerable habitats.

Reference levels: No reference levels have been set or proposed for the ANT indicator when used as a pressure metric to report on seafloor integrity for descriptor 6. Technically in the case of seafloor integrity the acceptable level of mobile bottom gear impact depends on the resilience and susceptibility of the habitat, and its key functions, to damage. Thus the appropriate reference level might vary between habitat types and impacting gears. However such an approach may not be practical and it would be desirable to define a reference level that is applied to all substrates and across all mobile bottom gears. When setting reference levels it should be noted that protecting rare and vulnerable habitats is different to protecting widespread seafloor ecosystem services and different reference levels may be needed for the ANT when applied to criterion 1.6 or 6.1.2.

Bearing in mind the desire to harmonise indicators and targets across policies it is pertinent to note that the CBD Aichi Biodiversity Targets specify that 'By 2020 … 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures…' (Strategic Goal C, Target 11).

Calculation development: SEC (2008) does not define an exact method of calculation of the ANT indicator, rather it specifies general steps for a point summation style of VMS analysis, furthermore it was specified prior to the definition of the GES criteria and would need slight adaptation to make it more directly applicable to criterion 6.1.2 or as a pressure indicator relating to 1.6. A more detailed description of the point summation method is presented by Lee *et al.* (2010). Although this only provides a description of the point summation method to calculate a layer of estimated hours fished per 3′x3′ cell, rather than a complete description of the calculation of an ANT indicator.

A potential method for converting the layer of estimated hours fished into an ANT value would be to convert the layer into estimated hours fished per km^2 per cell (to allow for the latitudinal variation in cell area) and then to designate each cell as 'impacted' or 'not impacted' by comparing the estimated hours fished per km^2 with a predefined reference level. Under the assumption that the location of effort within a 3′x3′ cell follows a Poisson distribution, and that mobile bottom gears operate at 4 knots and impact a swath 20m wide, on average it would take 4.7 hours trawling per km^2 for more than half the area to be impacted. Therefore 4.7 hours/km^2 could be proposed as the cut-off for defining a cell as impacted or not, however it should be noted that the calculation of the ANT is sensitive to the cut-off selected as shown in figure 8.1.3.1 based on an analysis of 5 nations VMS data collected during the MEFEPO project.

A further consideration is that one of the steps involved in the indicator calculation is determining which VMS records are associated with mobile bottom gears. This can be best determined by matching VMS records with log book records as individual vessels may operate with different gears at different times. To enable this, records would have to be worked up at a national level before being compiled into a multi-national dataset to allow the final indicator value to be calculated. If the final ANT is based on individually calculated data layers it is highly desirable to have a very clearly specified protocol of analysis to ensure comparability of national data layers. Having a common software analysis package would provide a mechanism to enable consistency of analysis. The VMStools R software package is such a tool that could be used for this task, although at present it only supports track interpolation analysis of VMS points rather than a point summation method as specified by SEC (2008).

In relation to use of a track interpolation method or the point summation method, it is briefly noted a number of different methods have been proposed to turn 2 hourly location records into spatial layers of fishing activity (e.g. Lee *et al* 2010, Hintzen *et al.* 2010), and whilst the strengths and weaknesses of each method can be debated there are likely to be biases or errors associated with each method, so establishing a common form of analysis is as important as the exact form of analysis.

GES criterion 6.1.2 calls for the calculation of the ANT by substrate type, and if VMS analysis of areas not trawled is applied with regards to habitats of biodiversity concern in relation to criterion 1.6 the ANT would have to be calculated per habitat of biodiversity concern. Currently SEC (2008) specifies that the ANT should be calculated by depth band. Therefore the areas by which ANT is calculated would need to be re-specified if the DFC indicator is to be calculated in support of GES assessment. However it is noted that for regions lacking robust region-wide substrate maps, depth based calculation of indicator could be employed for criterion 6.1.2 until such maps become available. An action under the DG MARE's Integrated Maritime Policy's EMODnet has resulted in the development of modelled seabed habitat maps (EUSeaMap[2]), including such a layer, and also actual substrate maps for some European regional seas.

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2 https://webgate.ec.europa.eu/maritimeforum/system/files/20110301_FinalReport_EUSeaMap_v2.9.pdf and http://jncc.defra.gov.uk/page-5020#Interactivemap

