02/22

RAPPORT
REPORT

Post-Brexit Management of Pelagic Fisheries in the North-East Atlantic: Norwegian Spring Spawning – Atlanto Scandian Herring, Mackerel, and Blue Whiting

Trond Bjørndal
Ragnar Arnason
Zvonimir P. Đ. Mrdalo
Max Nielsen

SNF

Samfunns- og næringslivsforskning AS
Centre for Applied Research at NHH

SNF
SAMFUNNS- OG NÆRINGSLIVSFORSKNING AS

- er et selskap i NHH-miljøet med oppgave å initiere, organisere og utføre eksternfinansiert forskning. Norges Handelshøyskole og Stiftelsen SNF er aksjonærer. Virksomheten drives med basis i egen stab og fagmiljøene ved NHH.

SNF er ett av Norges ledende forskningsmiljø innen anvendt økonomisk-administrativ forskning, og har gode samarbeidsrelasjoner til andre forskningsmiljøer i Norge og utlandet. SNF utfører forskning og forskningsbaserte utredninger for sentrale beslutningstakere i privat og offentlig sektor. Forskningen organiseres i programmer og prosjekter av langsiktig og mer kortsiktig karakter. Alle publikasjoner er offentlig tilgjengelig.

SNF
CENTRE FOR APPLIED RESEARCH AT NHH

- is a company within the NHH group. Its objective is to initiate, organize and conduct externally financed research. The company shareholders are the Norwegian School of Economics (NHH) and the SNF Foundation. Research is carried out by SNF´s own staff as well as faculty members at NHH.

SNF is one of Norway´s leading research environment within applied economic administrative research. It has excellent working relations with other research environments in Norway as well as abroad. SNF conducts research and prepares research-based reports for major decision-makers both in the private and the public sector. Research is organized in programmes and projects on a long-term as well as a short-term basis. All our publications are publicly available.

SNF Report No. 02/22

Post-Brexit Management of Pelagic Fisheries in the North-East Atlantic: Norwegian Spring Spawning – Atlanto Scandian Herring, Mackerel, and Blue Whiting

Trond Bjørndal
Ragnar Arnason
Zvonimir P. Đ. Mrdalo
Max Nielsen

SNF-project no. 10072:
Brexit and Fisheries Management in the Norwegian Sea

The project has been funded by Nordisk Arbeidsgruppe for Fiskeri (AG-Fisk) – Project (223)-2021-Brexit

CENTRE FOR APPLIED RESEARCH AT NHH
BERGEN, MARCH 2022

ISBN 978-82-491-1084-1 (Printed version)
ISBN 978-82-491-1085-8 (Online version)

ISSN 0803-4036

Abstract

The Norwegian Sea is home to three large pelagic fisheries for mackerel, Norwegian spring spawning – Atlanto Scandian herring and blue whiting. In 2019, the total catch of these three species was 3,113,000 tonnes with a total value estimated at EUR 2.011 billion. This means they represent some of the largest fisheries in the North Atlantic and are important in terms of income and employment for the participating countries. The purpose of this report is to analyse post-Brexit management of the fisheries. A number of countries including the EU, Norway, the Faroe Islands, Iceland, Greenland and Russia have traditionally fished these stocks and have internationally recognised fishing rights in the area. As the United Kingdom has left the EU, the legal status of both the UK and the EU has changed: while the UK is now a coastal state in all three fisheries, the EU is coastal state in the fisheries for mackerel and blue whiting while a distant water state in the herring fishery. The more countries involved, the more difficult to arrive at a cooperative agreement. Thus, with a new player post-Brexit, it may become even more difficult than before to agree to cooperate. The report takes a game theoretic perspective to the management of the fisheries in question. In a cooperative game, all parties cooperating is referred to as the grand coalition and there have been periods when the fisheries have been managed by grand coalitions. However, for mackerel, the grand coalition broke down in 2008; for herring, where there was full cooperation up to 2012, while for blue whiting, the grand coalition broke down in 2015. Currently, although the parties agree on TACs as recommended by ICES, national quotas are set unilaterally with the consequence the sum of quotas exceed ICES quota advice. The report analyses developments in the fisheries over time as well as conditions that must be met for renewed cooperation.

Acknowledgement
The authors thank Darius Campbell and Gordon R. Munro for insightful comments on the manuscript.

Table of contents

Abbreviations

Blim	= precautionary reference point for the biomass related to the risk of impaired reproductive capacity
Bpa	= precautionary reference point for the biomass related to the risk of impaired reproductive capacity
EBIDTA	= Earnings before interest, taxes, depreciation, and amortisation
EBIT	= Earnings before interest and taxes
EEZ	= Exclusive Economic Zone
CFP	= Common Fisheries Policy
F	= Fishing mortality
GT	= Gross tonnes
GRT	= Gross register tonnes
ICES	= International Council for the Exploration of the Sea
MSY	= Maximum sustainable yield
$MSY_{Btrigger,}$	= the parameter in the ICES MSY framework which triggers advice on a reduced fishing mortality relative to F_{MSY}
NEAFC	= North-East Atlantic Fisheries Commission
NSSH-ASH	= Norwegian spring spawning - Atlanto Scandian herring
RSW	= Refrigerated sea water
SSB	= Spawning stock biomass
TE	= Tonnage unit (gross tonnage)
TAC	= Total allowable catch quota
UNCLOS	= UN Convention on the Law of Sea
UNFSA	= UN Fish Stocks Agreement

1. INTRODUCTION

The Norwegian Sea, a sub-region of the North-East Atlantic, is an unusually fertile marine area sustaining a number of large pelagic fish stocks. These include mackerel, herring and blue whiting which are harvested by several countries. In the past 20 years, the combined average annual catch has amounted to 3.07 mill tonnes, ranging from 2.04 – 3.86 mill tonnes. This means they represent some of the largest fisheries in the North Atlantic and are important in terms of income and employment for the participating countries.

The purpose of this report is to analyse post-Brexit management of the fisheries for Norwegian spring spawning – Atlanto Scandian herring (NSSH-ASH), mackerel, and blue whiting. A number of countries including the EU, Norway, the Faroe Islands, Iceland, Greenland and Russia have traditionally fished these stocks and have internationally recognised fishing rights in the area. As the United Kingdom has left the EU, the legal status of both the UK and the EU has changed.

The UK has now become a coastal state in all three fisheries, while there are also changes in the coastal status of the EU. As a result, previous fishing agreements need to be re-negotiated. This happens in a situation where, in recent decades, it has been challenging to arrive at cooperative management solutions for the three fisheries. The agreements in question are complex and often precariously balanced with the consequence that they often break down, partially or fully. There are many reasons for that, including the fact that the migration patterns have changed, be it for climatic or other reasons (Bjørndal, 2009; Bjørndal & Ekerhovd, 2014). Moreover, there are ecosystem interactions between the three stocks. It is also well known that the more countries involved, the more difficult to arrive at a cooperative agreement (Bjørndal & Martin, 2007). Thus, with a new player post-Brexit, it may become even more difficult than before to agree to cooperate.

This report is organised as follows. In chapter 2 we give an overview over fisheries management in the Norwegian Sea and introduce aspects of game theory of relevance for the analysis of the fisheries in question. In chapter 3 we analyse the three different fisheries in terms of harvest and stock size and consider current and past fisheries agreements. In chapter 4 we consider the importance of these fisheries to the countries involved, not only in terms of harvests, but also in terms of revenues and profitability. Then, in chapter 5, we develop a number of strategic considerations for the management of the fisheries. Chapter 6 provides a brief summary, while quotas are outlined in detail in an appendix.

2. FISHERIES MANAGEMENT IN THE NORWEGIAN SEA

The fishing areas in the Norwegian Sea are illustrated in Figure 2.1, which shows the exclusive economic zones (EEZs) of coastal states in the area as well as international waters. All three stocks under consideration, mackerel, herring and blue whiting, undertake seasonal migrations between different EEZs and the high seas.

Figure 2.1. Fisheries zones in the North-East Atlantic.

Fish stocks that migrate between neighbouring EEZs and/or adjacent high seas give rise to various classes of transboundary fish stocks including: i) Shared stocks crossing the EEZ boundaries into the EEZs of one or more coastal states. ii) straddling fish stocks crossing EEZ boundaries into the adjacent high seas (and possibly other EEZs)[1]. Under this classification (Munro *et al.,* 2004), the three stocks under consideration are all straddling stocks. According to the 1995 United Nations Fish Stocks Agreement (UNFSA; see UN; 1995), straddling fish stocks and highly migratory fish stocks are to be managed by Regional Fisheries Management Organisations (RFMOs), consisting of coastal states and relevant Distant Water Fishing States (DWFSs) with a "real" interest in the fishery.

Management of straddling stocks in the North-East Atlantic is governed by the North-East Atlantic Fisheries Commission (NEAFC), an RFMO under the UNFSA (Bjørndal, 2009). The management area of NEAFC consists of two areas called the Regulatory Area and the Convention

[1] For sake of completeness, mention should also be made of highly migratory stocks, mainly tunas and tuna-like fish, as defined in the United Nations Convention on the Law of the Seas (UNCLOS), Annex 1.

Area. The Regulatory Area is the entire North-East Atlantic. A sub-region of this, the international waters between the mainland of Norway and Jan Mayen, and outside EEZs, known as "the Banana Hole", represents the Convention Area[2] (Figure 2.1).

The main objectives of NEAFC are to provide a forum for consultation and exchange of information on the state of fisheries resources in the North-East Atlantic, for developing management policies to ensure the conservation and optimal utilisation of such resources, and to set conservation measures in waters outside national jurisdiction (Bjørndal, 2009). NEAFC acts as a forum for consultation and exchange of information on the state of fishery resources in the Convention Area and on management policies, including examination of the overall effect of such policies on the fishery resources. There is no internal scientific body since scientific advice is provided by the International Council for the Exploration of the Sea (ICES).

The main fisheries in the Regulatory Area are NSSH, mackerel, and blue whiting. In 2019, the total catch of these three species was 3,113,000 tonnes, of which 795,737 tonnes was taken in the Convention Area[3]. The total value can be estimated at EUR 2.011 billion[4].

The stocks under consideration are harvested by coastal states and distant water fishing states (DWFS). For herring, Norway, Russia, Iceland, the Faroe Islands, and the UK are coastal states while the EU has now become a DWFS. Mackerel and blue whiting are harvested by the same countries; however, for these fisheries Russia is a DWFS harvesting in international waters. Greenland is now also considered a coastal state for mackerel as will be explained below.

For the three fisheries, the relevant coastal states engaged in the fisheries negotiate to set annual total allowable catch quotas (TAC) and quota shares, including for DWFSs. This is done based on scientific advice from ICES. While NEAFC in principle sets quotas and other regulations in the Convention Area, it has no power to enforce them.

<u>Game theory</u>

The countries exploiting the stocks have the option of cooperating or not cooperating, and we have seen instances of both for all three fisheries, as we shall return to below. In case of non-cooperation, theory predicts that the players will adopt strategies that will lead to excessive harvesting, stock depletion, and little or no long-term economic benefits. In the case of full cooperation, theory predicts that overall economic benefits from the fisheries will be maximised, harvest levels will be relatively modest, stocks large and the fisheries sustainable.

---

[2] NEAFC also has other convention areas, but they are not of relevance to this article.
[3] Source: 2019 NEAFC catch statistics https://www.neafc.org/system/files/2019%20Final.pdf (consulted 26th July, 2021).
[4] This is a rough estimate, assuming Danish prices as reported in Tables 4.1-4.3 are applicable to all harvests.

A cooperative game is one in which there must be a degree of trust among the players. Moreover, commitments of the players are binding and enforceable (Grønbæk *et al*., 2020). Binding may mean legally binding but could as well represent an implicit obligation based on trust. Bjørndal and Munro (2021) outline conditions that must be met for the solution to a cooperative game to be stable[5].

The first condition is that the players be able to communicate with one another effectively. The second, referred to as" individual rationality", is that each player must always anticipate a return, or "payoff," from the cooperative solution at least as great as he anticipates to obtain under non-cooperation. Thirdly, the solution must be "collectively rational" in that there cannot exist an alternative solution, which would make one or more players better off, without harming the others, i.e., the solution must be Pareto optimal. Fourthly, the cooperative agreement must be resilient, in the sense that the first three conditions must hold at all times even in the face of unpredictable shocks, be they environmental, economic, or political such as Brexit.

In order to enhance the likelihood that these conditions are met, it is important for the scope for bargaining to be as wide as possible. This brings up the issue of "side payments" and "side payment like arrangements" (Munro *et al.*, 2004). These could include trade or even security arrangements. In a fisheries context, a coastal state allowing other countries to harvest its quota in her EEZ could also be considered a side payment like arrangement.

In a cooperative game, all parties cooperating is referred to as the Grand Coalition. There is, however, also the possibility of sub-coalitions, for example the possibility of Norway, Russia and the EU playing cooperatively with each other (sub-coalition), while playing competitively against the other parties to the fisheries, a situation which has been observed in the past. Obviously, the number of possible sub-coalitions increases very fast (more than exponentially) with the number of players. The possibility of sub-coalitions increases the complexity of the game.

In addition, there is the problem of free riding, of a player defecting and enjoying the benefits of the cooperation by the others. This may be considered a variant of sub-coalitions, namely a player choosing to act as a singleton.

As a final comment, most games, be they non-cooperative or cooperative, are not simple "one shot", static simultaneous games. First, players may play sequentially, giving rise to multi-stage games. The sequencing of negotiations may have an impact on the final outcome. Secondly, the games, single-stage or multi-stage, are commonly repeated over time, i.e., they are dynamic. If non-cooperative games are repeated over an extensive period of time, they may evolve into cooperative

[5] These conditions have been applied to fisheries as diverse as those for Barents Sea cod (Bjørndal *et al.*, 2021) and North-East Atlantic and Mediterranean bluefin tuna (Bjørndal, 2021).

ones. The period of non-cooperation may of course endanger the sustainability of the fish stocks which will affect the way the game is played in the likelihood of cooperation.

In the pelagic fisheries game under consideration, although there are separate negotiations for all three fisheries, there are obviously also linkages between them. Thus, a combined analysis of all fisheries may be called for.

Matters for negotiation

Various matters may be subject to fishery game negotiations. Basically everything any party to the pelagic game is interested in may become a matter for negotiation with the others. The most prominent matters, however, are (i) total allowable catches (TACs) for each species, (b) the sharing of the TAC between the parties, i.e., national quotas, and (c) various other matters including access to other parties' EEZs, landing rights etc.

Every year a TAC must be set for each species. In the case of full cooperation, the parties must then agree on quota sharing, i.e., what percentage of the TAC is allocated to each country. In case of non-cooperation, each party may set its own quota; in case of partial cooperation, one or more coalitions may unilaterally set their quotas. We will return to this below.

Other matters are also important. One is access to each other's EEZ. Essentially, it is for each coastal state to determine whether fishermen from other states will have access to fishing in their EEZ. This may be important because, as we shall see below, the value of the fish may vary over the year due to variables such as fat contents and size. Another issue is landing rights in other countries. As we shall see below, these variables are likely to take on particular importance when there is less than full cooperation between the parties as states may then deny access to their EEZs or landing rights in their ports as part of the negotiations. In addition, the countries may negotiate on a number of technical fisheries measures (such as fishing gear and time-area restrictions) although these will not be considered much in this report.

Principles for quota sharing

Zonal attachment is a concept that has been suggested as a way to overcome disputes on how to share the TACs set for fish stocks. Briefly, this works as follows. "Zonal attachment" of a stock is the share of the stock residing within a particular country's EEZ, weighted by the time it spends in the zone over a year, if necessary. This may determine, or at least influences, the share that each country gets of the TAC for that stock.

Although this principle might appear easy to apply, this is not necessarily the case. Shepherd and Horwood (2019) point out that zonal attachment ignores several complicating factors. Fish migrate all the time, and there may be shifts in their distributions in response to climate change and other environmental factors. The reality is that one does not know where the fish are with any accuracy most of the time and there is no obvious basis for deciding how to assess and combine whatever information is available. Furthermore, any "objectively" determined percentages would inevitably fail to match historic shares, and thus generate conflict (Shepherd & Horwood, *op. cit.*).

There are numerous other qualifications to this principle. One is where the stock is most easily fishable. Also, as most stocks go through seasonal growth, it matters where the fish gain most of its weight. A third consideration may be the location of spawning grounds. Finally, as the Norwegian Sea covers a vast area, closeness to landing ports may be an important consideration for fishermen. All these variables may impact cost of harvesting and/or the price of fish. This suggests the use of a somewhat more sophisticated principle when it comes to quota sharing. One such example from game theory is what is known as the Shapley value, where a player's allocation is based upon the average of its contribution to all possible coalitions, in comparison with the average contributions of all other players (Bjørndal & Munro, 2012, pp. 199-201).

In the negotiations for a post-Brexit agreement with the EU, the UK government used the zonal attachment principle to demand larger quota shares. This met with only limited success (Bjørndal & Munro, 2021). Any attempt to adjust catch shares is guaranteed to lead to disputes, as the Brexit negotiations clearly demonstrated. In fact, "*…the required shares are hammered out by negotiation among the interested parties, a process that is certainly influenced by any relevant scientific information, but certainly not decided by it"* (Shepherd & Horwood, *op. cit.*). They go on to state that it would be inconceivable that market access is not considered as part of the negotiations. While market access may not be so much of an issue in the Norwegian Sea, other considerations are.

It is also important to bear in mind that zonal attachment is based solely on quantities. As will be illustrated below, prices vary between countries as do costs. This means that if benefits are shared in terms of revenues or net revenues, the outcome may be different from that of quantities[6]. It can be pointed out that what counts is the economic benefits from the harvests, not where the harvests are taken.

Climate and/or environmental changes have had important impacts on the fisheries in the Norwegian Sea. One example is provided by the mackerel fishery. Mackerel in the North-East Atlantic have expanded their northern distribution in recent years (Nøttestad *et al.*, 2016). As a consequence, since the end of the 2000s, mackerel has been found in substantial quantities also in the Icelandic EEZ although this has varied over time. This has caused conflicts, as Icelandic quotas would have to come at the expense of the quotas of the pre-existing incumbents. More recently, mackerel

[6] Bjørndal and Lindroos (2004) found this to be the case for North Sea herring.

migrated into the EEZ of Greenland in 2013-15, but quantities were then greatly reduced from 2016-18. Since 2019 there has been no mackerel in the waters of Greenland, which nevertheless is given a quota as a coastal state (Nøttestad *et al.*, 2016; Nøttestad *et al.*, 2014; 2020).

Unforeseen changes in fish stock migrations between national EEZs make the issue of arriving at and maintaining cooperative agreements on TACs and the distribution of these among interested nations difficult. With the division of catch quotas based on zonal attachment, it is not surprising that changes in fish migrations lead to a breakdown of existing agreements. This is an example in which a cooperative agreement may not be time-consistent. This was indeed the reason for the temporary breakdown in the cooperative management agreement for NSSH-ASH during the period 2003-07 (see Bjørndal and Munro, 2012 for further analysis).

3. THE FISHERIES FOR MACKEREL, HERRING AND BLUE WHITING

We will now look at the three fisheries in more detail in terms of development in stock size and harvest over time as well as quota setting and cooperation. Appendix provides information on quota setting and sharing.

First, it is important to be reminded which coastal states and DWFSs are active in the three fisheries (Table 3.1). Brexit caused some important changes in this respect. The UK is now a coastal state in all three fisheries. The EU, on the other hand, while remaining a coastal state for mackerel and blue whiting, has become a DWFS for herring. Another change relates to Greenland which has become active in these fisheries in recent years: as a coastal state for mackerel, due to the fact that mackerel migrated into the Greenland EEZ for two years (2013-14), and as a DWFS for herring and blue whiting. Nevertheless, it should be pointed out that when considering catches, Greenland is the smallest player overall in these fisheries.

Table 3.1. Coastal states and DWFSs in the three pelagic fisheries.

Fishery	Coastal states	Distant water fishing states
Mackerel	Norway, the EU, the UK, the Faroe Islands, Iceland and Greenland	Russia
Norwegian spring spawning – Atlanto Scandian herring	Norway, the UK, the Faroe Islands, Russia and Iceland	The EU, Greenland
Blue whiting	Norway, the UK, the Faroe Islands, and Iceland	Russia, Greenland

3.1 MACKEREL

ICES uses the term "North-East Atlantic Mackerel" (*Scomber scombrus)* to define mackerel present in the area extending from ICES Division IXa in the south to Division IIa in the north, including mackerel in the North Sea and Division IIIa. The stock is historically divided into three components, with the North Sea component (spawning areas IV and IIIa) considered to be over-fished since the late 1970s, and the western component (spawning areas VI, VII, VIIIa, b, e) contributing the vast majority of biomass and catch from the stock (Bjørndal & Ekerhovd, 2014)[7]. For management purposes, they are treated as one stock because the substocks mix at times when they are jointly harvested. Therefore, fishing effort is in the main not directed at any one of the three separate components, but at a single combined stock.

Spawning stock size (SSB) for the North-East Atlantic mackerel in 1980 was 4.13 mill tonnes (Figure 3.1). SSB went into decline in the mid-1980s to reach a bottom level of 2.13 mill tonnes in

[7] There is also a southern component with spawning areas VIIIc and IXa.

1998, where it levelled off. Later it increased to a peak of about 5.15 mill tonnes in 2014-15 but then declined, with 3.68 mill tonnes recorded for 2020.

In the 2009-19 period, the average annual catch of mackerel was 847,000 tonnes, with a minimum of 481,000 tonnes and a maximum of 1.393 million tonnes (2014). Annual harvest exceeded one million tonnes every year 2014-2018. In 2019, the harvest was 0.84 mill tonnes. Despite large harvests in recent years, ICES assesses that fishing pressure on the stock is below F_{MSY}, the fishing mortality associated with MSY and spawning-stock size is above $MSY_{Btrigger,}$ Bpa, and Blim[8]. This is largely due to good recruitment in recent years. Blim and Bpa are precautionary reference points for the biomass related to the risk of impaired reproductive capacity. $MSY_{Btrigge}$r is the parameter in the ICES MSY framework which triggers advice on a reduced fishing mortality relative to F_{MSY}[9].

As noted above, mackerel is harvested by the all the coastal states in the area, with Russia a DWFS harvesting in international waters as well as in the EEZs of some coastal states based on bilateral access agreements. Harvest by country is illustrated in Figure 3.2. It is noticeable that Iceland entered the fishery with a catch of 4,622 tonnes in 2006 and soon became the largest harvester after the EU (including the UK) and Norway.

