European Environment Agency

Integrated Marine Fish Accounts

An EEA pilot study for one component of marine ecosystem accounts

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Key Deliverable Task 1.6.3.b: Develop 'pilot European fish accounts' as contribution to developing an integrated EU ecosystem accounting system

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1 Introduction

This report describes one example of the development and application of the natural capital accounting framework for European marine ecosystems on regional sea and European level. The study focuses on ecosystem asset and service accounts for commercial fish stocks as one part of marine ecosystem capital and is suggested as a contribution to the INCA KIP project on building an EU ecosystem accounting system. The work presented was initially inspired by the approach put forward in the Ecosystem Natural Capital Accounts: A Quick Start Package (ENCA-QSP) and is now placed within the conceptual framework presented in SEEA EEA (UNSD handbook on experimental ecosystem accounting). It is now suggested as a potential satellite account to inform on the status of the commercial marine fish species, as also proposed in the KIP INCA Phase 1 report.

This report applies the ecosystem accounting framework to marine fish, specifically in relation to their capacity to deliver the ecosystem service 'Wild Seafood' Provisioning Service (WSPS). This is the one component of marine natural capital where available data and current knowledge provided a good platform for applying ecosystem accounting principles. The resulting marine fish asset and service accounts were tested through application in most of the EU marine regions (Figure 1) resulting in a consolidated European assessment and elaboration of the most relevant metrics. These different SEEA EEA related components were combined in one 'integrated marine fish account' (IMFA) that also includes a measure for sustainability of use of fish stocks. This integration allows a good link to EU policy by analysing how the metrics relate to the status of fish stocks as would be generated by the indicators and reference values proposed for the implementation of the relevant EU marine policy frameworks.

The main objectives of this pilot study are:

1. <u>Developing ecosystem accounts</u>: Developing a conceptual framework for European marine fish accounting, in particular:
    a. Conceptual and methodological elements, including their consequences for the reporting of meaningful and policy-relevant information
    b. Calculation of marine fish accounts for the 4 European regional seas as well as a European account
    c. Review of the quality of the assessment, i.e. in terms of representativeness expressed as the proportion of commercial species covered by the assessed stocks.

   <u>Developing the policy link of the accounts</u>: The potential of the marine fish accounting framework to provide (complementary) policy-relevant information was assessed through a comparison with a suite of indicators based on existing fisheries management indicators, involving fish stock assessments and possibly including socio-economic indicators.

The resulting pilot marine fish accounts help to test the utility of an ecosystem accounting framework as a complement to standard fisheries management metrics in informing policy making regarding marine fish stocks and their use. These objectives are set out in three sections:

2. Conceptual and methodological approach for the integrated marine fish accounts
3. Presentation of results and discussion
4. Review of approach and policy relevance

2 Material and methods: Integrated Marine Fish Accounts (IMFA)

The development of pilot marine fish accounts started in 2014 and has led to the development of an integrated European marine fish accounting framework including:

- the conceptual and methodological elements, and their consequences for the reporting of meaningful and policy-relevant information
- the calculation of several regional marine fish accounts as well as one European marine fish account
- an indication of the quality of the assessments in terms of their representativeness expressed as the proportion of commercial catch covered by the assessed stocks

Data availability allowed the calculation of marine fish accounts for most of the EU marine regions (Figure 1). For the European account data requirements meant that the existing fisheries indicators could only be calculated for the stocks covered by the International Council for the Exploration of the Seas (ICES), i.e. Northeast Atlantic and Baltic Sea, due to lack of comparability with the other regional seas, i.e. Mediterranean and Black Sea. However, even though the European account covers only the Northeast Atlantic (NEA) and Baltic Sea, it represents most of the EU landings, approximately 75%, and hence is considered reasonably representative of the EU marine fish food provisioning services.

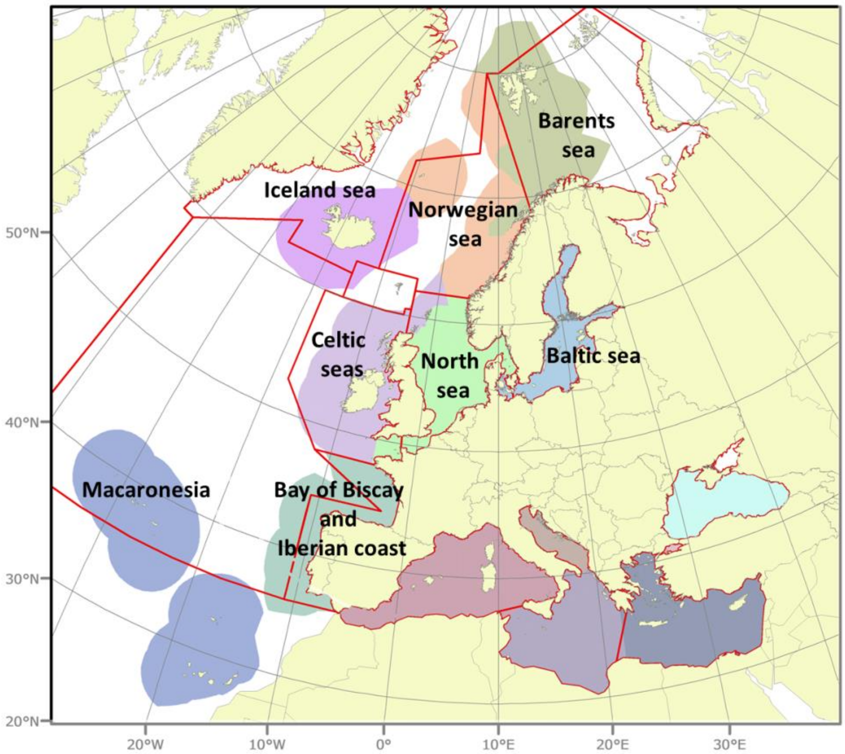

Figure 1. Marine regions according to the Marine Strategy Framework Directive (coloured) and corresponding ICES management areas (red lines). All named regions are included in the calculation of the IMFA.

2.1 Key IMFA metrics for analysing the state and exploitation of marine fish

The overall purpose of integrated marine fish accounts is to understand the sustainability of marine fish resources as a source of marine fish food provisioning services. This can be done by combining standard fisheries management knowledge with ecosystem accounting concepts and results in a potential implementation of bio-physical capacity accounts as proposed under SEEA-EEA. The use of fisheries management data implies that when referring to a fish stock this describes the characteristics of a semi-discrete group of fish with some definable attributes which are of interest to fishery managers. A fish population may therefore consist of several fish stocks.

Figure 2 illustrates how the population dynamics processes underpin the development of the fish assets (thus consisting of several fish stocks). When these fish stocks are harvested they generate an ecosystem service flow ('wild food harvest') which is presented by the fish landings. This process can be described via three separate IMFA components:

- **Processes**: '*Recruitment*', '*body growth*' and '*Natural mortality*' represent net production due to natural processes, equivalent to the total inflow into the asset.
- **Asset**: Aggregated commercial fish stock biomass
- **Service (=Flow)**: '*Catch*' represents the impact of the fishery as removals from the asset, equivalent to the total use of biomass. In practice the data usually represent the landings (which is catch without the discards).

The fish stocks are considered closed units (i.e. no emigration or immigration) which are usually attributed to one marine region. If this was not possible because one stock occurs in several regions it was divided between those regions according to the ratio of the landings.

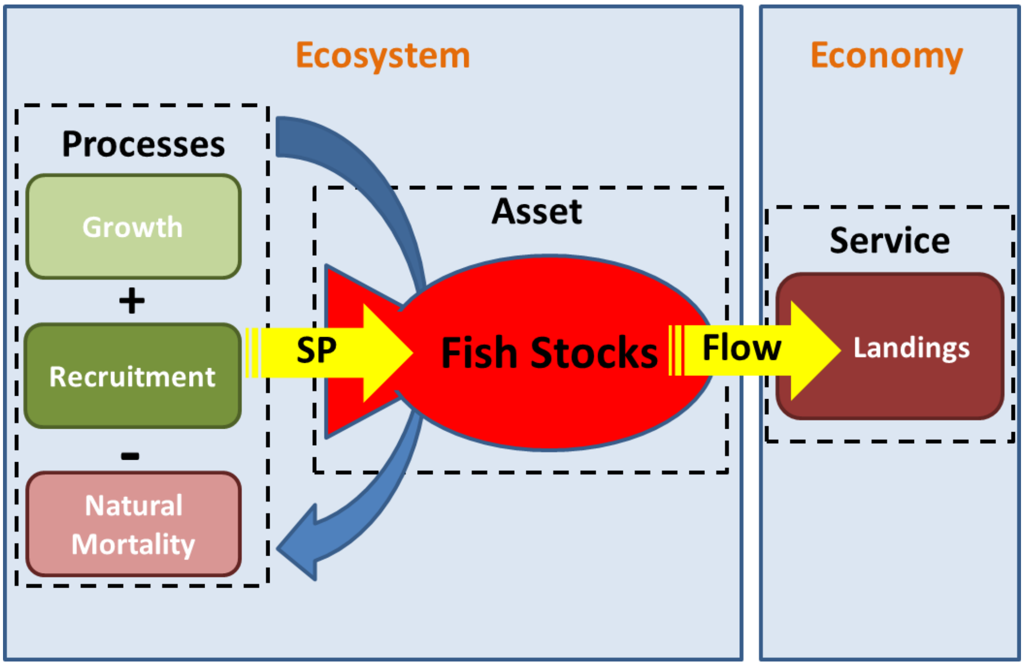

Figure 2 Basic processes determining fish stock dynamics and how they relate to (environmental) ecosystem accounting components and the delivery of ecosystem services

A review of marine and coastal ecosystem services by Liquete et al. (2013) showed that the few studies that deal with the assessment of marine ecosystem services have mainly focused on the ‘Wild Seafood’ Provisioning Service (WSPS), involving fisheries, probably due to its economic relevance and the existence of market prices to value it. According to this review, some of the most frequently used indicators of this service include: abundance or biomass of commercial marine living resources (i.e. capacity), catches or landings (i.e. flow) and income from fisheries (i.e. benefit).