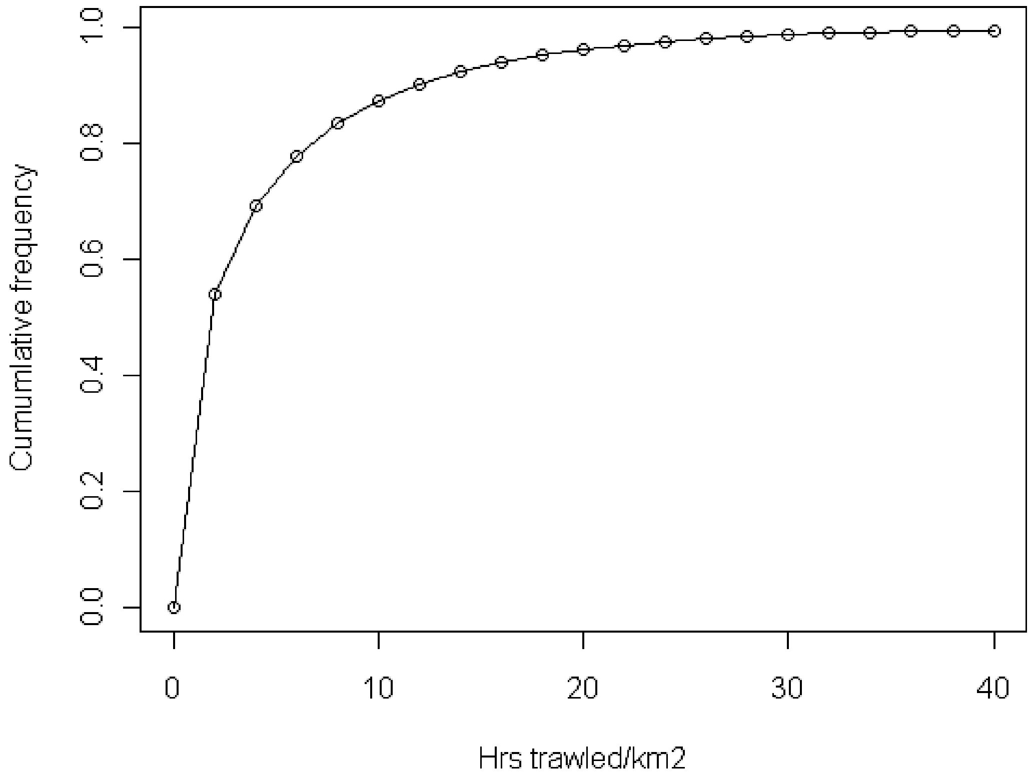

Figure 8.1.3.1: The variation in ANT depending on the choice of hrs trawled/km² cut-off based on all VMS records of vessels fishing with mobile bottom gears in UK, Irish, Dutch and Portugese waters in 2008.

When considering application of the DCF ANT indicator to the MSFD the issue of temporal scale of analysis needs to be considered. SEC (2008) specifies that the indicator should be calculated and reported on an annual basis. Recovery time of benthic habitats to impacts by mobile bottom gears varies depending on the type of habitat and gear used, and can vary from hours and days to years and decades (Jennings and Kaiser, 1998). Reporting the indicator on an annual basis is sufficient to understand impacts of fishing on sea-floor habitats where the recovery time from disturbance is less than a year; however for habitat-gear combinations where the recovery time is greater than a year, reporting the indicator on an annual basis will underestimate the extent of the impact. The time period over which VMS records should be amalgamated for calculating this indicator should be reassessed to ensure it is sufficient to allow for the prevalent recovery time with regards to the seafloor functions or habitats of concern.

A final note on calculating the DCF ANT indicator relates to the accessibility of VMS data. While national data are often available to the MS (but with differences in quality standards) there is no access to VMS data at the whole (sub)regional sea level. Availability of quality-checked international VMS data at (sub)regional sealevel is required for the calculation of these indicators.

8.1.4 Size at maturation

In Wright *et al.* (2011) an improved calculation of the size at maturation is presented.

8.2 ICES core set of fisheries indicators

ICES has at present a task of (supporting the) reporting of certain fisheries related indicators to EUROSTAT, and DGMARE, and supporting the EEA reporting on fisheries indicators. Some of these indicators are more or less overlapping or not optimal. In principle the MSFD indicators are a reflection of the DCF indicators (DGMARE) as far as fish populations and fisheries impacts are concerned.

The set of fisheries related indicators from the above organizations has been reviewed with a view of simplifying/reducing the number of indicators and at the same time using the data being collected under the DCF. A comparison of the full set of these indicators has been assessed in table 8.2.1.

Based on the assessment a potential framework for a core set of ICES indicators to report on the ecological impacts of fishing is presented in table 8.2.2. The aim is that these indicators will be calculated and published by ICES annually as part of the ecosystem overviews now being developed and that these can also serve the purposes of the DCF Appendix XIII, EUROSTAT and EEA.

For indicator calculations all data available to ICES will be used including VMS data based on data calls. There may be some outstanding issues such as resolution of VMS data provided, reporting sheets etc. ICES will be responsive to possible future requests by Member States and the European Commission for further development of the indicators but for the time being the Core set of indicators serves the present need of ICES. It should be mentioned that the indicators do not give any information on the social or economic performance of fisheries.

Table 8.2.1: Assessment of fisheries related indicators

	Indicator	Issue	Comment
EUROSTAT	Conservation of fish Stocks (State indicator)	Fish catches taken from stocks outside safe biological limits	This indicator raises the issue of proper definition of "safe biological limits". It can easily give the wrong signal. Example: a stock caught outside SBL- when the catch decreases due to depletion the indicator suggests improvement. Proposal for replacement: The indicator intention can be covered by MSFD D3 criteria 1 and 2 (Level of pressure of the fishing activity and Reproductive capacity of the stock)
	Fishing capacity (Pressure indicator)	Size of fishing fleet	Provides an index relating to the potential fishing power, rather than the actual applied fishing power. Does not account for technological creep. Alternative pressure indicators for commercial stocks and seafloor habitats can be derived from MSFD Descriptors 3.1 and 6.1.2. However no pressure indicators of fishing on species or community biodiversity are specified under the MSFD. See also comments below on Fishing fleet capacity (CSI 034)
EEA	Status of marine fish stocks (CSI 032) (State indicator)	Total catch in ICES and GFCM[3] fishing regions of Europe (note that this is expressed as a proportion of assessed stocks; showing also the proportion of stocks that are not assessed per region and not just catches) Status of the fish stocks in ICES and GFCM fishing regions State of commercial fish stocks in N E Atlantic and Baltic Sea State of commercial fish stocks in Mediterranean Sea	Total catch is OK but may create an issue regarding how to weight the catch and splitting of stocks covering several regions/ subregions. Although SSB_{MSY} is a goal there is for the moment often no solution as to how it can be estimated. Proposal for replacement: Indicators on status of fish stocks and catches area are reasonable but the same information can be provided by MSFD D3 criteria 1 and 2 (Level of pressure of the fishing activity and Reproductive capacity of the stock). For consistency it is preferable to apply MSFD Descriptor 3 indicators.
	Fishing fleet capacity (CSI	Changes in European fishing fleet capacity	This suite of Pressure indicators differs from the Eurostat "size of the

