MANAGEMENT WORKS – THE BENEFITS OF ENDING OVERFISHING

FINAL REPORT

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Report produced by

POSEIDON
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Disclaimer and Report Information

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EXECUTIVE SUMMARY

This report by Poseidon Aquatic Resource Management Ltd was commissioned by The Pew Charitable Trusts as part of its ongoing campaign to end overfishing in the waters of north-western Europe.

Many European Union (EU) fish stocks have been, and continue to be, fished above sustainable levels. Since 2014, the reformed Common Fisheries Policy (CFP) has included a legally binding commitment to fish at sustainable levels – the Maximum Sustainable Yield (MSY) – by 2015 where possible and for all stocks by 2020.

Exploiting fish stocks at rates equal to or lower than MSY allows them to recover to healthy levels, able to provide food for consumers while also maintaining important ecosystem and marine food web functions.

This report aims to highlight examples where fisheries management has worked to end overfishing, and showcase the resulting benefits, using a case study approach that focuses on five fish stocks[1]:

- haddock in the North Sea,
- plaice in the Eastern English Channel,
- horse mackerel in Atlantic Iberian waters,
- herring in the North Sea, and
- nephrops in Skagerrak and Kattegat.

These examples show that well-managed fisheries lead to healthy fish stocks and result in a cascade of positive outcomes, including increased income to fishers and reduced impacts on the wider environment.

Other benefits relate to improved efficiency: as fish stocks recover from overfishing, the time and fishing effort required to catch the same amount of fish (catch per unit effort [CPUE]) reduces.

For example, the Portuguese fleet targeting horse mackerel fished 5% fewer days at sea in 2015 compared to 2010, but shows a significantly improved CPUE (+93%) as the horse mackerel stock improved. The improved CPUE made possible due to recovered stocks means more efficient fishing, which helps to reduce the environmental impacts of fishing. As the fishing gear is in the water for less time, there is less impact on seabed habitats and bycatch species. This can also be seen in the case of Danish and Swedish fleets targeting improving nephrops stocks in the Skagerrak and Kattegat, which have been able to reduce both their fishing 'footprint' on the seabed and their bycatch of cod, thereby contributing to the Kattegat cod stock's recovery from overfishing.

Other environmental benefits are also identified in the report, including the fact that, as less fuel is used due to improved CPUE, atmospheric emissions from fishing vessels are reduced.

Bringing stocks to sustainable levels has made fleets more profitable as greater catching efficiency reduces operating costs. For example, the profitability of Scottish demersal trawlers fishing for North Sea haddock more than doubled from 2009 to 2015. While other factors – particularly lower fuel prices – had a significant impact, the good status of the haddock stock meant that more fish could be caught faster and with reduced operating costs.

Improved fleet profitability generates a range of social benefits, including increased incomes for fishers and related positive consequences for dependent coastal communities. Less tangible benefits have also been reported by the fishing industry, such as the improved reputation and access to markets that stem from being able to show that the industry is landing fish from a sustainable source.

The case studies presented in this report clearly show that ending overfishing, and so delivering on the CFP's objective to fish at sustainable levels, creates a wealth of benefits.

[1] Case studies were selected using the most recent International Council for the Exploration of the Sea (ICES) assessments available, with values that can be subject to revision subsequently, e.g. see haddock case study.

1 INTRODUCTION AND CONTEXT

1.1 INTRODUCTION

This report undertaken by Poseidon Aquatic Resource Management Ltd was commissioned by The Pew Charitable Trusts as part of its ongoing campaign to end overfishing in north-western European waters.

The European Union (EU) reformed its Common Fisheries Policy (CFP) in 2013, with the objective to restore and maintain fish stocks at healthy levels by ending overfishing. By agreeing to the new CFP, all EU Member States committed to fish at sustainable levels, by 2015 where possible, and no later than 2020 for all EU fish stocks. Despite this, many stocks remain overfished and not on track to meet this deadline. Further effort is needed to meet the commitments of the CFP and to reap the many benefits brought about by ending overfishing.

This study will briefly introduce the concept and consequences of overfishing, as well as key terminology of fisheries management and fishing gears. Subsequently, the report explores five positive case studies, illustrating how fisheries management can end overfishing and aid the recovery of fish stocks, and in doing so, achieve economic, social and environmental gains. Finally, common themes and conclusions are drawn from the case studies examined.

1.2 WHAT IS OVERFISHING AND HOW IS IT AVOIDED?

Overfishing takes place when more than the **sustainable share** is removed from a fish stock. This will reduce the population size, reduce the amount of recruitment[2] and lead to a decline in the overall size of the fish stock. In extreme cases, overfishing can lead to the complete collapse of a fish stock.

The largest share of fish that can be removed from a stock without these negative impacts is called the **Maximum Sustainable Yield (MSY)**. Fishing at MSY levels should ensure the capacity of the stock to continue to produce this level in the long term[3].

Maximum Sustainable Yield (MSY) is the largest yield (catch, in tonnes) that can be taken from a specific fish stock over an indefinite period under constant environmental conditions[4].

To manage a fish stock, reference points can be defined against which the status of the stock and the level of exploitation can be measured. The MSY level is a key reference point in the CFP and is applicable to both fishing mortality (F) and biomass levels (B). F_{MSY} is the fishing mortality rate that results in this MSY; and B_{MSY} is the biomass that allows this MSY to be maintained.

The International Council for the Exploration of the Sea (ICES) defines an additional MSY trigger level for biomass (MSY $B_{trigger}$); if this level is not reached ICES advises lower fishing limits to safeguard the stock.

Fishery managers can control the level of exploitation within a fishery (e.g. through Total Allowable Catches [TACs], quotas, technical measures and effort control) to maintain the MSY level and, if necessary, promote rebuilding. However, fisheries management does not guarantee an optimal outcome. A fish stock is a biological resource that undergoes natural fluctuations and often varied cycles of recruitment. The unpredictability of additional factors can be challenging, but highlights the crucial role of fisheries managers and decision-makers to effectively manage those variables that can be controlled.

[2] Recruitment overfishing occurs when adults are depleted to the point that they cannot replenish themselves (The Pew Charitable Trust, 2016. Harvest Strategies Glossary).
[3] Adapted from: Seafish, 2011. MSY Industry Guidance Note.
[4] Adapted from: European Commission, 2016. Establishing a mixed fishery multi-annual plan for demersal stocks and their fisheries in the North Sea.

These boxes explain some key terms in fisheries science used in this report:

Status of the stock

Biomass terminology

Biomass (B): This is the combined weight (in tonnes) of all the fish of one specific stock (including all ages and all genders of fish).

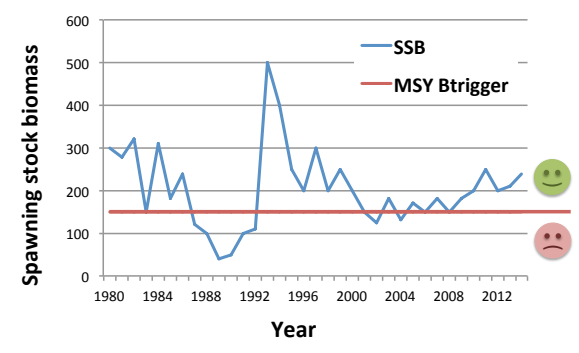
Spawning stock biomass (SSB): This is the combined weight (in tonnes) of all the fish of one specific stock that are capable of reproducing. It provides an indication of the status of the stock and the reproductive capacity of the stock.

Recruitment: The amount of new fish that join a defined group of fish each year—due to growth and/or migration. The defined group may be the exploited part of a population, which is described as recruitment to the fishery. The defined group also may be the whole population (fished or unfished) older than a certain age (e.g., age 1 or the age at maturity).[5]

MSY terminology

B_{MSY}: This is the biomass that enables a fish stock to deliver its Maximum Sustainable Yield. In theory, B_{MSY} is the population size at the point of maximum growth rate.

MSY $B_{trigger}$: ICES considers that a sustainably fished stock will fluctuate around B_{MSY}, so has defined **MSY $B_{trigger}$ as the lower bound** of this fluctuation[6]. ICES measures the status of a stock against MSY $B_{trigger}$. It should be noted that ICES does not provide B_{MSY} as part of its advice.



Explaining the graph:

The SSB (blue line) is calculated annually and plotted on a time series to determine the status of the stock in relation to the MSY $B_{trigger}$ (red line), which is the biomass reference point used by ICES.

If at or above the MSY $B_{trigger}$, ICES considers the stock at full reproductive capacity.

If below the MSY $B_{trigger}$, ICES recommends a reduction in the level of exploitation.

[5] The Pew Charitable Trust, 2016. Harvest Strategies Glossary

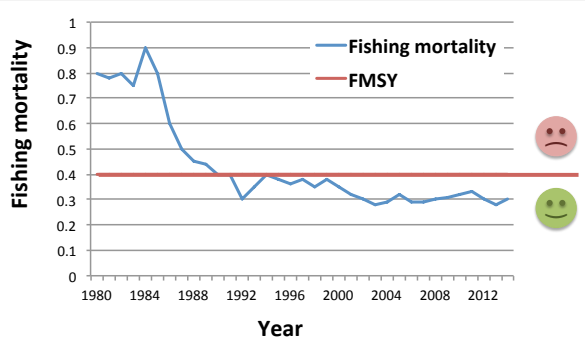
[6] ICES, 2016. ICES Advice Basis. February 2016
http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2016/2016/Introduction_to_advice_2016.pdf

Level of exploitation

Exploitation terminology

Yield (Y): This is the catch i.e. the fish removed from the water by fishing (in tonnes).

Fishing mortality (F): This is the proportion of fish within a stock that are caught and removed from it by fishing



MSY terminology

F_{MSY}: This is the maximum rate of fishing mortality allowing a population size to eventually reach or maintain B_{MSY} within a single stock, usually across a long time frame. F_{MSY} is set at a constant rate, which is different for each stock, and can be applied to any stock that is not impaired in its reproductive capacity.

Explaining the graph:

Fishing mortality can be managed by setting limits on the quantity of fish that can be caught and/or landed (e.g. via Total Allowable Catch [TACs] and quota allocations, days at sea, licences, etc.). Fishing mortality is plotted on a time series in relation to F_{MSY}.

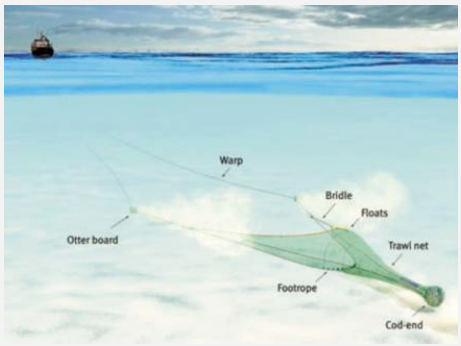
If above F_{MSY} then fishing mortality is too high to support B_{MSY} and should be reduced.

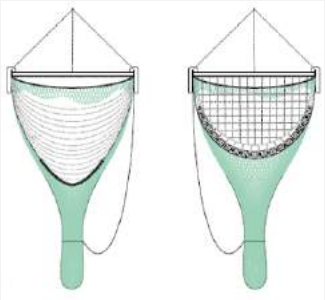
If at or below F_{MSY} then fishing mortality can be expected to allow a population size of B_{MSY}, as long as the stock is not impaired in its reproductive capacity.

The following provides a brief description of the fishing gears used within the case studies.