From a fisheries management perspective the capacity indicators make sense as they relate to the two processes through which harvestable biomass is generated: recruitment and growth. The recruitment potential is also reflected in one of the two indicators commonly used to report the status of commercial fish species, Spawning Stock Biomass (SSB), which represents the amount of biomass of a fish stock taking account of the proportion above a certain age/size which is considered mature and thus contributing to recruitment. However, as the indicator for the WSPS aims to represent the potential biomass that can be sustainably harvested (and hence provide the service) the preferred indicator would need to reflect just that, i.e. the amount of biomass that can be sustainably harvested. The *Surplus production (SP)*, a well-established concept in fisheries science, is considered to represent this concept best and is therefore proposed as the preferred metric for the WSPS ‘capacity’. In addition we present two other metrics that capture relevant processes determining *SP:* ecosystem productivity and fisheries exploitation. These concepts were used in developing IMFA and their associated metrics that are considered to represent the most relevant aspects of European fish stocks:

- **Surplus production (SP)** is the net result of several biological processes, i.e. growth, recruitment and natural mortality, and reflects the capacity of the marine fish populations (see 2.1.1) to deliver the food provisioning service.

- **Productivity** (= Surplus production/Total Biomass) reflects the amount of SP produced per unit of Biomass and is an ecosystem-specific measure of the capacity of the fish community (as represented by the selected fish stocks) to produce SP. This is considered a robust parameter as long as the subset of marine fish stocks is sufficiently representative of the targeted regional, marine fish community. In case regional selections are made this metric allows comparison between marine regions.

- **SBU** (Sustainability of Biomass Use = SP/catch) is a fisheries-specific measure showing to what extent the marine fish populations are exploited sustainably. More specifically it reflects the level of human exploitation in relation to the WSPS capacity of the marine fish populations. In case regional selections are made this metric allows comparison between marine regions.

SP is considered the best representation of the capacity of the marine fish to contribute to the WSPS. The SP concept is clearly related to (fisheries) exploitation. In an unfished population, the biomass (total weight) of fish is dominated by relatively large fish and will approach the carrying capacity (maximum amount that can live in an area) of that marine region. Fishing causes a higher turnover of individual fish by removing the many large older fish allowing younger, faster growing fish to replace them thereby increasing SP. However, if this SP is not harvested sustainably (i.e. landings > SP) it will result in a decrease of the stock biomass which, in turn, may compromise the stocks recruitment potential. The unfished resource can therefore be viewed as a relatively stable population with moderate SP whereas the fished population is a more dynamic population but with a higher SP.

The change in biomass represents the net change in basic stocks and the catch represents the removals. Surplus production itself represents the net inputs to the stock. This effectively divides the net change in biomass into ecological and fisheries induced components. For calculating ecosystem account in areas with varying levels of data availability, it is beneficial that these same basic components can be derived from both simple and more intricate stock assessments models.

Productivity is considered an informative metric because it ties the SP concept to other important characteristics of an ecosystem such as primary and secondary production. These characteristics not only differ between regions but may also change over time. A decrease in productivity should result in a decrease of SP even if the total fish biomass remains the same.

Another important metric is the Sustainability of Biomass Use (SBU). Figure 3 explains the concept SBU in more detail and shows how it is calculated on the basis of ecosystem Surplus Production and human use, i.e. fisheries landings, of marine fish biomass.

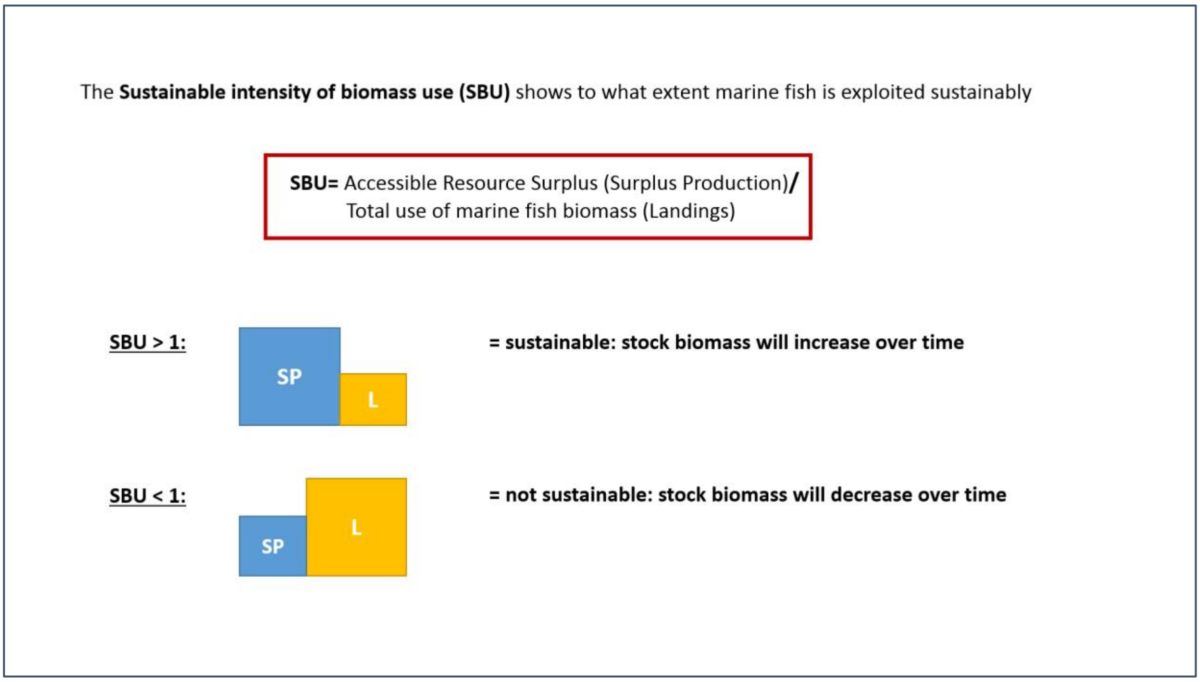

Figure 3 Sustainable intensity of biomass use (SBU)

2.1.1 Understanding marine fish stock dynamics in relation to IMFA

Fish stocks are dynamic resources. For management purposes fisheries scientists attempt to understand the flows and changes in this resource over time. Population dynamics describes how a population grows and shrinks over time as new fish enter and leave the population.

The basic component of population dynamics are birth, death, and migration, but growth is another important component when dealing with biomass rather than abundance. In fish population dynamic models migration is usually considered to be negligible for most managed fish stocks, since stock definitions (boundaries) are usually defined to ensure that managed stocks are closed units (i.e. no emigration or immigration). The difference between stock production (recruitment and body growth) and natural mortality is called the surplus production of a stock. In the absence of a fishery, this is greater than zero in growing stocks, and less than zero in declining stocks. If a fishery exists, even if surplus production is positive, if catch exceeds this the stock will decline. If surplus production is positive and greater than catch, the stock will increase. In other words, surplus production should not be viewed as purely biomass available to the fishery.

Surplus production models specifically estimate the production over time. However, this cannot be separated out into recruitment and growth due to the lack of age structure in the model. This makes it challenging to generically incorporate recruitment and growth separately in fish accounts for all stocks. Estimating natural mortality is even more problematic and for the vast majority of stocks this is usually simply assumed as a constant proportion over time and age. When looking at flows in an accounting context, surplus production (in comparison with catches) may be the best estimate that can be used.

A simple way to calculate surplus production is to look at change in biomass from one year to the next and to remove the impact of the catch thereby leaving the net stock growth in that first year. How the rearranging of the standard population dynamics equation can be used to calculate Surplus Production is given in Box 1.

Box 1. The main processes that determine marine fish stock dynamics and how they are applied to calculate Surplus Production (SP). See also Figure 2.

Change in biomass = (*recruitment* + *body growth*) - *natural mortality* – *catch*

where

(*recruitment* + *body growth*) - *natural mortality* = *Surplus Production*

and thus

Surplus Production = *Change in biomass* + *catch*

or

$$SP_Y = (B_{y+1} - B_y) + C_y.$$

with

SP_Y = Surplus production in year y

B_y = Biomass in year y

B_{y+1} = Biomass in year $y+1$

C_y = Catch in year y

Thus for accounting this implies that several stock-specific natural processes determine the inflow of biomass into the stock while the fisheries catches cause a flow out, together causing the stock biomass to grow or shrink over time

2.2 How IMFA is related to ecosystem accounting concepts

Ecosystem accounting concepts have been developed with a focus on terrestrial ecosystems. It is important, therefore, that the integration of marine ecosystems and their services into ecosystem accounting approaches is explored. Looking at marine fish stocks and the provisioning services they provide offers a good opportunity for methodological development as they are often well-documented and fisheries management frameworks exist that can provide underpinning data and ecological understanding. This section briefly discusses the approach proposed in this paper in relation to the UNSD System of Environmental Economic Accounting, in particular the handbook on Experimental Ecosystem accounting (SEEA EEA), as well as the methodological proposal for Ecosystem Natural Capital Accounts – A quick start package (ENCA-QSP), published by the Secretariat of the Convention for Biological Diversity.

The initial inspiration to develop and calculate IMFA came from the methodology proposed in the ENCA–QSP with regard to establishing accounts for biomass carbon. To produce the basic account in accordance with ENCA-QSP (Box 2) requires building Tables I, II, III and IV proposed in section 5.1 of the ENCA-QSP document.

Table I, Ecosystem Fish Biomass Balance consists of an Opening Stock (C1), with the Total inflow into the marine fish (C2) and Total outflow (C7; withdrawals of secondary biomass) to get the marine fish biomass basic balance (difference between C1 and C9) (see Box 2). This biomass basic balance is entirely based on the selected marine fish stocks.

Table II, Accessible Resource Surplus represents the Total inflow for which Surplus production is considered the best method to calculate it.

Table III, Total Uses of Ecosystem fish biomass, is best represented by the fisheries landings. Other uses are negligible compared to that of fisheries and the fact that this analysis is "only" based on a selection of commercial fish stocks is not an issue as these specifically represent the part of the whole marine fish community that contributes to the Total Uses of Ecosystem fish biomass.

Table IV, Sustainable intensity of biomass use can then be calculated as the ratio between the Total inflow biomass, i.e. net ecological Surplus Production, and Total outflow biomass, i.e. human use represented by fisheries landings.

Box 2 ENCA-QSP (Weber, 2014) and how this relates to the IMFA metrics.