[3]GFCM: General Fisheries Commission for the Mediterranean

	Indicator	Issue	Comment
	034) (Pressure indicator)	European fishing fleet capacity: Engine power … Country ratio in European fishing fleet capacity: Engine power… European fishing fleet capacity: Tonnage … Country ratio in European fishing fleet capacity: Tonnage … European fishing fleet capacity: Number of vessels … Country ratio in European fishing fleet capacity: Number of vessels…	fishing fleet" in that it provides additional information allowing a characterisation of the pressure beyond "just" the size of the fleet. Technology creeping is a problem and must be addressed. The indicator should possibly be redefined or even better substituted by Fishing Mortality. See also comments to Fishing capacity above Proposal for replacement: The fishing pressure can be described by information on catches and/or mortality and impacts on seafloor (MSFD indicator 3.1 and DGMARE indicators 5, 6 and 7). Those indicators depend on sufficient VMS/log-book data. Until the DGMARE indicators are fully functioning these indicators may be useful. Possibly "capacity" should be substituted by a measure of "effort".
DG MARE (DCF 1-9)	**These indicators are legally bound** and definitions are provided in Commission Staff Working Paper, 25-27 June 2007. DCF provides data.		
MSFD D3	**These indicators are legally bound** and may be derived based on the DCF data.		

Table 8.2.2: Framework for a potential ICES core set of indicators of the impacts of fishing on the marine environment.

Indicator	Issue	Comment
EUROSTAT/EEA Fishing capacity (Pressure indicator)	Size and other relevant characteristics of fishing fleet	The indicator should be redefined taking into account technology creeping. Alternative pressure indicators for commercial stocks and seafloor habitats can be derived from MSFD Descriptors 3.1 and 6.1.2.
EEA Status of marine fish stocks (CSI 032) (State indicator)	Total catch in ICES and GFCM fishing regions of Europe.	Alternatively or in addition the proportion of catch from assessed stocks, or proportion of catch from stocks full-filling GES criteria can be calculated. May create an issue regarding how to weight the catch and splitting of stocks covering several regions/ subregions. Although SSB_{MSY} is a goal there is for the moment often no solution as to how it can be estimated.
DG MARE DCF indicator 1	Conservation status of fish species	Indicator of biodiversity to be used for synthesising, assessing and reporting trends in the biodiversity of vulnerable fish species.
DCF indicator 2	Proportion of large fish	Indicator for the proportion of large fish by weight in the assemblage, reflecting the size structure and life history composition of the fish community.
DCF indicator 3	Mean maximum length of fishes	Indicator for the life history composition of the fish community.
DCF indicator 4	Size at maturation of exploited fish species	Indicator of the potential 'genetic effects' on a population.
DCF indicator 5	Distribution of fishing activities	Indicator of the spatial extent of fishing activity. It would be reported in conjunction with the indicator for 'Aggregation of fishing activity'.
DCF indicator 6	Aggregation of fishing activities	Indicator of the extent to which fishing activity is aggregated. It would be reported in conjunction with the indicator for 'Distribution of fishing activity'.
DCF indicator 7	Areas not impacted by mobile bottom gears	Indicator of the area of seabed that has not been impacted by mobile bottom fishing gears in the last year. It responds to changes in the distribution of bottom fishing activity resulting from catch controls, effort controls or technical measures (including MPA established in support of conservation legislation) and to the development of any other human activities that displace fishing activity (e.g. wind farms).
DCF indicator 8	Discarding rates of commercially exploited species	Indicator of the rate of discarding of commercially exploited species in relation to landings.
MSFD D3 3.1.1 Fishing mortality	Level of pressure of the fishing activity	
3.1.2 Ratio between catch and biomass index	Level of pressure of the fishing activity	
3.2.1 Spawning stock biomass (SSB)	Reproductive capacity of the stock	
3.2.2 Biomass indices	Reproductive capacity of the stock	

Indicator	Issue	Comment
3.3.1 Proportion of fish larger than the mean size of first sexual maturation	Population age and size distribution	
3.3.2 Mean max length across all species found in research vessel surveys	Population age and size distribution	
3.3.3 95% percentile of the fish length distribution observed in research vessel surveys	Population age and size distribution	
3.3.4 Size at first sexual maturation	Population age and size distribution	

9 Software for calculation indicators and reference values

9.1 MSFD R-based tool

The structure of the R-based tool

During the second ICES MSFD D3+ workshop a bundle of R-functions (referred to as the 'R-tool') was presented to calculate and analyze fish-related MSFD indicators as proposed under the Commission Decision 477/2010/EU. The R-tool provides a means for scientists and managers to compile survey data from the DATRAS database, landings data from the ICES catch statistic database and stock data from the ICES stock assessment working groups into a standardized data object. This data object is the foundation from which several functions draw data to calculate and analyze indicator time-series (Figure 9.1.1).