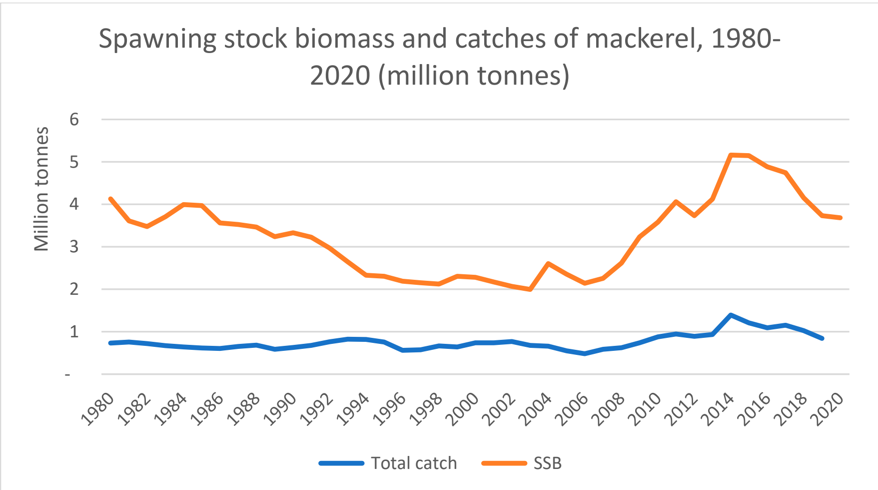


Figure 3.1. Spawning stock biomass and catches of mackerel, 1980-2020. Million tonnes.
Source: (ICES, 2020c).

[8] Source: ICES Advice on fishing opportunities, catch, and effort Ecoregions in the North-East Atlantic and the Arctic Ocean. Published 30 September, 2020.
[9] Source: ICES Advice. https://doi.org/10.17895/ices.pub.4503.

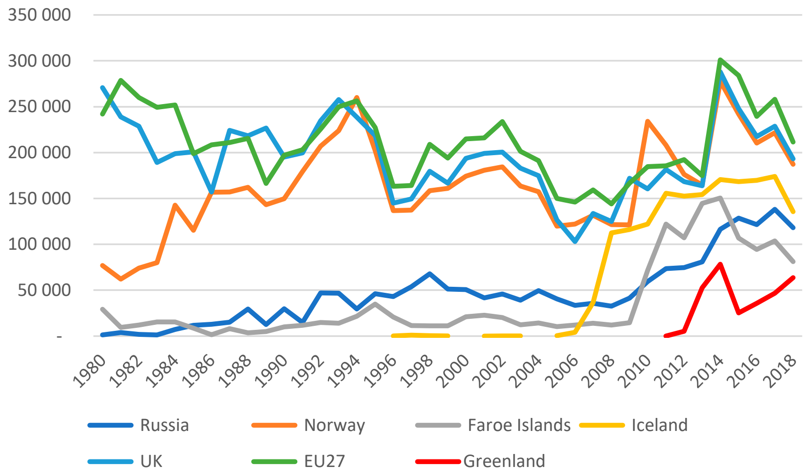


Figure 3.2. Catches of mackerel by country in the North-East Atlantic, 1980-2018. '000 tonnes.
Source: (ICES, 2020d) and (ICES, 2011) and (FAO, 2021). Retrieved from:
https://www.fao.org/fishery/statistics-query/en/capture/capture_quantity

In 1999, a costal management agreement between Norway, the EU and the Faroe Islands was agreed upon (Totland, 2020). The EU quota was 58%, while that of Norway was 30%; the ratio of the EU quota to the Norwegian was 1.92 (Williams, 2021). In addition, a number of management measures were agreed on to protect the North Sea component of the stock that is considered depleted, as well as to protect juvenile mackerel.

According to the official catch statistics, in 2005 about 60% of the catches were taken by member countries of the EU, followed by Norway (28%), Russia (9%), the Faroe Islands (2%), and Iceland (less than 0.1%).

Later, changes in the migratory pattern of mackerel had profound consequences of the management of mackerel. While Iceland had virtually no harvest of mackerel until 2007, this changed in 2008, when Icelandic fishermen caught 112,000 tonnes of mackerel, increasing to 116,000 tonnes in 2009. This appears to have been primarily due to changes in the distribution pattern of mackerel, which had commenced migrations into the Icelandic EEZ. While Iceland had no quota and hardly any catches in the past, this meant that the mackerel "game" has changed, with essentially the appearance of a new coastal state.

The international agreement for management of the mackerel fishery broke down after Iceland became a major player as of 2008. Even when an agreement was in place, despite attempts to control allowable catches, landings exceeded the annual TACs in most years, sometimes by a considerable amount. In 2009, the total agreed upon TAC was 605,000 tonnes, not including the unilateral TACs set by Norway, the Faroe Islands and Iceland; the Advisory Committee for Fisheries Management

(ACFM) catch was recorded at 735,000 tonnes. In 2009, EU countries accounted for 53.5% of harvest, followed by Norway (19.2%), Iceland (18.4%), Russia (6.6%), and the Faroe Islands (2.3%).

The tripartite agreement of 1999 between Norway, the EU and the Faroe Islands broke down in 2010, when the Faroe Islands unilaterally announced a quota of 85,000 tonnes or about 15% of the TAC recommended by ICES. This was based on a belief that changes in mackerel migrations meant increased attachment to Faroese waters although scientific evidence at the time was uncertain (Samró, 2015). As a consequence, for 2010, there was no internationally agreed upon TAC.

In 2013, the mackerel also migrated into the Greenland EEZ and Greenland has subsequently been considered a coastal state. All Greenland catches are harvested in their EEZ or in international waters while no foreign vessels have harvested in the Greenland EEZ. In 2014, Norway, the EU and the Faroe Islands agreed on a new tripartite coastal state agreement, which was later extended until 2020 (NFD, 2020). Norway and the Faroe Islands also agreed on mutual zonal access, while the mutual access agreement between Norway and the EU was continued. Attempts to include Iceland and Greenland in this agreement were unsuccessful. For 2021 onwards the parties have attempted to agree on a comprehensive agreement including quota sharing but so far without success (NFD, 2020). Table 3.2 illustrates the timeline when it comes to cooperation in the mackerel fishery.

Table 3.2. Timeline mackerel cooperation.

Year	Cooperation	Notes
1999-2009	Tripartite coastal agreement Norway, the EU and the Faroe Islands.	
2008-2009	Tripartite agreement Norway, the EU and the Faroe Islands; Iceland singleton.	Iceland entered the fishery in 2008.
2010-13	Norway-EU agreement; Iceland and the Faroe Islands singletons.	As a consequence of Faroese demands for higher quota shares in 2010, the tripartite agreement broke down. Iceland demanded quotas as a costal state. Norway-EU agreement included access. In 2013, mackerel migrated to the Greenland EEZ for the first time.
2014-20	Renewed tripartite agreement Norway, the EU and the Faroe Islands; Iceland singleton.	Greenland has had no bilateral agreements regarding mackerel with any other country.
2021-	Agreement on TAC, unilateral quota setting by all countries	The UK enters as a coastal state.

Based on: Bjørndal (2009), NFD (2020) and Williams (2021).

As already stated, the sum of quotas set by the countries in the fishery has for many years exceeded the TAC recommended by ICES (see Appendix). This is illustrated in Figure 3.3 and may be one of the reasons why SSB has been in decline since 2015. ICES recommended a reduction in the TAC from 922,000 tonnes in 2020 to 852,000 tonnes in 2021. Nevertheless, the sum of unilateral quotas increased from 2020 to 2021.

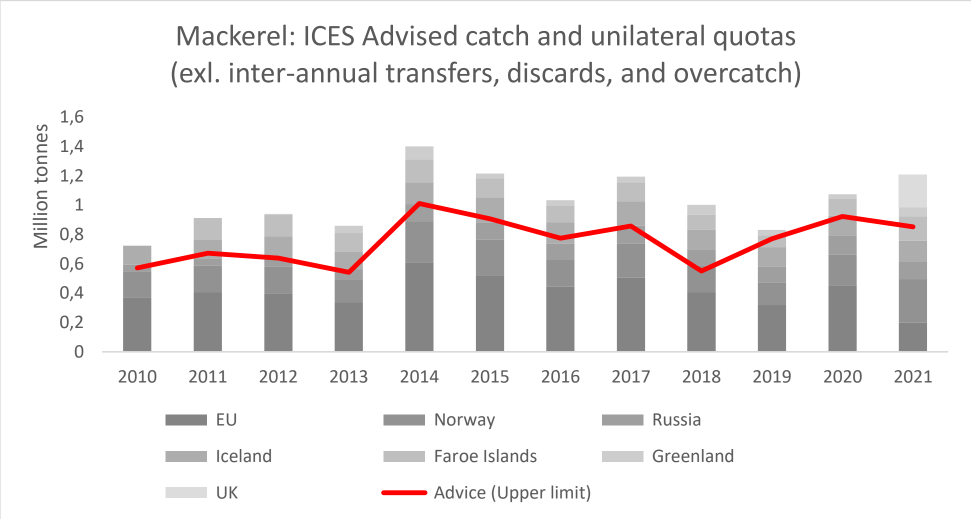


Figure 3.3. Mackerel: Unilateral quotas as set by participants in the fishery (excluding inter-annual transfers by participants, discards and overcatch) and the scientific advice on how much to take out of the stock (upper limit).

According to NEAFC, the total mackerel harvest in 2019 was 832,000 tonnes[10]. Of this, 482,000 tonnes or 57.9% was harvested in EU waters and 202,000 tonnes or 24.3% in the NEAFC regulatory area. In addition, there was a harvest of 33,183 tonnes in Faroese waters, 64,000 tonnes in the Icelandic zone, almost 37,000 tonnes in the Norwegian EEZ, and 6,650 tonnes in Greenland waters. Although there may be changes from year to year, this illustrates the importance of the EU EEZ for the harvest fishery. It is important to note that while the EU zone was dominant in 2019, almost all the mackerel was harvested in what is now the UK EEZ (see also Bjørndal and Munro, 2021).

Table 3.3 gives national quotas as percentage of ICES advice. It is seen that the total increases from 119.7% in 2020 to 141.5% in 2021. Iceland, the Faroe Islands and Norway have all increased their relative quotas for 2021, the Faroe Islands and Norway both by 50% so that Norway claims a

[10] This is slightly different from what is reported by ICES (see Appendix), presumably due to differences in geographical areas. See https://www.neafc.org/system/files/2019%20Final.pdf (accessed 2nd August, 2021).

share of 35%. The sum of the EU and UK relative quotas for 2021 is the same as the EU quota for 2020. As a consequence, if the unilateral quotas declared for 2021 are harvested, the consequence could be a further reduction in the SSB. In fact, the situation for 2021 is even worse than Table 3.3 suggests. If we include permitted inter-annual transfers of quotas by participants as well as discards and overcatch, the sum of unilateral quotas increased from 124.5% in 2020 to 153% in 2021 (see Appendix for details).

Table 3.3. Quotas relative to ICES advice. Percent.

Year	EU	UK	Norway	Russia	Iceland	Faroe Islands	Greenland[a)]	Total
2020	49.3%	-	22.5%	14.1	14.7	12.6	6.5	119.7
2021	23.2	26.1	35.0%	14.1	16.5	19.6	7.0	141.5

a) The numbers in the table are known from NEAFC, except for Greenland. The numbers for Greenland appear from Statistics Greenland (2021), Fishing quotas for marine fisheries in Greenland, available at: https://bank.stat.gl/pxweb/da/Greenland/Greenland__FI__FI10/FIXKVOT.px/.

For 2020, quotas were based on the tripartite agreement between a sub-coalition consisting of Norway, the EU and the Faroe Islands, while Iceland, Greenland and Russia determined their quotas unilaterally. For 2021, all countries have set quotas unilaterally, in principle also the EU and the UK, although their quota shares are unchanged due to 2020 UK-EU Trade and Cooperation Agreement (Bjørndal & Munro, 2021). For 2022, the parties have agreed on a TAC of 794,920 tonnes, based on ICES advice and a management plan agreed on by all coastal states (Agreed Record, 2021a). The parties also agree that each party may transfer to the following year unutilised quantities of up to 10% of its quota to be added to next year's quota; an overharvest of up to 10% in one year to be deduced from the next year's quota is also permitted (Agreed Record, 2021a). It is also important to note that a number of schemes agreed through NEAFC pertaining to technical regulations, electronic reporting systems, control and protection of vulnerable habitats are adhered to by all parties (Gullestad, Sundby & Kjesbu, 2020; Agreed Record, 2021a).

Harvesting is confined to national EEZs and international waters. Bilateral agreements regulate access to other countries' EEZ. In 2021, the UK and the EU had full access to each other's waters as part of the Trade and Cooperation Agreement; this is likely to persist in the future (Bjørndal & Munro, 2021). Moreover, Norway and the Faroe Islands had a reciprocal access agreement for 83,524 tonnes (Agreed Record, 2021a). Fishing areas for Norway much depend on the distribution of mackerel. Before Brexit, Norwegian fishermen had full access to harvesting the mackerel quota in the EU zone; for all practical purposes this means the UK zone. For example, in 2019, Norway harvested 129,355 tonnes out of a total mackerel harvest of 159,084 tonnes in the UK zone[11]. In 2021, Norway and the UK had no fisheries agreement as a consequence of which Norwegian fishermen were barred from harvesting mackerel in the UK zone; thus, harvesting was confined to Norwegian, Faroese and international waters. Norway and the UK have reached a fisheries agreement for 2022, which includes access to UK waters for the harvesting of agreed upon quantities of demersal fish, NSSH-ASH and North Sea herring, but not mackerel[12]. Quota exchanges are also regulated by bilateral agreements.

A major reason why quota sharing has proved so difficult is changes in the migratory pattern of mackerel. These changes may be due to several variables including climate, changes in zooplankton and stock changes. In recent years a more northern and eastern distribution of the stock has been observed (Nøttestad *et al.*, 2016; Nøttestad *et al.*, 2020). This has meant that there have been major changes in zonal attachment, cf. the discussion in chapter 2. To provide some examples[13], in 2009, 97% of the Icelandic harvest was taken in the Icelandic EEZ; in 2019, this was reduced to 51.3% with 48.2 taken in the NEAFC regulatory area. In 2009, Norway harvested 46.4% of mackerel in the EU zone which increased to 81.3% in 2019. In 2021, most of the Norwegian harvest will be in the Norwegian EEZ, although that is influenced by the fact that Norwegian fishermen are excluded from the British EEZ. In view of this situation, the Parties have established a working group to report on stock distribution (zonal attachment) as a basis for discussion of quota sharing in early 2022 (Agreed Record, 2021a).

The UK and the Faroe Islands had no fisheries agreement for 2021, however, the parties reached an agreement for 2022 but this pertains only to demersal fish, not pelagic[14]. As a consequence, fishermen from the Faroe Islands do not have access to the UK EEZ where they have traditionally harvested much of their mackerel quotas (Bjørndal & Munro, 2021). In 2021 the Faroese fishing fleet managed to harvest 104,779 tonnes or 63% of the unilaterally set quota of 167,048 tonnes (Faroese Administrative Regulation No125/2021). The largest catches of around 54,000 tonnes came from the Faroese waters followed by 28,000 from international waters and around 22,000 tonnes harvested in the Norwegian EEZ.

As there was some uncertainty as to whether Norway and the Faroe Islands would be able to harvest their full quotas in national EEZs, this might have been one of the reasons for their large

[11] Source: NEAFC. See www.neafc.org/system/files/2019%20Final.pdf.
[12] Source: Agreed Record of Fisheries Consultations between the United Kingdom and Norway for 2022. 21 December, 2021.
[13] Source: NEAFC. See www.neafc.org/catch.
[14] Agreed Record of Fisheries Consultations between the Faroe Islands and the United Kingdom of Great Britain and Northern Ireland for 2022. Signed 8th February, 2022.

increases in mackerel quotas for 2021. An important question remains whether they will manage to fully harvest their quotas when harvesting is confined to their own EEZs and international waters.

3.2 NORWEGIAN SPRING SPAWNING – ATLANTO SCANDIAN HERRING

NSSH-ASH (*Clupea harengus*) is a straddling stock that is found throughout large parts of the North-East Atlantic. The fishery follows the migration of the stock closely as it moves from the wintering and spawning grounds along the Norwegian coast to the summer feeding grounds in the Faeroese, Icelandic, Jan Mayen, Svalbard, and international areas. In the 1950s and the 1960s, NSSH-ASH was a major commercial species and the stock was subjected to heavy exploitation (Bjørndal *et al.,* 2004). The annual harvest peaked at two million tonnes in 1966, but by this time the stock was in serious decline and by the late 1960s the mature stock was almost completely depleted due to overfishing. A large increase in fishing effort, combined with improved fishing technology, contributed to the collapse of this stock by the late 1960s.

Due to the moratorium that was put in place to allow an increase in the spawning stock, the stock recovered by the late 1980s-early 1990s. Until 1994, the fishery was almost entirely confined to Norwegian coastal waters, but during the summer of 1994 there were also catches in the offshore areas of the Norwegian Sea for the first time in 26 years, due to the herring resuming its traditional migratory pattern. According to Gullestad, Sundby and Kjesbu (2020), the most apparent explanation for the changes in the geographical range of herring migrations is stock abundance rather than climate. They also point out that changes in overwintering areas appear to be closely related to the ratio of younger to older individuals, i.e., when young individuals dominate (strong yearclasses). Furthermore, during the summer feeding migration in the Norwegian Sea, there may be interactions with mackerel and blue whiting.

In 1995, the Advisory Committee on Fishery Management (ACFM) of the ICES recommended a TAC of 513,000 tonnes, but participating countries ignored the recommendation and the collective harvest of Norway, Russia, Iceland, the Faroe Islands and the EU exceeded 900,000 tonnes, almost twice the quantity recommended by ACFM. The fishery expanded further the subsequent year.

In 1996, the EU, the Faroe Islands, Iceland, Norway, and Russia agreed to implement a long-term management plan for NSSH. According to Gullestad, Sundby and Kjesby (2020), zonal attachment was modelled and “used as a starting point” for the negotiations. The Parties agreed to maintain a level of SSB greater than the critical level (B_{lim}) of 2,500,000 tonnes, and to restrict their fishing to TACs consistent with a fishing mortality rate of less than 0.125 for appropriate age groups as defined by ICES for the year 2001 and subsequent years.

In addition, there were a number of bilateral agreements between the countries involved. Fishermen from other countries were allowed to harvest part of their quota in the Norwegian EEZ and the control zone around Jan Mayen, which is under Norwegian jurisdiction, thus enabling them to harvest at a time of year when the herring contain more fat and thus are more valuable. Moreover, fishermen from other countries are allowed to land their harvests in Norway, which would tend to reduce transportation distances and thus increase the prices they would fetch[15]. This policy would also benefit the Norwegian fish processing industry.

Juvenile herring grow up in the Russian EEZ in the Barents Sea. The then Soviet Union harvested 82,000 tonnes in their EEZ in 1984-5 and, as a consequence, claimed coastal state status to the resource (Gullestad, Sundby & Kjesbu, 2020). The following year, Norway and the Soviet Union reached an agreement, whereby Norway granted the Soviet Union an annual quota of adult herring in Norwegian waters. This has had the effect of closing the Barents Sea to juvenile herring fishing. This agreement has been in effect ever since (Gullestad, Sundby & Kjesbu, 2020).

As the herring biomass is heavily dependent on strong year classes which tend to occur at discrete intervals, stock size varies considerably over time. Thus, the SSB increased from 2.1 mill tonnes in 1988 to 5.94 mill tonnes in 1998 (Figure 3.4). After a subsequent dip, a new peak of 7 mill tonnes was reached in 2007-08. Stock size has subsequently been in decline to 3.3 mill tonnes in 2020. ICES classifies the current status of the stock as having full reproductive capacity and being harvested sustainably.

In the 2000-19 period, the average annual catch of herring was 910,000 tonnes, varying between a minimum of 329,000 tonnes and 1.687 million tonnes. Harvest by country is given in Figure 3.5. As the figures shows, Norway is by far the greatest harvester.

[15] Similar landing allowances apply to a number of other countries.

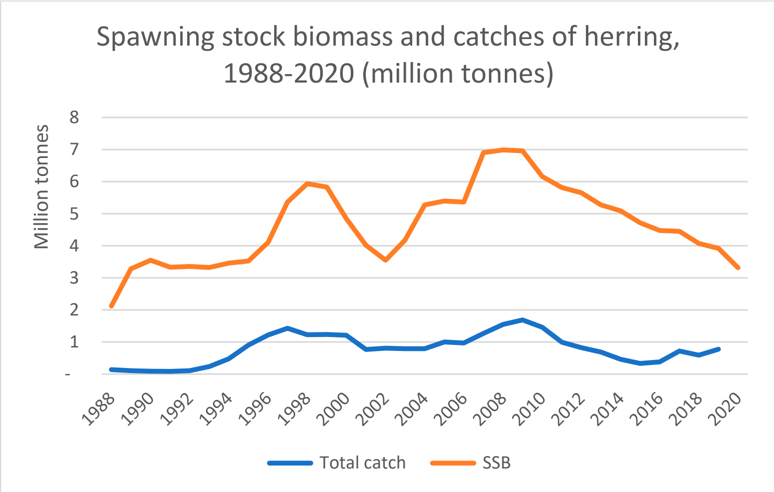


Figure 3.4. Spawning stock biomass and catches of NSSH-ASS, 1988-2020. Million tonnes.
Source: (ICES, 2020b).

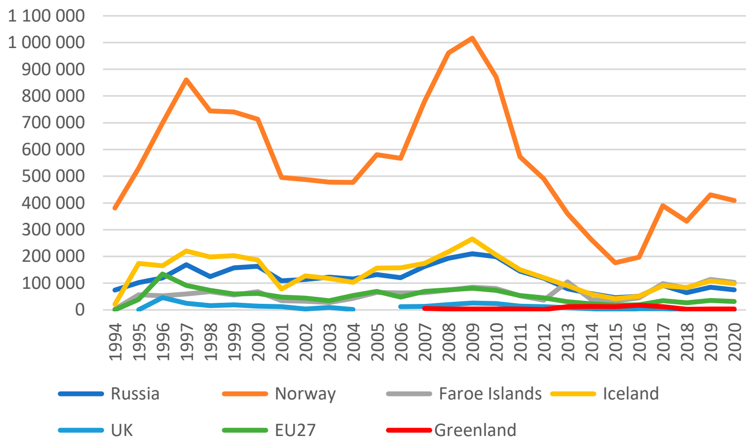


Figure 3.5. Catches of NSSH by country 1994-2020. '000 tonnes.
Source: (ICES, 2020d) and (ICES, 2011). Retrieved from
https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2021/2021/her.27.1-24a514a.pdf.

In the years 1997-2002, the partners agreed on the setting of the annual TAC and the shares for each country. This agreement broke down in 2003 because of Norwegian demands for a higher share of the TAC. These claims were based on the zonal attachment principle. It turned out that the herring spent more time in the Norwegian EEZ than expected when the first agreement was reached and, based on this principle, Norway laid claim to a greater share of the quota. This showed that the original cooperative agreement was not time consistent as it could not accommodate changes in migration. In the end, only minor adjustments to the quota shares were made. Although Norway's quota demands were not met, Norway preferred a cooperative agreement to a non-cooperative one.