Table I. Ecosystem Fish Biomass Balance C1 Opening Stocks C2 Total inflow C7 Total outflow (=C5 as C6 is currently ignored for lack of data) C9 Closing Stocks Table II. Accessible Resource Surplus C2 Total inflow of fish biomass = C2.b Total secondary biomass resource C2/C1 Productivity (= capability of the Stock to generate the Accessible Resource Surplus) Table III. Total Uses of Ecosystem fish biomass C5 Total use of ecosystem fish biomass = C3.b Withdrawals of secondary biomass Table IV. Table of indexes of intensity of use and ecosystem health SBU Sustainable intensity of fish biomass use (=C2/C5)

Note: This accounting table for fish biomass accounts has been developed from a proposed biomass carbon accounting table in the ENCA-QSP (see the annex for details of that table).

In SEEA EEA terms this approach corresponds to the concept of ecosystem capacity which has been initially defined as the "ability of an ecosystem to generate an ecosystem service under current ecosystem conditions and uses at the maximum yield or use level that does not affect the future supply of the same or other ecosystem services" (Hein *et al.*, 2016). Considerations for applying this concept in the SEEA EEA context currently focus on integrating (monetary) values for ecosystem and their services into national accounts, hence the emphasis is differently compared to the ENCA-QSP. However, there are opportunities for developing the concept of ecosystem capacity further in the SEEA context in a way that elaborates on the sustainable management of ecosystem assets and their services. One particular dimension that is important to consider in this context is the interest to explore the links between accounts for ecosystem extent and condition with ecosystem capacity and the (sustainability of) connected flows of ecosystem services. Figure 4 provides a first proposal for how these links could be seen:

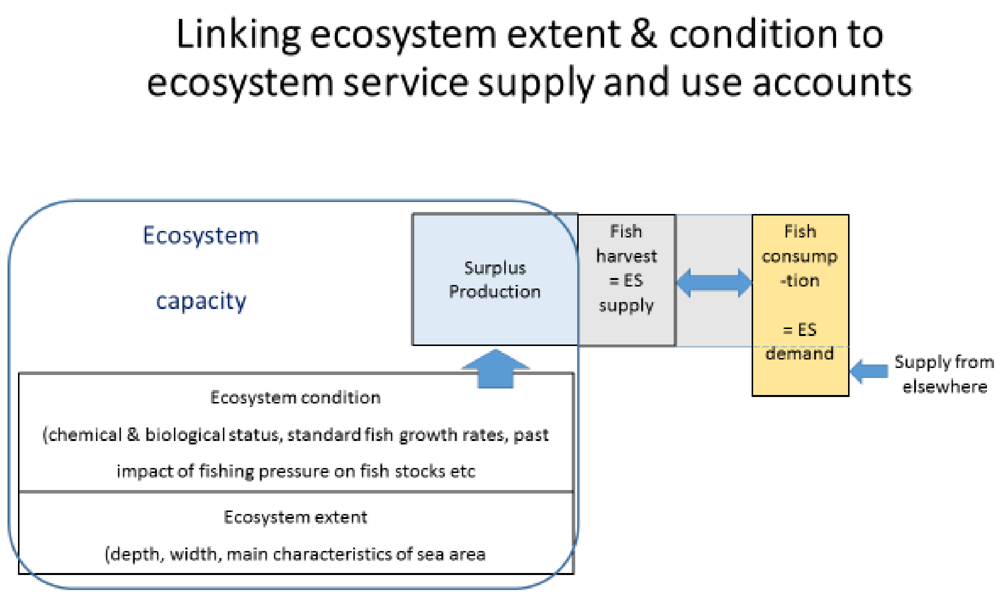

Figure 4 Schematic representation of links between accounts for ecosystem extent and condition, ecosystem capacity and ecosystem services

In this proposal ecosystem capacity is seen as encompassing the accounts for ecosystem extent and ecosystem condition, both of which underpin surplus production. Fish harvest is assumed to equal surplus production as ecosystem capacity is defined according to its ability to generate an ecosystem service at rates that correspond to Maximum Sustainable Yield (which is also the aim of current EU fisheries management). Fish demand in this case is greater than sustainable supply but the gap is assumed to be closed by fish supply from elsewhere (which is the case in many real-life situations, as it is in most European countries).

2.3 Data availability and the processing of data

As the calculation of the IMFA has specific requirements pertaining to the availability of data (sufficiently long time-series based on annual stock assessments reporting on total stock biomass) we made an inventory of all the marine fish species for which adequate information was available. This resulted in a selection of 54 commercial fish stocks (see Annex 3) available through a dedicated website, i.e. the ICES (International Council for the Exploration of the Seas) Stock Database, covering most European marine regions except for the Mediterranean and Black sea (see Figure 1). While several of the fish stocks in these regions are assessed and would fulfil the basic requirements further selections needed to be made to allow the calculation of consistent regional or European time-series of the main IMFA metrics. This requirement implied that all the Mediterranean and Black Sea stocks, for which the assessments did not fulfil the requirements, could not be included. While this reduces the spatial coverage of the IMFA it is not considered to bias the outcome substantially as an analysis of the available catch statistics for all EU marine regions showed that the stocks used for this European assessment cover on average ~75% of all landed marine fish caught in the EU marine waters (based on period 2006-2013).

The data used to calculate this IMFA is based on the information used to inform fisheries management of the commercial fish stocks. For the regional analysis we therefore needed to match the zonings applied for the management of fish stocks, i.e. ICES areas, to the (sub-) regions identified in the main policy framework for the marine environment, the Marine Strategy Framework Directive (MSFD), see figure 1.

The regional sea IMFA were calculated for fixed periods where the selection of the period was determined by the availability of data. In this fixed period the composition of the marine fish in the database was consistent so as to avoid bias through differences in data availability.

When combining the regional Total Biomass data with the landings data we attempted to use only the part of the landings that can be attributed to the stock in each region. If this was not possible, the total amount of landings was used which may cause an overestimation of the regional surplus production for that stock. This, however, did not concern any of the main stocks, nor did it affect the European IMFA.

3 Results: regional and European IMFA

The IMFA is based on the aggregated marine fish stock biomass across all species/stocks for which the required data are available which implies only commercial fish species subject to quantitative stock assessments and for which total biomass is reported.

3.1.1 Table I: Ecosystem Fish Biomass Balance

The marine fish Biomass basic balance over the period 1999–2013 shows that for Europe as a whole in- and outflow are fairly balanced but with marked regional differences (Table 1). In the Azores we observe the biggest decrease in fish biomass with approximately 25% while the Baltic sea as well as the Barents and Norwegian sea show a 15% increase.

Table 1 Marine fish biomass basic balance (in tonnes). Opening is in 1999, closing in 2013. The in- and outflow are summed over the whole period.

	Barents and Norwegian sea	Iceland sea	North Sea	Baltic sea	Celtic seas	Bay of Biscay and Iberian coast	Macaronesia
Opening	9548987	4986668	12700253	3652996	7197915	953184	141588
Additions	28270224	11984640	25621016	9463830	15911355	2947891	328985
Reductions	26839872	12435507	25935299	8905842	17078395	3131925	365161
Closing	10979339	4535801	12385970	4210984	6030876	769150	105412

3.1.2 Table II: Accessible Resource Surplus

For this aspect of the biomass account we not only considered the Surplus production of the marine fish but also their Productivity (= Surplus production / Total biomass) which indicates the capability of the standing stock to generate this Surplus production. Annual Surplus production per EU marine region is given in Figure 5. This shows considerable differences between the marine regions, or at least between the stocks as they are attributed to the marine regions. The regions contributing most to the SP are the North sea (32%) and the Barents and Norwegian sea (28%). Productivity is on average 18% with only minor differences between the regions (Table 2).

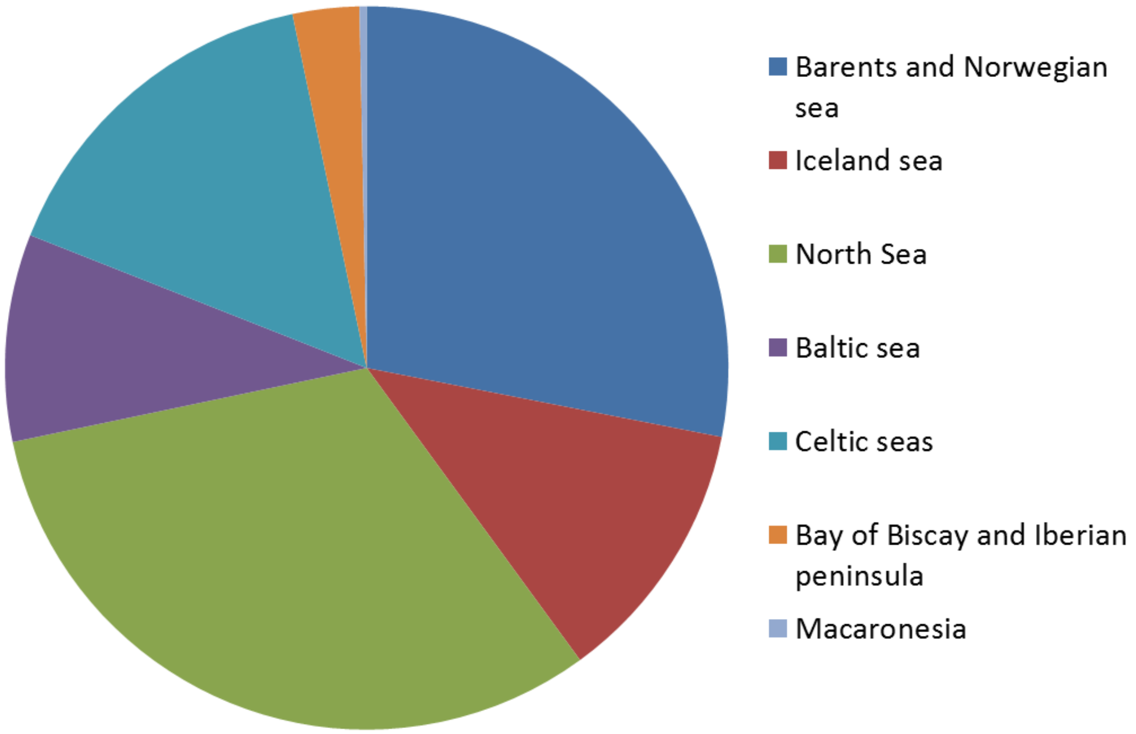

Figure 5 Share in annual Surplus Production for each EU marine region over the longest possible consistent time-period (1999-2013)

Table 2 Productivity (%) of marine fish per European marine region over a fixed period of time (1999-2013).