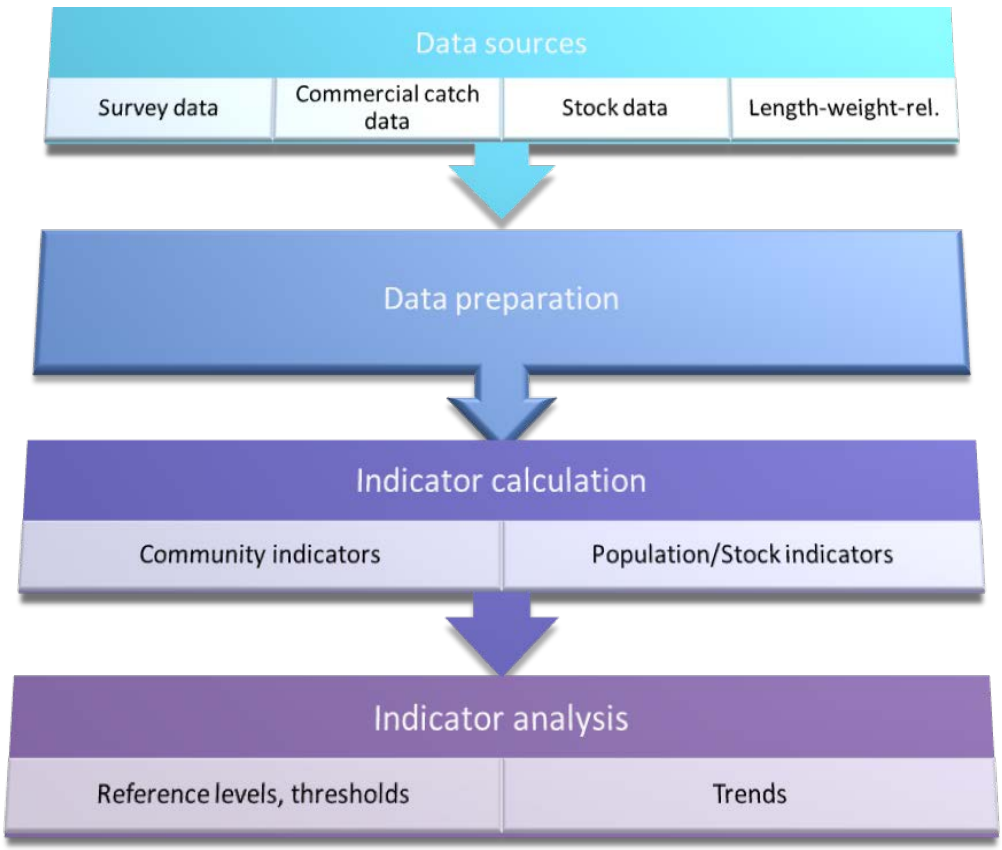

Figure 9.1.1: The structure of the R-based MSFD tool developed by the vTI-Instiute of Sea Fisheries. Survey data from the ICES Datras data base, commercial landings data from the ICES catch statistics data base, stock data from the ICES stock data base and biological data on length-weight relationships (vTI-internal data) are combined into a single data object. From this data object the necessary data are drawn to calculate fish community and population indicators.

The outcome of calculations

At the moment the MSFD R-tool can calculate indicators at the population and the community level. At the population level the log-transformed mean catch per unit effort (as the average No. of individuals caught per haul and year), the harvest rate (as ratio of annual commercial landings and the average biomass per haul and year), the mean length of the aggregated length-frequency distribution (L.mean) and the 95-percentile (L95) of any species which is present in the survey data. If available, the SSB and F time-series from the analytical stock assessments with according reference levels (F_{MSY} F_{PA}, B_{PA} and $B_{MSY\text{-}trigger}$) are also included. On the community level a suite of species can be defined for which the mean maximum length, the proportion of large fish and three diversity metrics can be calculated.

The tool also provides a function to plot the indicator time-series and to analyze periods of stable indicator values and trends (Fig.9.1.2 & Fig.9.1.3). Potential threshold and target values for the definition of good environmental status (GES) may eventually be drawn out of the time-series. The exploration of GES can be performed by estimating breakpoints in the time-series for horizontal linear regressions, thereby identifying periods of stable indicator values. Alternatively, the mean of recent years (to be defined by the user) can be compared against the total mean of the time-series. If no other information is available management authorities may decide to maintain the current state or to achieve the best value in the time-series and the MSFD R-tool provides support for these kinds of management objectives.

Problems

Currently there are a number of problems associated with the implementation of the functions, some of which are listed below:

- The data sources are in some cases incomplete or flawed. Survey data may not include all caught species, the naming of species may have changed over time and is not consistent in the data bases.
- For many species the landings data base contains catch information on a low taxonomic resolution. Divisions are not clearly assigned, double named or missing. Discard data is not included so the calculation of a catch/survey biomass ratio is not possible.
- For some species length-weight relationships are missing and are estimated by parameter means across all species.
- The functions to calculate the indicators are not cross-validated.
- Hence the outcomes of the functions and plots have to be considered with caution and a double-checking of the results is strongly recommended!

Despite the current caveats about the MSFD R-tool, there is a high potential for its use as a software package which provides guidance on how to calculate, visualize and analyze fish-related MSFD data. The inclusion of standardized survey, catch/landings and length-weight data would help to unify the outcomes of national assessments on a regional scale.

Future outlooks

After a revision of the existing functions they will be made available to workshop members together with a small tutorial script to be tested with their own data. During this testing phase weaknesses and problems associated with the functions and the provided data will be identified. Given a successful testing and implementation of the R-tool in other institutes it will have to be decided if further effort will be put into the professionalization of the tool.