GEAR TYPES

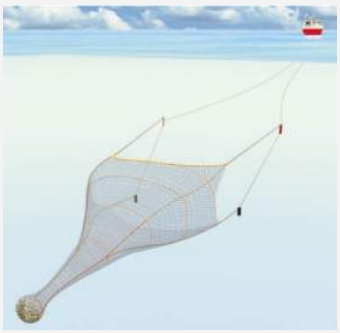
Demersal otter trawl, used to target haddock, plaice and nephrops, is a towed fishing gear designed and rigged to have bottom contact with the seabed during fishing. Gear can be operated as single, twin or pair trawl. The trawl itself is a cone-shaped net consisting of a body, closed by a cod end knot; the net is held open by two otter boards that also have contact with the seabed. Some trawls (including nephrops trawl) must be fitted with a selectivity device (the Seltra trawl and the Swedish grid are two common devices used) to avoid the bycatch of cod.



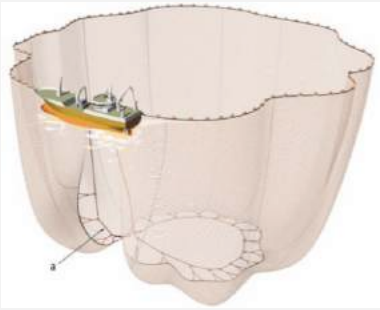


Beam trawl, used to target plaice, is towed from an outrigger boom, one on each side of the vessel. The trawl net is held open by a beam (which is normally a heavy steel tube and 7–12m long). Between the beam and the lower opening of the net several tonnes of tickler chains or chain mats are used to disturb fish that then enter the net. The beam, chains and ground-ropes all make contact with the seabed.

Demersal seine (Scottish seine or fly-dragging) used to target haddock, is a ground fishing method for which uses long lengths of rope to herd fish into the path of the net as the gear is hauled. The gear is set in a triangular shape, with a marker buoy attached to the first rope end, the net set behind the located fish, and the remaining rope set as the vessel returns to the buoy. The vessel then steams slowly ahead while heaving in both ropes, gradually advancing speed as the gear closes to keep the net moving forward at a steadily increasing rate to herd the fish into the net.



Pelagic trawl, used to target herring and horse mackerel, are towed in the water column to intercept target shoals of fish. The large net consists of a cone-shaped body, ending in a cod end. Nets are held open with mid-water otter boards. The gear has no contact with the seabed.



Purse seines, used to target large aggregations of pelagic fish including horse mackerel, are set to surround shoals of fish in mid-water or near the surface with a deep curtain of netting supported at the surface by floats. Small lead weights quickly sink the curtain under the shoal of fish, the net is then pursed by heaving on a wire (shown as “a” in the figure) which brings the shoal of fish to the surface.

[Images from Galbraith and Rice, 2004]

2 CASE STUDY APPROACH

2.1 WHAT MAKES A GOOD CASE STUDY?

This work highlights successes to show that a well-managed fishery can create a cascade of positive outcomes that result from healthy fish stocks, from boosting income to reducing environmental impacts.

There are hundreds of species and stock combinations in European waters. Some fisheries are well managed, others are less so, and many still lack the scientific data or modelling needed to provide evidence of performance. It is important to be able to link a particular stock with specific fishing fleets in order to explore how a fleet's economic performance and/or social and environmental gains are impacted by the status of that stock.

In total, 41 fish stocks in the north-east Atlantic region (including North Sea, Celtic Sea, English Channel, Baltic Sea, Kattegat, Skagerrak, Irish Sea, Celtic Sea and Iberian waters) for which data is available were reviewed and considered against the following criteria:

- that fishing mortality (F) has been consistently below (or at) the rate considered to enable MSY (F_{MSY}) for at least the last three to five years[7];
- that the case studies provide a range of species types, e.g. demersal roundfish, flatfish, pelagic fish, and shellfish; and
- that the case studies cover a range of seas and stock distributions within the north-east Atlantic region.

In accordance with these three criteria, five case studies were selected:

Common name	Type	Stock	ICES Divisions
Haddock	Demersal roundfish	North Sea, West of Scotland and Skagerrak	4, 3a (Skagerrak only) & 6a
Plaice	Flatfish	Eastern English Channel	7d
Horse mackerel	Pelagic fish	Atlantic Iberian waters	9a
Herring	Pelagic fish	North Sea, Skagerrak and Kattegat, Eastern English Channel	4, 3a & 7d
Nephrops	Shellfish	Skagerrak and Kattegat	3a

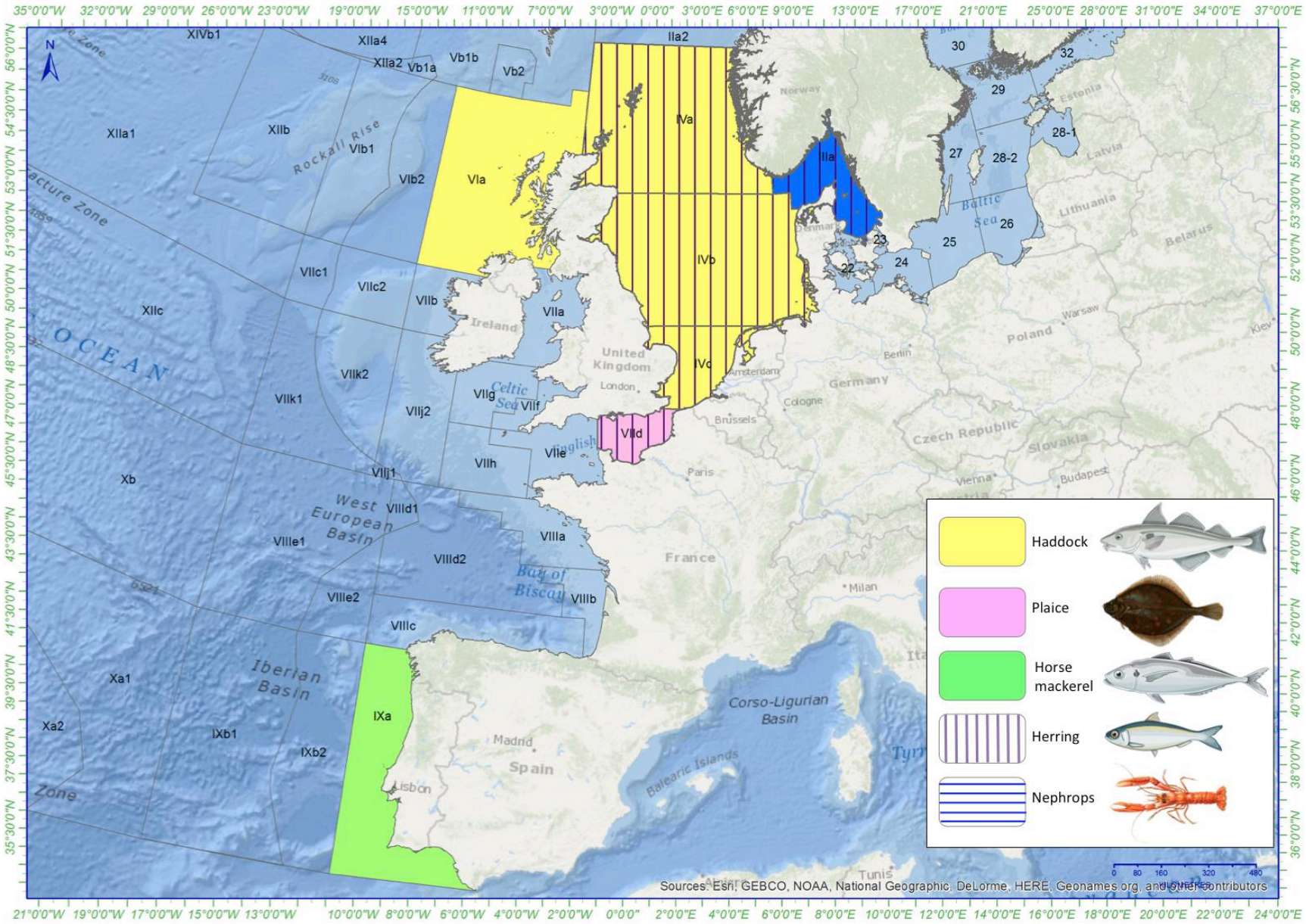
The locations of the case study stocks are shown in the map on the next page.

2.2 KEY INFORMATION SOURCES

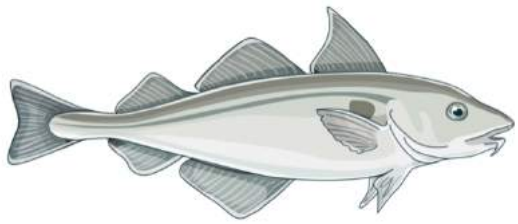
The five case studies are informed by key information sources including:

- ICES stock assessments, which provide insight into the status of the stocks and levels of exploitation over a long time period;
- data on EU landings by country, species, area and gear, collected under the EU Data Collection Framework (DCF); and
- EU Scientific, Technical and Economic Committee for Fisheries (STECF) Annual Economic Report (AER), which presents fleet performance data (also collected through the DCF).

[7] Case studies were selected using the most recent International Council for the Exploration of the Sea (ICES) assessments available, with values that can be subject to revision subsequently, e.g. see haddock case study.


Haddock
Plaice
Horse mackerel
Herring
Nephrops
Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

3 NORTH SEA, WEST OF SCOTLAND AND SKAGERRAK HADDOCK



Species: Haddock, *Melanogrammus aeglefinus*

Area: North Sea, West of Scotland, and Skagerrak

ICES Divisions: 4, 3a (Skagerrak only) & 6a

This case study was informed by the most recent ICES stock assessment available at the time of writing the report (2015[8]). Since then, ICES released the 2016[9] stock assessment for haddock (November 2016), which includes a large reduction in the value of F_{MSY}. This is due to the sustained low level of recruitment now being considered as representative of the stock productivity. Furthermore, an error in the computer code used for the ICES 2015 assessment was identified and therefore the 2016 assessment used an alternative model configuration. The resulting lower F_{MSY} (reduced from 0.37 to 0.19) and re-modelling means that the stock in 2016 is considered to be harvested above F_{MSY}; in addition SSB has fallen below MSY $B_{trigger}$ and advice is to heavily reduce the total catch in 2017. The haddock stock in 2016 is therefore considered to be overfished and would therefore not have qualified as a positive case study based on the selection criteria used.

Introduction to the haddock fishery

Haddock is a demersal roundfish species, meaning it remains near the seabed where it feeds on small bottom-living organisms, normally at depths of 80 to 200m[10]. Haddock are predominately caught by bottom fishing gears including otter trawl, pair trawl and demersal seine gears.

As a gadoid fish, haddock is very similar in size and taste to cod (*Gadus morhua*). Its white, tender meat is eaten throughout Europe, but it is a particular favourite in the UK market, where it is a popular choice in fish and chip shops, and sold breaded/battered in supermarkets. Other traditional haddock dishes include Scottish Arbroath smokies (smoked in the town of Arbroath), kedgeree (an Anglo-Indian dish), and Cullen skink (chowder soup).

Key fleets

The haddock fishery in the North Sea, West of Scotland and Skagerrak is worth over €80 million annually in first sale value[11] and is landed by more than ten different fishing nations.

[8] ICES, 2015. ICES advice for haddock in Subarea IV and Divisions Via and IIIa West.