Region	Productivity (%)
Barents and Norwegian sea	19
Iceland sea	18
North Sea	18
Baltic sea	17
Celtic seas	17
Bay of Biscay and Iberian peninsula	24
Macaronesia	18

3.1.3 Table III: Total Uses of Ecosystem Fish Biomass

The total use of marine fish biomass in each EU marine region shows markedly more variation over time than the aggregated (European) total use (see Figure 6). Over the time period considered the total EU landings represented by the included marine regions decreased by approximately 2% annually.

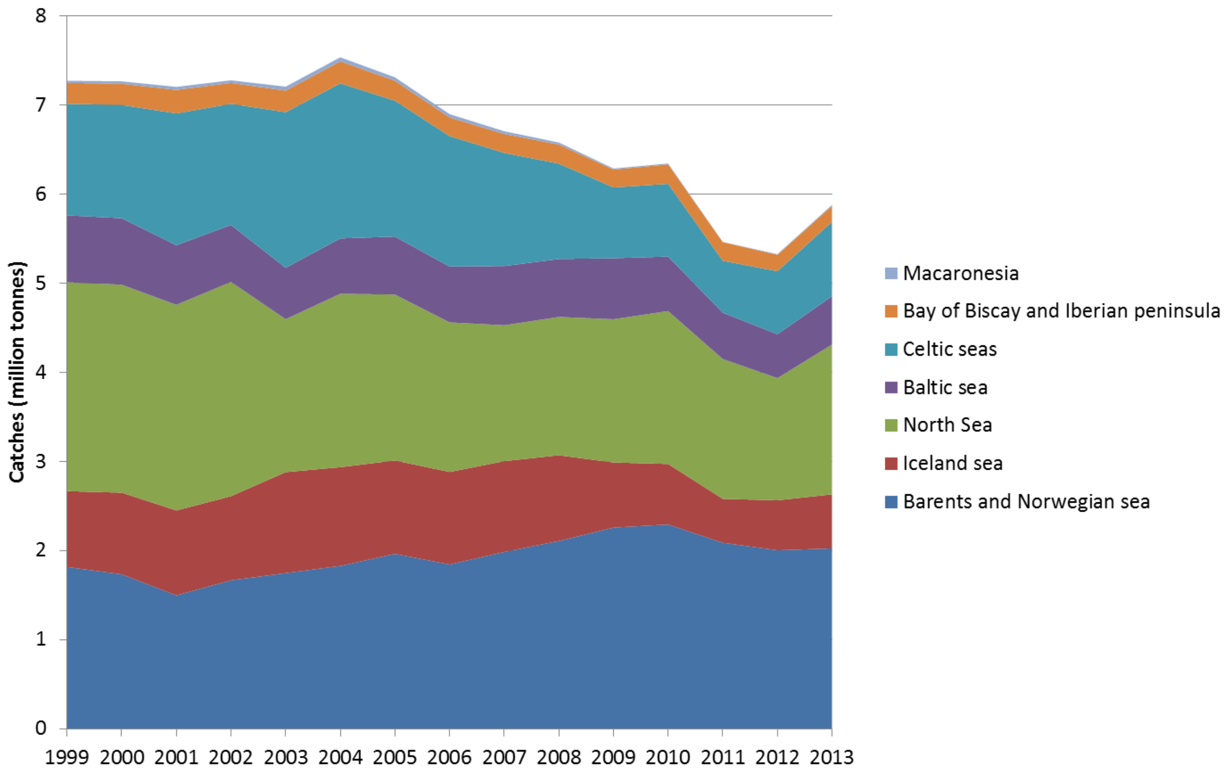

Figure 6 Total cumulated fisheries landing (million tonnes) over time per EU marine region

3.1.4 Table IV: Indexes of intensity of use

Table 3 shows the Sustainable intensity of biomass use (SBU=Accessible Resource Surplus / Total Uses of marine fish biomass) for marine fish over time per European region as well as for the whole EU (or at least the marine regions considered in this analysis). In the EU as a whole nearly all Surplus production is used up by the fishery and exploitation can be considered sustainable, i.e. SBU=1.05. However there are minor regional differences where in some regions the fishery uses slightly more than the surplus production (i.e. SBU<1) leading to a decrease over time of the total fish biomass, e.g. in the Iceland sea, Celtic seas, Bay of Biscay and Iberian peninsula and Macaronesia).

Table 3 Sustainable intensity of biomass use per EU region (period 1999-2013)

EU region	*SBU*
Barents and Norwegian sea	1.03
Iceland sea	0.97
North Sea	1.22
Baltic sea	1.04
Celtic seas	0.93
Bay of Biscay and Iberian peninsula	0.95
Macaronesia	0.89
EU	1.05

All regions show huge variation over time (Figure 7) caused by the large variation in Surplus production usually caused by a single stock of small pelagics which dominates the biomass in that particular region, i.e. Sandeel in the North sea, Herring in the Bay of Biscay and Iberian sea, Sprat in the Baltic sea (see section Accessible Resource Surplus).

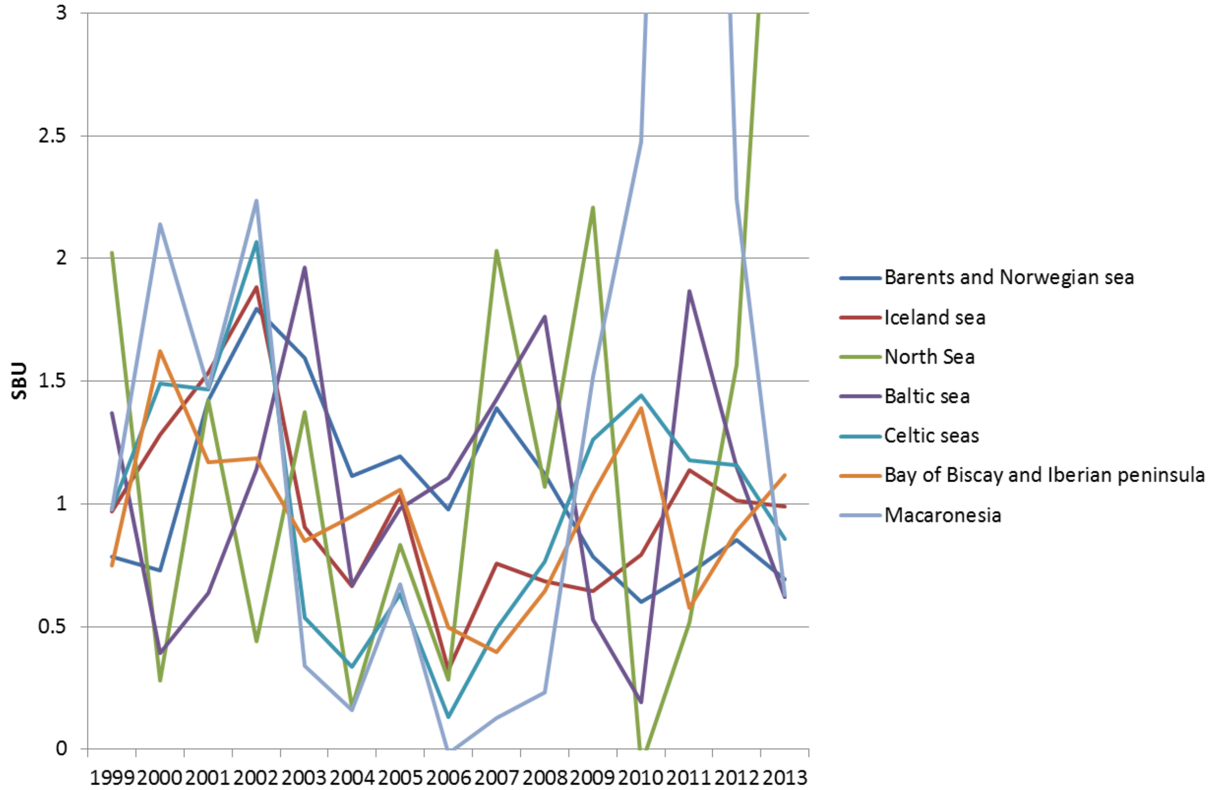

Figure 7 Sustainable intensity of biomass use (Surplus production/Landings) over time per EU marine region.

3.2 European assessment

This European assessment shows that Total Biomass (TB) remains fairly stable over time while the Total catch is gradually decreasing (Figure 8). The Productivity and SP show considerable variability over time but also, at least over the time period considered, decreasing trends. This is probably driven by the Productivity of the marine fish (i.e. the SP per unit of TB) where the same amount of TB is producing less SP and with high variability. This variable and decreasing Productivity is the result of natural processes which contrasts with the landings which are mostly driven by anthropogenic processes (i.e. fisheries management). This assessment shows that over the time-period considered fisheries management has succeeded in reducing the catches sufficiently to compensate for this reduced productivity and even succeeded in a slight increase of the European level SBU resulting in a slight increase in TB.