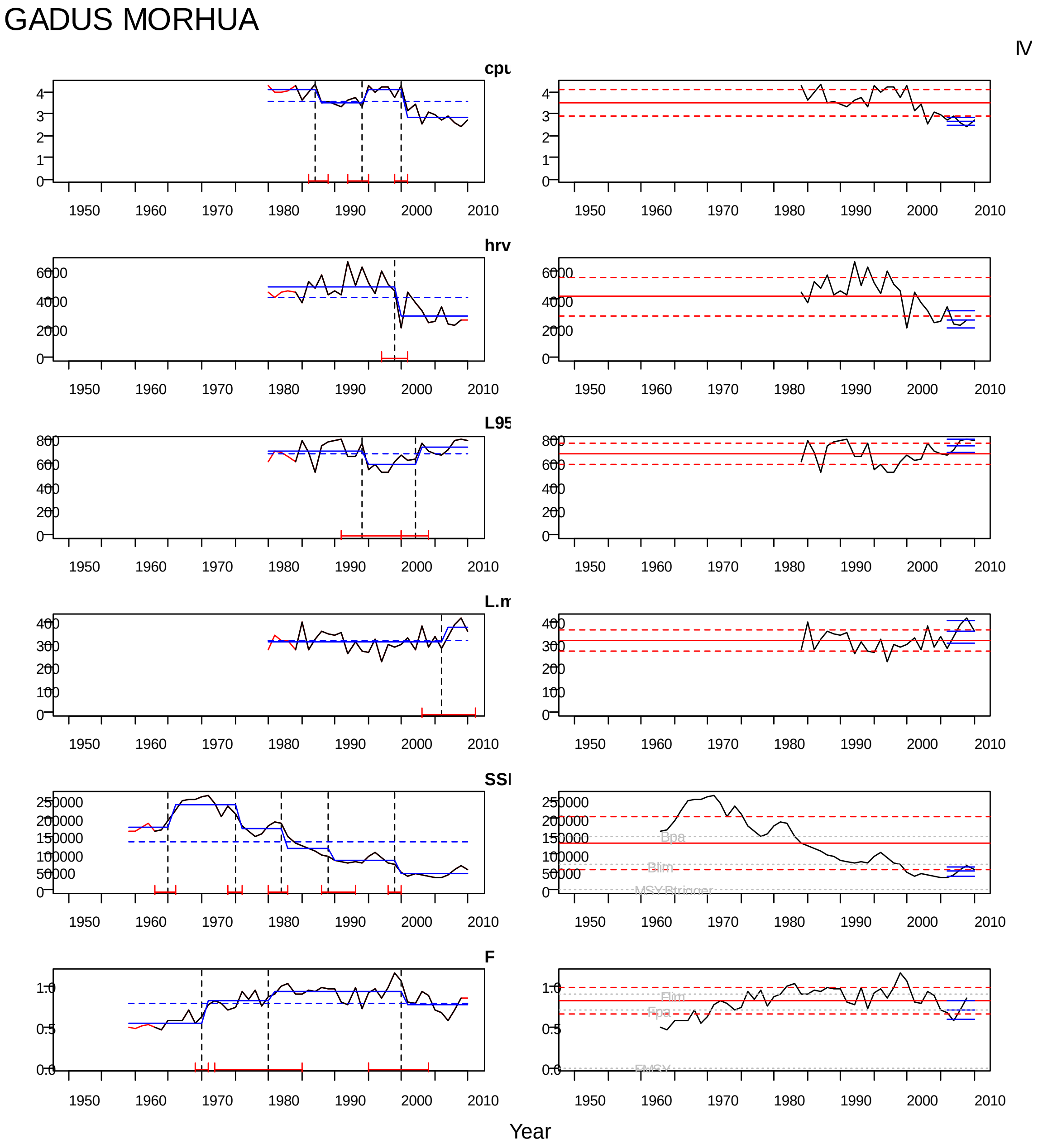

Figure 9.1.2: Population indicator time-series for North Sea Cod (Divisions IIIa, IVa, IVb, IVc, VIIe) of mean catch per unit effort (by numbers), harvest rate (hrv.rt), 95 percentile of length frequency distribution (L95), mean size (L.mean), spawning stock biomass (SSB) and fishing mortality (F). The left panels show the breakpoint estimates (vertical dashed lines) with confidence intervals (red horizontal lines) for linear horizontal regressions. Red parts of the time-series are smoothed by running mean average. The right panels show the deviation of the last year mean (blue line, 5 years) from the total mean of the time-series (solid red line). Dashed lines indicate standard deviation. For SSB and F, reference values are shown.