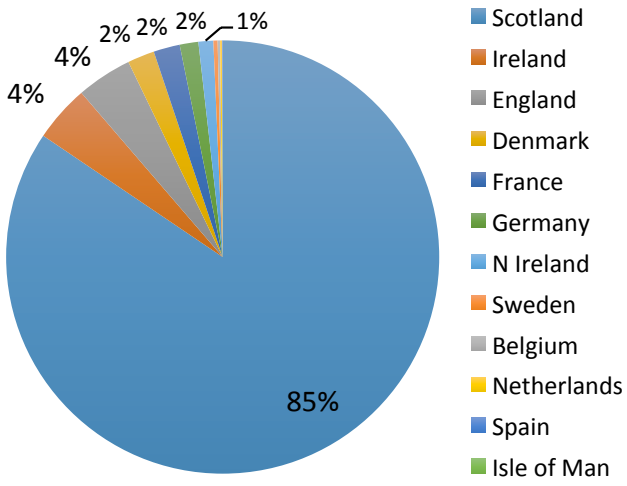
[9] ICES, 2016. 6.3.16 Haddock (*Melanogrammus aeglefinus*) in Subarea 4, Division 6.a, and Subdivision 3.a.20 (North Sea, West of Scotland, Skagerrak). Published 11 November 2016 Version 2: 18 November 2016

[10] Muus, B.J. and J.G. Nielsen, 1999. Sea fish. Scandinavian Fishing Year Book, Hedehusene, Denmark.

[11] First sale value is the value achieved at point of landing. Based on a ten-year average (2005–2014) of 45,000 tonnes being landed annually (EU DCF, 2016) at a value of €1,778.10 per tonne (based on UK price for haddock in 2014 [MMO, 2016]).

The Scottish demersal trawl fleet is responsible for 85% of the landings by weight[12], followed by Ireland and England (4% each). Haddock is currently the most important whitefish species for the Scottish fishing industry[13].

Much of the processing, added value, onward sale and consumption of Scottish haddock takes place in Scotland, making this stock of vital importance to ancillary businesses throughout the Scottish seafood supply chain.

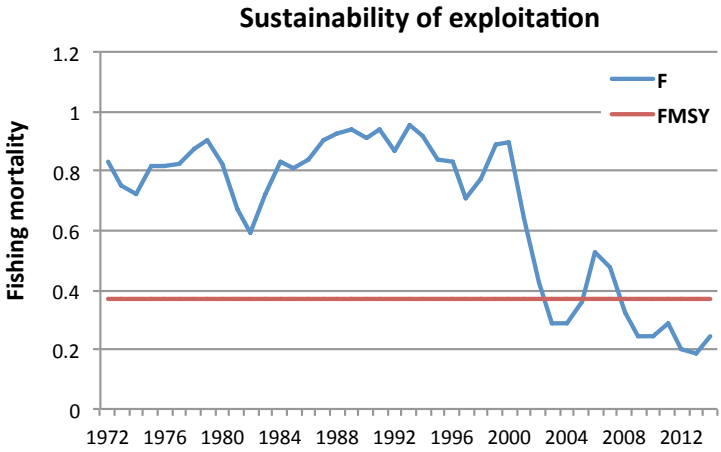


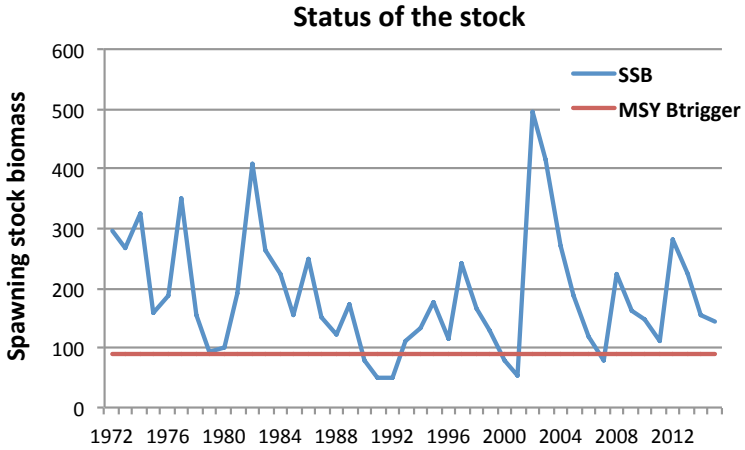
Proportion of haddock landings by fishing nation (landed weight from ICES Divisions 4, 3a & 6; average from 2005 to 2014. Data: EU DCF, 2016)

Sustainability of exploitation

The graph[14] shows that the rate of exploitation (i.e. fishing mortality, F) was too high (i.e. above F_{MSY}) between 1972 and 2002. However, a dramatic decrease in fishing mortality in 2003 brought the rate of exploitation to a position where it was fluctuating around F_{MSY}, before finally dropping below F_{MSY} in 2008, where it has remained to date.

The status of this haddock stock is good and it is currently considered to be at full reproductive capacity.





Across the same time series (from 1972 to 2014), the spawning stock biomass (SSB) has only fallen below MSY $B_{trigger}$ on three occasions, all for short periods of time.

Since 2008, the SSB has been above MSY $B_{trigger}$[14].

Key recruitment years occurred in 1973, 1979 and 1999[14] (with corresponding spikes in SSB shown in the graph for 1976, 1982 and 2002 when the new fish reached spawning size). After the 1979 recruitment the

[12] Based on a ten-year average (EU DCF, 2016).
[13] Scottish Government, 2016. Marine Scotland Science Fish and Shellfish Stocks. 2016 Edition.
[14] ICES, 2015. ICES advice for haddock in Subarea IV and Divisions Via and IIIa West.

rate of exploitation (shown on the first graph) decreased, which supported the growth of juvenile fish; however as soon as the fish reached spawning size (in 1982), fishing mortality rose sharply and continued increasing into the early 1990s, leading to a short period when SSB was below MSY $B_{trigger}$. This demonstrates that the opportunity to protect the good recruitment year was not taken and fishing mortality increased to the detriment of the stock[15].

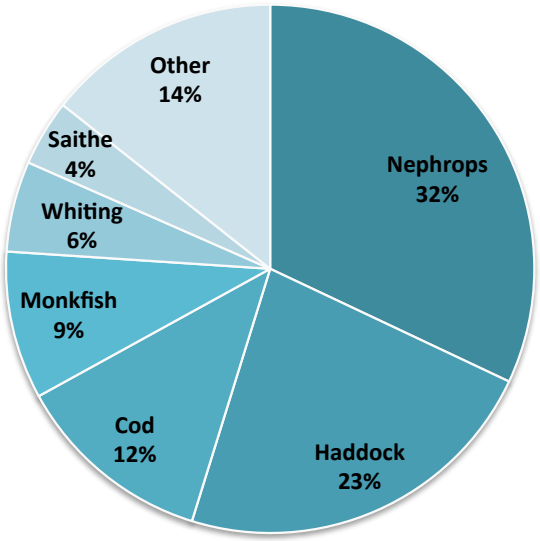
Fortunately, important lessons were learnt from these trends and management measures were in place by the time of the next big recruitment event in 1999. This time, fisheries managers reduced exploitation of the stock, thereby lowering the likelihood of juvenile fish from being caught and discarded. Crucially, this reduction continued even when the 1999 fish reached spawning size in 2001–2002, thereby safeguarding this year class.

Recruitment levels have been lower since 1999, but SSB has largely remained above MSY $B_{trigger}$, and considered to be at full reproductive capacity[14], highlighting the success of fisheries management in ensuring that exploitation is at a level that has maintained a sustainable biomass.

Economic, social and environmental benefits

Haddock is a key component of the catch of several fleets, providing a large proportion of fleet revenue. For the Scottish demersal trawl and seine fleet, 23% of landings value is from haddock[16], and among vessels not targeting nephrops the dependency on haddock is even higher.

Economic performance trend: seafish economic performance data for UK fisheries shows that, from 2006 to 2015, haddock fleets in the North Sea and West of Scotland used less time to catch more fish: the total days at sea per year reduced by 33%[17], while the landings per day at sea increased by 58%. This means that the vessels are catching haddock more efficiently, and using less time and resources to land higher quantities of fish. This represents an increase in the catch per unit effort (CPUE), which has in turn resulted in a significant increase in the operating profit per vessel. Profits on demersal trawlers over 24m in length more than doubled from €11,000 profit per full-time equivalent (FTE[18]) in 2009, to €30,500 in 2015[18]. However, it should be noted that a range of factors can affect operating profits, including fuel prices, which have gone down substantially since the high prices in 2012[19].



Proportion of landings by value for Scottish over 10m demersal trawl and seine fleet in 2014 from ICES Division 4 & 6a (total value= €198 million; not including pelagic species; Data: MMO, 2016)

[15] Fishing mortality is mainly managed by limiting fishing via Total Allowable Catches (TACs) set for the stock and allocated to different countries via a quota. Annual changes in the TAC must be within 15%, as per the Long-Term Management Plan for Haddock (ICES, 2014).

[16] Corroborated through MMO (2016) landings data and preliminary findings on fleet-stock dependency by Joint Research Council, 2016.

[17] Based on average from three fleets targeting haddock in North Sea and West of Scotland: demersal pair trawl and seine, demersal seiners, and demersal trawlers >24m in length (Seafish, 2016).

[18] Seafish, 2016 Economic Performance Data. Estimated employment based on survey data combined with MMO employment data. Sample information on the number of full-time and part-time crew was used to estimate total engaged crew based on vessel characteristics and level of activity. FTE jobs were then estimated based on national and harmonised definitions.

The Scottish Fisheries Sustainable Accreditation Group (SFSAG) achieved Marine Stewardship Council (MSC) certification for haddock in the North Sea in 2010. The good status of the haddock stock, particularly keeping the fishing mortality below F_{MSY}, were critical to it achieving MSC certification (and re-certification in 2016), as these aspects are scrutinised under the MSC standard. MSC certification has enabled Scottish haddock to maintain its market share within UK supermarkets and anecdotal reports indicate that it resulted in a price premium of 10% on first and onward sale value[20].

The consistent good status of the stock has provided stability and security to the fishery throughout the supply chain, including the fishers, processors and retailers.

Social benefits: for fishers that are paid a share of the catch value, an increase in CPUE means an increase in their wages. For the UK fleet targeting haddock in the North Sea and West of Scotland, fishing income per FTE has shown increases from a low of €97,000 in 2009 to €172,800 in 2015[21]. This provides evidence that the well-managed haddock fishery has resulted in higher wages for fishers, which support the fishing households and wider communities that depend on the industry.

The Scottish whitefish industry is passionate about the resource that it harvests and is committed to sustainable fishing practices. The SFSAG is proud that its haddock carries the MSC label, and is currently seeking MSC certification for other target species.

MSC-certified products display a blue tick MSC logo on packaging, or on menus, allowing consumers to identify fish and shellfish produce that meet this sustainability standard. For the Scottish haddock fishery, the MSC logo is displayed at fish and chip shops and across supermarket products, leading to good publicity that improves the public image and reputation of the whole Scottish fishing industry. An MSC certification also ensures traceability throughout the supply chain via chain of custody requirements. The main UK retailer purchasing Scottish haddock is committed to sourcing from certified fisheries – a message that is actively publicised in its marketing campaigns. This in turn raises consumer awareness of the provenance of their seafood and encourages responsible choices.

The box overleaf describes the many **environmental benefits** that result from well-managed fisheries, including this haddock stock.

Other factors that have contributed to this stock's success include recruitment that is characterised by occasional large year classes, with the last big year class recorded in 1999[22]. Successful recruitment years are clearly highlighted within ICES stock assessments and inform the advice made to the European Commission when proposing TACs. While TACs have been set in accordance with ICES advice and the long-term management plan for haddock, the actual landings have been consistently less than the TAC, with recent landings amounting to approximately 75% of TAC. External factors, including those linked to the economic market and the restrictions related to long-term plan for cod (including reductions in days at sea), have also contributed to achieving the objectives of the haddock management plan.

Another factor that has contributed to the successful recovery of the stock is the reduction in the level of haddock discards, which has been achieved through more selective gear, real-time closures, and cod management restrictions, as well as being naturally limited due to the low level of small-sized

[19] STECF, 2016. Annual Economic Report data illustrates a 51% reduction in fuel price from €0.725 per litre in 2012 to a predicted €0.357 per litre in 2016 in Great Britain (Scotland, England and Wales).