While the management plans and coastal state agreements were suspended (2003-2006), the bilateral agreements between Norway and other countries were also suspended[16], except for the one between Norway and Russia regarding juvenile herring. In January 2007, however, the parties signed a management agreement for 2007. This included the same long term management plan that the parties had agreed on in 1996 (NFD, 2020). The Parties agreed on a TAC for the NSSH-ASS of 1.518 million tonnes in 2008. The allocation of the quotas is as follows: European Community 6.52% (98,822 tonnes); the Faroe Islands 5.16% (78,329 tonnes); Iceland 14.51% (220,262 tonnes); Norway 61% (925,980 tonnes), and Russian Federation 194,607 tonnes or 12.81% (194,607 tonnes).

This agreement broke down in 2013 as the Faroe Islands believed they were entitled to a larger quota and unilaterally increased its quota to 17%; however, the other countries did not adjust their quotas (Williams, 2021). For 2014 and 2015 the Faroe Islands set quotas at 40,000 tonnes (Faroese Administrative Regulations No 84/2014 and No 100/2015), but in 2017 the quota increased to 17.7% or 125.597 tonnes (Faroese Administrative Regulation No 146/2016). In 2016, Greenland set a national quota at 20,000 tonnes. In these years Norway, the EU and Russia did not respond. In 2016, Norway harvested 51.5% of the total harvest. Norway reacted in 2017, setting a quota of 67%, gradually increasing to 76%. However, as other countries followed suit, Norway's real quota share in 2019 was 55.4%, reduced to just over 54% in 2020 (Williams, 2021). Table 3.4 gives the timeline when it comes to cooperation in the herring fishery.

[16] As an example, Icelandic fishermen were barred from landing herring in Norway. This was detrimental not only to the Icelandic fishermen, but also to Norwegian fish processors whose supplies and thus revenues were reduced.

Table 3.4. Timeline re NSSH-ASH cooperation.

Year	Cooperation	Notes
1996-2002	Full cooperation.	Long-term management agreement was agreed on in 1996.
2003-2006	No agreement.	The 2006 agreement broke down in 2003 because of Norwegian demands for a higher share of the TAC. Numerous bilateral agreements were suspended.
2007-12	Full cooperation.	New management agreement signed in January, 2007. Quota shares: EU 6.52%; the Faroe Islands 5.16%; Iceland 14.51%; Norway 61%, and Russia 12.81%.
2013-14	For 2013, the Faroe Islands unilaterally increased its quota to 17%, for 2014, it set a quota of 40,000 t; four party agreement between Norway, Iceland, Russia and the EU.	Four party coalition, the Faroe Islands operating as a singleton.
2015-16	The Faroe Islands quota: 40,000 t for 2015 and 2016. Greenland quota: 20,000 t for 2015. No four-party agreement.	Breakdown in cooperation.
2017-19	The five coastal states agreed on TACs but with unilateral quota setting.	Norway increased her quota from 61% to 67% in 2017, 70% in 2018 and then to 73%, based on zonal attachment.
2020-	Agreement on TAC but with unilateral quota setting.	Norway increased her quota to 76%.
2021	Agreement on TAC but with unilateral quota setting.	Norway set her quota at 76%. The UK enters as a coastal state.

Based on: Bjørndal (2009), NFD (2020) and Williams (2021).

According to ICES, based on the long-term management strategy in place, catches in 2021 should be no more than 651 033 tonnes[17]. In 2019, fishing pressure was above F_{MSY} and the fishing mortality stipulated in the management plan, nevertheless, harvesting was still considered sustainable by ICES.

Currently, the coastal states agree on the management plan for herring and the annual TAC while national quotas are set unilaterally (Agreed Record, 2021b). Harvesting is in national EEZs or international waters, and the parties agree on a number of technical measures. For 2022, the coastal states have agreed on a TAC of 598,588 tonnes. As for mackerel, transfers of quota from one year to the next are permitted. The parties agreed to establish a working group on the distribution of herring with quota sharing to be addressed in 2022 (Agreed Record, 2021b).

[17] ICES Advice on fishing opportunities, catch, and effort Ecoregions in the North-East Atlantic and the Arctic Ocean. Published 30 September, 2020.

Bilateral agreements have regulated quota exchanges between parties and access arrangements. In 2021 the EU could harvest all its quota in UK EEZ; the EU and Norway had a reciprocal access agreement and most of the EU harvest of NSSH-ASH remain in 2021 originating in the Norwegian EEZ; Norway had until 2020 some catches of herring in the EU zone caught in the UK EEZ, but since no agreement is reached between the UK and Norway in 2021, Norway could not fish NSSH-ASH in the UK EEZ while for 2022 there is mutual access for limited quantities; Russia could harvest in Norwegian and Faroese waters; Iceland and the Faroe Islands could harvest their entire quotas in each other's zones (Agreed Record, 2021b); Greenland had a bilateral agreement with the Faroe Islands and a quota on 2,500 tonnes in the Faroese EEZ. The parties also agree on a number of technical measures.

In 2021 the Faroese harvest of NSSH-ASH was around 120,000 tonnes, about 7,000 tonnes less than its unilaterally set own quota (Faroese Administrative Regulation No7/2021). The largest catches of around 65,000 tonnes came from Faroese waters followed by 44,000 tonnes harvested in the Icelandic EEZ and 10,000 tonnes in international waters.

Figure 3.6 shows the advised herring catch by ICES in the period 2016-2020 (grey) and the excess catch (red), i.e., how much the total catch by all participants in the fishery exceeded the advised catch. The percentages show by how much the advised catch was exceeded. The lowest excess was 16% in 2016 and the highest was 82% in 2017, more than 360,000 tonnes. This excess catch is likely one of the reasons explaining the recent decline in the SSB.

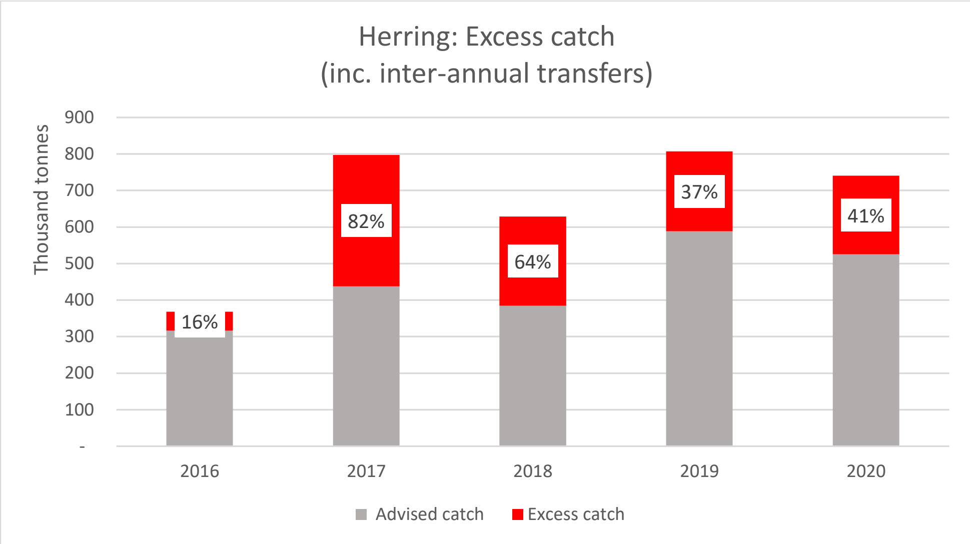


Figure 3.6. Herring: The advised catch and how much the total catch by all participants in the fishery has exceeded scientific advice. This includes inter-annual transfers by participants.
Source: Authors' estimates (Appendix).

3.3 BLUE WHITING

Blue whiting (*Micromesistius poutassou*) is a pelagic gadoid that is widely distributed in the eastern part of the North Atlantic. The highest concentrations are found along the edge of the continental shelf in areas west of the British Isles and on the Rockall Bank plateau where it occurs in large schools at depths ranging between 300 and 600 m. It is also present in almost all other management areas between the Barents Sea and the Strait of Gibraltar and west to the Irminger Sea.

Multinational fishing for blue whiting started at the end of the 1970s, with participation mainly from the then Soviet Union and Norway (Standal, 2006; Ekerhovd, 2007). In most of the 1980s and 1990s, catches were rather stable. In the 2000-19 period, the average annual catch of blue whiting was 891,000 tonnes, varying between a minimum of 104,000 tonnes and 2.401 mill tonnes. Catches increased rapidly after 1998 (Figure 3.7), and a new catch record was set almost every year, reaching a maximum of 2.401 mill tonnes in 2004, representing the largest fishery in the North Atlantic. After declining to a nadir of 104,000 tonnes in 2011, harvest increased to 1.709 mill tonnes in 2018, down to 1.502 mill tonnes in 2019.

The stock reached a peak of 6.88 mill tonnes in 2003. It then went into a trough and subsequently recovered to 6.2-6.3 mill tonnes in 2017-18. It has subsequently declined to 3.25 mill tonnes in 2021. Catches by country are shown in Figure 3.8.

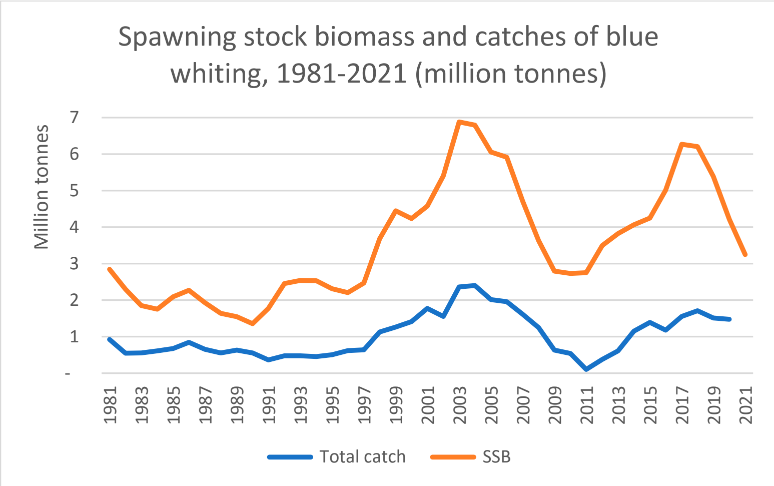


Figure 3.7. Spawning stock biomass and catches of blue whiting, 1981-2020. Million tonnes.
Source: (ICES, 2020a).

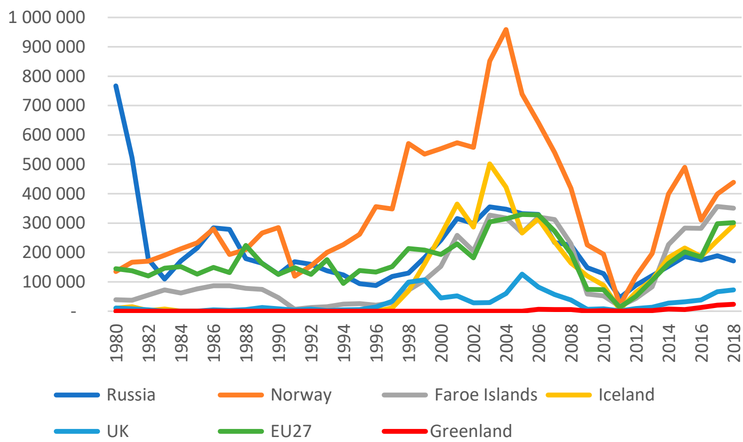


Figure 3.8. Catches of blue whiting by country in the North-East Atlantic, 1980-2018. '000 tonnes.
Source: (ICES, 2020d), (ICES, 2011) and FAO (2021). Retrieved from:
https://www.fao.org/fishery/statistics-query/en/capture/capture_quantity

On December 16, 2005, after six years of negotiations, the coastal states, the EU, the Faroe Islands, Iceland, and Norway signed an agreement. The agreement, starting in 2006, includes a long-term management strategy that implies annual reductions in landings until management goals are reached (Bjørndal, 2009). The agreement was such that first a certain quantity was allocated to DWFSs (Russia and Greenland) in international waters, with the remainder shared by the coastal states (NFD, 2020). This arrangement provided for catches in 2006 of 2 mill tonnes allocated as follows: EU 30.5%, the Faroe Islands 26.13%, Norway 25.75% and Iceland 17.63%. Russia was accommodated by transfers from some of the coastal states and additional catches in the NEAFC regulatory area (Bjørndal, 2009). In 2006, Russian catches represented 16.3% of total catch.

The history leading up to the 2005 agreement is interesting. Apart from the Russia and Norway, which developed the fishery, blue whiting was initially mainly fished by vessels from the Faroe Islands and EU countries. Only minor fishing was carried out by Icelandic vessels until the mid-1990s, when a new Icelandic fishery was initiated by a fleet of powerful vessels (Pálsson, 2005). Consequently, Icelandic catches of blue whiting increased rapidly, reaching 501,000 tonnes in 2003 (Bjørndal, 2009).

The 2005 blue whiting agreement broke down in 2015. The EU refused to continue the agreement but did not increase its quota share (Williams, 2021). However, the Faroe Islands and Norway increased their shares with the consequence that the EU's real share was reduced. In the negotiations for 2017, the parties agreed on the TAC and a new management plan for the fishery which ICES deems to be according to the precautionary principle (NFD, 2020). However, the parties did not agree on quota sharing so that since 2017, each country has set unilateral quotas. Currently, the EU has 31.8%, the Faroe Islands 27.3%, Iceland 16.2% and Norway 18.16% (Williams, 2021). Table 3.5 provides a timeline for blue whiting cooperation.

Table 3.5. Timeline blue whiting cooperation.

Year	Cooperation	Notes
2006-14	Full cooperation. Quota shares: EU 30.5%, the Faroe Islands 26.13%, Norway 25.75%, Iceland 17.63%, Russia 16.3%.	Framework agreement between coastal states – Norway, the EU, Iceland and the Faroe Islands – with an allocation of quota to Russia in international waters.
2015-16	Breakdown in cooperation. Unilateral quota setting.	
2017	Agreement on TAC and management plan.	
2018-20	Agreement on TAC based on management plan but unilateral quota setting.	
2020		Norway: 26.25% of TAC after allocation to NEAFC for harvesting in international waters.
2021	Agreement on TAC based on management plan but with unilateral quota setting.	The UK enters as a coastal state.

Based on: Bjørndal (2009), NFD (2020) and Williams (2021).

ICES advises that when the long-term management strategy agreed by the European Union, the Faroe Islands, Iceland, and Norway is applied, catches in 2021 should be no more than 929,292 tonnes[18]. Fishing mortality (F) is estimated to have been above F_{MSY} since 2014. Spawning-stock biomass (SSB) has been decreasing since 2018; however, it is still estimated to remain above $MSY_{Btrigger}$ from 2017 to 2020 is estimated to be low, following a three-year period of high recruitment. Nevertheless, according to ICES, the stock is harvested sustainably.

As noted, the coastal states agree on the management plan for blue whiting and the annual TAC while quotas are set unilaterally (Agreed Record, 2021c). Harvesting is in national EEZs or international waters, and the parties agree on a number of technical measures. For 2022, the parties have agreed on a TAC of 752,736 tonnes (Agreed Record, 2021c). As for mackerel and herring, quota sharing arrangements are to be considered anew in 2022, and the parties agree on a number of technical measures. Moreover, quota transfers from one year to be next are permitted.

Bilateral agreements regulate quota exchanges between parties and access arrangements. In 2021, the EU and the UK had full access to each other's waters as was the situation between Iceland and the Faroe Islands; Norway and the EU could harvest up to 141,648 tonnes in each other's zone; Russia could harvest 25% of its NEAFC quota in Faroese waters and Greenland could harvest a quota of 14,700 tonnes there (Agreed Record, 2021c).

In 2021 the Faroese harvest of blue whiting was 197,212 tonnes, almost matching its quota of 197,595 tonnes (Faroese Administrative Regulation No205/2020). Of this, 169,000 tonnes came from Faroese waters with around 24,000 from international waters.

Figure 3.9 shows advised catch of blue whiting by ICES in the period 2016-2020 (grey) and excess catch (red), i.e., how much the total catch by all participants in the fishery exceeded the advised catch. This includes inter-annual transfers by participants The percentages show how much catch exceeded advice. The lowest excess was 26% in 2017 and the highest was 51% in 2016. For 2018-20, excess catch represented 34-40% of advised catch.

[18] ICES Advice on fishing opportunities, catch, and effort Ecoregions of the North-East Atlantic and Arctic Ocean. Published 30 September, 2020.

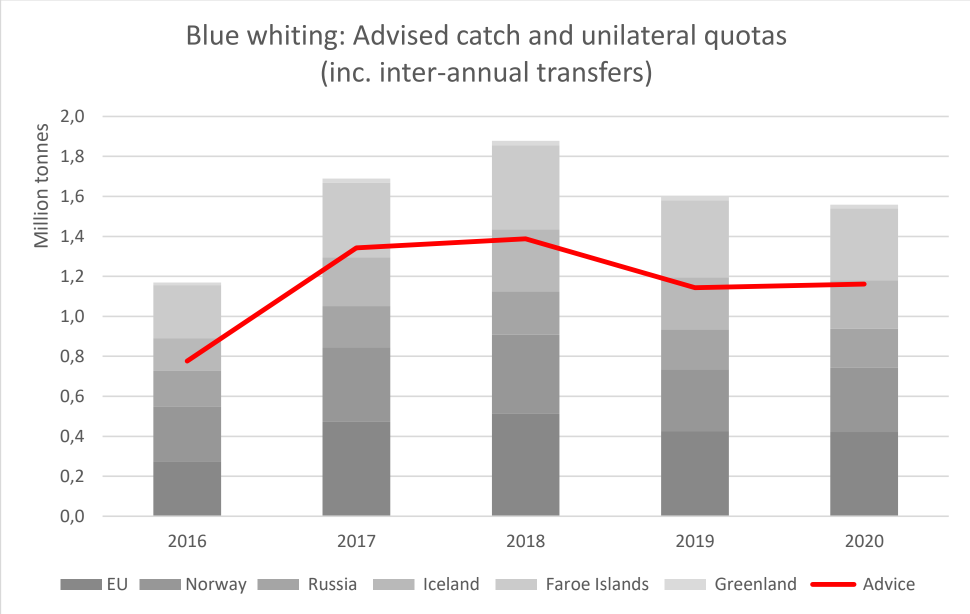


Figure 3.9. Blue whiting: Unilateral quotas as set by participants in the fishery (including inter-annual transfers by participants) and the scientific advice on how much to take out of the stock, 2016-2020.

3.4 SUMMARY

Status of the stocks:

ICES assesses that fishing pressure on the mackerel stock is below F_{MSY}, while SSB is above $MSY_{Btrigger}$, Bpa, and Blim. Nevertheless, the stock is in a decline. For NSSH-ASS, ICES classifies the current status of the stock as having full reproductive capacity and being harvested sustainably. In the case of blue whiting: SSB has been decreasing since 2018; however, it is estimated to remain above $MSY_{Btrigger}$ from 2017 to 2020 is estimated to be low, following a three-year period of high recruitment. Nevertheless, the stock is harvested sustainably.

Although the three stocks are assessed to be sustainably harvested, it is important to note that the SSB is in decline for all three stocks. One reason for this is the fact that there is "excess" harvesting of all three stocks in the sense that harvest is substantially higher than the TACs recommended by ICES. However, stock decline may also be due to changes in climate and migratory patterns as well as natural cycles and variability. If current conditions remain unchanged, it is nevertheless possible that the stocks will continue to decline. A number of commentators (e.g. Williams, 2021) are concerned about developments. It can also be mentioned that due to the uncertain stock situation for mackerel, in March 2019 the Marine Stewardship Council suspended its eco-labelling certification[19].

[19] See https://www.msc.org/media-centre/press-releases/press-release/msc-certificates-suspended-for-all-north-east-atlantic-mackerel-fisheries

The MSC certifications of blue whiting and NSSH-ASS were suspended as of 30th December, 2020[20]. This has happened despite the stocks being sustainably harvested according to ICES.

Degree of cooperation: Summary

Tables 3.6-3.8 summarise the current states regarding cooperation when it comes to the three fisheries. It is important to note that there are many similarities, in particular:

i. For all three stocks, the parties agree on the science-based management plans.

ii. There is cooperation between the parties with regard to technical regulations, science, information exchange and more.

iii. Bilateral agreements provide access to EEZs as well as quote exchanges. This applies to some fisheries and countries, but not to all.

Points i)-iii) indicate that the parties communicate, an important condition for a cooperative solution to a game (Bjørndal & Munro, 2021). Furthermore, iii) suggests the existence of side payments and "side payment like arrangements" (Munro *et al.*, 2004) that may help facilitate a cooperative agreement.

When it comes to quota exchanges, it is important to note that the relevant "market" is much wider than these three fisheries. As an example, it is perfectly feasible for a country to give up quota in a pelagic fishery in the Norwegian Sea in exchange for groundfish elsewhere, say in the North Sea or the Barents Sea. This adds more flexibility to a potential agreement. At the same time, due to different perceptions regarding the valuation of exchanges, e.g. pelagic vs. groundfish[21], the pelagic and Barents Sea trawler fleets in the Faroe Islands separately expressed disquiets about those exchanges, possibly resulting in lower levels of enthusiasm to accept the agreement.

Two consequences of Brexit should also be pointed out. The relative quota shares of the UK and the EU are determined by the 2020 Trade and Cooperation Agreement, although there will be some adjustments in quota shares for some species over time (Bjørndal & Munro, 2021). Moreover, there is also reciprocal EEZ access between the UK and the EU. More as a fallout of Brexit, for 2021, neither Norway and the UK nor the Faroe Islands and the UK reached fisheries agreements for 2021 that allowed reciprocal access. For 2022, there is still no bilateral agreement between the UK and the Faroe Islands, while the one between the UK and Norway does not include access or exchanges for mackerel and blue whiting.

[20] See www.msc.org/media-centre/press-releases/press-release/AS-herring-blue-whiting-suspension.
[21] In 2021 Russian vessels were permitted to fish 82,000 tonnes of blue whiting, 14,500 tonnes of mackerel and 7,000 tonnes of herring in the Faroese Fishing Zone in exchange for 17,690 tonnes of cod, 1,769 tonnes of haddock, 900 tonnes of flat fish and 4,000 tonnes of shrimps to be harvested by the Faroese fleet in the Russian EEZ in the Barents Sea (Protocol Faroese – Russian Fisheries Commission, Dec. 2020).

Despite cooperation in so many areas, and agreement about annual TACs for all three fisheries, there is no agreement about quota sharing. Nevertheless, agreeing on annual TACs implies that the parties agree on a base for quota sharing. However, the consequence of each country seting its own quota has been – and still is - that the sum of unilateral quotas exceeds the recommended TACs. For this reason, many commentators are concerned about the future sustainability of the fisheries.

Table 3.6: Cooperation in the mackerel fishery.