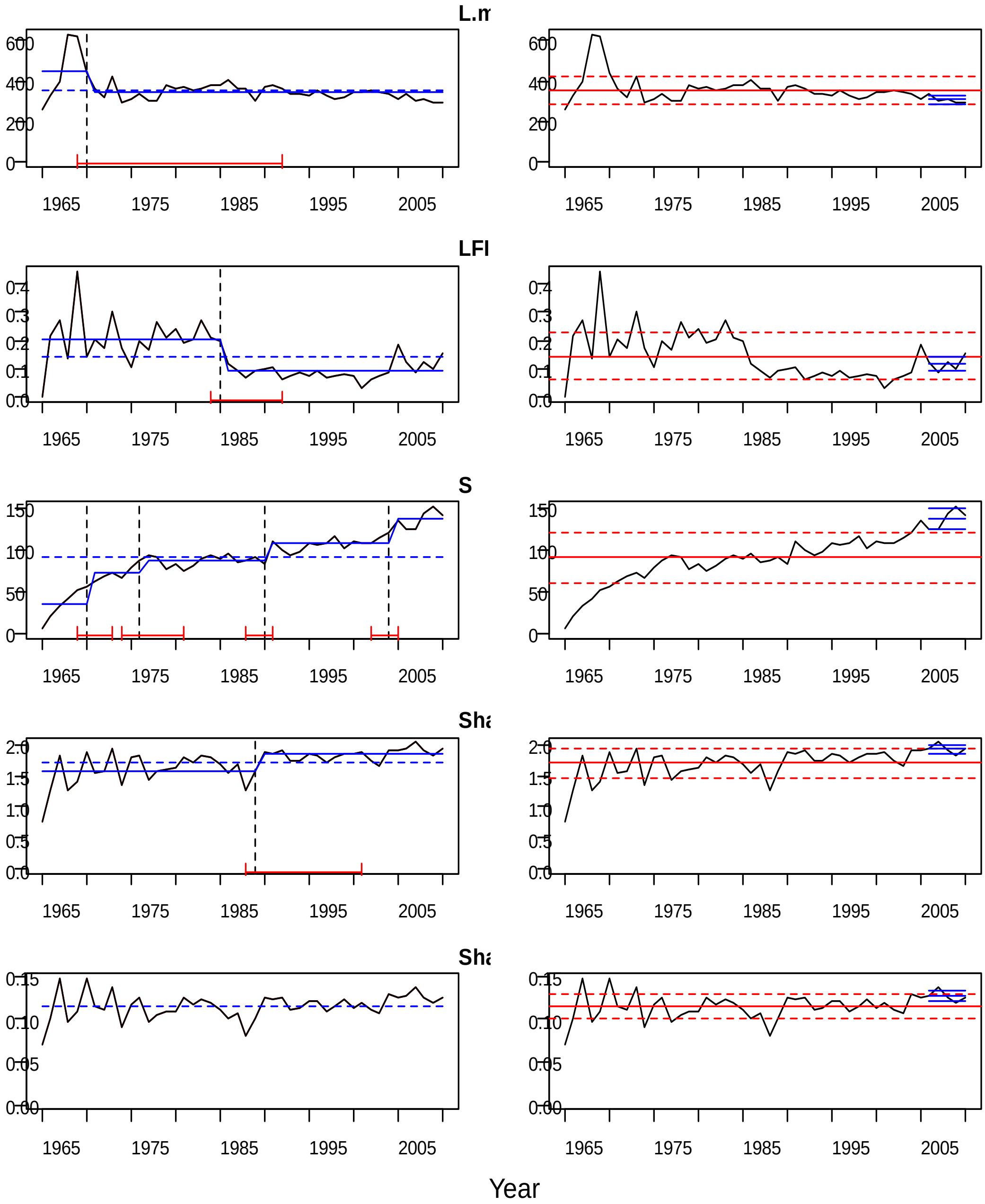

Figure 9.1.3: Community indicator time-series for the North Sea IBTS (Quarter 1, all areas, all species included), mean maximum size (weighted by CPUE numbers), the proportion of large fish (LFI, size threshold >40 cm), species richness (S), Shannon-Wiener-diversity (Shannon.div) and Shannon evenness (Shannon.even). Note how species richness is constantly increasing over time reflecting an increase in survey effort rather than a true increase in biodiversity! For explanations of lines, and trends please refer to Figure 9.1.2.

9.2 An Index Method (AIM) for the calculation of reference values

The Commission Decision on criteria and methodological standards on good environmental status (GES) (2010/477/EU) states in relation to Descriptor 3 that, when the secondary indicator 3.1.2 ("catch/biomass ratio") is used, a proxy value for F_{MSY} in the context of the indicator needs to be determined. Similarly, when the secondary indicator 3.2.2 ("Biomass indices") is used, scientific judgement should be exercised to determine that the stock will be able to replenish itself under the prevailing exploitation conditions. These issues are challenging and a presentation was made in the second ICES MSFD D3+ workshop about a method that might be helpful in certain circumstances. This section provides a summary of the presentation.

The method is called AIM (An Index Method) and was developed by Dr. Paul Rago (Northeast Fisheries Science Center, NOAA, USA) and is freely available in the NOAA Fisheries Toolbox at http://nft.nefsc.noaa.gov/AIM.html. The following description of the method is taken directly from this web address, highlighting in italics the aspects that could make it appealing in the context of Indicators 3.1.2 and 3.2.2:

"An Index Method (AIM) allows the user to fit a relationship between time series of relative stock abundance indices and catch data. Underlying the methodology is a linear model of population growth, which characterizes the population response to varying levels of fishing mortality. If the underlying model is valid, *AIM can be used to estimate the level of relative fishing mortality at which the population is likely to be stable. The index methodology can be used to construct reference levels based on relative abundance indices and catches* and to perform deterministic or stochastic projections to achieve a target stock size."

There is no manual for AIM, but a "Help" tab in the software interface provides information about its use and the underlying model assumptions. It is fairly easy to use, following the instructions and description of the method provided with the software. The data requirements are only a time series of catch $\{C_t\}$ and a biomass index $\{I_t\}$ and the method essentially fits a linear relationship taking log($RepRatio_t$) as response variable and log($relF_t$) as explanatory variable. $RepRatio_t$ means "Replacement Ratio at time *t*" and is defined as:

$$RepRatio_t = I_t \,/\, Iav_{t,J}$$

where $Iav_{t,J}$ denotes the average of the biomass index values during the *J* time steps immediately preceding *t*. $relF_t$ means "relative F at time *t*" and is defined as:

$$relF_t = C_t \,/\, I_t$$

which corresponds exactly to Indicator 3.1.2. Alternative definitions of $relF_t$ consider an average of *K* time steps in the denominator, which can be lagged (time steps before *t*, up to and including *t*) or centred (time steps before and after *t*).

From the definition of *RepRatio*, a value of 1 indicates a stable population, whereas *relF* is an indicator of fishing pressure. Therefore, performing a linear regression of log($RepRatio_t$) on log($relF_t$), the value of *relF* that leads to the fitted value log(*RepRatio*)=0 is the level of fishing pressure (in whatever scale *relF* is defined) that keeps the population stable (based on the historic period analysed). This is potentially useful to find a reference level for Indicator 3.1.2, but this *relF* reference value may act as an F_{MSY} proxy only if the historic period analysed contains both high and low exploitation levels. It will not be appropriate if the whole time period corresponds to heavy over- or under-exploitation. Making this determination will require expert judgement and may not be easy, raising difficulties for the applicability of AIM in the MSFD context.

In the case where the reference value of *relF* can be assumed to be a suitable F_{MSY} proxy, it is possible to determine the reference value implicitly needed for Indicator 3.2.2 on the scale of the relative abundance index $\{I_t\}$ provided that external information is available about likely MSY values. In that case, the reference level required for the MSFD in the context of Indicator 3.2.2 would be MSY/(reference value of *relF*). As this requires external information about likely MSY values (requiring *e.g.* expert judgement about historic conditions in the stock and fishery), it also limits its applicability for the MSFD.