[20] Poseidon, 2014. Assessment of the benefits of MSC certification to a major UK fishery and its supply chain. For SFSAG.

[21] Seafish, 2016. Economic Performance Data.

[22] ICES, 2015. ICES advice for haddock in Subarea IV and Divisions Via and IIIa West.

haddock (linked to recruitment). In fact, low recruitment in the haddock fishery is likely to be the main driver of lower discarding in the fishery.[23]

The economic performance of the fleet is influenced by several factors, some of which are linked to the status of the stock (increases in efficiency resulting from increased CPUE); others are independent of the biological resource (e.g. fuel prices). The Annual Economic Report for 2016[24] shows that fuel consumption decreased overall between 2008 and 2014, while the average fuel consumption per vessel per day is shown to be stable for both the small and large-scale fleets of the EU-15 Member States[25]. This means that reductions in fuel consumption are primarily due to reductions in effort across the EU fleet that have been made possible due to increased CPUE.

Haddock summary

Haddock is an essential ingredient in many classic British dishes, including traditional fish and chips. It is the most economically important whitefish species for the Scottish seafood industry.

The haddock fishery in the North Sea, West of Scotland and Skagerrak is well managed. The stock is subject to natural variations linked to recruitment, but fisheries management has been successful in limiting increases in fishing pressure to ensure the maintenance of good year classes, which supports stock growth.

The good condition of the haddock stock, together with other external factors including reduced fuel prices, has resulted in the profitability of the fishery more than doubling since 2009, resulting in increased wages for fishers and more income provided to the fishing households and communities that depend on the industry.

[23] ICES, 2014. North Sea EU–Norway request to evaluate the performance of the Long-Term Management Plan for North Sea haddock

[24] STECF (2016) Scientific, Technical and Economic Committee for Fisheries (STECF) – The 2016 Annual Economic Report on the EU Fishing Fleet (STECF-16-11). 2016. Publications Office of the European Union, Luxembourg, 470 pp.

[25] EU-15 relates to the 15 Member States of the European Union as of December 31, 2003.

The box below describes a number of environmental benefits that result from well-managed fisheries.

ENVIRONMENTAL BENEFITS

The fundamental environmental benefit of well-managed fisheries is healthy, robust stocks. This supports an increase in CPUE, which reduces the time required to fish, thereby reducing operating costs like fuel consumption and its related emissions and pollution. More efficient catching means that the fishing gear is in the water for less time, which also lessens any negative effects on the wider ecosystem.

For demersal otter trawls, there is reduced contact with the seabed so a lower overall benthic impact, which will benefit those seabed communities. More efficient catching can also mean less interaction with bycatch for the gears considered within these case studies. For example, good stock status in a nephrops fishery means that vessels catch their nephrops quota more efficiently, reducing the time the gear is catching other species as bycatch. This benefits stocks that have not yet recovered from overfishing, such as cod in the Kattegat.

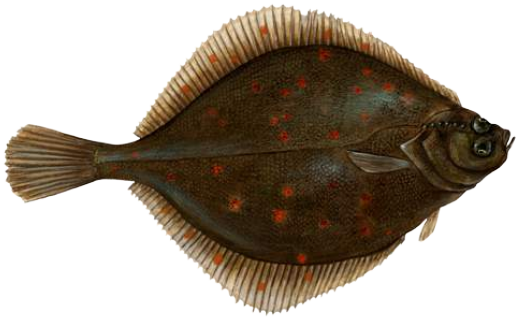
Overfishing can have profound impacts on entire ecosystems and cause regime shifts[26] due to habitat disturbance and/or removal of key species.

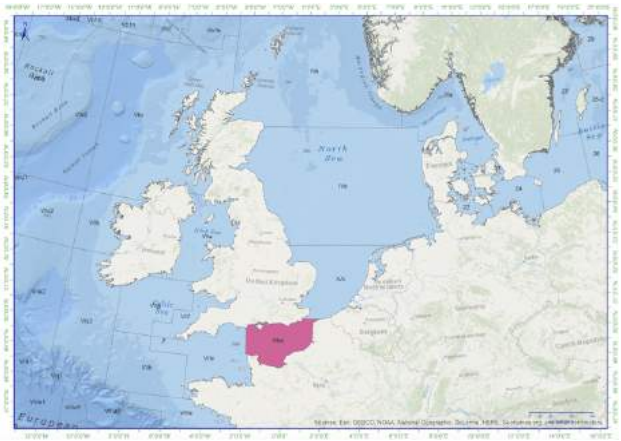
Removal of top predators often leads to cascading effects down the food web as it releases some species from predation pressure and imposes it on others[27]. Conversely the removal of key prey (such as herring caught in large shoals by pelagic trawlers) will force predators to seek alternative food sources, with the potential to ultimately impact the entire food web structure. For simple food webs, this can have particularly serious effects, for example in the Baltic where the cod, herring and sprat stocks are inter-dependant.

Additional environmental benefits derive from fisheries seeking sustainability certification. Many such schemes encourage continuous improvements to management and record keeping (e.g. of bycatch and protected species interactions) to progress towards minimising the overall ecological impact of the fishery.

[26] Jackson *et al*., 2001. Historical Overfishing and the Recent Collapse of Coastal Ecosystems. Science 293(5530): 629–637.
[27] Pauly, *et al.,* 1998. "Fishing Down Marine Food Webs." Science 279(5352): 860–863.

4 EASTERN ENGLISH CHANNEL PLAICE





Species[28]**:** Plaice, *Pleuronectes platessa*

Area: Eastern English Channel

ICES Division: 7d

Introduction to the plaice fishery

Plaice is a flatfish that lives on soft sandy and muddy habitats in shallow waters, down to around 100m depth. They are active at night, feeding on shellfish (cockles and razor shells), worms and crustaceans, and spend daylight hours buried in sand[29].

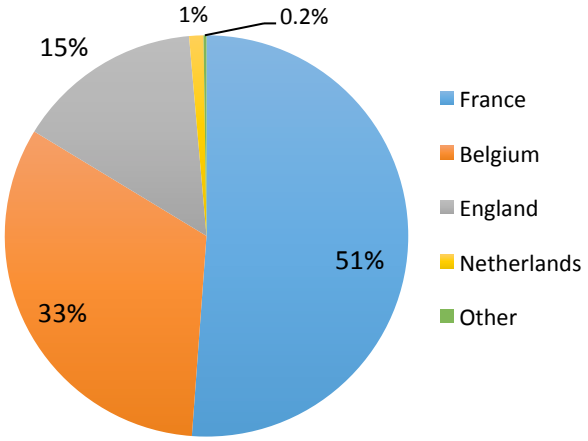
Plaice have a striking appearance with reddish-orange spots on their upper body and a pearly white underside, making them easily distinguishable from other flatfish. The European plaice is widely distributed from the Baltic to the Mediterranean and is managed as discrete stocks, with ICES providing ten separate scientific assessments for European sea areas, including the major plaice fisheries in the North Sea, the English Channel and the Celtic Seas.

Plaice is commonly eaten throughout Europe and very popular in Germany and Denmark, where it is often battered, pan-fried and eaten hot or cold in open sandwiches or served as fish and chips. It is a much cheaper, but delicious, alternative to the prized European sole (*Solea solea*), and the two species are often caught together in fisheries targeted by beam and otter trawlers. Trammel and gill nets are also used to fish for plaice and these can be more selective due to the placement and mesh size of the gear.

Key fleets

The plaice fishery in the Eastern English Channel is worth €85 million annually in first sale value[30] and is predominately landed by four different countries.

French otter trawlers targeting mixed demersal species are responsible for



Proportion of plaice landings by fishing nation (landed weight from ICES Division 7d; average from 2005–2014. Data: EU DCF, 2016)

[28] Plaice picture from Scandinavian Fishing Year Book, 2016.

[29] Fishbase, 2016. *Pleuronectes platessa* http://www.fishbase.org/summary/1342

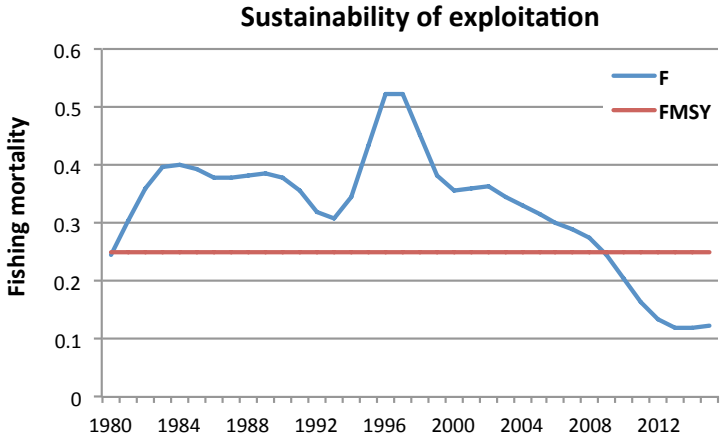
[30] Based on a ten-year average (2005–2014) of 7,050 tonnes being landed annually (EU DCF, 2016) at a value of €410,767 per tonne (EUMFOA, 2016).

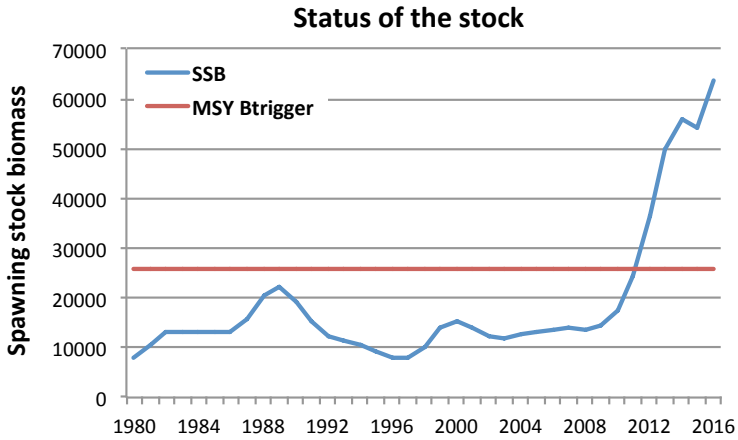
landing 51% of plaice from Area 7d[31]; Belgian beam trawlers targeting sole land 33%; and English fleets using beam trawl, bottom otter trawl, and trammel and gill nets are responsible for 15% of plaice landings.

Sustainability of exploitation

Until recently, plaice in the Eastern English Channel was not harvested sustainably; fishing mortality was above the rate of exploitation that would support MSY (i.e. $F>F_{MSY}$)[32].

The exploitation rate peaked in 1997, but has gradually and consistently decreased since then, reaching a level appropriate for MSY in 2009. In the past few years, fishing mortality has continued to decrease, to well below F_{MSY}, further reducing the risk of overfishing occurring.





The status of the plaice stock has closely followed the exploitation trend. Until very recently, the spawning stock biomass has been historically low and consistently below the MSY $B_{trigger}$ reference point. The lowest SSB is seen at the same time as the peak in fishing mortality occurred (1996–1997).

The stock responded rapidly to the reduction in the rate of exploitation, with SSB growing substantially from 2010 onwards and remaining above the MSY $B_{trigger}$ since 2012. The biomass reached a record high in 2016. The stock is at full reproductive capacity and well above its MSY $B_{trigger}$ level.

Regular annual recruitment is recorded for this stock; peaks have occurred in 1986, 1997 and 2009–2010[32]. Recruitment has also been higher than average from 2009 onwards, which has clearly assisted growth in SSB.

In 1998, ICES advised a major reduction in fishing mortality of around 30%[33]. This advice was heeded and managers reduced TAC by 24% from 1998 to 2000, which is reflected in the steep drop shown in the first graph. After 1999, ICES advised the fishery not to exceed average landings from previous years. In fact, fishing mortality continued to decrease from 2000 to 2012, with the corresponding significant growth in biomass from 2012 onwards shown on the second graph. The low rate of

[31] Based on a ten-year average (EU DCF, 2016).