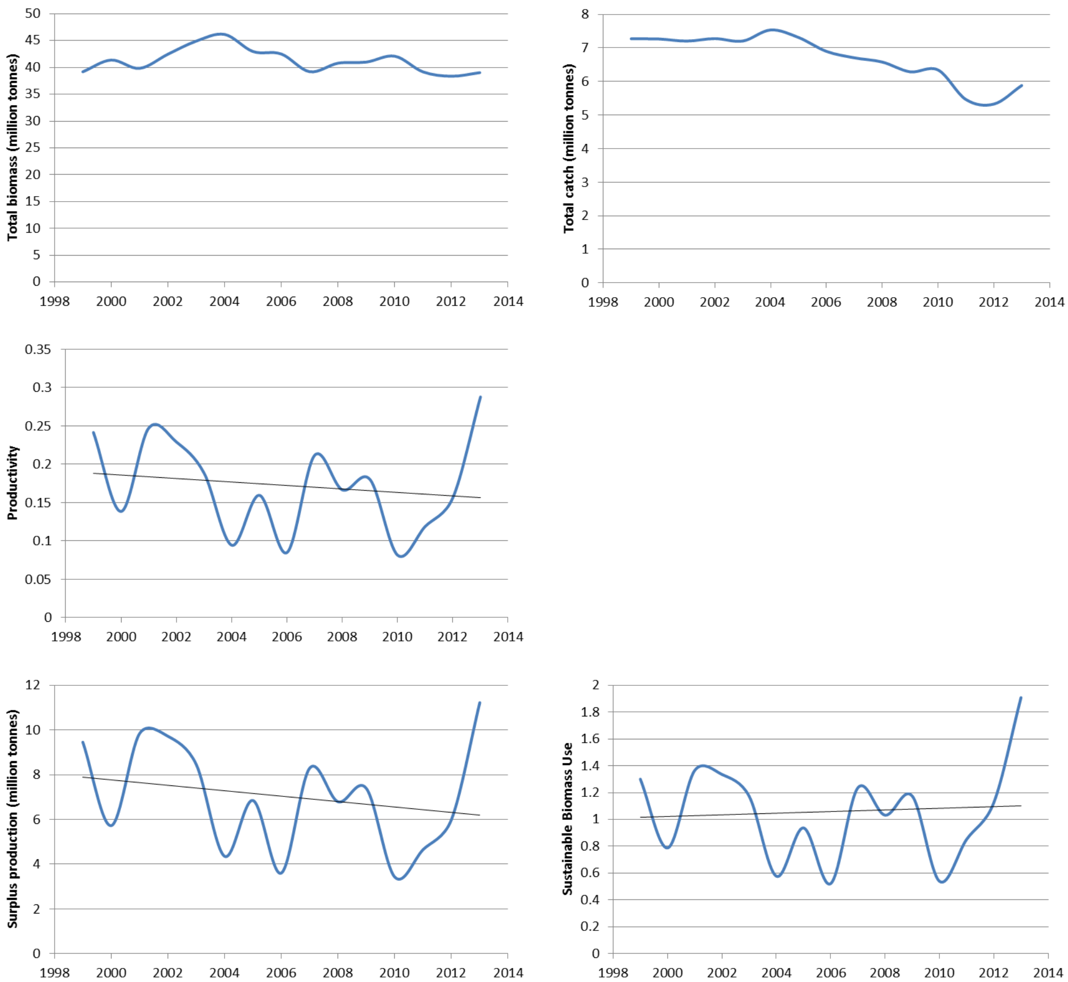

Figure 8 Marine fish indicators and metrics for all stocks in the ICES region. Units are in million tonnes, except productivity and SBU which are ratios.

The relative contribution of the different stocks to SP is far from equal and few stocks are responsible for most of the SP. The main stocks consist of two so-called straddling stocks or widely distributed species, i.e. Blue whiting (whb-comb) and Mackerel (mac-nea), two pelagic species, i.e. Herring with stocks in the Barents and Norwegian sea (her-noss) and North sea (her-47d3) and Sprat with two stocks in the North sea (spr-nsea)and Baltic sea (spr-2232) and Arctic cod which together make up almost three-quarters of the total European SP see Figure 9). Only the latter, i.e. Arctic cod is not a pelagic species. Five out of eight of these stocks are decreasing. These large variations over time are due to various natural processes, notably pelagic species are known to have highly variable recruitment. Although the decreasing trend in productivity over time could be cause for alarm it is almost entirely driven by only few stocks and considering the large fluctuations in productivity and the recent increase, one or two additional years of higher productivity could provide an entirely different perspective. Probably the main (positive) conclusions is that fisheries management appears to have adequately responded to deal with these natural variations.

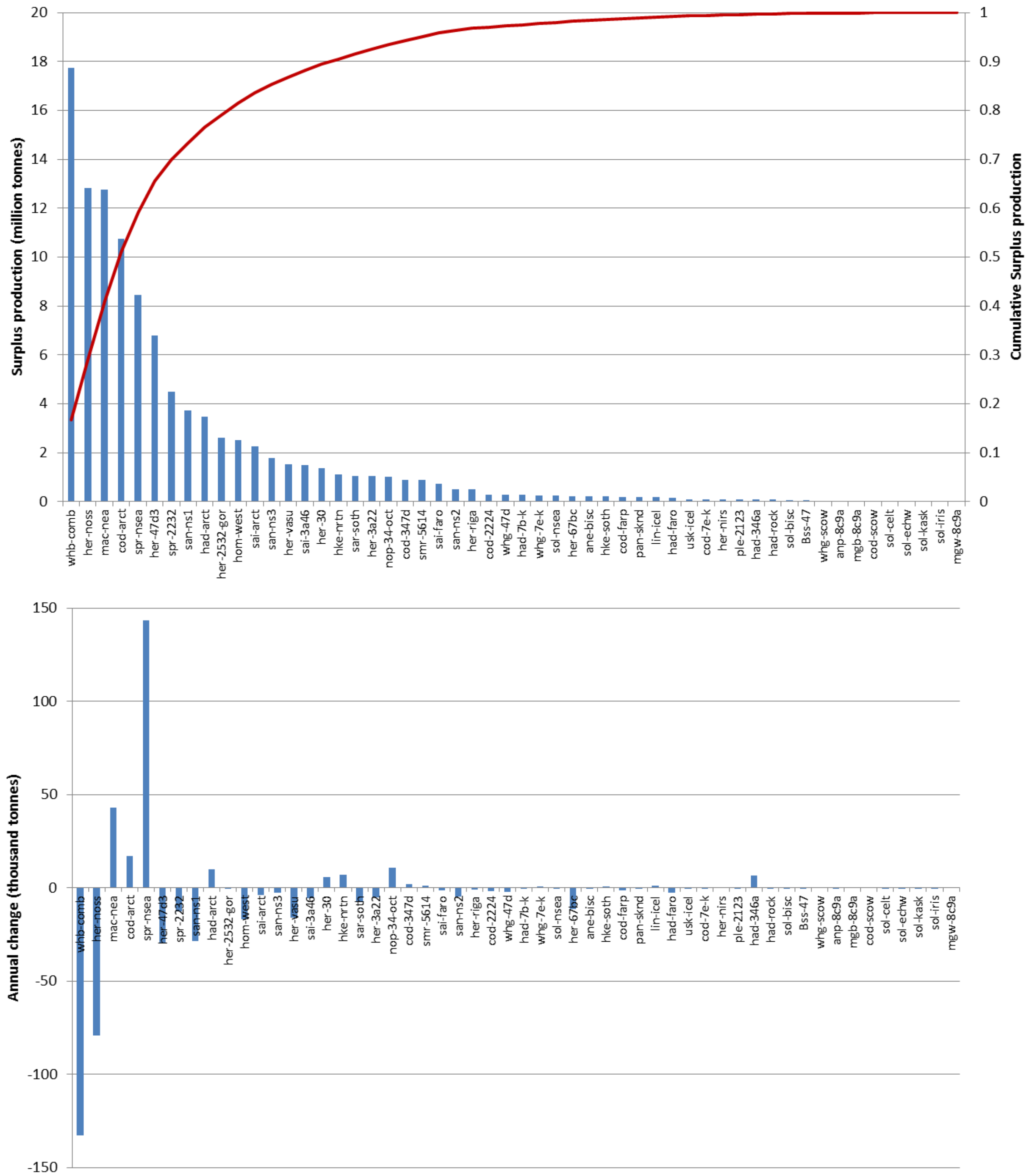

Figure 9 Surplus production per stock ordered according to the total SP over the study period and the cumulative SP (upper graph) and the mean annual change over time per stock (lower graph).

3.3 Quality of European Assessment

The quality of the assessment is reflected best by the extent to which the European marine fish are represented by the fish stocks/species for which sufficient data are available to calculate the IMFA metrics. As these metrics are primarily considered to be relevant for the marine ecosystem food provisioning service the quality is expressed by the proportion of the landings covered by the stocks in this assessment. To determine the proportion of the landings covered by these stocks the Official Nominal Catches 2006-2013, were downloaded from the ICES website (http://www.ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx). The proportion of the catch represented by species included in the calculation of the IMFA was approximately 75% and covering many biological guilds, e.g. demersal and pelagic, benthivorous and piscivorous. Therefore this assessment can be considered reasonably representative even though two marine regions could not be included.

4 Discussion and policy relevance of IMFA

The findings above are based on analysis at a highly aggregated level, i.e. European or regional and over a relatively long time-period (1999 – 2013, i.e.14 years). As information is disaggregated or the time-period shortened the meaningful patterns are likely to disappear due to the high variability in the ecosystem. Thus, the requirement of relatively long periods may need to be balanced against the limitations in terms of data availability and/or a potential requirement of selecting specific periods in which a specific management regime occurred (e.g. revisions of the CFP). The question 'what can be considered an appropriate period for obtaining meaningful results from the calculation of these accounts' needs to be further explored.

The development of the IMFA did result in three potential IMFA metrics, i.e. Surplus production (SP), Productivity and Sustainability of Biomass use (SBU). Surplus production, a well-established concept in fisheries science can be considered the best indicator for the "Food provisioning-wild capture sea food" ecosystem service (Piet et al., 2017). The relevance of the other IMFA metrics follows from how they relate to the Surplus production. Productivity reflects relevant characteristics of the (populations that make up the) marine fish, i.e. the supply side, as the same amount of biomass may result in a different Surplus production depending on the functioning and/or composition of the marine fish. The Sustainability of Biomass use shows to what extent the marine fish are exploited sustainably. It reflects the level of human exploitation of the marine fish populations, i.e. demand side. Thus, with Surplus production as the main metric, Sustainability of Biomass use is probably also relevant for reporting purposes as productivity is an intrinsic characteristic of the marine fish and the ecosystem not subject to any political decision-making.

The application of IMFA as part of any regional or European marine natural capital accounting framework based on absolute biomass values of the assessed commercial species is hampered by the fact that these species represent a (regional) subset of the marine fish resulting in a systematic underestimation of the total fish biomass. However, while the commercial marine fish covered by stock assessments only make up a relatively small component in terms of their contribution to the total fish biomass in the marine ecosystem, they make up a key component in terms of their contribution to the marine ecosystem "Food provisioning-wild capture sea food" service. The value of the IMFA information presented here should therefore be considered from that perspective. As such this IMFA reveals relevant information on the biomass fluxes on which most of our food provisioning service depends. It shows how the natural production (i.e. Surplus production) shows great variability over time but because this production for the current year is unknown while the exploitation aims to capture all of this accessible resource surplus, exploitation levels are likely to overshoot in one year and undershoot the other causing the asset (i.e. Total fish stock biomass) to change over time, albeit with much less variability than the SP.