Type of cooperation	**Parties involved**	**Type of cooperation/agreement**
Management of the stock; TAC setting	All coastal states	Cooperation
Technical regulations, science, information exchange, habitat protection	All coastal states	Cooperation
Quota sharing	-	Unilateral quota setting
Access (2021-)	Full access: UK and EU; Norway and the Faroe Islands	Bilateral agreements
Quota exchanges (2021)	EU transfer to UK (305 t); the Faroe Islands transfers to Iceland (1,300 t), Norway (6,600 t) and Russia (14,500 t); Norway transfer to EU (251 t); UK transfer to EU (758 t)	Bilateral agreements

Source: Agreed Record (2021a).

Table 3.7. Cooperation in the NSSH-ASH fishery.

Type of cooperation	**Parties involved**	**Type of cooperation/agreement**
Management of the stock; TAC setting	All coastal states	Cooperation
Technical regulations, science, information exchange, habitat protection	All coastal states	Cooperation
Quota sharing	-	Unilateral quota setting
Protection of juvenile herring	Russia and Norway	Bilateral agreement
Access (2022)	Full access: UK and EU; EU in Norway; Norway and the Faroe Islands; Iceland and the Faroe Islands; UK can harvest up to 17,000 tonnes in the Norwegian EEZ. Russia access to Norwegian and Faroese waters.	Bilateral agreements
Quota exchanges (2021)	UK transfer to EU (5,294 t); the Faroe Islands transfers to Russia (10,000 t) and Greenland (6,500 t).	Bilateral agreements

Source: Agreed Record (2021a).

Table 3.8. Cooperation in the blue whiting fishery.

Type of cooperation	Parties involved	Type of cooperation/agreement
Management of the stock; TAC setting	All coastal states	Cooperation
Technical regulations, science, information exchange, habitat protection	All coastal states	Cooperation
Quota sharing	-	Unilateral quota setting
Access (2021)	Full access: UK – EU; Norway – the Faroe Islands. Norway and the EU could harvest up to 141,648 tonnes in each other's zone; Russia could harvest 25% of its NEAFC quota in Faroese waters and Greenland could harvest its entire quota of 5,032 tonnes there.	Bilateral agreements
Quota exchanges (2021)[a)]	EU transfer to Norway (37,500 t); the Faroe Islands transfers to Russia (82,000 t) and Greenland (14,700 t); Iceland transfer to Russia (2,000 t); Norway transfer to Russia (16,175 t).	Bilateral agreements

a) Some of the transfers to Russia are part of the coastal state agreement for blue whiting.

Source: Agreed Record (2021a).

According to Gulland (1980), there are two levels of cooperation when it comes to the management of international fishery resources, primary and secondary (see also Munro, Van Houtte and Willmann, 2004). The primary level involves cooperation in scientific research while the second involves cooperation in management. For all three fisheries under investigation, there is cooperation at the primary level pertaining to issues such as technical regulations, science, information exchange and habitat protection (Tables 3.6-3.8). At the secondary level, there is at best only weak tacit cooperation in the sense that the parties agree on the overall TACs, however, there is no agreement on quota sharing, in particular, the principles underlying quota sharing. We will revert to these questions in chapter 5 after having studied the fisheries of some of the main countries involved.

4. THE PELAGIC FISHERIES OF NORWAY, ICELAND, THE FAROE ISLANDS, THE EU AND THE UK

We will now analyse the pelagic fisheries of all relevant countries except for Russia, as data for this country are not available. We will consider fleets involved, harvest, revenues and, where possible, cost of production, including comparative cost of production.

As profitability will be an important part of this analysis, we start by considering prices. Tables 4.1-4.3 give average annual prices for different countries for 2010-20. The prices in question are "first hand", i.e., prices paid to fishermen.

Based on an inspection of these tables, some important observations can be made. First of all, mackerel is by far the most valuable species, while blue whiting fetches the lowest price. Moreover, for each species, there are differences between some of the countries for reasons we shall revert to below. This implies that revenue shares are different from quantity shares.

Table 4.1. Mackerel prices per country. 2010-20. EUR/kg.

	Norway	UK	Iceland	Denmark	Faroe Islands
2010	1.00499	1.00744	0.3961	1.09079	0.60
2011	1.60847	1.29821	0.6969	1.63948	0.70
2012	0.99598	1.15696	0.5910	0.98916	0.83
2013	1.13572	1.05565	0.6167	1.12718	0.66
2014	0.84551	0.97909	0.5782	0.97103	0.73
2015	0.94972	0.88805	0.4209	0.85452	0.79
2016	1.2680	1.05971	0.4802	1.03294	0.91
2017	1.0354	1.02265	0.4271	0.98061	0.93
2018	1.3896	1.19683	0.4335	1.24317	1.06
2019		1.36395	0.4829	1.43401	1.15
2020		1.14575		1.21063	1.09

Table 4.2. Herring prices by country 2010-20. EUR/kg.

	Norway	UK	Iceland	Denmark	Faroe Islands
2010	0.363	0.39	0.2658	0.41	0.50
2011	0.679	0.55	0.4442	0.60	0.68
2012	0.824	0.54	0.5176	0.75	0.81
2013	0.659	0.42	0.4295	0.53	0.47
2014	0.661	0.36	0.4003	0.45	0.69
2015	0.749	0.48	0.3667	0.55	0.81
2016	0.827	0.75	0.4242	0.71	0.97
2017	0.491	0.49	0.2960	0.52	0.50
2018	0.467	0.49	0.3076	0.46	0.54
2019		0.60	0.3196	0.57	0.57
2020		0.65		0.54	0.56

Table 4.3. Blue whiting prices by country 2010-20. EUR/kg.

	Norway	UK	Iceland	Denmark	Faroe Islands
2010	0.2347	0.25	0.2315	0.01	0.39
2011	0.20154	0.53	0.3082	0.00	0.72
2012	0.31057	0.44	0.2640	0.02	0.45
2013	0.24968	0.26	0.1742	0.38	0.32
2014	0.17246	0.23	0.1677	0.21	0.21
2015	0.21006	0.29	0.1802	0.24	0.26
2016	0.29386	0.28	0.2166	0.31	0.29
2017	0.15434	0.20	0.1478	0.18	0.19
2018	0.225	0.24	0.1701	0.23	0.23
2019		0.25	0.1949	0.24	0.27
2020		0.34		0.27	0.28

4.1 THE ICELANDIC PELAGIC FISHERIES

The fishing industry is probably Iceland's most important base industry[22]. It's direct contribution to Iceland's GDP is currently about 6% (Statistics Iceland 2021). Including indirect effects (see Agnarsson and Arnason, 2007), its contribution to the GDP is probably close to 20%[23].

The most import component of the Icelandic fisheries is the demersal fisheries; however, the pelagic fisheries also constitute a substantial part. They account for about 48% of the export volume and about 21% of the export value of fish products[24]. Their direct contribution to the Icelandic GDP could be about 1.5%.

The pelagic fish stocks

The Icelandic pelagic fisheries are almost entirely based on five fish stocks, two of which, the Icelandic capelin and the Icelandic summer spawning herring, reside mostly within the Icelandic EEZ, while three, NSSH-ASH, blue whiting and mackerel, roam widely around the North-East Atlantic and are shared with other nations.

The three shared pelagic stocks account for about 60% in the export value of all the Icelandic pelagic fisheries and generate around 12-13% of the total value of the Icelandic fisheries. A considerable part, around 40%, of Iceland's harvest from the shared pelagic stocks in terms of volume (and much more in terms of value) has been taken within the Icelandic EEZ. The rest is taken in other parts of the North-East Atlantic.

[22] For the concept of base industries, see e.g. Agnarsson and Arnason (2007) and Roy et al. (2009) and references therein.
[23] In spite of a great expansion in the tourism industry since 2011, its total contribution to the GDP is still probably considerably less than that of the fishing industry.
[24] Virtually all of the pelagic harvests are exported.

The pelagic industry

The Icelandic pelagic fishing industry has over time evolved from consisting of a large number of small harvesting companies and separately run processing firms to a highly concentrated industry consisting of few relatively large integrated harvesting, processing and marketing companies. Currently (2021), over 95% of the industry consists of 10 integrated companies operating 20 large pelagic fishing vessels and 10 processing plants conducting their own product development and marketing operations (Fiskistofa, 2021). The remainder of the industry consists of numerous small vessels with very small pelagic fishing quotas (mainly mackerel and herring) and a few small-scale processors and distributors.

Figure 4.1. A typical Icelandic pelagic fishing vessel.

The pelagic fishing vessels are both large and technically advanced. Their average length is 64 m and tonnage 2300 GT (see Samgöngustofa, 2021). Most of them are equipped to harvest both by pelagic purse seine and mid-water trawl. Effective fishing by the latter requires great engine power so most of the pelagic fishing vessels are equipped with engines of several thousand horsepower. Many of the vessels are factory vessels in the sense that they can process and freeze their harvest on board. Unless the harvesting is close to shore with short sailing time to on-land processing facilities, all harvest for human consumption is processed in this way aboard the vessels. A photograph of a typical pelagic fishing vessel is given in Figure 4.1.

The pelagic fisheries

Due to stock variability, especially that of capelin, Iceland's annual harvest from the five demersal stocks has been quite variable with an average harvest during the decade 2010 to 2019 of some 717,000 tonnes with a coefficient of variation of some 21%. In terms of volume, the largest catch is from Icelandic capelin and blue whiting, but the catch from the two herring stocks and mackerel is much more valuable. The development of catches by stocks is illustrated in Figure 4.2.

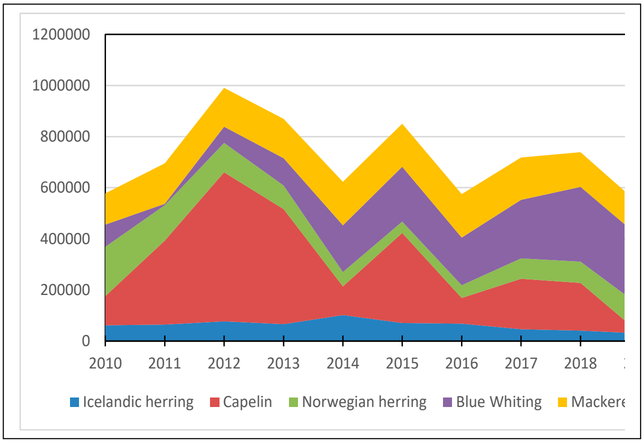


Figure 4.2. Pelagic landings (tonnes).
Source*:* Statistics Iceland (2021b).

As Figure 4.2 suggests, there is a statistically significant declining trend in the capelin catches, probably due to larger stocks of the main capelin predators, cod and cetaceans, and a less significant increasing trend in the catch of blue whiting. The combined catch from the three shared stocks has been more stable with an annual average of 412,000 tonnes and a coefficient of variation of just 17%.

Fishing areas

The greater part of Iceland's fishery from the three shared pelagic stocks is taken within the Icelandic EEZ. It is really only the blue whiting fishery that primarily takes place outside the Icelandic EEZ. However, the share of the catch taken in the various North-East Atlantic regions varies a great deal, reflecting variability in the locations of fish concentrations.

Figure 4.3 illustrates the location of the Icelandic catch of mackerel during the period 2010-19. As the figure indicates, over 70% of the catch has been taken within the Icelandic EEZ during this period. However, this proportion of the catch has gradually declined with an increasing proportion being taken on the high seas. This trend no doubt reflects less abundance of mackerel in Icelandic waters due to a diminishing stock size and possibly changes in the migration pattern for mackerel.

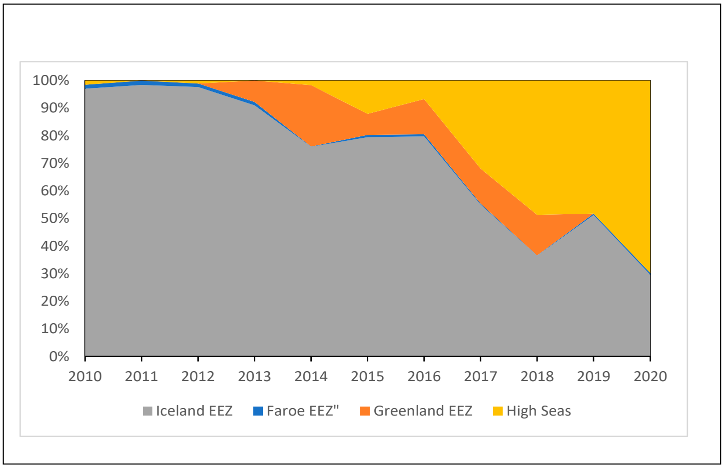


Figure 4.3. Mackerel: Location of catches.
Source: Statistics Iceland (2021b).

Figure 4.4 illustrates the location of the Icelandic catch of NSSH-ASH. When the spawning stock of this species is of a normal size it typically undertakes feeding migrations to Icelandic waters where it becomes very fishable. As a consequence, the Icelandic share of this fishery is usually taken mostly within the Icelandic EEZ. Figure 4.4 confirms this. It is only in the abnormal years 2014-17 that most of the harvest was taken outside the Icelandic EEZ. For the period 2010-19 as a whole, 47% of the Icelandic harvest was taken within the Icelandic EEZ. Most of the rest was taken on the high seas (see Figure 4.4).

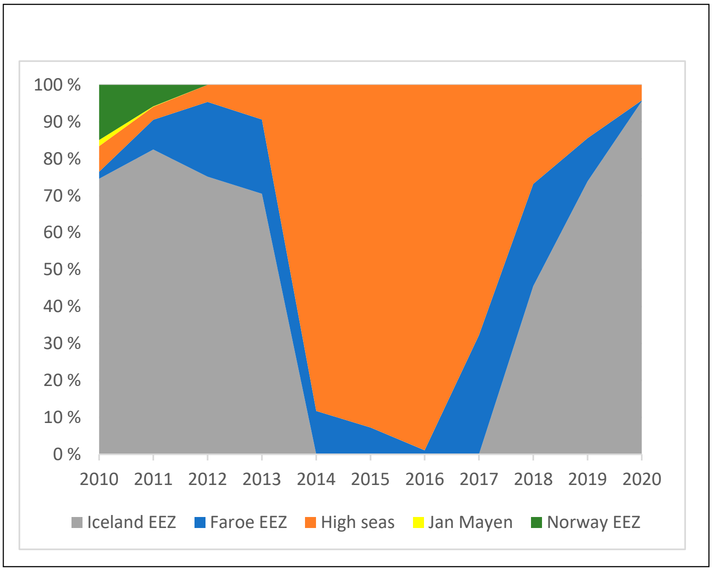


Figure 4.4. Norwegian spring spawning herring: Location of catches.
Source: Statistics Iceland (2021b).

The Icelandic blue whiting fishery takes place mostly in the Faroese EEZ under a fisheries agreement between the two nations. During the years 2010-19, only about 14% of the Icelandic catch was taken within the Icelandic EEZ (Figure 4.5).

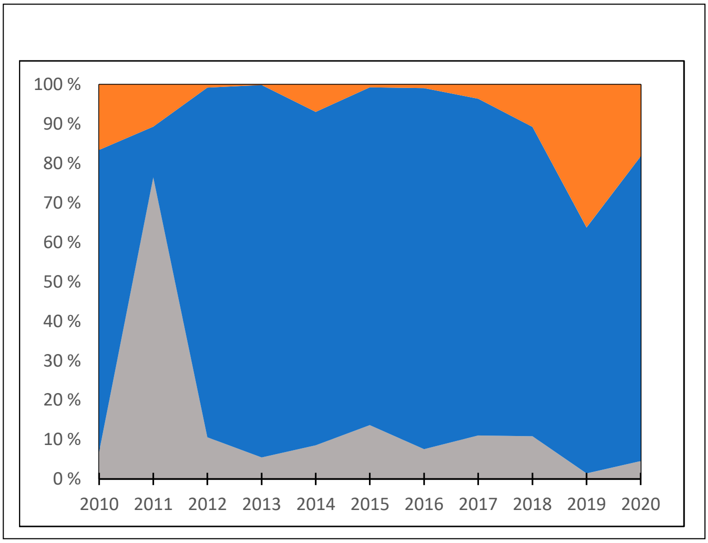


Figure 4.5. Blue whiting fishery: Location of catches.
Source: Statistics Iceland (2021b).

Processing

Most of the Icelandic catch of herring and mackerel is processed for human consumption, mostly either filleted or unfilleted frozen products. By contrast, most of the catch of blue whiting and capelin is used for production of fishmeal and oil. The proportions of the catch allocated to the various processing sectors in 2019-20 are listed in Table 4.4.

Table 4.4. Allocation of catch to processing.

	Reduction	Freezing	Salting	Fresh	Other
Herring	28%	67%	3%	1%	2%
Capelin	77%	23%			
Blue whiting	95%	4%		1%	
Mackerel	9%	89%		1%	1%

Source: Statistics Iceland (2021b).

Since fish products for direct human consumption are generally much more valuable, there has been a clear trend toward that type of processing. However, in spite of considerable efforts, it has proven difficult to economically produce much products for human consumption from capelin and blue whiting.

Both the reduction and the human consumption processing sectors are technically advanced, highly automated with minimal use of labour. This is both to save on labour costs which are high in Iceland and to maintain the required quality standards necessary to obtain high export prices.

Industry profitability

Most of the pelagic companies are integrated fishing companies engaged in other types of fishing as well. Therefore, official statistics on the profitability of the integrated pelagic operations are not available. Official profits and loss accounts for the pelagic fishing fleet are on the other hand available. According to those, profitability in this sector is good. Average EBIDTA during 2010-19 has been about 24% and profits (earnings before tax) 11.2% of revenues.

Other parts of this report indicate that the price of landed pelagic catch in Iceland may be considerably lower than in the other countries. Since the Icelandic processing and marketing sector appears to be as least as efficient as those in the other countries, this suggests that the profitability in this part of the pelagic operations is even better than in the harvesting part.

4.2 NORWEGIAN FISHERIES FOR PELAGIC SPECIES

In 2016, the year for which the most recent official data are available, Norway was the ninth largest producer of capture fish in the world and by far the largest producer in Europe (FAO, 2020). In 2020, the total Norwegian capture fish production was 2.607 mill tonnes at a first hand value of NOK 22.41 billion. Pelagic fish represented 1,442 thousand tonnes at a value of NOK 8.29 billion, while the harvest of cod and cod-related species was 648 thousand tonnes at a value of NOK 10.9 billion. Thus, in terms of quantity, pelagic fish represents the largest sector of the Norwegian fishing industry, but not in terms of value.

In overall terms, fisheries and fish processing represent a very small part of GDP. Nevertheless, the industry is important for income generation and employment in many coastal areas. Fish is also one of the most important export commodities from Norway. In 2020, fish exports amounted to almost NOK 102 billion, however, of this farmed salmon represented NOK 70.1 billion (source: Statistics Norway).

Pelagic fisheries

In the last decade, the total annual harvest of pelagic species by Norwegian fishermen has varied between 1.1 – 1.8 million tonnes.

In Table 4.5, we give landings by Norwegian fishermen of NSSH-ASH, other herring, mackerel and blue whiting as well as aggregates. Other herring is mainly North Sea herring and is included because it is impossible to distinguish between different kinds of herring in some of the statistics to be presented below. As the table illustrates, there are substantial differences in harvest from year to year, for individual species as well as in aggregate.

The table also gives total for herring, mackerel and blue whiting as well as for all pelagics. When comparing these, it can be inferred that other species than herring, mackerel and blue whiting are also important for Norwegian fishermen. This includes capelin, with highly variable catches, Norway pout and sandeel.

Total value has increased in recent years and stood at NOK 8.3 billion in 2020, of which more than NOK 7 billion from herring, mackerel and blue whiting. When comparing the value to weight ratios, it can be inferred that unit values for herring and mackerel are higher than for other species. This is because they are largely used for human consumption whereas others to a large degree are reduced into fish meal and oil. We will revert to that below.

Table 4.5. Landings of pelagic species by Norwegian fishermen 2010-20. Value in NOK '000. Weight in Tonnes.

	2010		2011		2012		2013	
	Value	Weight	Value	Weight	Value	Weight	Value	Weight
NSSH	2,536,941	873,572	2,997,688	1,840,854	1,840,854	572,238	2,999,513	491,000
Other herring	209,295	50,169	335,634	591,086	591,086	60,864	561,181	119,713
Mackerel	1,817,270	233,957	2,560,516	1,430,461	1,430,461	207,955	1,290,111	176,109
Blue whiting	363,131	194,318	65,731	384,954	384,954	20,540	276,742	118,176
Total	4,926,638	1,352,016	5,959,570	4,247,354	4,247,354	861,598	5,127,547	904,999
Pelagics total	5,870,696	1,810,493	7,199,538	4,850,016	4,850,016	1,382,417	5,777,894	1,248,163

	2014		2015		2016		2017	
	Value	Weight	Value	Weight	Value	Weight	Value	Weight
NSSH	1,164,277	176,176	1,494,112	197,421	1,771,682	389,383	1,434,639	263,131
Other herring	695,413	136,920	958,399	154,289	525,752	137,594	486,561	144,173
Mackerel	2,029,550	241,988	2,433,423	210,346	2,109,571	222,307	1,936,808	277,735
Blue whiting	922,868	489,439	837,829	310,412	579,985	399,363	579,249	399,520
Total	4,812,109	1,044,523	5,723,763	872,469	4,986,990	1,148,647	4,437,257	1,084,558
Pelagics total	5,516,064	1,347,125	6,315,347	1,060,540	5,651,448	1,390,385	4,949,136	1,303,866

	2018		2019		2020	
	Value	Weight	Value	Weight	Value	Weight
NSSH	1,492,926	332,028	1,883,443	430,507	2,398,630	409,433
Other herring	660,742	168,360	691,280	131,028	746,858	118,009
Mackerel	2,476,819	187,223	2,508,591	159,085	2,770,599	211,617
Blue whiting	943,985	438,428	882,561	350,974	1,133,716	354,033
Total	5,574,472	1,126,038	5,965,576	1,071,594	7,049,803	1,093,092
Pelagics total	6,500,097	1,465,392	6,711,822	1,302,069	8,291,871	1,441,846

Source: Directorate of Fisheries, Norway.

Fishing areas

Norwegian fishermen harvest herring, mackerel and blue whiting in the economic zones of Norway (NEZ) and other countries, as well as in international waters – the NEAFC regulatory area. An overview over the distribution of catches in recent years is given in Tables 4.6-4.8.

For NSSH, a very large proportion is harvested in the NEZ. This is natural, because the herring spawns in Norwegian waters and spends much of its life there (cf. section 3.2). Moreover, there is also harvest in international waters. It appears that the proportion harvested in the NEAFC regulatory area is larger when the overall quota is larger.

Table 4.6. Norwegian NSSH-ASH Catches by Area 2018-20. Tonnes.