[32] ICES, 2016. Advice on fishing opportunities, catch, and effort. Greater North Sea Ecoregion. Published 30 June 2016. 6.3.35 Plaice (*Pleuronectes platessa*) in Division 7.d (Eastern English Channel)

[33] ICES, 2000. 3.6.3 Plaice in Division VIId (Eastern Channel)

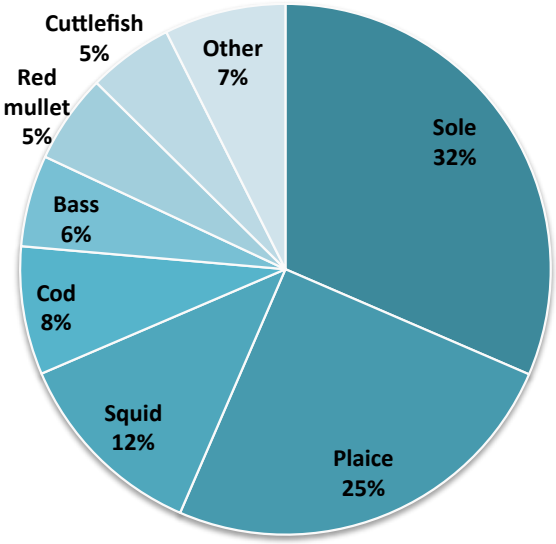
exploitation has supported further growth in spawning stock biomass, resulting in a 160% increase in the TAC from 2015 to 2016

Economic, social and environmental benefits

Plaice is landed within a mixed bottom trawl fishery and a targeted sole beam trawl fishery. The pie chart illustrates that while sole is the primary economic species in the Eastern English Channel, plaice forms an important portion (25%) of revenues that also depend on a mixture of other species.

Economic performance trend: the French demersal trawl fleet (that principally targets sole and monkfish as part of a mixed fishery) has increased the total number of days at sea in the Eastern English Channel across a five-year period[34] (+30%), and has a lower CPUE for plaice[35] (-13%)[36]. Therefore, the economic performance of the French fleet has been decreasing despite the good status of the plaice stock. This is largely because its main target species, sole, is currently fished above F_{MSY}, and its SSB is below MSY $B_{trigger}$; therefore the sole stock is considered at increased risk. The total sole TAC for this area was reduced by 45% between 2013 and 2016.

While the Belgian beam trawl fleet (that principally targets sole and other flatfish species) has decreased its total days at sea[34] (-10%) as the number of vessels decreased to around 80, the CPUE for plaice improved (+36%). The growing plaice quota has been important to the Belgian fleet in recent years as the sole quota became more limited[37].



Proportion of landings by value for all countries using beam trawl, bottom trawl, trammel & gill net in 2014 from ICES Division 7d (total value = € 336 million; based on landings data from EU DCF, 2016 and European price data from EUMFOA, 2016)

According to projections by the Belgian Ministry of the Flemish Community, Agriculture and Fisheries, a state of long-term MSY will result in continued improved economic performance for the Belgian fishing fleet, which is heavily dependent on sole and plaice. The EU annual economic report showed a 22% increase in revenue for the Belgian fleet, relating to only 2% rise in costs; this is due to increased landings with improved CPUE [38]. However, as these are mixed fisheries, with sole the key target species, it is very difficult to infer that these changes are specifically linked to the improvements in the plaice stock alone.

Social benefits: the limited availability of sole, the main target species for French and Belgian trawl fleets operating in the area, makes the increases to the plaice quota resulting from stock recovery all

[34] From 2010 to 2014.
[35] Based on landings of plaice (kg) per day at sea.
[36] Based on cross correlating EU DCF landings data and EU AER effort data (STECF, 2015).
[37] The Belgian fleet experienced a 4% reduction in total sole quota in 2013. The Eastern English Channel was one of the few areas where sole quota increased in 2013, but fishing pressure for sole remained above F_{MSY} and the Eastern Channel sole stock has since declined to below MSY $B_{trigger}$. (ICES, 2016).
[38] From 2013 to 2014 a 27% increase in landings to 27,000 tonnes is associated with a 22% increase in revenue and only a 2% increase in total costs. Gross profit and net profit improve to €19 million and €11 million respectively and GVA/FTE, already high in Belgium, reaches €240,000 (STECF, 2015).

the more welcome to vessel owners and crew, and the households and communities which depend on them.[39]

Additional **environmental benefits** resulting from well-managed fisheries, including this plaice stock, are outlined in the box on page 13.

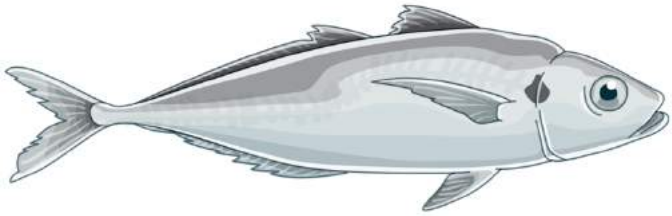
Other factors that have contributed to this fishery's success include management measures to reduce fishing mortality of sole in the Eastern English Channel.

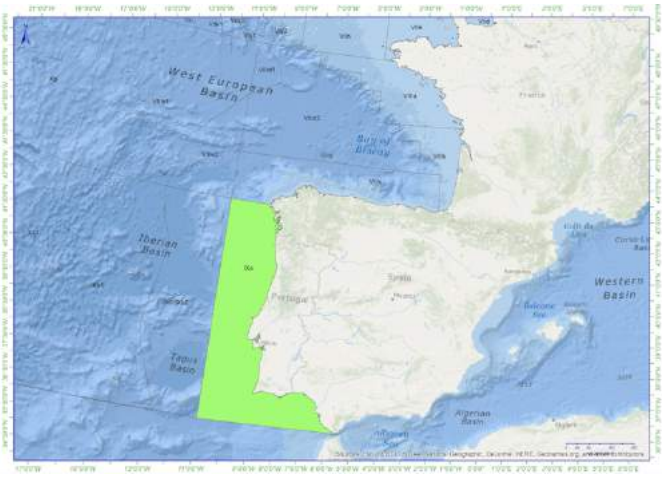
Plaice summary

Plaice is a very popular food choice throughout Europe. The need to control increasing exploitation levels was advised by ICES and implemented by managers, with large reductions of TACs made in the late 1990s in order to bring fishing down to sustainable levels. The Eastern English Channel plaice stock has seen significant growth since 2010 and fisheries management has successfully maintained a sustainable rate of exploitation.

[39] A precautionary TAC is in place for monkfish (key target species for French trawlers) and a 24% reduction in TAC for 2017 is proposed for sole (key target species for Belgian trawlers).

5 ATLANTIC IBERIAN HORSE MACKEREL





Species: Atlantic horse mackerel, *Trachurus trachurus*

Area: Atlantic Iberian waters (West Portuguese waters)

ICES Division: 9a

Introduction to the horse mackerel fishery

The horse mackerel is a pelagic fish that is fast-swimming and known for extensive migrations. It derives its name from the legend that smaller species of fish could ride on its back over great distances. Horse mackerel form large schools over sandy substrates on continental shelves, usually down to over 200m[40], and are targeted by both pelagic and bottom otter trawls.

African countries are key markets for the human consumption of horse mackerel, as is Portugal, but it is becoming more popular in Spain and Japan. The Japanese call horse mackerel 'aji' and prefer to eat it salted and dried for breakfast, or in raw or lightly seared form known as 'tataki'. It is also increasingly used in sushi and sashimi dishes. In Portugal, horse mackerel has been popular and economically important for many centuries and the Portuguese often cook it in an escabeche (fried then steeped in a sweet pickle liquor).

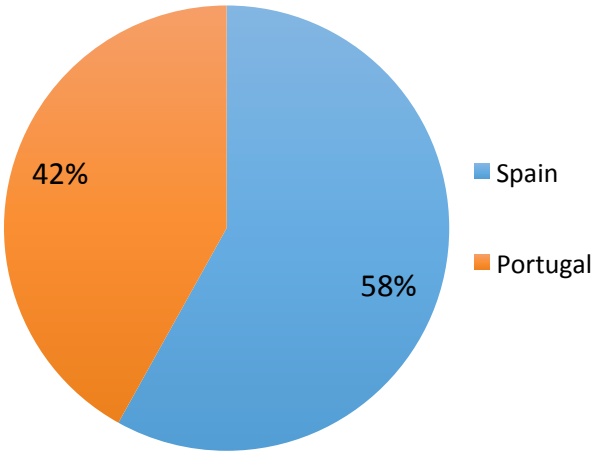
Horse mackerel is also used for bait and in the fishmeal industry, however stock from area 9a principally enters consumer markets.

Key fleets

The horse mackerel fishery in ICES Division 9 (a and b[41]) is worth €28 million annually in first sale value[42] and is landed by two countries, Spain and Portugal.

The Spanish fleet accounts for 58% of the landings of horse mackerel by weight[43], with most effort coming from Spain's pelagic trawl fleet (which takes 60% of the Spanish catch), as well as bottom otter trawls.

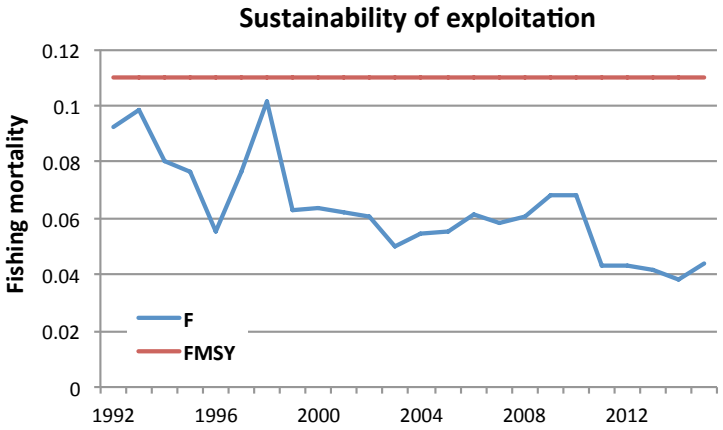
The Portuguese fleet – consisting of bottom otter trawls, pelagic trawls and purse seines land 42% of the horse mackerel from this stock.



Proportion of horse mackerel landings by fishing nation (landed weight from ICES Division 9; average from 2005 to 2014. Data: EU DCF, 2016)

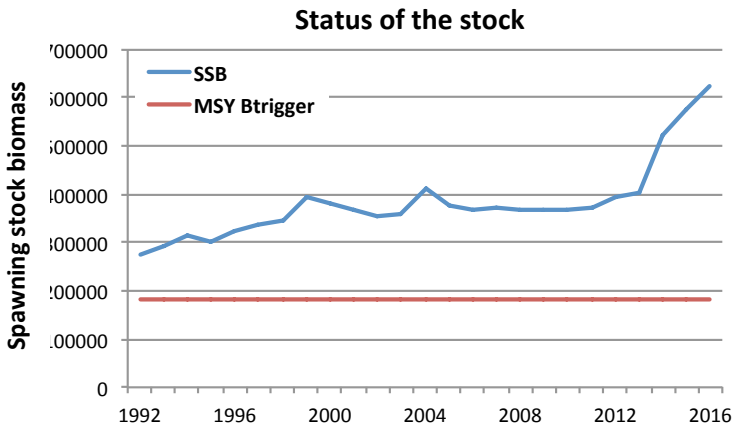
[40] Fishbase, 2016. *Trachurus trachurus* http://www.fishbase.org/summary/1365
[41] Separate landings data is not available for ICES Divisions 9a and 9b.
[42] Based on a ten-year average (2005–2014) of 23,264 tonnes being landed annually (EU DCF, 2016) at a value of €855 per tonne (EUMFOA, 2016).
[43] Based on a ten-year average (EU DCF, 2016).