Moreover, the relative aspects of these accounts (i.e. Productivity or SBU) are not systematically underestimated by the fact that these are based on a subset of the species but may suffer in terms of accuracy if for example two regions are not adequately represented by this subset. Obviously any increase in the number of species/stocks that can be included in the calculation of the IMFA or the length of the time period will improve the accuracy of the accounting framework.

4.1 EU policy relevance of Marine fish biomass accounts

An exploration of how this accounting concept links to existing policy through a modelling exercise for several stocks showed that an exploitation using most (all) of the surplus production is in line with the policy requirements of exploitation levels that deliver Maximum Sustainable Yield (MSY). However, simply ensuring catch does not exceed surplus production may ensure sustainable use of the resource, but does not guarantee optimal use or Maximum Sustainable Yield (MSY) which is what current EU policies aim to achieve.

In the short term, natural fluctuations in stock productivity will lead to large variations in Surplus production and, depending on the stock, a “fishing at MSY” strategy may even give temporary negative Surplus production. Hence periods of stock decline and stock increase can be expected even when fishing within the range of fishing-induced mortalities compliant with an “fishing at MSY” strategy. So while in an optimally managed stock you would expect to land all of the surplus production in the long term, this cannot be expected over relatively short time periods. Thus any short-term (e.g. annual) index of Sustainable Biomass Use (SBU) cannot be used to draw conclusions on the long term appropriateness of current management. Likewise, the current level of surplus production should not be the basis to inform current fisheries management.

As such, both IMFA metrics, i.e. SP and SBU, are probably best suited as “surveillance indicators” which are not supposed to underpin specific management advice but rather provide complementary information (including warning signals) that provide a broader and more holistic picture of state, and inform and support policy (Shephard et al., 2015). Pertaining to this we need to bear in mind that also in the biomass data, on which these accounts are based, the last (most recent) year will always be the most poorly estimated. This is the inherent difficulty of fisheries management, i.e. never knowing the exact current status, nor what this is likely to be in the immediate future.

Acknowledging that these accounts are not very informative when calculated annually or even relatively short-term, i.e. multi-annual, we attempted to calculate them for the longest period possible which was sometimes hampered by the availability of data. Aggregating across stocks within a region or even better aggregating to a European level has the advantage that much of the stock-specific variation disappears and meaningful patterns emerge. These show that the SBUs over time or per region are usually close to the SBU=1 level indicating all surplus production is used by the fishery and only some regions in specific periods of time are unsustainably exploited. What should be an appropriate period to calculate and report on this account, however, still needs to be assessed.

For management purposes, more detailed stock assessments, e.g. involving age-structured Virtual Population Analysis (VPA) and Statistical Catch-at-Age (SCA) models, are better for observing the performance of management in relation to policy. These more detailed, relatively data-heavy models provide better insights into the impact of current fishing pressure on stock size in relation to policy targets. Developing full age-disaggregated stock assessment models for all stocks, however, is an unreasonable aim. So when developing an accounting approach that can be more universally applicable (e.g. to the more data poor areas) simpler approaches are necessary. Surplus production models have much simpler data requirements than full age-based models. Often only total catch and effort data are required, though fisheries independent indices can also be included where available. As such these methods can be more generally applied to produce the desired IMFA metrics. Note, however, these metrics should not be used to trigger any fisheries management action but rather to support policy with an evaluation of historic management and possible regional differences therein.

4.2 Conclusion and way forward

This report presents one potential component account for marine natural capital accounts, i.e. IMFA. The IMFA currently includes all the main requirements of an asset account, i.e. Opening Stock, the Additions to the asset (Total inflow) and Reductions to the asset (Total outflow) of which the balance produces the Closing Stock. All this is based on the subset of the marine fish for which the required information is available in the marine region, i.e. commercial fish stocks covered by stock assessments. The Opening Stock is equal to the Total Biomass in a particular year. The Total inflow is equal to the Surplus production over a certain period, while the Total outflow is equal to the total catch (or actually landings = catch-discards) over that same period. As the amount of discards (= unwanted catch returned to the sea) may differ over time and between regions this may affect the IMFA estimates.

The IMFA reflects a (regional) account of the marine fish biomass including best estimates of the net inflow due to natural processes and the outflow caused by human activities. This distinction then allows the calculation of an “index of sustainability of use” (SBU = Total Inflow / Total Outflow) as proposed in ENCA-QSP. The accuracy of this SBU per marine region is expected to depend on the proportion of the marine fish covered by the species/stocks in the analysis as well as discarding practices. While there are some issues that could be further explored for an assessment based on IMFA, this pilot account and its metrics can be considered operational.

In SEEA EEA terms this approach corresponds to the concept of ecosystem capacity which has been initially defined as the “ability of an ecosystem to generate an ecosystem service under current ecosystem conditions and uses at the maximum yield or use level that does not affect the future supply of the same or other ecosystem services. The example in this report shows that there is good alignment between the ENCA-QSP proposal to develop an index of sustainability of use and the SEEA EEA concept of ecosystem capacity. The report also illustrates how to construct accounts that implement these concepts.

The discussion in chapter 4 above shows that the potential of integrated marine fish accounts to inform policy decisions in Europe lies mainly in their ability to signal risks rather than as a basis for concrete fisheries management decisions. This is not surprising, however, as the basic data and concepts for fisheries management in Europe have been developed over several decades already and are thus difficult to improve with other approaches. This accounting approach, however, is strongly aligned with the current fisheries management of commercial fish stocks as it is based on the same information source and also strives toward exploitation at Maximum Sustainable Yield (MSY). This approach is complementary to existing indicators on the status of commercial fish stocks that primarily reflect the performance of fisheries management whereas this emphasizes their status in relation to their food provisioning capacity (see Piet et al. 2017). In regions that have less sophisticated fisheries management systems and fewer data on fish stocks accounts based on surplus production may be a good first information for a better management of regional or national fish stocks. In any case, this work provides a foundation for including aspects of marine ecosystem capital in overall natural capital accounts.

In practical term, the way forward therefore mainly involves addressing/resolving the pending issues mentioned in this report. These issues all revolve around the availability of data which hamper including ideally all marine fish but realistically at least the main commercial fish species. While this applies to all regions this is most apparent in the Mediterranean and Black sea regions.

The fact that the two most relevant SP-related metrics, Production and Sustainability of Biomass use, could also be calculated through Surplus production models which have much simpler data requirements than the full age-structure models usually applied to inform fisheries management may alleviate some of the problems to calculate these metrics. This means that in the near future a truly European assessment involving stocks from all regions may be conducted over a longer time-period than currently available. Due to ongoing efforts at ICES and by EU Member States it is expected that more stocks will begin to fulfil the data requirements and hence the reliability and accuracy of the IMFA and its metrics will likely increase with every annual update.

It has been shown that surplus production models have much simpler data requirements than full age-based models. Often only total catch and effort data are required, though fisheries independent indices can also be included where available. As such these methods are sufficient to develop IMFA as part of an ecosystem accounting system for marine ecosystems. Note, however, these metrics should not be used to trigger any fisheries management action but rather to support policy with an evaluation of historic management and possible regional differences therein. They are nevertheless a useful approach for integrating aspects of the marine capital into an overall ecosystem accounting approach.

5 Glossary

Integrated Marine Fish Account (IMFA): Because all fish data are reported in terms of biomass and the corresponding IMFA metrics were deemed more relevant for the Target 2/Action 5 of the EU 2020 Biodiversity Strategy, the IMFA was to represent the marine fish component in the natural capital accounting framework. Note that because of data requirements this IMFA is calculated based on only a subset of the commercial fish, i.e. those covered by stock assessments.

IMFA metrics: These are Surplus Production (SP), Productivity and Sustainability of Biomass use (SBU). For further explanation see below.

Surplus Production (SP): This is the part of the fish production that can be harvested and is actually increased through this activity. The unfished population can be viewed as a relatively stable population with moderate production. The fished population, on the other hand, is a dynamic population with a higher turnover of individual fish as the older fish are replaced by younger, faster growing fish. The SP metric is probably the most appropriate metric to represent the capacity of the marine fish to deliver the ecosystem service "Food provisioning-wild capture sea food" and as such very relevant for an assessment for the Target 2/Action 5 of the EU 2020 Biodiversity Strategy. The concept of Maximum Sustainable Yield (MSY) often used as a target for policy is the maximum surplus production that can be harvested sustainably.

Productivity: This reflects the amount of SP produced per unit of Biomass and is a characteristic of the fish community as represented by the selection (e.g. regional) of fish stocks. As such this metric allows comparison between marine regions. As this is a ratio it is not affected by the fact that often only a subset of marine fish are considered providing this subset is sufficiently representative of that marine fish community (e.g. regional).

Sustainability of Biomass use (SBU): This is essentially the ratio between the surplus production and the exploitation level (i.e. landings) and is a characteristic of the human use of the resource. This metric allows comparison between marine regions. As this is a ratio it is not affected by the fact that often only a subset of marine fish are considered providing this subset is sufficiently representative of that marine fish community. SBU≥1 indicates sustainable use (but not necessarily optimal, i.e. MSY) and SBU<1 unsustainable use resulting in a decrease of fish biomass.

Surveillance indicators: Such indicators monitor key aspects of the ecosystem for which there is: firstly, insufficient evidence to define targets and support formal state assessment; and/or secondly, where links to anthropogenic pressures are either weak or not sufficiently well understood to underpin specific management advice. Surveillance indicators are not expected to directly track state in relation to policy objectives, but provide complementary information (including warning signals) that provide a broader and more holistic picture of state, and inform and support science, policy and management (Shepard *et al.*, in press).