	NEAFC regulatory area	Norwegian Economic Zone	Total
2015		176,176	176,176
2016	12,341 (6.3%)	185,081 (93.7%)	197,422
2017	157,794 (40.5%)	231,589 (59.5%)	389,383
2018	34,849 (10.5%)	297,178 (89.5%)	332,027
2019	113,309 (26.3%)	317,195 (73.7%)	430,504
2020			

Sources:
2015-17: NEAFC.
2018-19: Agreed Record of Conclusion of Fisheries Consultations between Norway, the European Union, the Faroe Islands, Iceland, the Russian Federation and the United Kingdom on the Management of the Norwegian Spring-Spawning (Atlanto Scandian) Herring in the North-East Atlantic in 2021. 20-21 October, 2020.

The situation is very different when it comes to blue whiting, where only 5-13.3% is harvested in the NEZ. The importance of other zones varies over time, however, since 2016, 76-78% of the Norwegian catch has been taken in the EU zone. In these statistics, the EU zone includes the UK EEZ. Norwegian fishermen harvest blue whiting both in what is now the EU zone, Ireland in particular, and the UK zone, but the exact distribution is not known.

Table 4.7. Norwegian Blue Whiting Catches by Area 2018-20. Tonnes.

	NEAFC regulatory aArea	EU zone	Faroese Zone	NEZ	Total
2015	244,138	101,405	78,457	65,439	489,439
2016	64,026	214,531	739	31,116	310,412
2017	77,714	287,558	3,034	31,057	399,363
2018	61,685	345,267	8,726	22,750	438,428
2019	55,690	267,271	2,452	21,582	350,974
2020[a)]	57,927	267,802	878	24,241	350,849

a) Provisional

Sources:
2015-17: NEAFC.
2018-20: Agreed Record of Conclusion of Fisheries Consultations between the European Union, the Faroe Islands, Iceland, Norway and the United Kingdom on the Management of Blue Whiting in the North-East Atlantic in 2021. Online 19-20 October, 2020.

The distribution of the mackerel catch has changed tremendously over time. In 2015-16, more than 90% was harvested in the NEZ, since 2017, this has been reduced to 15-19%. In recent years, more than 80% of the Norwegian mackerel harvest has been in the EU zone – predominantly in what is now the UK EEZ.

Table 4.8. Norwegian Mackerel Catches by Area 2018-20. Tonnes.

	NEAFC regulatory area	EU zone	Faroese zone	NEZ	Total
2015		19,438 (8%)	5	222,544 (92%)	241,987
2016		12,933 (6.1%)		197,412 (93.9%)	210,345
2017	17,102 (7.7%)	46,661 (21%)	4,221 (1.9%)	154,413 (69.4%)	222,397
2018	2,843 (1.5%)	156,884 (83.8%)		27,496 (14.7%)	187,223
2019		129,355 (81.3%)		29,729 (18.7%)	159,084
2020		84%		16%	

Source: NEAFC.

Processing and exports

While virtually all NSSH-ASH and mackerel is used for direct human consumption, blue whiting is used for reduction into fish meal and fish oil[25]. So as to get an overview over processing in Norway, it is necessary to consider i) landings by Norwegian fishermen abroad and ii) landings by foreign fishermen in Norway. This varies by species. In 2020, about 25% (61,500 tonnes) of the Norwegian catch of blue whiting was landed abroad, mainly in Denmark, while landings by foreign fishermen in Norway were much smaller (11,600 tonnes). The same year, foreign fishermen landed 112,000 tonnes mackerel in Norway, roughly equal to 15% of mackerel landings by Norwegian fishermen, while Norwegian fishermen landed 6,200 tonnes abroad. Landings by foreign fishermen of NSSH-ASH in Norway were 18,300 tonnes in 2020, as compared to Norwegian fishermen landing 11,686 tonnes abroad. These statistics appear to be representative, although the situation may vary over time.

Export statistics give a good overview over usage and processing. This is because a very large proportion of catches is exported. Table 4.9 gives information about exports since 2015. Total exports of pelagics vary in the range 680 – 940,000 tonnes annually; it must be noted that this is product weight, not round weight. Total value is increasing over time to just over NOK 9.1 billion in 2020. This represents about 30% of total capture fish exports. This numbers may be an underestimate of the importance of exports of pelagic fish due to the fact that some fish meal and fish oil is exported, which is not included in these statistics.

[25] Reference for this and other factual information in this paragraph: Noregs Sildesalslag. www.sildelaget.no/media/172663035/omsetningsstatistikk-2020-linjert.pdf (consulted 25th August, 2021).

Table 4.9. Norwegian Exports of Blue Whiting, Mackerel, Herring and Pelagics Total, Value (NOK '000) and Quantity (Tonnes). 2015-2020.

	Value NOK '000						Quantity (tonnes)					
	2015	2016	2017	2018	2019	2020	2015	2016	2017	2018	2019	2020
Pelagic total	6,937,682	7,795,903	7,696,853	7,573,676	8,015,941	9,131,949	791,603	675,811	839,258	874,895	709,466	693,723
Blue whiting total	331,592	228,400	199,396	422,166	217,902	178,137	170,190	83,466	131,472	196,693	89,691	61,621
Fresh/ch	331,592	228,400	199,392	420,173	217,902	177,673	170,190	83,466	131,471	196,261	89,691	61,501
Frozen	.	.	4	1,992	.	464	.	.	1	432	.	120
Mackerel total	3,827,457	4,065,204	4,116,975	3,818,631	4,282,897	4,974,990	352,307	309,017	336,341	255,114	238,451	299,349
Fresh/ch	33,168	30,247	90,901	166,768	162,252	121,373	1,813	1,377	7,203	12,043	9,356	7,850
Frozen	3,790,920	4,032,861	4,022,943	3,650,766	4,117,936	4,852,518	350,421	307,600	329,099	243,056	229,054	291,486
Processed	3,369	2,096	3,130	1,096	2,708	1,099	73	40	40	15	42	12
Herring total	2,395,996	3,096,059	2,808,017	2,632,962	3,196,210	3,797,803	216,109	235,838	291,146	291,985	353,732	317,712
Fresh/ch	135,755	151,519	154,709	126,498	171,134	162,999	23,064	21,823	32,899	27,853	33,381	24,279
Frozen	1,963,391	2,588,315	2,363,611	2,189,310	2,695,214	3,187,044	175,711	196,467	240,060	242,450	298,497	265,793
Smoked	142	438	18	98	239	275	3	6	0	2	3	1
Salted	96,165	107,968	89,941	86,709	72,339	131,510	6,722	6,273	6,598	7,082	5,635	9,244
Processed	200,542	247,818	199,737	230,348	257,283	315,975	10,609	11,270	11,588	14,598	16,215	18,396

Source: Seafood Council of Norway.

Frozen product dominates for both mackerel and herring. For mackerel, frozen whole fish is most important; for herring, frozen fillets are most important. Much effort is devoted to increasing the degree of processing for these species. For herring, exports of frozen fillets, salted and processed products show great increases over time.

There is a fairly substantial export of blue whiting, although this is highly variable from year to year. This is, however, landings by Norwegian vessels abroad, in particular Denmark, but also with some deliveries to Ireland and Iceland.

Fleets and Cost of Production

Purse seiners and pelagic trawlers are the two main vessel groups in these fisheries; in addition, various kinds of coastal vessels are active. Purse seiners and pelagic trawlers are ocean going vessels persecuting these fisheries in the Norwegian Sea and will be subjected to further analysis here. All information in this section is taken from the Directorate of Fisheries, Norway unless otherwise noted.

Purse seiners

Since 2015, about 70 purse seiners have been active in these fisheries. In 2019, the average length of purse seiners was 66.67 m, size in TE 1,980, 860 GRT and average age 17.33 years. According to industry sources, the current (2021) cost of a conventional purse seiner is about NOK 400 million. This vessel will have a length of 80 m with a cargo capacity of 2,500 tonnes. The harvest will be kept in refrigerated seawater (RSW) tanks, but the vessel will not undertake on-board processing or freezing. The value of quotas can be assessed at NOK 400-500 million, although it is important to note there is substantial variation from vessel to vessel.

Revenue and cost data are presented in Table 4.10. According to the definition used by the Directorate of Fisheries, operating costs include crew costs, fuel, depreciation of vessel and licenses[26], maintenance of vessels and gear, insurance and numerous other costs. It is important to bear in mind that these are accounting, not economic, costs. One may also question this definition of costs. Crew remuneration is mainly based on the sharing system and as such represents an income reduction rather than a direct variable cost. The implication of this is that if catch is constant but revenue increases due to higher prices, crew "costs" increase. In addition, there are some elements of a fixed nature in crew costs such as part of the payments to the vessel's officers. Maintenance is to some degree to be considered a fixed cost. Altogether, this implies that there will be important fixed elements in the definition of operating costs as used by the Directorate of Fisheries.

We will use the definition used by the Directorate of Fisheries, with one major exception: Depreciation will not be included in our estimates. This is because normally depreciation is considered a fixed cost.

Fixed costs, in particular the opportunity cost of vessels and permanent licenses as well as depreciation on the full economic value of vessels, are not considered. This is because accounting costs are used by the Directorate of Fisheries which implies that vessel values are commonly underestimated.

Overall, purse seiners are profitable with a high EBIT (Table 4.10). In recent years the operating margin has varied between 36-42.4%. Average annual harvest per vessel varies between 9,500 – 14,100 tonnes. When looking at the composition of harvest, the proportion of herring, mackerel and blue whiting in total harvest varies between 78% (2019) and 85% (2016).

It is impossible to estimate costs for the different fisheries. With the data available, all that can be done is to calculate average cost per tonne harvested which is in the range NOK 2,600-3,500 which converts to EUR 280 - 360/tonne. The cost is highest in 2016, the year with the lowest catch, presumably for the reasons discussed above.

[26] Vessels may have fishing licences that are valid only for a certain period of time. These may be depreciated. Permanent licenses, on the other hand, may not be depreciated.

Table 4.10. Revenues, Costs and Vessel Characteristics. Averages for Purse Seiners 2015-19.

	2015	2016	2017	2018	2019
Revenues	49,933,587	58,608,282	53,904,018	64,202,338	62,860,575
Total operating costs without depreciation	31,963,287	33,752,176	33,679,334	38,649,754	39,226,555
Total operating costs					
-Of which labour	12,876,273	15,673,095	14,235,984	16,195,130	16,423,678
-Of which fuel	4,700,572	3,374,812	4,828,285	6,655,764	5,799,856
EBIT	17,970,300	24,856,106	29,224,684	25,552,584	23,634,020
Operating margin (%)	36.0	42.4	37.5	39.8	37.6
No of operating days	178	151	168	182	145
No of vessels	74	73	72	71	67
Average harvest per vessel (tonnes)	12,008	9,453	12,739	14,124	11,183
-Of which herring, mackerel and blue whiting[a)]	10,020	8,075	10,930	9,208	8,725
Average operating cost NOK/tonne	2,662	3,571	2,644	2,736	3,508
Average operating cost EUR/tonne	297.41	384.34	283.36	285.05	357.75

a) For 2015-17, all herring; for 2018-19 only NSSH-ASH.

We will next make an estimate of the economic costs of harvesting. This will be based on the following assumptions:

1. Investment in vessel: NOK 400 million.
2. Value of licences: NOK 450 million.
3. The vessel is depreciated over 20 years according to the annuity method. License values are not depreciated.
4. Annual operating costs: NOK 39 million – an average of 2018 and 2019.

Results are given in Table 4.11 for two alternatives regarding annual harvest quantity. One is 12,000 tonnes, which is the average for 2015-19. The other is 14,000 tonnes, the harvest for 2018 and the largest observed for the period. Estimates are also made for two alternative interest rates – 4% and 6%.

Compared with Table 4.10, it is noticeable that including the opportunity cost of capital and depreciation makes a substantial difference on total and average cost, as expected. Results suggest there are economies of scale, as an increase in quantity leads to a reduction in average cost. Furthermore, as expected, choice of interest has an important impact on costs. If anything, estimates in Table 4.11 may underestimate total costs. As mentioned above, vessels may have temporary licenses, and depreciation on these is not included. Moreover, any vessel will normally also require some land-based facilities which is also not included.

Table 4.11. Estimate of Full Economic Costs for Purse Seiners.

	4% interest rate	4% interest rate	6% interest rate	6% interest rate
Annual harvest (t)	12,000	14,000	12,000	14,000
Annual operating costs (‘000 NOK)	39,000	39,000	39,000	39,000
Annual depreciation and interest on vessel[a)] (‘000 NOK)	29,440	29,440	34,880	34,880
Annual interest on license values (‘000 NOK)	16,000	16,000	24,000	24,000
Unit operating costs/tonne	3,250	2,786	3,250	2,786
Unit depreciation and interest cost on vessel NOK/tonne	2,453	2,103	2,907	2,491
Unit interest cost on license values NOK/tonne	1,333	1,143	2,000	1,714
Total cost (AC) NOK/tonne	7,036	6,032	8,157	6,991
AC EUR/tonne	656.34	562.69	760.91	652.15

a) The annual amortisation factor is 0.0736 for a 4% interest rate and 0.0872 for a 6% interest rate, lifespan 20 years.
b) An exchange rate of EUR 1 = NOK 10.72 has been used. This is the average exchange rate for 2020 (source: Bank of Norway). In the 2010-20 period, this exchange varied between 7.47 (2012) and 10.72 (2020). In other words, the rate used is the highest since 2010.

If we compare the average costs per tonne with the prices Norwegian fishermen fetch for the species under consideration (Tables 4.1-4.3), some interesting observations emerge. Average cost is higher than the blue whiting price for all years; indeed, it is also higher than the herring price for some years. The implication of this is that mackerel is the most important fishery in the sense that a large harvest is required so as to cover fixed costs. The blue whiting fishery, on the other hand, is a marginal fishery in the sense that it is undertaken provided revenues cover marginal costs, while the herring fishery will provide some contribution to fixed costs. These results are probably applicable also to the other countries in the fishery.

Pelagic trawlers

In recent years, 15-17 pelagic trawlers have been active. In 2019, average length was 57.1 m, size in TE 1,336 and average age 17 years. According to industry sources, a new pelagic trawler will be of about 70 m length, equipped with RSW tanks, have a cargo capacity of 2,000 tonnes and come at a cost of about NOK 350 million (2021). It is very difficult to assess the quota value. This is because trawlers have a much more varied pattern of operations than purse seiners, so the composition of quotas also varies substantially. Thus, to arrive at quota value, specific assumptions about quota holdings would need to be made, and we will not go into that any further.

Table 8 presents data for pelagic trawlers. Average annual harvest varies between 10,000 – 15,600 tonnes, somewhat higher than for purse seiners. An important difference between the two vessel groups is that compared to purse seiners, herring, mackerel and blue whiting represent a much smaller share of total harvest – in most years, a bit more than 40%. Moreover, blue whiting represents a larger share of the herring, mackerel and blue whiting harvest than for purse seiners. Other important species for pelagic trawlers include Norway pout and sandeel which are of limited importance for purse seiners. All in all, most of the landings by pelagic trawlers is for reduction purposes.

Average operating cost varies between NOK 1,939 – 2,538/tonne, corresponding to EUR 210-270/tonne. This is considerably less that for purse seiners due to the fact that the trawlers mainly fish for reduction so that there is only limited onboard processing. It is also noticeable that the highest operating cost of NOK 3,080/tonne is observed in 2016, the year with the lowest average catch per vessel.

Table 4.12. Revenues, Costs and Vessel Characteristics. Averages for Pelagic Trawlers 2015-19.

	2015	2016	2017	2018	2019
Revenues	36,900,060	40,103,509	39,512,478	42,825,594	57,839,858
Total operating costs without depreciation	25,484,457	25,494,672	26,483,928	27,513,186	35,985,281
-Of which labour	9,748,832	11,387,698	10,699,486	10,565,818	15,277,922
-Of which fuel	4,819,229	4,536,563	5,264,612	6,613,437	7,248,128
EBIT	11,415,603	14,608,837	13,028,550	15,312,408	21,854,577
Operating margin (%)	30.9	36.4	33.0	35.8	37.8
No of operating days	240	245	235	255	259
No of vessels	17	14	15	14	17
Average harvest per vessel (tonnes)	13,143	10,044	13,843	13,377	15,617
-Of which herring, mackerel and blue whiting[a)] (tonnes)	5,620	4,769	7,204	5,811	6.097
Average operating cost NOK/tonne	1,939	2,538	1,964	2,057	2,304
Average operating cost EUR/tonne	216.65	273.23	210.53	214.24	233.93

a) For 2015-17, all herring; for 2018-19 only NSSH-ASH.

As we do not have license values for pelagic trawlers, we will not estimate full economic costs for this vessel group.

4.3 THE PELAGIC FISHERIES OF THE EU AND DENMARK

European Union catches

The pelagic fisheries in the European Union are spread over several countries. The northern countries catch both small pelagics such as mackerel and herring for human consumption and species such as sandeel, sprat, Norway pout and blue whiting for reduction. The southern countries fish tuna, anchovies and sardines. The 2018 catches of the different EU countries of the three stocks appear from Table 4.13. United Kingdom is included in the table, but described separately in the next section. The European Union is referred to EU28 and when excluding United Kingdom to EU27.

Table 4.13. EU catches of mackerel, blue whiting and NSSH-ASH, 2018, tonnes.

Country	Catches (tonnes)		
	Mackerel	NSSH-ASH	Blue whiting
Belgium	168	0	0
Denmark	30690	17052	87348
France	21471	0	16784
Germany	19883	1989	47708
Ireland	66747	2428	49903
The Netherlands	30392	4290	121864
Poland	4057	0	12152
Portugal	4565	0	2497
Spain	33329	0	24718
Sweden	3966	425	16
United Kingdom	193105	2582	72884
EU28	408373	28766	435874
Total	1026437	592899	1711477

Source: International Council for Exploration of the Sea (2020).

In 2018, the EU28 fisheries represented 40% of the total catches of mackerel, 25% of blue whiting and 5% of NSSH-ASH. United Kingdom, Ireland, Spain, Denmark and the Netherlands have the largest catches of mackerel, the Netherlands and Denmark of blue whiting and Denmark of NSSH-ASH. Excluding United Kingdom does not affect the overall allocation of catches between member states for NSSH-ASH and blue whiting, but with United Kingdom by far being the largest mackerel fishing nation, only 21% of total mackerel catches remain to EU27.

Since Denmark is fishing on all three stocks, Danish pelagic fisheries are described in details below as an example of an important EU fishery. Danish fisheries account for 14% of the EU27 catches of mackerel, 24% of blue whiting and 65% of NSSH-ASH.

The pelagic fisheries in Denmark

The Danish fishing industry consist in the end of 2018 of 2.123 registered vessels with totally 72,014 GT, of which 526 vessels are commercial active (have an annual turnover on more than EUR 36,000).

The total catch was 789.000 tonnes of fish, corresponding to total landing value on EUR 487 million. The activity in the whole fishing sector, including primary fishing, aquaculture and value chain operations, corresponds to a gross value added of 0.26% of the Danish GDP. Employment in primary fishing was 2.714 persons in 2018, of which 985 were full time employed onboard commercial active vessels (Nielsen *et al.*, 2020).

The development in Danish catches 2010-2020 on the four pelagic stocks and the five reduction stocks appears from Figure 4.6. Mackerel, herring and fish for reduction contributes with half the landing value in 2018, while demersal species form the other half. The largest vessels (> 40 m) target mainly mackerel and herring and fish for reduction.

The catches on the pelagic fish stocks are relatively stable, in particular for mackerel. The catches of reduction species are more fluctuating and the sandeel catches always fluctuate substantially, due to stock variability of the short living species. Catches of the sprat stock both in the North Sea (NS) and the Baltic Sea (BS) are more stable, while Danish vessels did not target blue whiting before 2014, after which the catches grew.

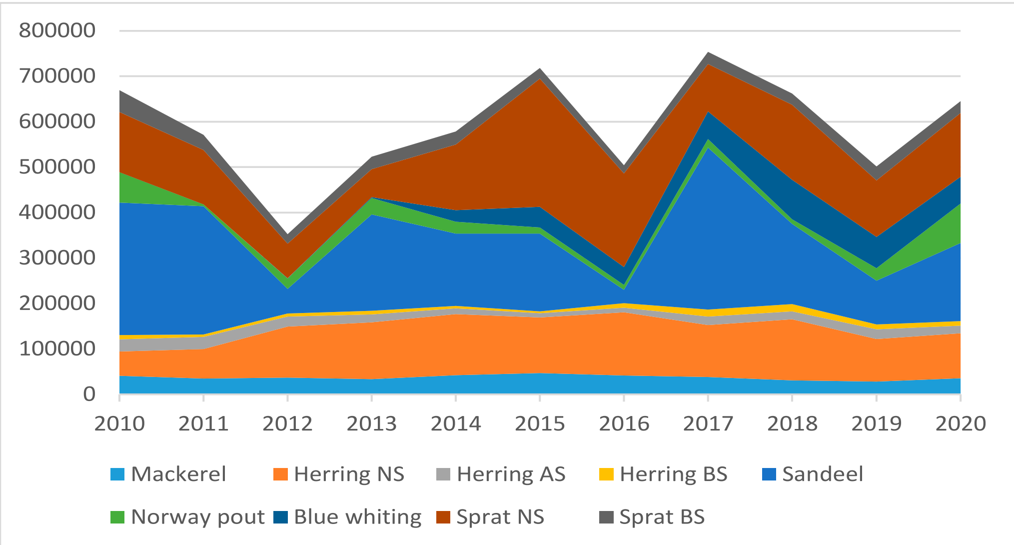


Figure 4.6. Danish catches of mackerel, herring and fish for reduction, tonnes, 2010-2020.
Source: Danish Directorate of Fisheries (2021a).

Pattern of fishing on the Danish pelagic fish stocks

The Danish pelagic and reduction fisheries target the North-East Atlantic mackerel stock and the herring stocks, NSSH-ASH, North Sea herring and Baltic Sea herring. The main foundation for Danish reduction fisheries is sandeel, North Sea sprat, blue whiting, Baltic Sea sprat and Norway pout. In 2018, largely all mackerel was caught in EU28 waters, with fishing in Norwegian waters forming less than 0.1% of these catches. For NSSH-ASH, 86% were caught in the Norwegian zone and 12% in international waters. Hence, of the total Danish catch of herring on 167,743 tonnes, 90% were caught in EU28 waters (Danish Directorate of Fisheries, 2021). For blue whiting, largely all were caught in EU28 waters, with fishing in Norwegian, Faroese and international waters forming only 0.7% of this. Of the total catches of fish for reduction (sandeel, sprat, blue whiting and Norway pout) of 465,000 tonnes, largely all originates inside EU28 waters (Danish Directorate of Fisheries, 2021).

While most of the Danish catches originate from EU28 waters, 97% of the 2018 catch of 30,696 tonnes originates from the British EEZ. For blue whiting, 29% comes from the British zone. Where the NSSH-ASH is caught in Norwegian and international waters, 88% of the remaining herring catches of 137,053 tonnes come from the British zone.

The three analysed pelagic stocks account for 30% of the total landing value of all the Danish pelagic and reduction fisheries on EUR 216 million. Of this value, EUR 42.7 million (20%) is caught in the British EEZ and EUR 6.7 million (3%) in the Norwegian EEZ. The development in the location of mackerel catches on economic zones appear from Figure 4.7.