Sustainability of exploitation



The **level of exploitation** of horse mackerel in Atlantic Iberian waters has been sustainable ($F<F_{MSY}$) since 1992. It peaked in 1998, but has been substantially lower than F_{MSY} from 1999 onwards, and at record lows for the past five years (2011–2015)[44].

The **status of the horse mackerel stock** has been stable and consistently above MSY $B_{trigger}$ for the whole time series. The recent increase in SSB is linked to strong recruitment years in 2011 and 2012. Ensuring that F remained below F_{MSY} following these good recruitment years has safeguarded the stock and led to the recent substantial increase to its current record high SSB levels.



Since 2010, the TAC for horse mackerel in area 9a could have been increased to allow F to more than double and reach F_{MSY}. Instead, the low level of exploitation has allowed a greater increase in biomass than would have occurred by fishing at F_{MSY}.

The constant fishing rate, coupled with a higher stock biomass, since 2010, has recently allowed for higher TACs, as evidenced by the 70% increase in TAC from 2014 to 2015, and 15% increase from 2015 to 2016. This has led to the slight rise in exploitation in the last two years, as shown in the top graph.

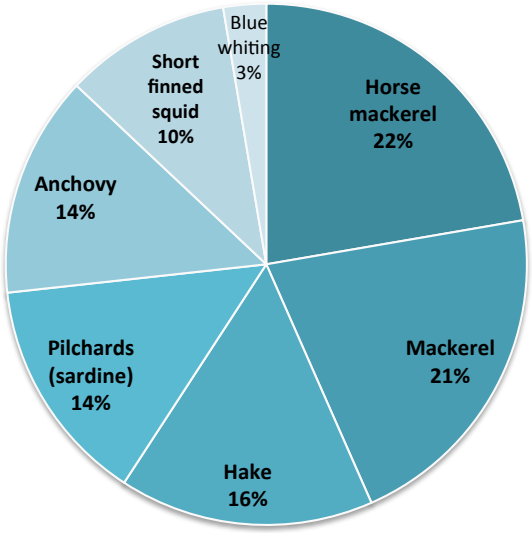
Economic, social and environmental benefits

In terms of the proportion of fleet revenue coming from this stock, the Spanish and Portuguese bottom and pelagic trawl fleets have a dependency of 22% on horse mackerel landings from ICES Division 9a. It is thus a vital source of income and revenue.

Economic performance trend: across a five-year period,[45] the Portuguese bottom trawl fleet shows a slightly decreased trend in days at sea (-5%), but has a significantly improved CPUE for horse mackerel (+93%)[46]. Horse mackerel has contributed to the continued improved economic performance seen in the Portuguese small-scale fleet[47].

[44] ICES, 2016. ICES Advice on fishing opportunities, catch, and effort in the Bay of Biscay and the Iberian Coast Ecoregion. Published 14 July 2016. 7.3.22 Horse mackerel (Trachurus trachurus) in Division 9.a (Atlantic Iberian waters).
[45] From 2010 to 2014.
[46] Based on cross correlating EU DCF landings data and AER effort data.
[47] STECF, 2016

The recent substantial increase in the horse mackerel TAC, together with consumer preference for other species (notably sardines and chub mackerel) is considered by the industry to have contributed to a recent decline in the horse mackerel price. The exceptionally high Portuguese landings, peaking in May 2016 at over 80% more than the same month in 2015, resulted in the first-sales price to drop to 0,69 EUR/kg, the lowest for three years[48]. This has led to public demands by producer organisations to agree to a lower TAC than that proposed by ICES.



Proportion of landings by value for Spanish and Portuguese bottom and pelagic trawls in 2014 from ICES Division 9a (total value = €125 million; based on landings data from EU DCF, 2016, and European price data from EUMFOA, 2016)

Social benefits: Atlantic horse mackerel is a prominent species within the Spanish processing industry, where it is processed for onward sale in frozen form.

In Portugal, the species is primarily consumed fresh. It is one of the most important species in overall catches, not only for the large-scale fleets but also for the small-scale fleet. For example, the port of Peniche is home to a significant inshore fleet[49] and accounts for around 15% of all horse mackerel landings in Portugal. Here, the health of the horse mackerel stock has contributed to a stable inshore fleet with positive economic returns, in contrast to the decline seen elsewhere. Tourism is also essential to the local economy of Peniche and the horse mackerel stock provides important supplies of fresh fish at affordable prices for both local inhabitants and tourists.

Horse mackerel is also gaining increased importance in the Portuguese canning industry. The fish processing industry accounts for 46% of the gross value added (GVA) generated by the country's food industry. As the development of the canning sector has been limited by a lack of raw materials, mainly resulting from the 78% reduction in sardine landings over the last five years, the growth in horse mackerel supply has helped to sustain Portugal's canneries and the 5,000 jobs they support[50].

Cross cutting **environmental benefits** resulting from well-managed fisheries, including this horse mackerel stock, are outlined in the box on page 13.

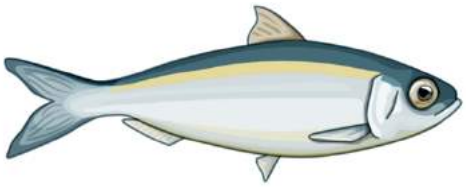
Horse mackerel summary

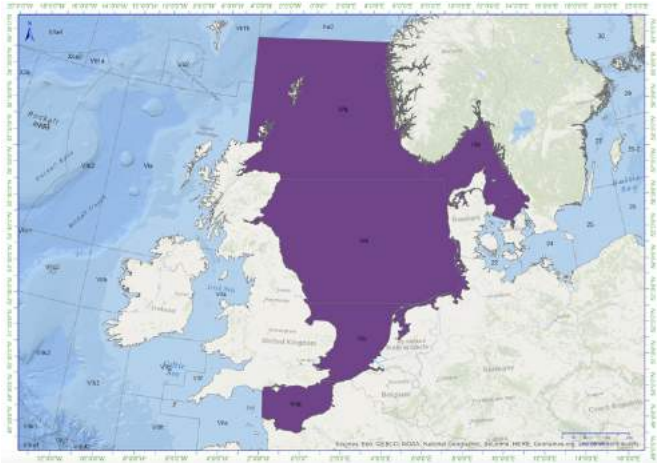
Horse mackerel remains popular in Portugal and is emerging as a new culinary favourite in Spain and Japan, where it is growing in popularity for the sushi market.

The stock biomass has grown dramatically since 2013, while fishing mortality has remained low. Maintaining a consistently low fishing rate, especially after good recruitment years, has ensured a healthy biomass, which has resulted in substantially higher catches of horse mackerel in recent years. The large increase in TACs since 2014 has also led to lower overall prices, which makes the species an affordable option for low income households, and means that Portuguese canneries are increasingly using horse mackerel, which has helped sustain employment in the sector.

[48] EUMOFA monthly highlights, August 2016.
[49] 700 of 800 vessels operating from Peniche are below 12m in length (MRAG, *et al.*, 2011).
[50] European Parliament (2015) report estimates that of the 5,000 jobs, 3,500 are directly employed in canneries (of which 90–95% are women) and 1,500 are indirectly employed in ancillary businesses.

6 NORTH SEA, EASTERN ENGLISH CHANNEL AND SKAGERRAK & KATTEGAT HERRING





Species: Herring, *Clupea harengus*

Area: North Sea, Eastern English Channel and Skagerrak & Kattegat

ICES Divisions: 4, 7d and 3a

Introduction to the herring fishery

Herring is a small pelagic species that migrates between spawning and wintering grounds in coastal areas and feeding grounds in the open sea[51]. Unlike most fish species (that spawn in open water), herring lays and attaches eggs to gravelly substrate, making spawning grounds well defined, but sensitive to human disturbance, particularly the extraction of marine sand and gravel[52].

Herring forms a central component in the ecosystems of the North Sea, Eastern English Channel, Skagerrak and Kattegat, both as predator and as prey, with schools attracting a range of predators including fish, birds and marine mammals.

As it is an open water schooling fish, it is almost exclusively targeted by pelagic trawl vessels.

Herring is an oily fish, popularly consumed in Scandinavian countries in pickled form, but also fermented, cured or eaten raw. The Dutch celebrate seasonal new herring with annual festivals, where it is consumed quick-cured in brine and served with diced onions. In the UK and Belgium, 'kippers' – which are whole herrings, salted or pickled and cold-smoked over woodchips – are a traditional breakfast.

Dutch herring festival, photos from www.holland.com

Key fleets

The herring fishery is worth €300 million annually in first sale value[53] and is landed by eight different countries.

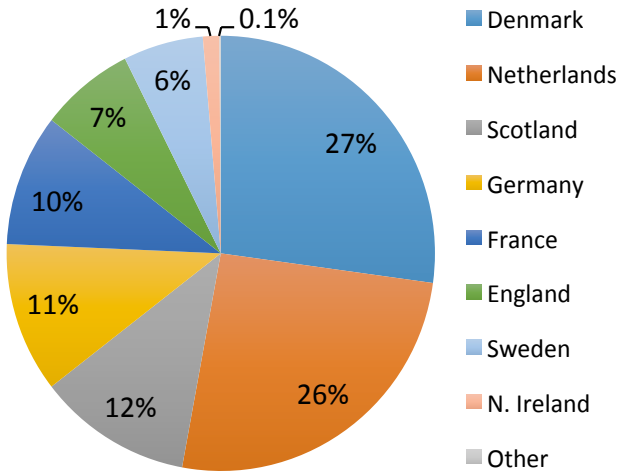
[51] Fishbase, 2016. *Clupea harengus* http://www.fishbase.org/summary/24

[52] ICES, 2016. ICES Advice on fishing opportunities, catch, and effort. Greater North Sea Ecoregion. Published 31 May 2016. 6.3.18 Herring (Clupea harengus) in Subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak, Kattegat, and Eastern English Channel).

[53] Based on a ten-year average (2005–2014) of 283,860 tonnes being landed annually (EU DCF, 2016) at a value of €793 per tonne (EUMFOA, 2016).

Denmark and the Netherlands land the majority (27% and 26% by weight[54], respectively), with the remainder split between the UK (Scotland, England and Northern Ireland), Germany and France.

The stock is exploited by a number of seasonal fisheries that harvest from various populations throughout the year. For most of the year the different populations mix, but during the spawning season they migrate to their separate areas. This means that assessments and management of the stock have to consider autumn spawners in the North Sea and spring spawners in the Western Baltic.