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7 Annexes

Annex 1: Ecosystem carbon accounts as proposed in ENCA-QSP

SEEA-EEA & ENCA-QSP land cover ecosystem units		LCEU 1	LCEU 2, 3, 4	LCEU 5	LCEU 6	LCEU 7, 8, 9, 10, 11, 12	LCEU 12	LCEU 13, 14	Total inland & coastal eco-systems	Open sea, oceans	Atmosphere	TOTAL	Supply & use system
	IPCC land use classification	SL = Settle-ments	CL = Cropland	GL = Grass-land	FL = Forest Land	OL = Other Land	WL = Wetlands	Water bodies, rivers					
I. Ecosystem Carbon Basic Balance													
C1	Opening Stocks												
C2.3	*NPP (Net Primary Production)*												
C2.4	*Secondary ecosystem repiration (heterotrophic)*												
C2.a	NEP (Net Ecosystem Production) = C2.3-C2.4												
C2.b	s/Total secondary biocarbon resource												
C2	Total inflow of biocarbon (gains) = C2.a+C2.b												
C3.a	Harvest of agriculture crops, wood & other vegetation												
C3.b	Withdrawals of secondary biocarbon												
C3	Total withdrawals of biocarbon = C3.a+C3.b												
C4	Net indirect anthropogenic losses of biocarbon & biofuel combustion												
C5	Total use of ecosystem biocarbon = C3+C4												
C6	Natural processes and disturbances												
C7	Total outflow of biocarbon (losses)												
C8.1	NECB 1 [Flows] = Inflows - Outflows = C2-C7												
C8.2	Adjustment and reappraisals												
C8.3	NECB 2 [Stocks] = Change of biocarbon stocks												
C9	Closing Stocks = C1+C8.1+C8.2 or = C1+C8.3												
II. Accessible Resource Surplus													
C2	Total inflow of biocarbon (gains) = C2.a+C2.b												
C10	Accessibility net correction												
C11	Net Ecosystem Accessible Carbon Surplus = C2 + C10												

SEEA-EEA & ENCA-QSP land cover ecosystem units		LCEU 1	LCEU 2, 3, 4	LCEU 5	LCEU 6	LCEU 7, 8, 9, 10, 11, 12	LCEU 12	LCEU 13, 14	Total inland & coastal eco-systems	Open sea, oceans	Atmosphere	TOTAL	Supply & use system
IPCC land use classification		SL = Settle-ments	CL = Cropland	GL = Grass-land	FL = Forest Land	OL = Other Land	WL = Wetlands	Water bodies, rivers					
III. Total Uses of Ecosystem Bio and Geo-Carbon													
C5	Total use of ecosystem biocarbon = C3+C4												
C12.1	*Imports of biocarbon/ commodities & residuals content*												
C12.2	*Exports of biocarbon/ commodities & residuals content*												
C12a	Direct use of biocarbon = C5+C12.1												
C12.3	*Virtual biocarbon embedded into imported commodities*												
C12c	Biocarbon requirement = C12a+C12.3												
C12b	Domestic consumption of biocarbon = C5+C12.1-C12.2												
C13a	Direct use of fossil carbon												
C13.3	*Virtual fossil carbon embedded into used commodities*												
C13b	Fossil carbon requirement = C13a+C13.3												
C14a	Total Carbon Direct Use = C12a+C13a												
C14b	Total Carbon Requirement = C12c+C13b												
IV. Table of indexes of intensity of use and ecosystem health													
C11	Net Ecosystem Accessible Carbon Surplus = C2 + C10												
C5	Total use of ecosystem biocarbon = C3+C4												
SCU	Sustainable intensity of carbon use = C11/C5												
CEH	Composite ecosystem biocarbon health index												
CIP	Biocarbon ecological internal unit value = AVG(SCU+CEH)												

Annex 2. European marine regions according to the MSFD.

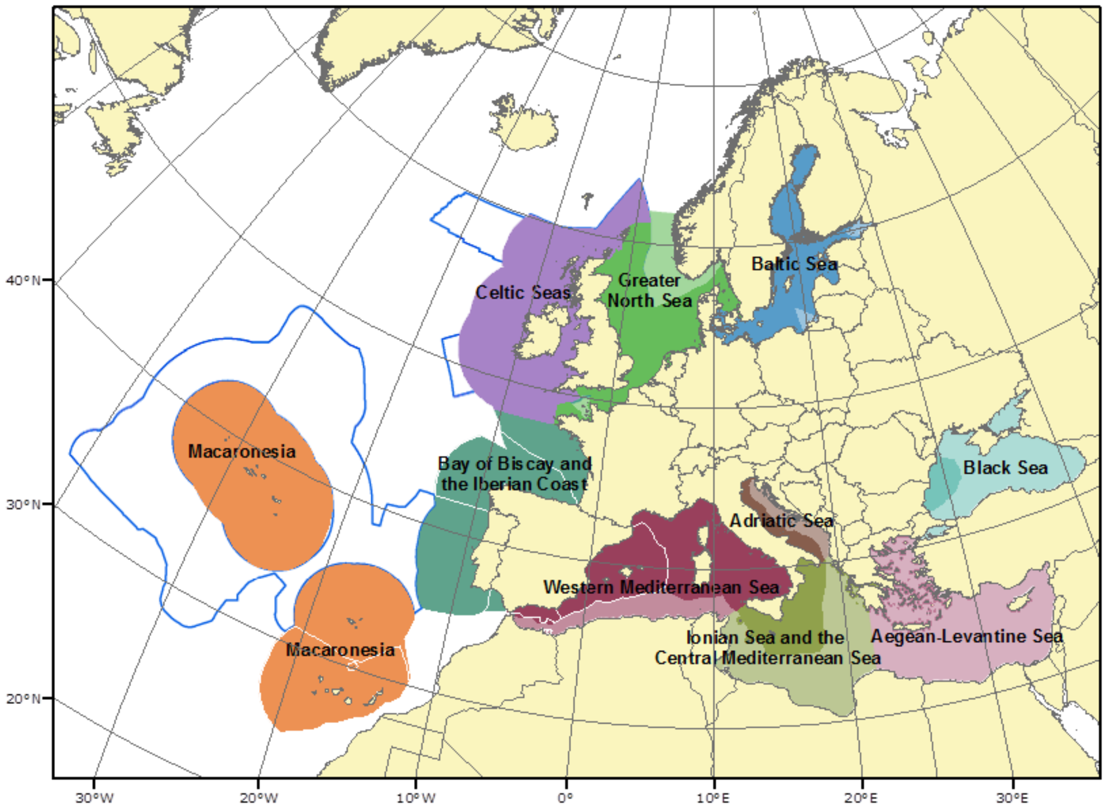

Figure 1 Draft map of MSFD regions and sub- regions (Note: this is a 'live' map, subject to changes as MSs provide input through the MSFD CIS-related processes)

These MSFD (sub-) regions are the basis for the marine fish biomass accounting.

(a) the Baltic Sea;

(b) 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;

(c) 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.

(d) the Black Sea.

Annex 3. Detailed information on stocks used and corresponding species and areas selection for the European assessment

The biomass accounts for the North East Atlantic (consisting of several subregions) and the Baltic sea have been calculated using the ICES (International Council for the Exploration of the Sea) stock database. This database has been downloaded from http://www.ices.dk/marine-data/tools/Pages/stock-assessment-graphs.aspx. Official citation: "ICES Stock Database, Extraction date: 2016/05/16 of all stocks 2015. ICES, Copenhagen". The downloaded ICES Stock database consists of 112 stocks providing information by stock and year on a number of variables for assessment year 2015. The time period for which this information is available varies per stock.

For the regional assessments stocks with absolute biomass and catch estimates are included in the analysis, resulting in a selection of 54 fish stocks (Table 1). These stocks have been assigned to a MSFD region based on the ICES Subareas and Divisions mentioned in their stock description (Table 1). The definition of the MSFD Ecoregions can be found in Table 2. Note that the assigned MSFD regions to the fish stocks in this study are not final and still subject to discussion.

According to their stock description 11 stocks cover more than one region (Table 1: stocks in bold). For the regional analysis involving biomass and catch estimates it was necessary to redistribute these stocks over the different regions. This was done according to their catches as they occur in the ICES Official Nominal Catches 2006-2014 (Official citation: "Version 12-05-2016. Accessed 30-05-2016 via (http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx. ICES, Copenhagen."). The redistribution fractions are based on the summed catches for the period 2006-2014 which were assigned to MSFD regions as defined in Table 2. For example, for stock bss-47 catches were taken from areas IVb and c, VIIa and VIId-h. Catches for areas IVb and c and VIId were then assigned to the North Sea region and catches for areas VIIa, e-h to the Celtic Seas region (see also Table 3). This resulted in 55% and 45% of the absolute biomass and catch estimates for bss-47 being attributed to the North Sea and Celtic Seas Ecoregion respectively. Table 4 gives an overview of the redistribution fractions that were used for the 11 stocks.

The biomass accounts have been calculated for the time period in which information was available for a consistent number of stocks, i.e. 1999-2013.

Table 1: Overview of selected 54 stocks that are included in the analysis. Bold stocks cover more than one MSFD region. (source: http://www.ices.dk/marine-data/tools/Pages/stock-assessment-graphs.aspx). [*1] For area coverage for the MSFD Ecoregions see Table x.2. [*2] Assigned MSFD regions differ from the MSFD regions assigned by ICES.