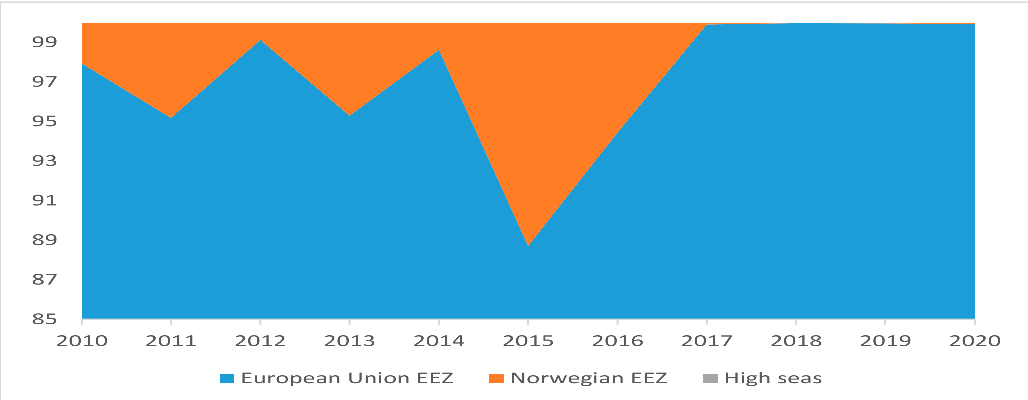


Figure 4.7. Location of Danish catches of mackerel on economic zones, percentage of quantity, 2010-2020.
Source: Danish Directorate of Fisheries (2021a).

Danish vessels catch 90% or more of mackerel in EU28 in the whole period. In the period 2010-2016, except for 2015, the share was also above 95%. From 2017, largely all mackerel are from EU28 waters. In 2018, 97% of the Danish catches originate from the British EEZ. The development in the location of mackerel catches on economic zones appear from Figure 4.8.

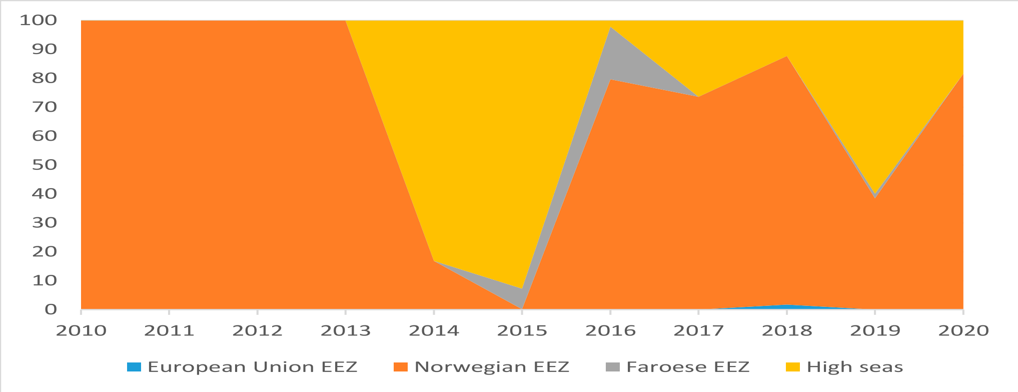


Figure 4.8. Location of Danish catches of NSSH on economic zones, percentage of quantity, 2010-2020.
Source: Danish Directorate of Fisheries (2021a).

The catches of Danish vessels of NSSH-ASH fluctuate substantially over the period. From 2010-2013, all catches originated from the Norwegian EEZ, while in 2014-2015, more than 80% was caught in international waters. In 2016-2020, the share from Norwegian waters varied between 40-80%, with the rest caught mainly on the high seas and partly in Faroese waters (2015-2016).

The development in the location of blue whiting catches on economic zones appear from Figure 4.9 for the period 2013-2020. The years 2010-2012 are omitted, since the catches were very small (every year < 400 tonnes).

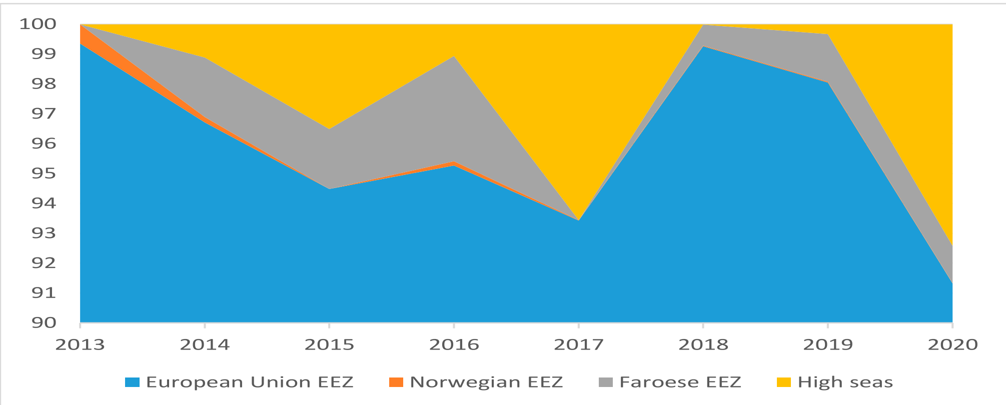


Figure 4.9. Location of Danish catches of blue whiting on economic zones, percentage of quantity, 2013-2020.
Source: Danish Directorate of Fisheries (2021a).

Over the period 2013-2020, more than 90% of Danish blue whiting catches are from EU28 EEZ. In some years, catches from international waters are of importance (such as in 2017 and 2020) in others it is neglectible. The catch in the Norwegian EEZ is largely zero, while in most years some Danish catches originate from the Faroese EEZ. The main development for blue whiting is that the catch increased from 141 tonnes in 2010 to 87,302 tonnes in 2018.

Prices and markets

Danish pelagic fishers land mainly in Denmark, but for mackerel and herring to some extent also in other countries. The price of mackerel was in 2020 1.21 EUR/kg, more than double of NSSH-ASH at 0.54 EUR/kg, which again is the double of the blue whiting price on 0.27 EUR/kg. Price developments appear as an index from Figure 4.10 with 2020=100.

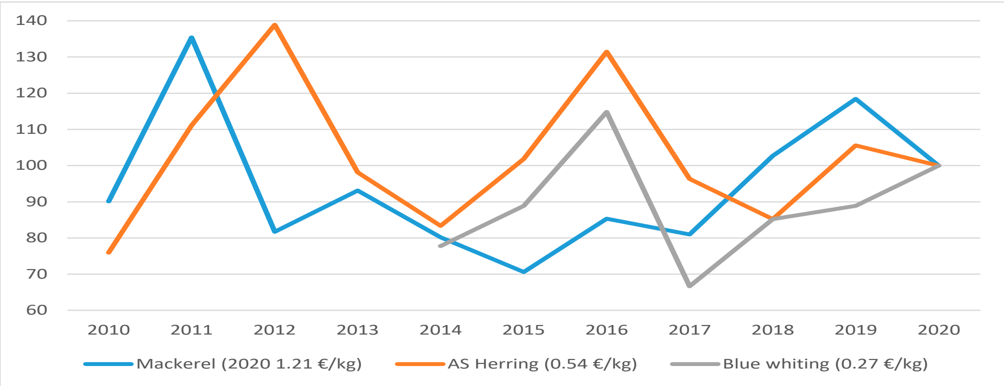


Figure 4.10. Prices on mackerel, AS herring and blue whiting by Danish vessels, 2020=100, annual prices, 2010-20.
Source: Danish Directorate of Fisheries (2021b).

With blue whiting used for producing fishmeal and oil in Denmark, the price follows the price of fish for reduction. This price is affected by the supply and demand of fishmeal and oil on the world market, with supply being determined mainly by Peruvian anchovies and Chilean jack mackerel and demand determined by the continued rising demand for feed to the growing aquaculture sector worldwide. The price is also affected by exchange rates between Danish kroner and US$, since transactions are typically made in US$. With these price drivers, the blue whiting price fluctuates substantially in the period 2014-2020. Herring and mackerel prices also fluctuate, with drivers being fluctuating supply from the two large stocks.

Mackerel, herring and fish for reduction landed in Denmark by Danish fishers are processed and/or sold by wholesale companies. The processing and trading sector further import raw materials of herring, mackerel and fish for reduction that is later re-exported mainly to the other European markets. Mackerel and herring are used for human consumption, while blue whiting is used as raw material for the processing of fishmeal and oil. The product processed and exported appear from Table 4.14.

Table 4.14. The Danish industries sale of product of own processing and export of mackerel, herring and fish for reduction, 2018, tonnes and DKK million.

	Processing			Export		
	Value (EUR million)	Quantity (1000 tonnes)	Price (EUR/kg)	Value (EUR million)	Quantity (1000 tonnes)	Price (EUR/kg)
Mackerel:						
Fresh				32	24	1,33
Frozen				22	15	1,48
Fillets				4	1	3,57
Smoked	3	0	8,21	1	0	12,26
Prepared/preserved	46	11	4,04	36	9	4,19
Total	49	12	4,17	95	49	1,94
Herring:						
Fresh				31	60	0,52
Frozen				9	7	1,32
Fillets	16	14	1,14	16	13	1,28
Salted, dried, smoked	4	2	2,20	11	5	2,13
Prepared/preserved	80	36	2,20	55	27	2,05
Total	100	52	1,92	122	112	1,09
Fish for reduction:						
Fish oil	101	67	1,50	191	141	1,36
Fishmeal	311	225	1,38	281	204	1,38
Total	412	292	1,41	472	345	1,37
Total	561	356	1,57	689	505	1,36

Source: Statistics Denmark (2021ab).

Total Danish export of mackerel, herring and blue whiting corresponds to EUR 689 million, total processing to EUR 561 million. Fishmeal and oil are the most important products, but since produced on several different reduction species, only a part of this is founded on blue whiting. In 2018, 19% of total landings of reduction species were blue whiting, corresponding to an export value of EUR 90 million. Hence, herring is with an export on EUR 122 million of largest importance, followed by mackerel (EUR 95 million) and blue whiting (EUR 90 million).

Danish processing is based on Danish caught raw material, but also raw material from Sweden, Norway and others. The main products are fish oil and fish meal mainly sold to the growing aquaculture sector worldwide, saured herring, which is a semi-processed product used for pickled herring in glasses typically finalized in Eastern Europe. The main market for herring from Denmark is Europe, north of a line between Moscow and Paris. The main mackerel product is mackerel in tomato processed by one Danish factory (Sæby Fiskeindustri).

Economics

The Danish pelagic and reduction fisheries have been heavily affected by the introduction of Individual Transferable Quotas over 2004-2007 (Asche, Bjørndal & Bjørndal, 2014), as well as by the continuous technological development. Earlier fishing spread over both larger and medium-sized vessels, where today it is concentrated on the large vessels. Hence, 28 vessels above 40 m length account for 90% of the total catch value of pelagic and reduction species. In the year 2000, the corresponding number of vessels was 42. The vessels are from Northern and Western Jutland, most from the harbours of Skagen and Hirtshals. In 2018, 15 of these vessels are trawlers solely fishing for reduction at an average size of 595 GT with a total employment on 47 full time persons, average physical assets on EUR 3.5 million per vessel and permanent quota share assets of EUR 3.3 million per vessel.

The remaining largest 13 vessels are purse seiners, some combinations with trawl that have an average size of 2,168 GT, with a total employment on 104 full time persons, an annual average turnover per vessel of EUR 15 million, with average physical assets on EUR 37 million per vessel and average permanent quota share assets of EUR 52 million per vessel. The economics of the two groups of vessels are analysed in this section. Key economic numbers appear for purse seines above 40 m from Table 4.15.

Operating costs include salary for hired crew and working owners, fuel, maintenance, quota rent, services, landing fee, distribution, administration, insurance, depreciations, etc. Wages are determined by the crew share system, where all crew members dependent on their job receive a share of the turnover minus some pre-defined cost items. Hence, crew costs follow turnover. Some cost items, such as for administration and depreciations, may be considered a fixed cost.

Table 4.15. Key economic numbers for Danish purse seiners over 40 m, average per vessel, 2015-2019.

	2015	2016	2017	2018	2019
Turnover (EUR 1,000)	13250	14638	12092	15170	15428
Total operating costs (EUR 1,000)	4486	5030	4674	5646	5993
- Of which labour (EUR 1,000)	1701	1926	1780	1983	2169
- Of which fuel (EUR 1,000)	903	725	917	1376	1345
EBITDA (EUR 1,000)	8764	9608	7418	9524	9435
Operating margin (%)	66	66	61	63	61
Days at sea	188	173	200	223	194
No. of vessels	12	13	13	13	10
Average harvest per vessel (tonnes)	27942	23239	33349	33872	28797
- Of which mackerel, NHHS-ASH herring and blue whiting	5649	5089	6295	7231	7330
Average operating costs (EUR/tonnes)	161	216	140	167	208

Source: Statistics Denmark (2021c).

Average annual harvest per vessel varies between 23,239 and 33,872 tonnes. The turnover in 2015-2019 is allocated between fish for consumption with mackerel and herring (19-25% and 32-47%, respectively) and fish for reduction (19-32%). Mackerel, NSSH-ASH and blue whiting accounts totally for between 27-36% of turnover in the period.

Danish purse seiners over 40 m are profitable with a very high EBITDA of EUR 7.4-9.6 million per vessels per year over the period, corresponding to an operating margin between 61-66% of turnover.

It is not possible to estimate costs for the fishing on individual species. With the data available, only annual average operating cost per tonne harvested is identified. It varies between EUR 140 per tonne in 2017 and EUR 208 per tonne in 2019. Operating cost per tonne harvested depends on the catch composition between different priced fish for consumption and reduction that varies over time. Key economic numbers for reduction trawlers over 40 m are given in Table 4.16.

Table 4.16. Key economic numbers for Danish reduction trawlers over 40 m, average per vessel, 2015-2019.

	2015	2016	2017	2018	2019
Turnover (EUR 1,000)	3661	2474	2325	2413	3072
Total operating costs (EUR 1,000)	2221	1695	1728	1749	1962
- Of which labour (EUR 1,000)	594	463	499	481	573
- Of which fuel (EUR 1,000)	367	253	323	370	429
EBITDA (EUR 1,000)	1440	780	597	664	1111
Operating margin (%)	39	32	26	28	36
Days at sea	160	134	136	134	151
No. of vessels	17	17	16	15	16
Average harvest per vessel (tonnes)	13611	8481	11999	9335	10229
- of which mackerel, AS herring and blue whiting	1131	1078	1291	1752	2061
Average operating costs (EUR/tonnes)	163	200	144	187	192

Source: Statistics Denmark (2021c).

Average annual harvest per vessel varies between 8,481 and 13,611 tonnes. Between 83-88% of turnover in the period comes from fish for reduction. Blue whiting, NSSH-ASH and mackerel account totally for between 7-20% of turnover with an increasing trend in the period. Other important species for the reduction trawlers are sandeel, sprat and Norway pout.

Danish reduction trawlers over 40 m are profitable with an EBITDA on EUR 597,000 - 1.4 million per vessels per year over the period, corresponding to an operating margin between 26-39% of turnover. Annual average operating cost per tonne harvested is identified between EUR 144 per tonne in 2017 and EUR 192 per tonne in 2019.

We will next make an estimate of the economic costs of harvesting respectively for purse seiners and trawlers. This will be based on the assumptions that the investment in one new average purse seine cost EUR 45 million and one new trawler EUR 5.0 million, that the value of the permanent (corresponding to that the share can be terminated after a notice period of 16 years) individual transferable quota share values are EUR 52 million and EUR 3.3 million respectively for purse seines and trawlers as was the case in 2018, that the vessel is depreciated over 20 years according to the annuity method, that permanent quota shares are already fully depreciated and that the annual operating costs corresponds to an average of 2018 and 2019.

Results are provided in Table 4.17 for two alternative assumptions on interest rate (4% and 6%). Compared with Table 4.15-4.16, it is noticeable that including the opportunity cost of capital and depreciation makes a substantial difference on total and average cost, as expected. It is also important to note that harvest quantity and choice of interest rate has an important impact on costs.

Table 4.17. Estimate of full economic costs for Danish purse seines over 40 m and for reduction trawlers over 40 m based, average annual costs per vessel, based on 2018-2019 accounts.

	Purse seines over 40 m		Reduction trawlers over 40 m	
	4% interest rate	6% interest rate	4% interest rate	6% interest rate
Annual harvest (tonnes)	31335	31335	9782	9782
Annual operating costs (EUR 1,000)	5820	5820	1856	1856
Annual depreciation and interest costs physical assets[1] (EUR 1,000)	3312	3924	368	436
Annual interest costs on permanent quota shares[2] (EUR 1,000)	3827	4534	243	288
Unit operating costs (EUR/tonne)	186	186	190	190
Unit depreciation and interest costs on physical assets (EUR/tonne)	106	125	38	45
Unit operating costs including depreciation/return on physical assets (EUR/tonne)	291	311	227	234
Unit interest costs on permanent quota shares (EUR/tonne)	122	145	25	29
Unit operating costs with depreciation/return on total assets (EUR/tonne)	414	456	252	264

Note: 1. These numbers are, for example for purse seines calculated for an interest rate on 4% and 20 years lifespan, corresponding to an annual amortisation factor on 0.0736. The annual depreciation and interest costs on physical assets on EUR 3.312 million appear as 0.736 multiplied by the price of a new vessel which is estimated to EUR 45 million. Physical assets are assumed to include all other assets than the value of permanent quota shares. The annual amortisation factor for a 6% interest rate over a 20 years lifespan is 0.0872.
2. These numbers are identified using the same annual amortisation factor as for physical assets. The annual interest costs on permanent quota shares on EUR 3.827 million appear as 0.0736 multiplied by the value of the permanent quota shares in 2018 on EUR 52 million.

Comparing the estimated full costs in Table 4.17 with the prices in Figure 4.10, reveal that the unit costs of purse seines are substantially lower than mackerel prices, but also lower than prices of NSSH-ASH. Since purse seines fish on all three species, it is clear that mackerel is most important for the Danish purser seines, followed by herring and blue whiting in that order. This corresponds to that fishermen from an economic point of view prioritise to fish mackerel first in the season and then herring as second priority. Sometimes but not always reduction fishery is also undertaken by these vessels, but only when the marginal turnover from this exceeds the marginal costs of reduction fishing. Fishing for reduction is considered more detrimental to vessels and gear than fishing for mackerel and herring due to the large quantities caught. In 2018, 32% of the turnover of Danish purse seiners over 40 m originate from reduction fishery. For trawlers, unit costs of their main reduction fishery (in 2018 88% of the turnover comes from fish for reduction) is close to the price, indicating that trawlers are less economically beneficial than purse seines, although they also catch minor amounts of mackerel and NSSH.

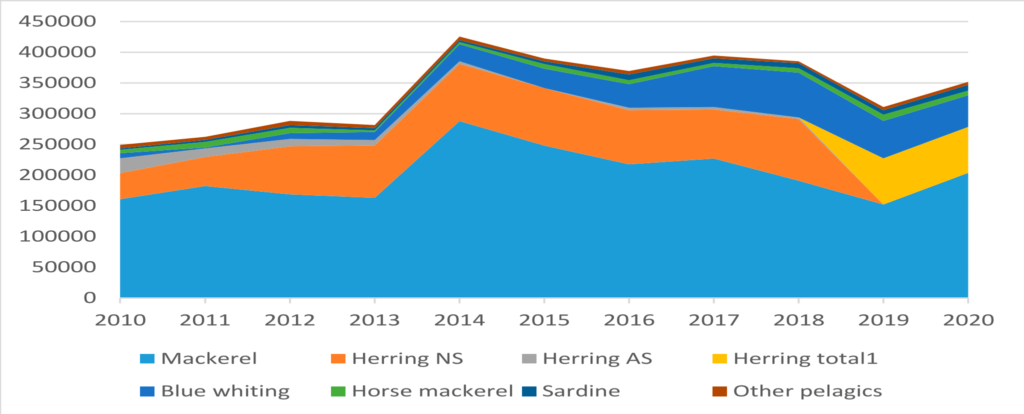
4.4 THE PELAGIC FISHERIES OF THE UNITED KINGDOM

During the 2010-2020 period analysed, United Kingdom was part of the European Union and British fisheries regulated as part of the Common Fishery Policy. However, since this report focuses on future management, the British fisheries is considered separately. Mackerel is the main species with catches in 2018 on 193,105 tonnes, while NSSH-ASH catches was 2,582 tonnes and blue whiting catches formed 72,884 tonnes. Hence, mackerel is by far the most important of the three stocks for British fishers.

The United Kingdom catches in 2018 formed 43% of the total EU28 catches of mackerel, 9% of EU28 catches of NSSH and 17% of EU28 catches of blue whiting. Hence, Brexit reduce the EU catch share on all three stocks, but mackerel in particular.

The United Kingdom fishing industry consist in the end of 2018 of 6,036 registered vessels with totally 191,178 GT. In 2017, 4,709 vessels were active. The total catch was 698.000 tonnes, corresponding to total landing value on EUR 1.118 billion. 2,923 vessels are from England and 2,083 from Scotland. The activity of primary fishing corresponds to a gross value added on 0.02% of the United Kingdom GDP. Employment in primary fishing was 11,961 persons in 2018, of which 9,588 are regular employed and 2,373 are part-time employed.

Mackerel, herring and blue whiting contributes with half the landing value in 2018, while demersal species including haddock, cod, hake, saithe, plaice, monkfish, Norway lobster, scallops and crabs forms the other half (Bjørndal & Munro, 2021). The largest vessels (> 40 m) target mainly mackerel, herring and blue whiting. The development in the British catches 2010-2020 on the six main pelagic stocks and “Other pelagics” appears from Figure 4.11. The herring catch is split between stocks in 2010-2018. For 2019-2020, only total numbers are available.



Note: 1. Data for splitting herring on the North Sea and the NSSH stock not available.

Figure 4.11. British catches of pelagic fish species, 2010-2020.
Source: Marine Management Organisation (2015, 2020) and ICES (2020).

Mackerel catches are relatively stable until 2013, increase substantially in 2014 and fall slowly until 2019. Catches of North Sea herring have an increasing trend until 2018, while NSSH-ASH is falling. NSSH-ASH loose grounds over the period, but more than offset by increasing catches of North Sea herring. Blue whiting catches increase until 2018 from a very low level in the beginning of the period. Horse mackerel, sardine and other pelagics are in comparison of minor importance.

Fishing pattern

The British pelagic fisheries target mainly mackerel, NSSH-ASH, North Sea herring and blue whiting. Mackerel and herring are used for human consumption and blue whiting for reduction. 96% of the total British catches of all fish species originates in 2019 from EU28 waters, with the last 4% largely being caught in Norwegian EEZ (Marine Management Organisation 2021a). 81% of the total catches originates from British waters and 15% from EU27 waters. The development in the location of mackerel catches on economic zones appear from Figure 4.12.