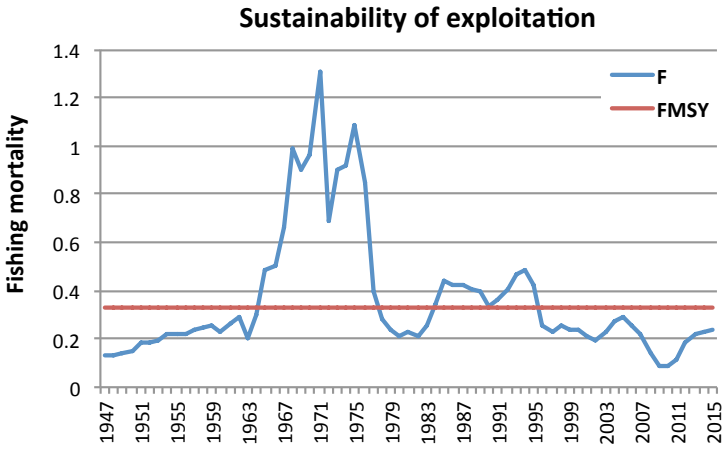


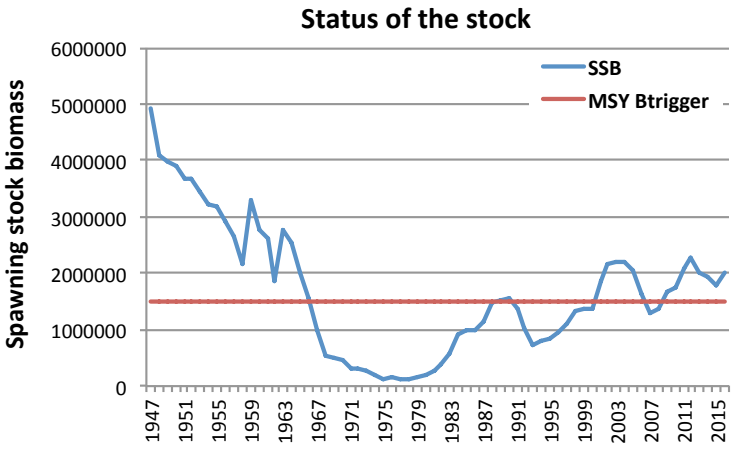
Proportion of herring landings by fishing nation (landed weight from ICES Divisions 3a, 4 & 7d; average from 2005 to2014. Data: EU DCF, 2016)

Sustainability of exploitation

A combination of very high fishing mortality and low recruitment in the early 1970s led to the North Sea herring stock collapsing from 1971 to 1980, as illustrated in the stock status graph, below, by the sudden fall in SSB that remained dramatically low during this period[55].

As a short-lived species, the SSB of herring is highly linked to recruitment. The stock depletion in the 1970s resulted in a four-year closure of the directed fishery (hence the sudden drop seen in fishing mortality). The remaining fishing mortality during this period was due to bycatch from industrial fisheries such as for sandeel. During the 1980s, the stock recovered and the directed fishery re-opened.





From the mid-1980s, both F and SSB began to stabilise towards MSY (moving towards $F < F_{MSY}$ and SSB > MSY $B_{trigger}$).

Since 1996, fishing mortality has been appropriate to support MSY. Fisheries managers reacted to a lower than average recruitment in the 2000s by reducing TACs, which has allowed SSB to remain fluctuating around MSY $B_{trigger}$.

[54] Based on a ten year average (EU DCF, 2016).

[55] ICES, 2016. ICES Advice on fishing opportunities, catch, and effort. Greater North Sea Ecoregion. Published 31 May 2016. 6.3.18 Herring (Clupea harengus) in Subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak, Kattegat, and Eastern English Channel).

In 2008, a Management Plan was introduced for this herring stock, followed by a Long-Term Management Strategy (LTMS)[56] in 2014. During this period, the exploitation rate has been below F_{MSY} and SSB has been improving (and above MSY $B_{trigger}$ since 2009).

Although fisheries managers have followed ICES advice and implemented harvest control rules (HCRs) as set out in the LTMS, SSB still fell below the MSY $B_{trigger}$ point in 2007. This illustrates that management actions cannot always avoid the natural variability in recruitment, which is particularly evident in pelagic stocks. However, being able to identify and appropriately respond to such events is essential to prevent overfishing.

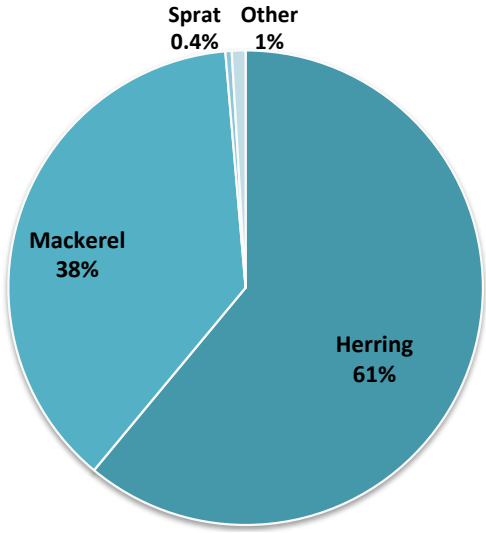
An additional regulation was introduced in 2009[57] to reduce discarding. This prohibited slipping and high grading, which is the practice of untying the bottom of nets and dropping the catch, if the fishers decide they would rather dump the fish caught in order to use the quota to catch larger or better quality herring. This regulation, together with technology that allows fishers to identify fish sizes within schools, means that discarding has been significantly reduced and is now considered to be negligible in the fishery[58].

Economic, social and environmental benefits

In terms of the proportion of fleet revenue from this stock, herring accounts for just under two-thirds (61%) of the value landed by pelagic trawls in ICES Divisions 3a, 4 and 7[59]. It is the most important species, followed by mackerel, which accounts for 38% of the catch value. In 2013, Atlantic herring generated a landing value of €74 million for the Danish fleet.

Economic performance trend: the CPUE[60] for herring and mackerel has significantly improved in this area for the Dutch, UK and French pelagic trawl fleets (by +149%, +127% and +165%, respectively)[61]. Days at sea have increased slightly for all fleets across the five years analysed[62].

Pelagic fleets have become the most profitable segments of the European fleets, with stock recovery, combined with improved catching efficiency, and the comparatively low fuel consumption for mid-water trawls and seines compared to bottom trawls, all contributing to positive economic performance.



Proportion of landings by value for all countries using pelagic trawls in 2014 from ICES Division 3a, 4 and 7d (total value = € 4,929 million; based on landings data from EU DCF, 2016 and European price data from EUMFOA, 2016)

[56] 2014 LTMS includes a 15% constraint on TAC changes and introduced an inter-annual quota flexibility of ±10%.
[57] EC Council Reg No 43/2009.
[58] ICES, 2016. ICES Advice on fishing opportunities, catch, and effort. Greater North Sea Ecoregion. Published 31 May 2016. 6.3.18 Herring (*Clupea harengus*) in Subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak, Kattegat, and eastern English Channel).
[59] EU Data Collection Framework, 2016. Landing data for ICES Divisions 3a, 4 and 7.
[60] CPUE is based on days at sea from 2012 to 2014 for the Danish fleet and 2010 to 2014 for the French and Dutch fleets. CPUE trends have been calculated by dividing the total landings of herring and mackerel (for EU DCF data, 2016) by the days at sea (from EU AER data, 2016) and comparing annual variations.
[61] CPUE for the Danish pelagic trawl fleet has decreased by 34% as herring is taken as bycatch in fisheries for sand eel and sprat that have been highly variable in recent years.
[62] +10% for Danish fleet, +3% for French fleet, +14% for Dutch fleet and +20% for UK fleet.

Social benefits: many people, particularly in the Netherlands and Scandinavia, are passionate about their herring traditions and a sustainable fishery supports this heritage.

The large increases in CPUE in targeted fisheries translate into a higher income per FTE. The wages of pelagic crews are now among the highest in the fishing industry, and while many other fleets struggle to recruit and maintain crew, places on board the modern, well-equipped pelagic vessels are highly sought after.

Cross cutting **environmental benefits** resulting from well-managed fisheries, including this herring stock, are outlined in the box on page 13.

Herring is a keystone species that plays a critical role in the ecosystem of the North Sea, Eastern English Channel, Skagerrak and Kattegat. Maintaining a healthy biomass of the herring stock ensures sufficient prey is available to many other commercial species, including cod, salmon and tuna, as well as to seabirds and marine mammals[63].

Other factors that have contributed to this stock's success include the recognition of herring spawning areas in the management of other activities (such as extraction and renewable energy development) that could have potentially impacted the spawning habitat, thereby avoiding any disturbance to recruitment.

Further benefits are derived from the inclusive and consultative nature of the herring stock assessment process. In 2009, representatives from the pelagic industry expressed concern that juvenile herring abundance was higher than predicted in the assessment. ICES identified an underestimation in the 2007 year-class and corrected the subsequent assessments. This more inclusive approach fosters greater industry confidence in the stock assessments and resulting management actions. Pelagic fisher's associations are now actively involved in surveys. The excellent economic performance of the European pelagic sector in recent years, enabled by stock recovery, has led to recent instances of the industry funding additional surveys where it feels more information is needed to ensure the best possible scientific advice[64].

Herring summary

North Sea herring was one of the biggest fisheries throughout the 20th Century, before stock collapse in the 1970s caused closure of the fishery. It has now recovered to once more become one of Europe's most valuable fisheries, with landings valued at €300 million per year. Annual festivals are held to celebrate new herring fishing seasons and the Dutch are particularly passionate about consuming quick-cured herring.

Herring is vital to the pelagic trawl fleet, which is now one of the most profitable fishing fleets in Europe. Since the recovery of the stock and re-opening of the fishery, managers have remained vigilant and maintained appropriate fishing pressure. The stock biomass is considered sustainable at present (>MSY $B_{trigger}$), but does undergo fluctuations.

The international importance of the fishery has resulted in a comprehensive assessment and management regime in which the industry actively contributes.

[63] DFPO, 2016. North Sea herring Marine Stewardship Council assessment. https://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/north-east-atlantic/dppo-and-dfpo-north-sea-herring

[64] 'PFA and SPFA undertake first industry-led herring survey' http://www.pelagicfish.eu/01235/ October 2016

7 SKAGERRAK AND KATTEGAT NEPHROPS

Species[65]**:** Nephrops, *Nephrops norvegicus*

Area: Skagerrak and Kattegat Functional Unit

ICES Division: 3a

Introduction to the nephrops fishery

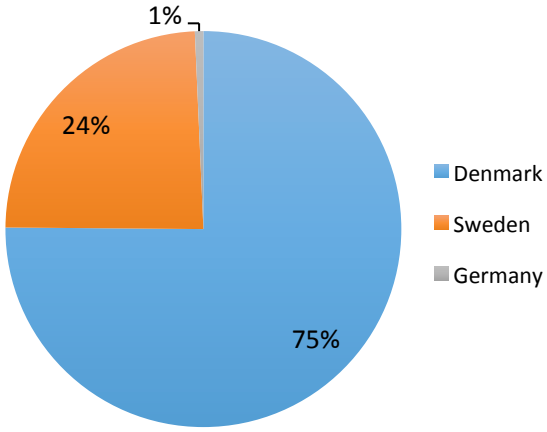
Nephrops (also known as langoustine, Norway lobster, or scampi) are a type of shellfish closely related to, but smaller than, the lobster, that live in burrows within muddy, soft sediments in water from 20 to 800m[66]deep. They spend most of their time in their burrows, which can be over a metre long, and penetrate the sediment to a depth of 20 to 30 cm, but do come out for feeding and mating. The age class of shellfish like nephrops is very difficult to determine and so the scientific assessment of nephrops stocks measures abundance by using underwater cameras on towed sleds to count the number of burrows on the seabed.

Most nephrops in the Skagerrak and Kattegat are caught by demersal otter trawlers, often twin rigged with two nets. Due to the depth of their burrows, nephrops are often protected from trawls unless they have come out to feed or mate. Berried females tend to remain within burrows, which means that males dominate trawl catches for most of the year. Nephrops also support coastal pot fisheries that achieve a higher price for their catch of larger, live individuals.

Langoustine meat is white, sweet and succulent, making them high-value and popular throughout Europe, particularly in France, Spain and Portugal. Nephrops are sold both live (packed on ice), frozen (ready-prepared with the shell removed) and cooked. Fresh nephrops are usually roasted or boiled and served with butter and lemon, or aioli. They are also traditionally eaten as scampi (deep-fried in batter) or added to Spanish paella.

Key fleets

The nephrops fishery in the Skaggerak and Kattegat is worth €10.8 million annually in first sale value[67] and is mainly targeted by Danish and Swedish vessels.