Despite the abovementioned difficulties, it was found relevant to explore the use of the method and it is illustrated in this section for the stock of monkfish (*Lophius piscatorius*) in ICES divisions VIIIc and IXa, currently assessed by ICES using a surplus production model (ASPIC) based on catch and two commercial CPUE indices. AIM was tried for this stock using the commercial catch time series and a relative biomass index provided by the Spanish bottom trawl survey in quarter 4 (instead of the commercial CPUE series used in the ASPIC assessment, the reason for this departure being that the randomisation test included in the AIM software gave non-significant results for the commercial CPUE series whereas it gave significant results for the survey index).

Figure 9.2.1 displays the linear regression fit for this stock.

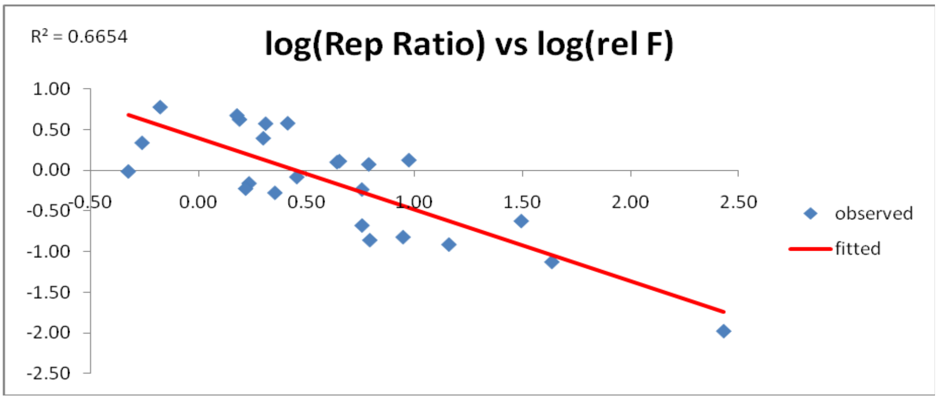

Figure 9.2.1. Linear fit for monkfish in ICES divisions VIIIc and IXa

By eye from Figure 9.2.1, log(*relF*)=0.45 corresponds to a fitted value log(*RepRatio*)=0. Hence, *relF*=exp(0.45)=1.57 is the value of fishing pressure (in the scale used for *relF*) that keeps the population stable. As explained above, caution must be exercised in determining whether this *relF* value may be taken as an F_{MSY} proxy. For the sake of this exercise, we accept this in this instance and compare the results obtained from the current ICES assessment with ASPIC (which estimates a time series of F/F_{MSY}; blue line in Figure 9.2.2) with the time series of *relF*/(reference value of *relF*) obtained from AIM (red line in Figure 9.2.2). The results are fairly similar, despite the different biomass indices used for ASPIC and AIM, as mentioned above. Both methods indicate that F in 2010 is just below F_{MSY}.

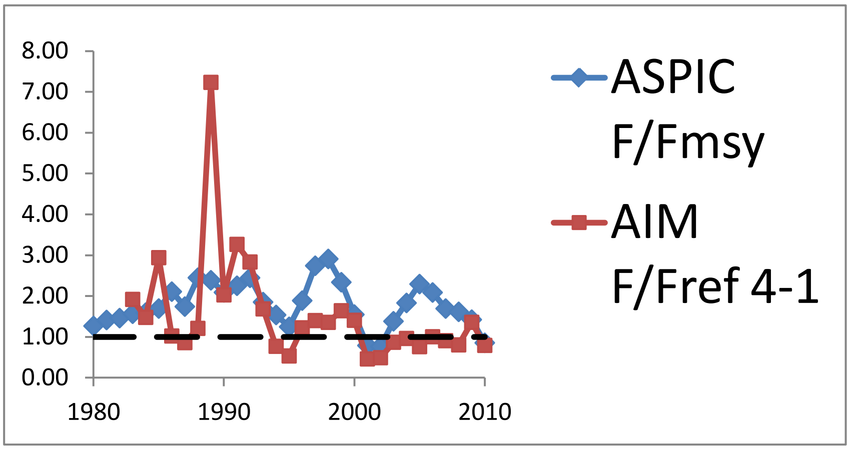

Figure 9.2.2. Monkfish: relative F from ASPIC (blue line) and AIM (red line)

Again for the sake of this exercise, using as "external information" the MSY value obtained from the ASPIC fit (MSY= 7.288 kt) and dividing it by the reference value of *relF* (1.57), the reference value needed when using the Spanish survey index in the context of Indicator 3.2.2 is 7.288/1.57 = 4.64. Figure 9.2.3 compares the results obtained from the ASPIC assessment (which estimates a time series of B/B_{MSY}; blue line in Figure 9.2.3) with the time series of (survey index)/4.64 (red line in Figure 9.2.3). As was the case with fishing pressure, the results are not dissimilar, despite the different biomass indices used for ASPIC and AIM. Both methods indicate that the biomass in 2010 is in between 20% and 30% of B_{MSY}.

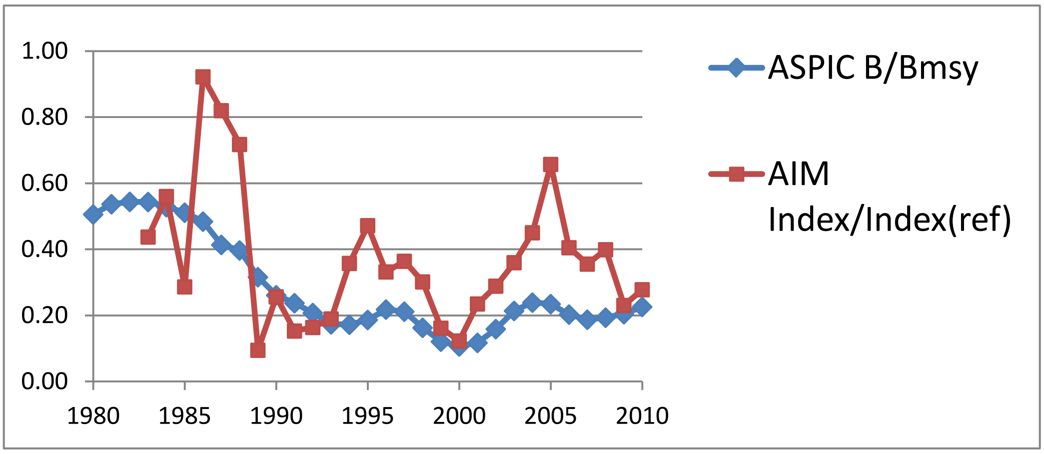

Figure 9.2.3. Monkfish: relative biomass from ASPIC (blue line) and AIM (red line)