Fishstock	Stock description	MSFD Ecoregion(s) [*1]
Ane-bisc[*2]	Anchovy (*Engraulis encrasicolus*) in Subarea VIII (Bay of Biscay)	Bay of Biscay and the Iberian Coast Ecoregion
Anp-8c9a	White anglerfish (*Lophius piscatorius*) in Divisions VIIIc and IXa (Cantabrian Sea, Atlantic Iberian Waters)	Bay of Biscay and the Iberian Coast Ecoregion
Bss-47	**Seabass (*Dicentrarchus labrax*) in Divisions IVb and c, VIIa, and VIId–h (Central and South North Sea, Irish Sea, English Channel, Bristol Channel, Celtic Sea)**	**Greater North Sea Ecoregion** **Celtic Seas Ecoregion**
Cod-2224	Cod (*Gadus morhua*) in Subdivisions 22–24 (Western Baltic Sea)	Baltic Sea Ecoregion
Cod-347d[*2]	Cod (*Gadus morhua*) in Subarea IV and Divisions VIId and IIIa West (North Sea. Eastern English Channel. Skagerrak)	Greater North Sea Ecoregion
Cod-7e-k[*2]	Cod (*Gadus morhua*) in Divisions VIIe–k (Western English Channel and Southern Celtic Seas)	Celtic Seas Ecoregion
Cod-arct[*2]	Cod (*Gadus morhua*) in Subareas I and II (Northeast Arctic)	Barents and Norwegian Sea Ecoregion
Cod-farp[*2]	Cod (*Gadus morhua*) in Subdivision Vb1 (Faroe Plateau)	Iceland and East Greenland Ecoregion
Cod-scow	Cod (*Gadus morhua*) in Division VIa (West of Scotland)	Celtic Seas Ecoregion
Had-346a	**Haddock in Subarea IV and Divisions IIIa West and VIa (North Sea, Skagerrak and West of Scotland)**	**Greater North Sea Ecoregion** **Celtic Seas Ecoregion**
Had-7b-k[*2]	Haddock in Divisions VIIb,c,e-k	Celtic Seas Ecoregion
Had-arct[*2]	Haddock in Subareas I and II (Northeast Arctic)	Barents and Norwegian Sea Ecoregion
Had-faro[*2]	Haddock in Division Vb	Iceland and East Greenland Ecoregion
Had-rock	Haddock in Division VIb (Rockall)	Celtic Seas Ecoregion
Her-2532-gor	Herring in Subdivisions 25 - 29 (excluding Gulf of Riga) and 32	Baltic Sea Ecoregion
Her-30	Herring in Subdivision 30 (Bothnian Sea)	Baltic Sea Ecoregion
Her-3a22	**Herring in Division IIIa and Subdivisions 22 - 24 (Western Baltic spring spawners)**	**Baltic Sea Ecoregion** **Greater North Sea Ecoregion**
Her-47d3	Herring in Subarea IV and Divisions IIIa and VIId (North Sea autumn spawners)	Greater North Sea Ecoregion
Her-67bc	Herring (*Clupea harengus*) in Divisions VIa and VIIb,c (West of Scotland, West of Ireland)	Celtic Seas Ecoregion
Her-nirs	Herring in Division VIIa North of 52° 30’ N (Irish Sea)	Celtic Seas Ecoregion
Her-noss[*2]	**Herring in Subareas I, II, V and Divisions IVa and XIVa (Norwegian spring-spawning herring)**	**Barents and Norwegian Sea Ecoregion** **Greater North Sea Ecoregion** **Iceland and East Greenland Ecoregion**
Her-riga	Herring in Subdivision 28.1 (Gulf of Riga)	Baltic Sea Ecoregion
Her-vasu[*2]	Herring in Division Va (Icelandic summer-spawners)	Iceland and East Greenland Ecoregion
Hke-nrtn[*2]	**Hake in Division IIIa, Subareas IV, VI and VII and Divisions VIIIa,b,d (Northern stock)**	**Greater North Sea Ecoregion** **Celtic Seas Ecoregion**

		Bay of Biscay and the Iberian Coast Ecoregion
Hke-soth	Hake in Division VIIIc and IXa (Southern stock)	Bay of Biscay and the Iberian Coast Ecoregion
Hom-west[*2]	**Horse mackerel (*Trachurus trachurus*) in Divisions IIa, IVa, Vb, VIa, VIIa-c, e-k, VIII (Western stock)**	**Barents and Norwegian Sea Ecoregion** **Greater North Sea Ecoregion** **Iceland and East Greenland Ecoregion** **Celtic Seas Ecoregion** **Bay of Biscay and the Iberian Coast Ecoregion**
Lin-icel	Ling (*Molva molva*) in Division Va	Iceland and East Greenland Ecoregion
Mac-nea[*2]	**Mackerel in the Northeast Atlantic (combined Southern, Western and North Sea spawning components)**	**Barents and Norwegian Sea Ecoregion** **Baltic Sea Ecoregion** **Greater North Sea Ecoregion** **Iceland and East Greenland Ecoregion** **Celtic Seas Ecoregion** **Bay of Biscay and the Iberian Coast Ecoregion** **Azores Ecoregion**
Mgb-8c9a	Four-spot megrim (*Lepidorhombus boscii*) in Divisions VIIIc and IXa	Bay of Biscay and the Iberian Coast Ecoregion
Mgw-8c9a	Megrim (*Lepidorhombus whiffiagonis*) in Divisions VIIIc and IXa	Bay of Biscay and the Iberian Coast Ecoregion
Nop-34-oct[*2]	Norway Pout in Subarea IV (North Sea) and IIIa (Skagerrak - Kattegat) - Autumn assessment	Greater North Sea Ecoregion
Pan-sknd	Northern shrimp (*Pandalus borealis*) in Divisions IIIa West and IVa East (Skagerrak and Norwegian Deeps)	Greater North Sea Ecoregion
Ple-2123	Plaice in Subdivisions 21, 22, and 23 (Kattegat, Belts, and Sound)	Baltic Sea Ecoregion
Sai-3a46	**Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall)**	**Greater North Sea Ecoregion** **Celtic Seas Ecoregion**

Table 1: Continued

Fishstock	Stock description	MSFD Ecoregion(s)*
Sai-arct*2	Saithe in Subareas I and II (Northeast Arctic)	Barents and Norwegian Sea Ecoregion
Sai-faro*2	Saithe in Division Vb (Faroe Saithe)	Iceland and East Greenland Ecoregion
San-ns1	Sandeel in the Dogger Bank area (SA 1)	Greater North Sea Ecoregion
San-ns2	Sandeel in the South Eastern North Sea (SA 2)	Greater North Sea Ecoregion
San-ns3	Sandeel in the Central Eastern North Sea (SA 3)	Greater North Sea Ecoregion
Sar-soth	Sardine in Divisions VIIIc and IXa	Bay of Biscay and the Iberian Coast Ecoregion
Smr-5614	**Golden Redfish (*Sebastes norvegicus*) in Subareas V, VI, XII and XIV**	**Iceland and East Greenland Ecoregion Celtic Seas Ecoregion Azores Ecoregion**
Sol-bisc	Sole in Divisions VIIIa,b (Bay of Biscay)	Bay of Biscay and the Iberian Coast Ecoregion
Sol-celt	Sole in Divisions VIIf, g (Celtic Sea)	Celtic Seas Ecoregion
Sol-echw*2	Sole in Division VIIe (Western Channel)	Celtic Seas Ecoregion
Sol-iris	Sole in Division VIIa (Irish Sea)	Celtic Seas Ecoregion
Sol-kask	**Sole in Division IIIa and Subdivisions 22-24 (Skagerrak, Kattegat, and the Belts)**	**Baltic Sea Ecoregion Greater North Sea Ecoregion**
Sol-nsea	Sole in Subarea IV (North Sea)	Greater North Sea Ecoregion
Spr-2232	Sprat in Subdivisions 22 - 32 (Baltic Sea)	Baltic Sea Ecoregion
Spr-nsea*2	Sprat in Subarea IV (North Sea)	Greater North Sea Ecoregion
Usk-icel*2	Tusk in Division Va and Subarea XIV	Iceland and East Greenland Ecoregion
Whb-comb*2	**Blue whiting in Subareas I-IX, XII and XIV (Combined stock)**	**Barents and Norwegian Sea Ecoregion Baltic Sea Ecoregion Greater North Sea Ecoregion Iceland and East Greenland Ecoregion Celtic Seas Ecoregion Bay of Biscay and the Iberian Coast Ecoregion Azores Ecoregion**
Whg-47d*2	Whiting Subarea IV (North Sea) and Division VIId (Eastern Channel)	Greater North Sea Ecoregion
Whg-7e-k*2	Whiting in Division VIIe-k	Celtic Seas Ecoregion
Whg-scow	Whiting in Division VIa (West of Scotland)	Celtic Seas Ecoregion

Table 2: Overview of area coverage for different MSFD Ecoregions. [*1] ICES further splits this Ecoregion into (i) Norwegian Sea Ecoregion (ICES Subarea I) and (ii) Barents Sea Ecoregion (ICES Subarea II). [*2] ICES further splits this Ecoregion into (i) Iceland Sea Ecoregion (ICES Subarea Va), (ii) Faroes Ecoregion (ICES Subarea Vb), and (iii) Greenland Sea Ecoregion (ICES Subarea XIV).

MSFD Ecoregion	**Area coverage**
Barents and Norwegian Sea Ecoregion[*1]	ICES Subareas I, II
Baltic Sea Ecoregion	ICES Subarea III (excl. Division IIIa)
Greater North Sea Ecoregion	ICES Division IIIa, Subarea IV, Division VIId
Iceland and East Greenland Ecoregion[*2]	ICES Subareas V, XIV
Celtic Seas Ecoregion	ICES Subareas VI, VII (excl. Division VIId)
Bay of Biscay and Iberian Sea Ecoregion	ICES Subareas VIII, IX
Azores Ecoregion	ICES Subareas X, XII

Table 3: Total catches for stock bss-47 by year and ICES division as described in the stock description in Table 1 and corresponding fraction that has been used to redistribute this stock over the Ecoregions.

	IVb	IVc	VIId	VIIa	VIIe	VIIf	VIIg	VIIh
	Greater North Sea			Celtic Seas				
2006	11	551	1231	16	1352	145	57	10
2007	7	544	1566	23	1126	197	35	22
2008	17	548	1341	18	808	212	46	18
2009	21	696	1792	21	1406	147	43	147
2010	21	733	1686	11	2217	103	65	117
2011	24	611	1512	11	1685	148	56	136
2012	10	410	1532	12	1616	156	48	98
2013	8	505	1723	18	1667	148	56	114
2014	17	495	1192	16	820	142	51	73
Total	**18804**			**15433**				
Fraction of redistribution	**0.55**			**0.45**				

Table 4: Fractions that have been used to redistribute total biomass and catch estimates over the different Ecoregions. Calculations of the fractions are based on the ICES Official Nominal Catches 2006-2014 (Official citation: "Version 12-05-2016. Accessed 30-05-2016 via (http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx. ICES, Copenhagen.")

MSFD Ecoregion	Bss-47	Had-346a	Her-3a22	Her-noss	Hke-nrtn	Hom-west	Mac-nea	Sai-3a46	Smr-5614	Sol-kask	Whb-comb
Barents and Norwegian Sea Ecoregion				0.681		0.005	0.228				0.087
Baltic Sea Ecoregion			0.434				0.000			0.178	0.000
Greater North Sea Ecoregion											
Iceland and East Greenland Ecoregion				0.153		0.001	0.167		1.000		0.269
Celtic Seas Ecoregion	0.449	0.100			0.559	0.751	0.232	0.078	0.000		0.560
Bay of Biscay and Iberian Sea Ecoregion					0.297	0.090	0.040				0.026
Azores Ecoregion							0.000		0.000		0.019
Barents and Norwegian Sea Ecoregion				0.681							
Baltic Sea Ecoregion											
Greater North Sea Ecoregion	0.551	0.900	0.566	0.166	0.144	0.154	0.333	0.922		0.822	0.040
Iceland and East Greenland Ecoregion											