Proportion of nephrops landings by fishing nation (landed weight from ICES Divisions 3a; average from 2005 to 2014. Data: EU DCF, 2016)

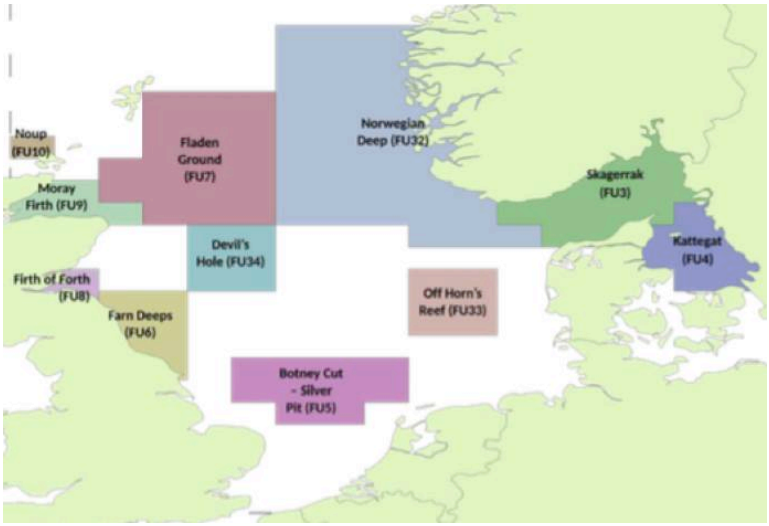
[65] Nephrops image from ec.europa.eu

[66] Sea Life Base, 2016. *Nephrops norvegicus* http://www.sealifebase.org/summary/Nephrops-norvegicus.html

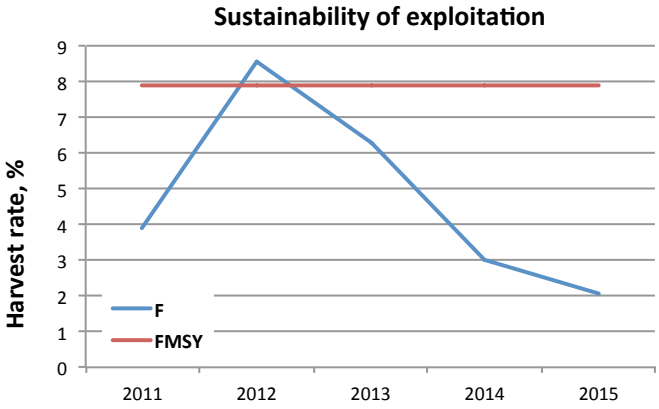
[67] Based on a ten-year average (2005–2014) of 3,000 tonnes being landed annually (EU DCF, 2016) at a value of €8,800 per tonne (EUMFOA, 2016).

Sustainability of exploitation

There are eleven discrete populations of nephrops identified in the North Sea, Skagerrak and Kattegat, which are referred to as functional units (FUs), see map on right. These are assessed by ICES to be independent stocks, but despite this individual stock advice, a single TAC is set for the whole North Sea (except the Norwegian Deep) and does not prescribe where the catches should be taken from. In the North Sea, this mismatch could lead to uneven exploitation patterns across the various FUs, resulting in the over-exploitation of an individual FU even when overall annual TACs are not exceeded.



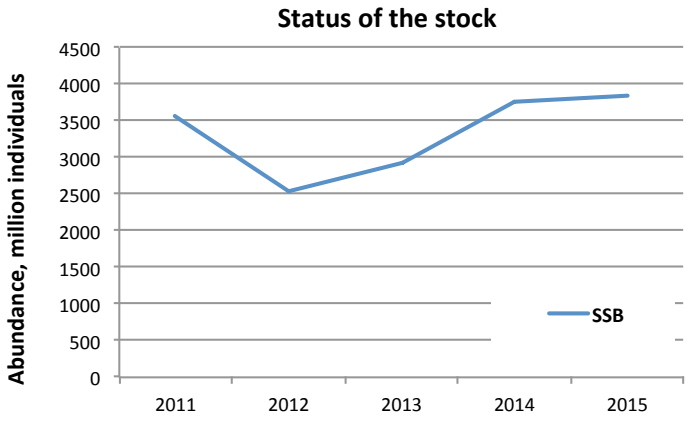
Nephrops functional units in the North Sea and Skagerrak and Kattegat region (ICES, 2016)



However, this case study relates to the situation in the Skagerrak and Kattegat, where management is appropriate to the scientific advice. This is because ICES undertake a stock assessment for Skagerrak and Kattegat and a separate TAC is now set for nephrops in this area, thereby reducing the risk of over-exploitation.

The **harvest rate[68] for this stock** is currently below F_{MSY}, so it is considered to be harvested appropriately. The harvest rate peaked at just above F_{MSY} in 2012, but this has since been reduced[69].

The **Skagerrak and Kattegat nephrops stock** size is considered to be stable, although it has not been possible for ICES to define an MSY $B_{trigger}$ reference point due to the short survey time series[69]. Records of abundance for the stock only began in 2011. A dip in abundance was seen in 2012, but has now been at a record high for the past two years.



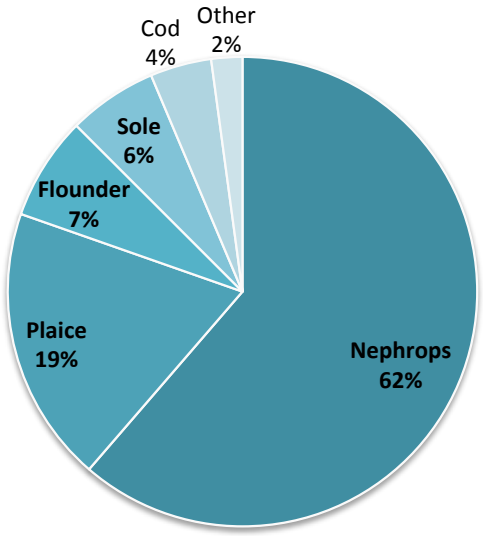
[68] Nephrops cannot be aged directly and so an index of stock abundance is used, instead of SSB. Harvest rate is used as a proxy for fishing mortality and is derived as the ratio between total catch and absolute abundance.

[69] ICES, 2016. Advice on fishing opportunities, catch, and effort. Greater North Sea Ecoregion. Published 30 June 2016. Version 2: 19 August. 6.3.23 Norway lobster (*Nephrops norvegicus*) in Division 3.a (Skagerrak and Kattegat)

In 2016 fishery managers reduced the minimum landing size[70] for nephrops, removing a mismatch with the mesh size used in the fishery so that fewer marketable nephrops are discarded. This is expected to increase the landings per unit effort for this fishery as more of the catch is now retained and landed for sale.

Economic, social and environmental benefits

Nephrops are economically one of the most important resources in the Kattegat and Skagerrak commercial fisheries. In terms of the proportion of fleet revenue from this stock, the Danish and Swedish nephrops trawl fleet have a 62% dependency on nephrops in the Skagerrak and Kattegat (ICES Division 3a).



Proportion of landings by value for Danish and Swedish demersal trawl fleet in 2014 from ICES Division 3a (total value = €17.7 million; based on landings data from EU DCF, 2016 and European price data from EUMFOA, 2016)

Economic performance trend: the CPUE for Danish and Swedish vessels targeting nephrops in the Skagerrak and Kattegat has increased in recent years. Even though days at sea have decreased in the same period, the average wage earned in the Danish and Swedish fleets has increased by 6% and 34% respectively, as a result of the improved landings and a reduction in fuel costs[71]. Swedish authorities have encouraged the use of passive gear (pots and traps) to target nephrops, which sell into the live trade at a premium price. Over 90% of the nephrops landed by the Swedish fleet is consumed in Sweden, and is typically sold as live, fresh or cooked. These local market preferences mean that the fleet benefits from a robust first sales price of over €13 per kilo, which is more than 30% higher than the average for imported nephrops[72].

Wider environmental benefits resulting from well-managed fisheries, including this nephrops stock, are outlined in the box on page 13. More specifically, the presence of nephrops indicates a habitat that is recognised as a feature of conservation importance, known as "sea-pen and burrowing megafauna communities". These habitats are characterised by a stable muddy seabed where animals (nephrops and shrimps) form a network of burrows that are sometimes interconnected, and which support and provide shelter to a diverse range of marine life. Rare species are also found within this habitat, including the tall sea-pen and burrowing fireworks anemone. An improved stock of nephrops promotes the increased creation of this supporting habitat type.

Other factors that have contributed to this stock's success: the fishery is managed, exploited and monitored by Denmark, Norway, Sweden and Germany. Ecosystem-based management has been delivered through a joint Scandinavian discard ban in the Skagerrak (implemented from 1 January 2014), closure of areas, and a reduction in the number of days at sea. This joint Nordic

[70] Under the landing obligation, the minimum landing size is now termed the 'minimum conservation size' as all should be landed.
[71] STECF, 2015
[72] EUMOFA Monthly highlights, no. 1, 2016: https://www.eumofa.eu/documents/20178/22933/Monthly+Highlights+-+No.+2016.pdf/1022b321-b6ec-4bfa-90d5-ce6f347a1c3d

interdisciplinary approach has brought about closer cooperation between managers, scientists and the industry, ensuring that decisions are based on the best possible knowledge related to the fishery's spatial and seasonal distribution patterns. Central to the successful implementation of new management is the fishing industry, which, for this nephrops stock, has actively participated in the decision-making processes through the Sustainable Nephrops Project (Bærekraftig sjøkrepsfiske[73]), to ensure that economic and fisheries-related incentives are taken into account.

Nephrops summary

The Skagerrak and Kattegat are the only functional units (FU) for which TACs and quotas are set separately, allowing the individual FU stock assessments undertaken by ICES to inform appropriate levels of exploitation. The time series for measuring the exploitation and status of this stock is relatively short (beginning in 2011), but already indicates that a decrease in fishing rates has supported growth in biomass.

The FU approach to management has been shown to work for this stock, and is advocated for implementation across other FUs in the North Sea.

[73] http://www.imr.no/sjokrepsfiske/bakgrunn/berekraftig_sjokrepsfiske/nb-no

8 CONCLUSIONS

In recent years, EU fisheries ministers have set more appropriate fishing limits (in the form of TACs, effort restrictions and technical measures), that have worked to reduce the level of exploitation and therefore reduced overfishing in the EU for certain stocks. Yet fishing limits still exceed scientifically advised levels far too often and by too much.[74]

The case studies presented here show clear instances where stock recovery was aided and subsequently maintained by management actions that successfully ended overfishing. The case studies show that fisheries management works, and that reversing overfishing is therefore possible and achievable for other stocks. There are also numerous other environmental, economic and social benefits that result from sustainable exploitation.

The following general conclusions can be drawn:

- Fishing stocks at or below Maximum Sustainable Yield allow stocks to remain robust and able to provide food both for human populations and other species within the marine ecosystem.

- An improved Catch Per Unit Effort in a well-regulated fishery reflects more efficient fishing. This can result in less impact to seabed habitats and on bycatch species as the vessels can catch the same amount of fish in less time.

- As less fuel is used as a result of more efficient catching, atmospheric emissions by the fishing industry are reduced.

- Bringing stocks to sustainable levels has made fleets more profitable as an enhanced catching efficiency reduces operating costs.

- Improved fleet profitability results in higher incomes for fishers, with further positive consequences for dependent coastal communities.

- Less tangible social benefits reported by the fishing industry include an improved reputation and better access to markets due to being able to show that it is landing fish from a sustainable source.

Ending overfishing delivers on the CFP objective to bring fishing to sustainable levels. The numerous environmental, economic and social benefits highlighted in these case studies are often foregone where overfishing continues. These instances of overfishing should be identified and addressed as a priority.

[74] STECF-16-03

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