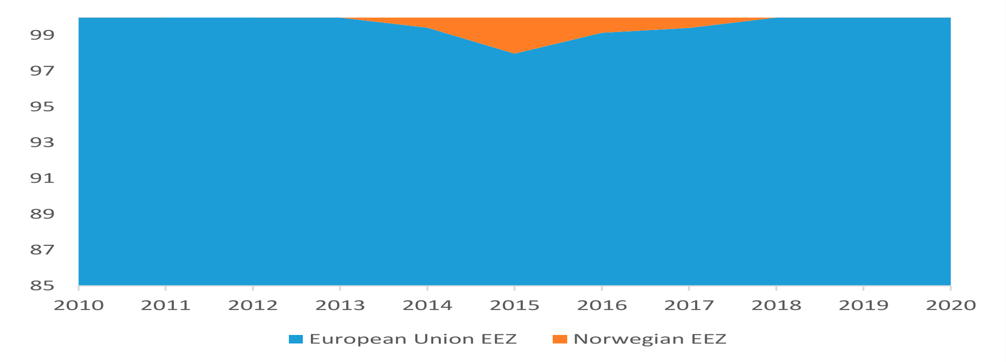


Figure 4.12. Location of British catches of mackerel on economic zones, percentage of quantity, 2010-2020.
Source: Marine Management Organisation (2021b).

British vessels catch all mackerel in EU28 waters in the whole 2010-2020 period, except for minor catches in the Norwegian zone in 2014-2017. The development in the location of NSSH catches on economic zones appear from Figure 4.13.

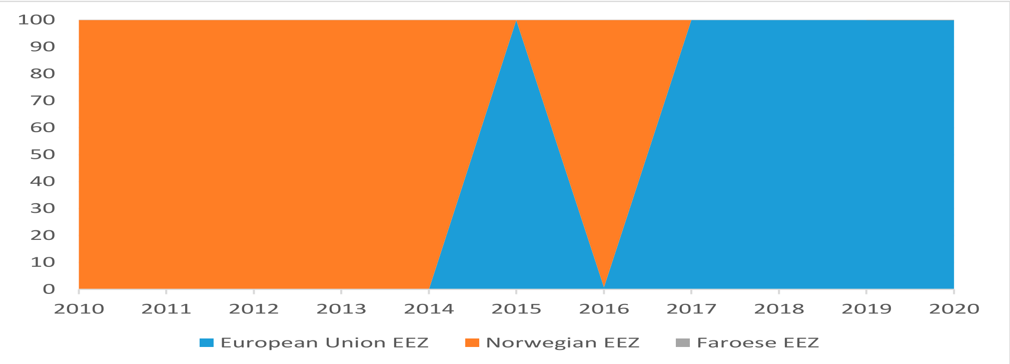


Figure 4.13. Location of British catches of NSSH-ASH on economic zones, percentage of quantity, 2010-2020.
Source: Marine Management Organisation (2021b).

The catches of British vessels of NSSH-ASH have been reduced from 24,191 tonne in 2010 to 1,981 tonnes in 2020. From 2010-2016, all catches originated from the Norwegian EEZ, except in 2015 where the total catch on only 55 tonnes was caught in Norwegian waters. From 2017 and onward all catches originate in the EU28 zone, but at a lower level with annual catches these years in the range from 1,801 tonne to 4,389 tonne.

The catches of British vessels of blue whiting have grown from 7,969 tonnes in 2010 to 51,551 tonnes in 2020. In the whole period, all catches originate in the EU28 zone. In 2019, 81% of the

British blue whiting catches in EU28 waters originates from the Irish part of the EU27 EEZ (Marine Management Organisation 2021a).

Prices and markets

British pelagic fishers landed 71% of the catch value outside the UK for mackerel, herring and blue whiting. Norway, the Netherlands and Ireland are the largest receivers. The price of mackerel was in 2020 1.01 EUR/kg, the price of NSSH-ASH 0.39 EUR/kg and the blue whiting price 0.25 EUR/kg. Price developments appear as an index from Figure 4.14 with 2020=100.

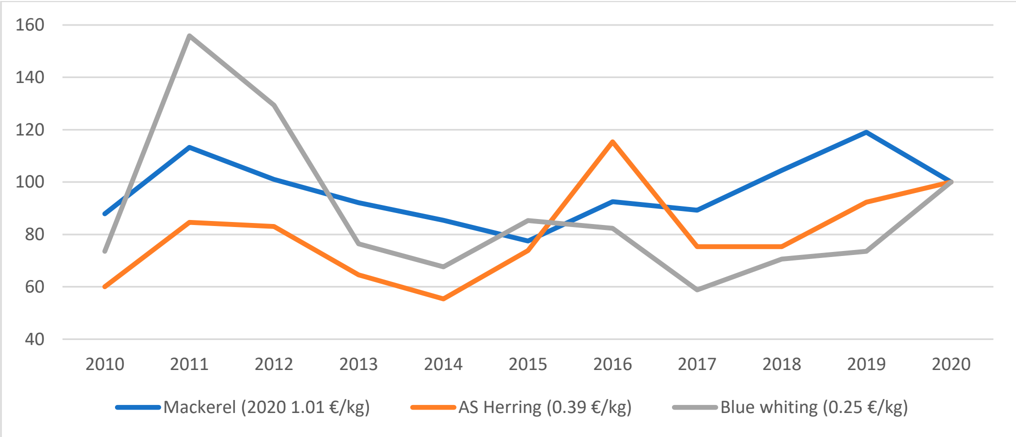


Figure 4.14. Prices on mackerel, AS herring and blue whiting by British vessels, 2020=100, annual prices, 2010-20.
Source: Marine Management Organisation (2015, 2020).

With blue whiting used for producing fishmeal and oil, the price follows the price on fish for reduction, revealed from the world market prices of fishmeal and oil. Herring and mackerel prices fluctuate, driven among other from fluctuating supply from these two large stocks.

British import and export of mackerel, herring and fish for reduction appear from Table 4.18. For each of the species and for fish for reduction, landings of British vessels outside United Kingdom is separated from the remaining export, as well as foreign vessels landings in United Kingdom is shown separate from the remaining import.

Table 4.18. British import and export of mackerel, herring and fish for reduction, 2018, tonnes and EUR million.

	Value (EUR million)	Quantity (1000 tonnes)	Price (EUR/kg)
Import:			
Mackerel landings in the UK by foreign vessels	16	15	1.08
Mackerel processed	46	14	3.26
Mackerel total	61	29	2.15
Herring landings in the UK by foreign vessels	3	1	3.24
Herring processed	12	4	2.71
Herring total	15	5	2.80
Blue whiting landings in the UK by foreign vessels	1	0	7.30
Fish oil	31	42	0.74
Fish meal	107	118	0.91
Fish for reduction total	139	160	0.87
Import total	**216**	**194**	**1.11**
Export:			
Mackerel landings by UK vessels abroad	132	110	1.20
Mackerel processed	91	67	1.35
Mackerel total	223	178	1.36
Herring landings by UK vessels abroad	31	55	0.56
Herring processed	48	51	0.75
Herring total	69	106	0.65
Blue whiting landings by UK vessels abroad	13	53	0.25
Fish oil	30	11	2.73
Fish meal	39	25	1.56
Fish for reduction total	82	89	0.93
Export total	**374**	**3.72**	**1.01**

Source: Marine Management Organisation (2018).

For both mackerel and herring, export is larger than import, indicating that those species are mainly consumed outside United Kingdom. Norway is the main market for mackerel and herring, with British vessels landing directly in Norway. The largest export market of processed mackerel is the Netherlands. For fishmeal and oil, import is larger than export to fulfil the demand for feed to the Scottish salmon aquaculture industry.

For mackerel, 60% of the export value is landed by UK vessels abroad, while this share is 45% for herring. This corresponds to that 68% and 30%, respectively of mackerel and herring, of the total catches by British vessels are landed outside United Kingdom. For blue whiting, this number is 18%.

Financial accounts

British pelagic fisheries are concentrated on the large vessels. Hence, 27 vessels above 40 m length account for more than 95% of the total catch value of pelagic species. In 2008, the corresponding number of vessels was 31. The vessels are mostly from Scotland. In 2018, these vessels are at an average size of 2,440 GT and have an annual turnover on EUR 11.6 million per vessel. Assets are EUR 18.71 million on average per vessel. Employment is 87 full time persons (2017). Key economic numbers appear in Table 4.19.

Table 4.19. Key account numbers for United Kingdom vessels over 40 m, average per vessel, 2015-2019.

	2015	2016	2017	2018	2019
Turnover (EUR 1,000)	9955	11055	10191	11561	9940
Total operating costs[a)] (EUR 1,000)	6320	6147	4742	6738	4690
- Of which labour (EUR 1,000)	2386	2363	2289	2549	2172
- Of which fuel (EUR 1,000)	784	595	704	957	693
EBITDA (EUR 1,000)	3636	4907	5449	4823	5250
Operating margin (%)	37	44	53	42	53
Days at sea	77	71	66	63	62
No. of vessels	28	28	27	27	29
Average harvest per vessel (tonnes)[b)]	13604	12670	14217	13822	10113
- Of which mackerel, NSSH and blue whiting (tonnes)[c)]	10920	10148	11772	10887	8084
Average operating costs (EUR/tonne)	465	485	334	487	464

a) Total operating costs include: (i) crew costs, (ii) energy costs, (iii) repair and maintenance costs, (iv) lease and rental payments for quotas, (v) other variable costs and (vi) other non-variable costs.

b) Average harvest per vessel is known in 2015-2017, but calculated for 2018-2019 assuming that the group of vessels over 40 m achieve the same share as the total British catches of mackerel, NSSH, North Sea herring and blue whiting as in 2017.

c) The average catches of vessels over 40 meter of mackerel NSSH and blue whiting is approximated by assuming that these vessels catch the same share of the three species of total British pelagic catches as totally for Britain. In 2019, the allocation of catches between NSSH and North Sea herring is not known and therefore assumed to have the same allocation as in 2018.

Source: Scientific, Technical and Economic Committee of the European Commission (2020).

Average annual harvest per vessel varies between 10,113 and 14,217 tonnes. The turnover in 2015-2019 for all British catches is allocated between fish for consumption with mackerel and herring (74-81% and 14-22%, respectively) and blue whiting used for reduction (3-6%). Mackerel, NSSH-ASH and blue whiting account totally for around 80% of turnover in all the years.

Operating costs include salary, fuel, repair and maintenance, quota rent, other variable and non-variable costs. Crew costs are determined by a crew share system, as in the other countries. Some cost items included in the operating costs may be considered fixed.

British pelagic vessels over 40 m are profitable with a very high EBITDA on EUR 3.6-5.4 million per vessels per year over the period, corresponding to an operating margin between 37-53%

of turnover. It is not possible to estimate costs for the fishing on individual species. With the data available, only annual average operating cost per tonne harvested is identified. It varies between EUR 334 per tonne in 2017 and EUR 487 per tonnes in 2018.

We will next make an estimate of the economic costs of harvesting. This is based on the assumptions that the investment in one new average pelagic vessel (purse seine) cost EUR 40 million, that the value of the fishing rights is EUR 26.3 million as was the case in 2018, that the vessel is depreciated over 20 years according to the annuity method, that permanent quota shares are already fully depreciated and that the annual operating costs corresponds to an average of 2018 and 2019. Results are provided in Table 4.20 for two alternative assumptions on interest rate (4% and 6%).

Table 4.20. Estimate of full economic costs for British pelagic vessels over 40 m, average annual costs per vessel based on 2018-2019 accounts.

	4% interest rate	6% interest rate
Annual harvest (tonnes)	11968	11968
Annual operating costs (EUR 1,000)	5714	5714
Annual depreciation and interest costs physical assets[1] (EUR 1,000)	2944	3488
Annual interest costs on permanent quota shares[2] (EUR 1,000)	1936	2293
Unit operating costs (EUR/tonne)	477	477
Unit depreciation and interest costs physical assets (EUR/tonne)	246	291
Unit operating costs with depreciation/ return on physical assets (EUR/tonne)	723	769
Unit interest costs on permanent quota shares (EUR/tonne)	162	192
Unit operating costs with depreciation/return on total assets (EUR/tonne)	885	961

Note: 1. These numbers are calculated for an interest rate on 4% and 20 years lifespan, corresponding to an annual amortisation factor on 0.0736. The annual depreciation and interest costs on physical assets on EUR 2.944 million appear as 0.736 multiplied by the price of a new vessels which is estimated at EUR 40 million. The annual amortisation factor for a 6% interest rate over a 20 years lifespan is 0.0872.
2. These numbers are identified using the same annual amortisation factor as for physical assets. The annual interest costs on permanent quota shares on EUR 1.936 million appear as 0.0736 multiplied by the value of the permanent quota shares in 2018 on EUR 26.3 million.

Comparing the estimated full costs in Table 4.20 with the prices in Figure 4.14, reveal that the unit costs of the pelagic vessels are lower than mackerel prices, but higher than prices of NSSH-ASH. The high costs compared with the purse seines in the other countries reflects that mackerel is the all-dominating species for the British pelagic fleet. The low number of fishing days per year shown in Table 4.20 further reflect that the vessels are active largely only in the mackerel season, with other activities during the year including only a bit of blue whiting fishery and limited fishing for herring in the North Sea and on NSSH-ASS.

4.5 THE FAROE ISLANDS PELAGIC FISHERIES

According to Faroese statistics, the direct contribution of the fishing industry was, on average, approximately 17% of the GDP over the period 2010-2019. If indirect effects were taken into consideration, the contribution to GDP would be even larger. In the same period, 92% of total exports of goods came from fish-related products. Thus, it would not be wrong to call the Faroe Islands' fishery industry a base industry[27], similar to the case of Iceland.

In this respect, the Faroese fisheries, which differ across operational aspects of the fleet associated with demersal or pelagic catches, have shown mixed results. The Faroese Economic Council report from 2014 points to the overcapacity of the home fleet that struggled to break even, while at the same time the report also notes the positive levels of economic returns for the pelagic fleets of 27%. Indeed, over the last decade, the total export income from fish-related products almost doubled from EUR 629 million in 2010 to EUR 1,126 million in 2020, where the three most valuable pelagic fish stocks, mackerel, herring and blue whiting accounted for 42% of total exported quantities and 20% of the export value.

The pelagic industry

At the end of 2020, there were 16 active pelagic fishing vessels - pelagic trawlers or purse seiners - equipped mainly[28] with RSW tanks, with average LOA of 77 m and 2970 GT. This segment of the Faroese fishing fleet was responsible for catching 95.5% and 99.8% of total herring and blue whiting volumes between 2010 and 2020. However, due to the allocation of fishing opportunities to other fleet segments, pelagic fishing vessels landed 80% of total mackerel catches, the remainder harvested by small and mid-size stern-trawlers (without RSW tanks). Consequently, the pelagic vessels on average managed to get 30% higher price than stern-trawlers, making it 87% of total revenue.

The bar chart in Figure 4.15 illustrates a wide variance in gear types and fleet segments per each year. It is worth mentioning that the average vessel age for the pelagic segment was 16 years, while smaller and mid-size trawlers were on average 22 years and 25 years old, respectively. At the time of this writing, a brand-new pelagic factory vessel that costs around EUR 40 million, LOA 90 m and 3500 tonnes of processed fish capacity (frozen catches at sea) is scheduled to be delivered to their owners March 2022, which would represent the first newly built vessel to the Faroese pelagic fleet over the last 12 years (Figure 4.16).

---

[27] See Agnarson and Arnason (2007).

[28] Including two large vessels that process and freeze their catch at sea along making fish-feed.

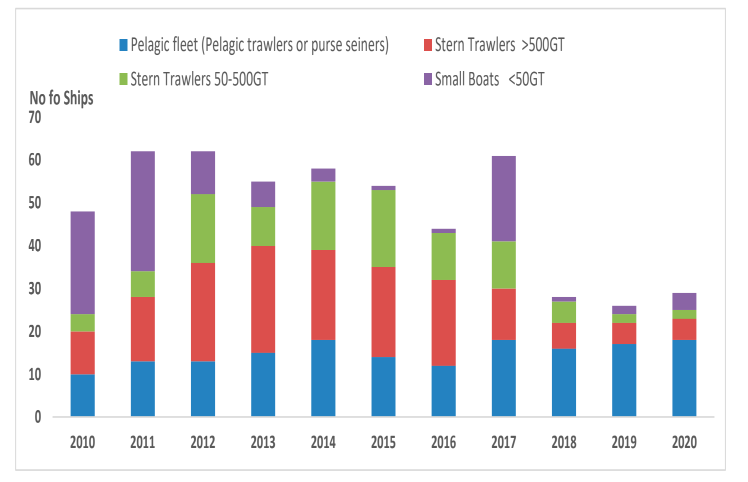


Figure 4.15. The Faroe Islands fleet per gear type.
Source: Vørn, Teyggjan

Figure 4.16. A new "Christian í Grótinum" factory vessel scheduled for delivery 2022.
Source: Karstensens Skibsværft.

Harvests and values

The total Faroese pelagic catches were on average 537 thousand tonnes per year between 2017 and 2020, an increase of 63% from the average of the previous period 2010-2016 of 330 thousand tonnes. Compounded Annual Growth Rate (CAGR) for the whole period was 10%, although such increase was mainly driven by blue whiting fisheries where the catches have been rather steadily increasing from 48 to 341 thousand tonnes (CAGR 21%). Overall, 4.5 million tonnes were landed, of which the largest share, or 53%, is blue whiting, followed by mackerel and herring, being 24% and 19%, respectively.

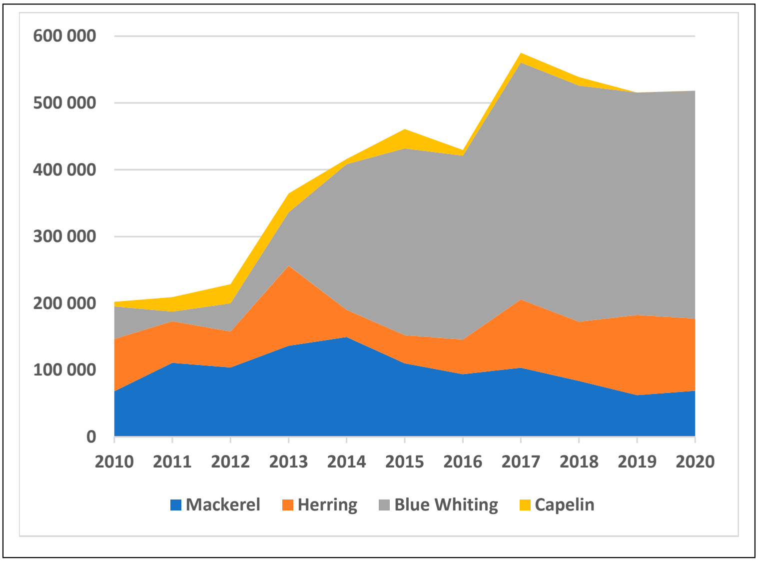


Figure 4.17. Pelagic landings tonnes.
Source: Vørn

Figure 4.17 shows a steady increase of mackerel catches reaching a historical maximum of 150 thousand tonnes in 2014 (CAGR 22%). It is worth noting that the mackerel catches were only 9,6 thousand tonnes in 2008. This steep increase of mackerel landings was due to so called mackerel-conflict[29], where the new mackerel migration patterns and fruitless attempts to re-negotiate three parties (Norway, EU & the Faroe Islands) coastal agreement from 1999, caused the Faroese authorities to unilaterally set their own mackerel quotas (cf. ch. 3).

As to be expected, the increased catches helped to achieve record revenue values shown in Figure 4.18 with a peak of around EUR 230 million during 2019 and 2020, a whole 124% increase from the beginning of the period. CAGR for the whole period was slightly lower at 8.4%, although like quantities developments, the blue whiting catches monetary values increased almost fivefold, from EUR 19 million to EUR 94 million (CAGR 17%). At the same time, mackerel and herring achieved lower but nevertheless solid CAGR, 6% and 4%, respectively. Consequently, the total value of catches for the whole period was EUR 2,1bn (Dkr15,7bn), the largest share belonging to mackerel at 43%, followed by almost equal shares coming from blue whiting (29%) and herring (25%).

[29] See Totland (2020).

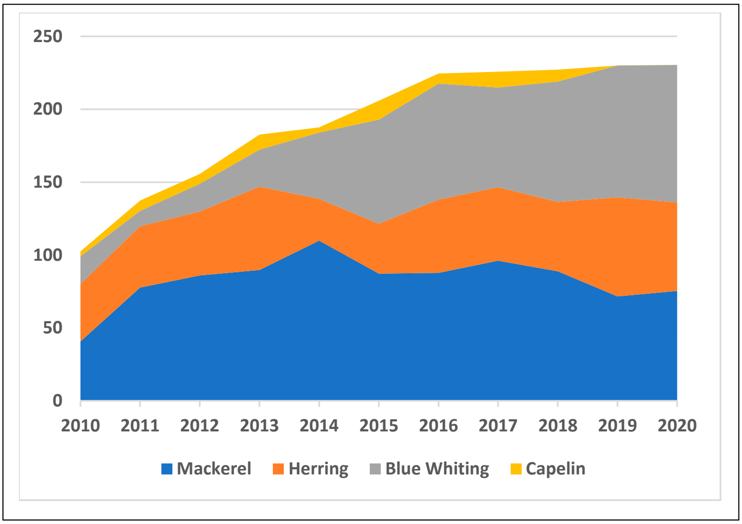


Figure 4.18. Pelagic values of landings (EUR million).
Source: Vørn

Fishing areas

Based on aggregated data, Figure 4.19 shows the location of total catches for three shared stocks per each EEZ area. The resulting data indicates that on average 78% of catches took place within the Faroese EEZ for the whole period, although during 2011-2013, 93% of total catches on average has been caught within the same domestic EEZ. Since then, total catches coming from the Faroese EEZ have been gradually decreasing, coming down to 65% for 2020.