Even though the AIM results are rather similar to the current ICES assessment for this monkfish stock, this does not hold in general (as expected). An example where results are very different is the hake stock in ICES divisions VIIIc and IXa. The current ICES assessment is performed with the software Gadget (which is based on an age- and length-structured population dynamics model), using 2 survey indices, several commercial CPUE series and length structure information from the data. On the other hand, AIM was applied using just the commercial catch data and one of the survey indices (the Spanish bottom trawl survey in quarter 4). Figure 9.2.4 is the counterpart of Figure 9.2.2 and displays (in blue) the estimates of F/F_{MSY} from the current ICES assessment and in the remaining colours *relF*/(reference value of *relF*) time series obtained using AIM with different configurations (different choices of *J* for the denominator of the replacement ratio and *K* for the denominator of relative F). The results from all AIM configurations are very similar to each other but they are all very different from the ICES assessment results. Two aspects are likely to contribute to this very large difference: (a) the very different assumptions made in the assessment with Gadget and AIM, with the Gadget assessment being much more complex and using many more sources of data than AIM, (b) the fact that, according to the Gadget assessment, the hake stock has been heavily over-exploited over the entire historic period analysed. As mentioned above, in this kind of situation the reference value of *relF* found with AIM cannot be assumed to be a suitable F_{MSY} proxy.

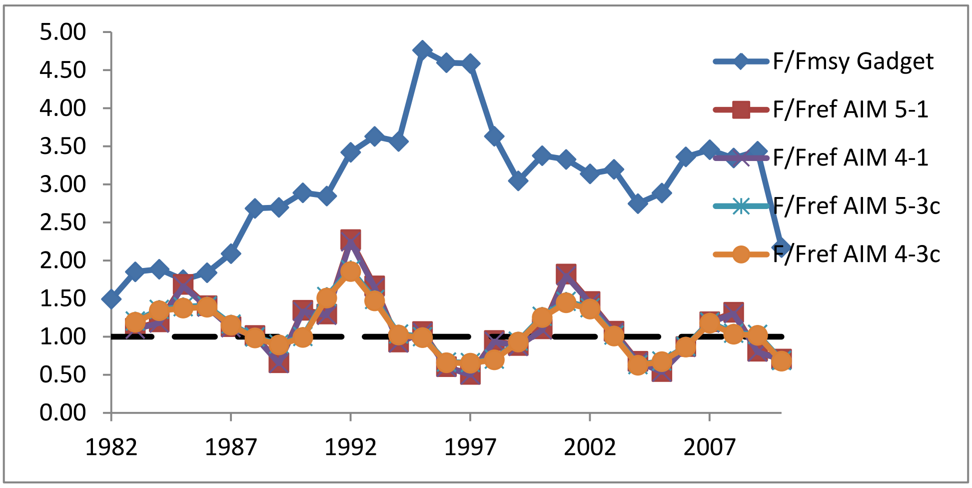

Figure 9.2.4. Hake: relative F from Gadget (blue line) and different configurations of AIM (other lines)

Conclusions about the potential use of AIM to set reference levels consistent with the MSFD requirements for Indicators 3.1.2 and 3.2.2 can be briefly summarised as follows:

AIM is a rather easy to use method, based on finding a linear relationship between log(relative F) and log(Replacement Ratio)

Data requirements: time series of catch and a biomass index

It finds the value of relative F that the keeps the population stable based on the historic period examined – *this is potentially useful for Indicator 3.1.2*:

- If the historic period contains high and low exploitation levels, the reference relative F may act as an F_{MSY} proxy.
- Otherwise the reference relative F is likely to be suboptimal and not consistent with F_{MSY}.

If the reference relative F value can be considered as an F_{MSY} proxy and external information about MSY is available, a reference level for the relative index corresponding to B_{MSY} can be computed – *this is potentially useful for Indicator 3.2.2*

Problems that may arise when using AIM:

- An underlying premise is that log(relative F) should be negatively correlated with log(Replacement Ratio). However, strong recruitment pulses may cause the correlation to become positive.
- Noisy catch or index data can result in non-significant correlation between log(relative F) and log(Replacement Ratio).
- The method will fail if catch does not have a major influence on stock abundance.

10 The way forward

At this point we have developed a framework for the assessment of GES of Descriptor 3 of the MSFD. This framework is applied in a number of case studies covering several of the MSFD (sub)regions providing results for (parts of) the assessment process to assess current status in relation to GES. Based on these results we attempted to develop a generic roadmap that captures much of the variety of approaches without attempting to suggest a "best" method. An evaluation of the different approaches could be done with the information currently available and could possibly provide this "best" method but the time available just did not allow this. This should be the next step in the process started by this group resulting in better guidance for the MSs on how to conduct the assessments for MSFD Descriptor 3.

During the process of the different (sub)regional GES assessments analyses were conducted in different ways and code was developed to automate this process. But none of this was scrutinized for correctness or standardized in any way. Therefore our recommendation is that certified scripts and associated documentation become available that cover each of the different parts of the GES assessment process in a standardized manner and that can be applied jointly with the roadmap allowing the MSs flexibility in their choices as they go through the process. Similarly certified scripts are required to calculate the section 8 indicators.

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