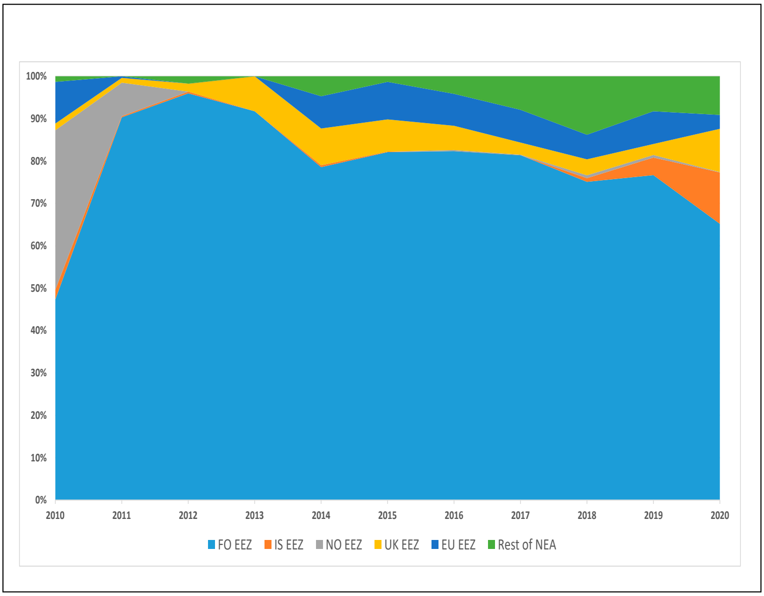


Figure 4.19. Pelagic values of landings (EUR million).
Source: Vørn

One of the reasons behind high catches coming from Faroese EEZ in 2013 can be found in the Faroe Islands refusal to continue with pre-existing catch-allocation agreement (five coastal parties agreement from 2007, EU, the Russian Federation, Norway, Iceland and the Faroe Islands) and where Faroese authorities decided to set their own catch limit of 105 thousand tonnes for NSSH-ASH (see ch 3)[30]. Consequently, such developments have created higher reliance on catches within the Faroese EEZ being 91% on the average for the 2013-2019, in comparison to 50% of catches being taken in Norwegian EEZ during 2010 and 2011 as shown in Figure 4.20. It is worth mentioning that during 2020, 53% or almost 60 thousand tonnes of the Faroese catches came from the Icelandic EEZ, and 43% from its own EEZ.

[30] The European Commission, "Commission implementing regulation (EU) No 793/2013", Official Journal of the European Union, 2013.

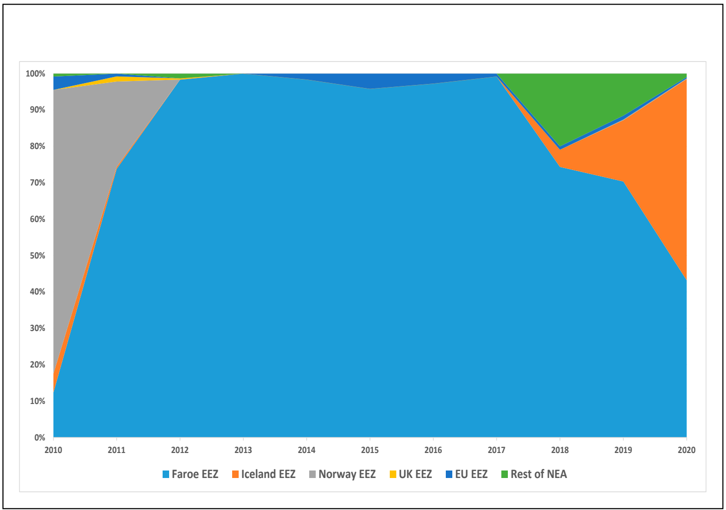


Figure 4.20. Norwegian spring spawning herring: Location of catches.
Source: Vørn

The above-mentioned dispute with regards to allocation of the NSSH-ASH catches as part of the TAC for such species, have induced the EU to prohibit imports of both herring and mackerel catches from the Faroe Islands. However, following dispute being brought to WTO by Denmark in respect of the Faroe Islands in 2013, three parties (Norway, EU, and the Faroe Islands) have been able to reach an agreement on mackerel in 2014[31], where 13% of TAC has been allocated to the Faroe Islands in comparison to 5,16% previously allocated share. Figure 4.21 above shows distributional consequences of disputed management arrangements where mackerel catches coming from the Faroese EEZ have gradually decreased from 100% peak level in 2013 to 51% in 2020. At the same time, it is important to note that 22% of average mackerel catches for the 2014-2020 came from the UK EEZ, especially noticeable high 48% share or 32 thousand tonnes for 2020.

[31] 2014 Mackerel Agreement expired end 2018 but have been extended to the end of 2020 in November 2018.

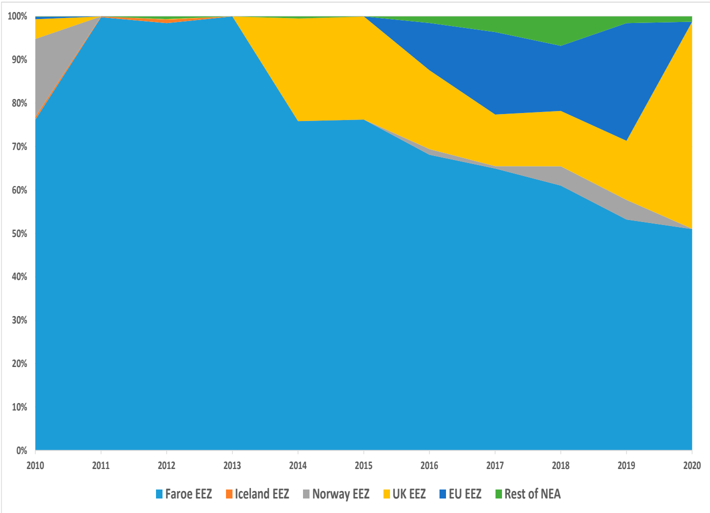


Figure 4.21. Mackerel: Location of catches.
Source: Vørn

Finally, and according to ICES WGWIDE report from 2020, there is a long-term management strategy agreement between EU, Norway, Iceland, and the Faroe Island for blue whiting, although the same report states that TACs were in line with ICES's scientific advice for 2010-2013, but unilateral quotas being 20%-50% above the scientific advice were implemented since 2014. On average, about 80% of the Faroese catch was taken within the Faroese EEZ, although 247 thousand tonnes were caught on average per year from 2014 onwards in comparison to 33 thousand tonnes per year prior to 2014 (Figure 4.22).

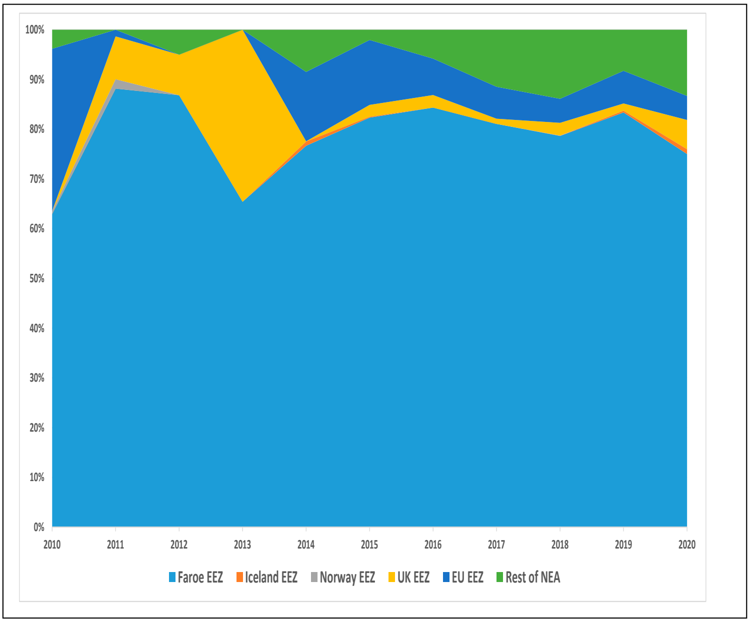


Figure 4.22. Blue whiting: Location of catches.
Source: Vørn

Processing

At present (2022), there are four processing plant on shore that can process pelagic catches both from Faroese as well as foreign vessels fishing in the North Atlantic. However, prior to 2009, there was no onshore processing of high-grade pelagic fish for human consumption in the Faroe Islands.

The oldest processing plant was established in 1965 and is specialised in producing salmon feed and fish-oil from predominately blue-whiting (low-food-value) processing on average 200-250 thousand tonnes of raw material per year, but some years was able to process up to 340 thousand tonnes. The other three, relatively newer (est. 2009-2014) processing plants possess a modern production facility with 500-1000 t/days freezing capacity that can produce range of products for human consumption, mainly from mackerel and herring (head-off and gutted whole frozen products and fillets).

Overall, the total cumulative revenue for all four processing plants is estimated to be EUR 3.1 billion, with EBITDA and pre-tax margins being 12% and 8% on average during 2010-2020. Additionally, our estimates for pelagic fleet point to pre-resource fee EBITDA margin to be between 35%-45%, while pre-tax & pre-resource fee profit margin is estimated to be around 25%-35%, or around EUR 0.10-0.15/kg.

Not surprisingly, and based on evidential facts, such healthy returns would attract both new investors (assuming relaxed barriers to entry) and the host government. Indeed, from 2015, the

Faroese government coalition introduced regulatory changes, including applying resource fees for mackerel, herring, and blue whiting in the calendar years 2017-2020, and so far, the Faroese Government has collected around EUR 182 million in such fees.

Economics

The Faroe Islands Statistical agency does not produce economic reports that can be included in this report, however, it has been possible to assemble data sets that enable identification of key economic numbers as it will be shown below. Since the focus is on the pelagic fisheries that rely on using pelagic trawlers or purse seiners, we excluded other fleet segments' (stern trawlers) from our economic analysis, a selection process which produced the criteria that will permit us to compare our findings across other countries in a meaningful way.

Table 4.21 below shows the main economic figures for the whole Faroese fleet that targeted three main pelagic species (mackerel, herring, and blue whiting) with pelagic trawl or purse seine. It was impossible to separate catches caught by few trawlers without RSW tanks who delivered their catches to the pelagic vessels at sea. Having that on mind, our data shows average annual catches to be around 33 thousand tonnes per vessel, the largest proportion belonging to blue whiting (65%), followed by herring and mackerel (17% and 15%), while there have been around 3% of capelin landings, but none in last two years on record.

The total pelagic fisheries fleet catches during 2015-2020 were 2,944 million tonnes with average annual harvest of 490 thousand tonnes p/a for the whole period, however, average annual harvest of 419 thousand tonnes p/a for 2015 & 2016 was well below average of 526 thousand tonnes p/a for 2017-2020. Consequently, total fleet's turnover was EUR 1.275,0 million for the whole period, although average sales of EUR 16,4 million p/a per vessel for 2015&2016 were around 20% higher in comparison to EUR 13.7 million p/a for 2017-2020, as number of vessels increased from 12 to 16. Similarly, average unit price for the whole period was EUR 0,45/kg, although the same average unit price was the highest at EUR 0,51/kg for 2016, and the lowest at EUR 0,37/kg during 2016.

Looking further at EBITDA, we notice relatively high average EBITDA at EUR 5,4 million p/a, or 33% operating margin during 2015/16 followed by considerable decline to EUR 3.2 million p/a (24%) for 2017-2020. Such substantial decrease in operative earnings per vessel can partly be explained by the Faroe Islands' parliament increase of fixed resource fee[32] charges for three main pelagic species under consideration, along already mentioned increased number of fishing vessels. Accordingly, Table 4.21 assesses the impact of such charges by stating two sets of calculations with regards to average operating costs that include and exclude the resource fees.

[32] Faroese Parliament regulations No 150 from Dec 2016, No 172 from Dec 2017 and No 171 from Dec 2019.

Table 4.21. Key economic for the Faroe Islands pelagic fleet (pelagic trawlers or purse seiners) – full sample.

	2015	2016	2017	2018	2019	2020
Turnover (EUR 1,000)	15.609	17.212	12.661	13.867	14.248	14.302
Total operating costs (EUR 1,000)	10.508	11.376	9.564	10.635	11.243	10.492
- Of which resource fee (EUR 1,000)	1.795	1.849	1.863	2.166	2.053	2.100
- Of which labour (EUR 1,000)	4.781	5.465	4.077	4.239	4.476	4.334
- Of which fuel (EUR 1,000)	1.649	1.390	1.585	2.220	2.250	1.726
EBITDA	5.101	5.836	3.097	3.232	3.005	3.810
Operating margin (%)	33	34	24	23	21	27
Days at sea	166	150	149	156	142	155
No of Vessels	12	12	16	16	16	16
Average harvest per vessel (tonne)	36.067	33.883	34.071	33.211	32.014	32.250
Of which mackerel, herring and blue whiting	33.645	33.166	33.159	32.413	32.014	32.250
Average Operating Costs RF incl. (EUR /tonne)	291	336	281	320	351	325
Average Operating Costs RF excl. (EUR /tonne)	242	281	226	255	287	260

Sources: Faroese Fisheries Directorate-Vørn, Teyggjan, Faroese Statistics, Companies Annual Accounts, Author's own calculations

In a like manner, and to reflect on existing real-world complexities while trying to analyze fishery related management issues, we decided to include key economic figures for the curtailed sample in Table 4.22 below, being restricted by empirical observation where 11 out of 16 fishing vessels landed 90% of total catches, which in process made 91% of total turnover. As a matter of fact, the average catches per vessel were on average 25% higher for the curtailed sample, and as a result average EBITDA was higher for 39% in relation to the full sample shown in Table 4.21 above. Corresponding operating margin was on average higher at EUR 1,5 million per vessel, although we can observe the steeper decline in operating margin expressed in % of turnover partly caused by increased resource fee payments levies based on fixed and predetermined Dkr/kg[33] for mackerel, herring, and blue whiting.

[33] Faroese Parliament regulations No 77 from May 2021 employs various threshold rates in order to express resource fee charges in % of landing price, to be implemented throughout 2022.

Table 4.22. Key economic for the Faroe Islands' pelagic fleet (pelagic trawlers & purse seiners) – curtailed sample.

	2015	2016	2017	2018	2019	2020
Turnover (EUR 1,000)	19.069	20.524	17.349	19.027	18.333	16.814
Total operating costs (EUR 1,000)	10.330	13.467	12.963	14.552	14.062	12.326
- Of which resource fee (EUR 1,000)	2.137	2.202	2.489	2.932	2.575	2.382
- Of which labour (EUR 1,000)	5.668	6.462	5.544	5.817	5.595	5.136
- Of which fuel (EUR 1,000)	1.621	1.646	2.149	3.038	2.814	2.028
EBITDA	8.739	7.058	4.386	4.475	4.271	4.488
Operating margin (%)	46	34	25	24	23	27
Days at sea	173	160	164	168	155	172
No of Vessels	9	10	11	11	11	11
Average harvest per vessel (tonne)	43.165	40.294	46.230	44.835	40.607	36.612
Of which mackerel, herring and blue whiting	40.266	39.442	44.992	43.759	40.607	36.612
Average Operating Costs RF incl. (EUR /tonne)	239	334	280	325	346	337
Average Operating Costs RF excl. (EUR /tonne)	190	280	227	259	283	272

Sources: Faroese Fisheries Directorate-Vørn, Teyggjan, Faroese Statistics, Companies Annual Accounts, Author's own calculations

At the end, it is worth mentioning that at present, the effects of reduced earnings at the firm level are not fully understood, where the Faroe Islands' government total takes from the pelagic fleet expressed as sum of corporation tax and resource fee payments for the period 2017-2020 was EUR 0.075/kg or 17.8% of revenue on average, in comparison to 2008-2016 where the very same take was EUR 0,018/kg or 3.8% of revenue. Bearing in mind that retained earnings are the cheapest source of internal financing, it remains to be seen if increased fiscal take will have any effect on fleet's ability to re-invest in new and technologically advanced fishing vessels.

4.6 COMPARATIVE COST OF PRODUCTION

In this chapter we have, among other things, looked at first-hand prices in relevant countries as well as cost of production for some vessel groups. We will take this further to consider competitiveness of different national fleets. For all countries we consider economic costs rather than accounting costs.

We have, as far as possible, used the same assumptions across countries and vessel groups. This includes:

1. The opportunity cost of capital is set at 6%.
2. Vessels are depreciated over 20 years.
3. Interest on vessel capital and depreciation is estimated according to the annuity principle.

Results are presented in Table 4.23. For each vessel group, we also give information about usage for human consumption and reduction into fishmeal and fish oil.

Table 4.23. Cost of production for selected vessel groups. 6% interest rate.

	Iceland	Norway[a)]	Norway[a)]	Denmark	Denmark	UK	Faroe Islands
Fleet group	**Trawler/ purse seiners[d)]**	**Purse seiners**	**Pelagic trawlers**	**Purse seiners**	**Pelagic trawlers**	**Pelagic fleet**	**Trawlers & purse seiners**
Annual harvest (t)	32,833[e)]	14,000	14,000	31,335	9,782	11,968	41,957
Usage of harvest[b)] (2019)	HC=39% Red=61%[e)]	HC = 56% Red = 44%	HC = 33% Red = 67%	HC = 68% Red =32%	HC =12% Red =88%	HC =94% Red =6%	HC =90% Red =10%
Annual operating costs ('000 EUR)	5,519	3,638	3,078	5,820	1,856	5,714	10,505[c)]
Annual depreciation and interest on vessel ('000 EUR)	3,052	3,254	2,403	3312	368	2944	3,511
Annual interest on license values ('000 EUR)	2,120	2,239	-	3827	243	1936	-
Unit operating costs EUR/tonne	**168**	**260**	**220**	**186**	**190**	**477**	**252**
Unit depreciation and interest cost on vessel EUR/tonne	93	232	172	106	38	246	84
Unit operating, depreciation and interest cost EUR/tonne	**261**	**492**	**392**	**291**	**227**	**723**	**336**
Unit interest cost on license values EUR/tonne	65	160	-	122	25	162	-
AC EUR/tonne	**326**	**652**	**-**	**414**	**252**	**885**	**-**

a) Based on Tables 4.11 and 4.12 above, exchange rate EUR 1 = NOK 10.72.
b) HC = human consumption; Red = reduction into fishmeal and oil. Measured in percentage of values.
c) Resource fee payments excluded.
d) The entire Icelandic pelagic fleet is combination trawler/purse/seiners.
e) Average for 2018-19; capelin included. A considerable part of this harvest is capelin**.** Without capelin the average catch is about 29,000 tonnes.
- = not available.

Harvest: UK and Denmark, average for 2018-19; the Faroe Islands: average for 2015-20; Norway: 2018 for purse seiners, 2017 for pelagic trawlers.

A number of variables must be considered when undertaking a comparison of cost of production. One is technology. Various fleets are included, from purse seiners to pelagic trawlers and vessels that combine purse seining and trawling. As shown above, this implies that investments in vessels vary. Moreover, technology also depends on the fisheries targets and will thus have an impact on both quantity harvested and unit cost of harvesting but also revenue.

Another important variable is usage, human consumption or for reduction purposes, although this to a degree is also linked to technology. There is wide variation in this regard, from the Faroese and UK fleets, harvesting almost exclusively for human consumption, to pelagic trawlers in Denmark, with almost 90% of catches for reduction. In general, cost of harvesting for human consumption will be higher than for reduction purposes, among other things, for quality considerations. In addition, boat loads may be lower.

Quota management will also be important. In the case of individual transferable quotas such as in Iceland and the Faroe Islands, vessels can optimise harvest. This is not true to the same extent in countries such as Norway and the UK where vessels have individual quotas which imply restrictions on quota sales. This will also have an impact on license values.

It may be most appropriate to compare average operating costs. Here the UK is a clear outlier with EUR 477/tonne, which is considerably higher than all other countries. This may be explained by lower capacity utilisation than for other fleets. When it comes to profitability, it also important to keep in mind that catches are primarily for human consumption with mackerel the most important species.

The lowest unit costs are obtained for the Icelandic fleet and Danish purse seiners, which by far have the highest average harvests of all fleets. Nevertheless, Danish pelagic trawlers, harvesting mainly for reduction, also have very low costs. The costs of Norwegian purse seiners and the Faroese fleet are very similar.

Capacity utilisation will also influence average cost. Although some information about this can be gleaned by comparisons between countries, to analyse this issue, it is necessary to have larger data sets, both cross section and time series, for the fleets involved. This is an interesting question for further research.

5. STRATEGIC CONSIDERATIONS

In the above, we have described the three large international pelagic fisheries in the in the Norwegian Sea as well as the fishing industries of the coastal states involved and reviewed the collective management of these fisheries. On the basis of this information, we will now consider some implications for future management.

5.1 GENERAL CONSIDERATIONS

It seems we may take it for granted that all the parties involved would like to maximise their perceived benefits from the Norwegian Sea pelagic complex. These perceived benefits appear to involve both large catch shares and large stocks that will permit sizable harvests on a sustainable basis. Thus, objectives seem to involve both maximum shares in the harvests and fish stock conservation.

In chapter 2, certain necessary conditions for a cooperative game were outlined. A cooperative game is one in which there is a degree of trust among the players. This implies that commitments of the players are binding and enforceable. Bjørndal and Munro (2021) outline necessary conditions that must be met for the solution to a cooperative game to be stable (see chapter 2).

The first condition is that the players be able to communicate with one another effectively. The second, referred to as" individual rationality", is that each player must always anticipate a payoff from the cooperative solution at least as great as what he anticipates to obtain under non-cooperation. Thirdly, the solution must be "collectively rational" in that there cannot exist an alternative solution, which would make one or more players better off, without harming the others, i.e., the solution must be Pareto optimal. Fourthly, the cooperative agreement must be resilient, in the sense that the first three conditions must hold at all times even in the face of unpredictable shocks, be they environmental, economic, or political such as Brexit. Obviously, the fourth condition is a very tall order. It may well be that it is so demanding that the set of globally stable agreements if not empty, is very small.

In order to enhance the likelihood that these conditions are met, it is important for the scope for bargaining to be as wide as possible. This brings up the issue of "side payments" and "side payment like arrangements" (Munro *et al.*, 2004). Bilateral agreements in the different fisheries (Tables 3.6-3.8) represent side payment like agreements. An example of such agreements is a coastal state allowing other countries to harvest their quota in her EEZ which may also serve to increase the overall returns from the fishery.

In a cooperative game, all parties cooperating is referred to as the Grand Coalition. There have been periods when some of the Norwegian sea pelagic fisheries have been managed by Grand

Coalitions (see Tables 3.2, 3.4 and 3.5). Now, however, they are now characterised by singletons (parties acting on their own) and sub-coalitions.

Most games are not simple “one shot” games. In particular, games are commonly played sequentially over time, i.e., they are dynamic. This is the current situation for mackerel, herring and blue whiting, where there are negotiations every year about the setting of TACs and quota sharing. It may be noted that if (cooperative) games are played sequentially over an extensive period of time, non-cooperation may evolve into cooperation. The period of non-cooperation may of course endanger the sustainability of the fish stocks which will affect the way the game is played including the likelihood of cooperation, for seriously declining stocks increase the relative benefits of cooperation.

In the pelagic fisheries games under consideration, although there are separate negotiations for all three fisheries, there are obviously also linkages between them. Thus, a combined analysis of all fisheries jointly may be called for. Moreover, one should bear in mind that the Norwegian Sea is home also to other fisheries, in particular pelagic redfish which is quite a valuable fishery (Bjørndal, 2009). Thus, there may be interactions between all these fisheries. However, considering fisheries beyond the three pelagic ones is beyond the scope of this report.

In chapter 4 we have primarily considered the coastal states. When it comes to DWFSs, Russia is by far the most significant player. Presumably Russia has the same objectives as the coastal states in terms of harvest shares and sustainability. Note that for individual nations, the distinction between being a coastal state rather than a DWFS may vary by fishery and over time. Thus, in the fishery for NSSH-ASH, Russia is a coastal state even if she harvests mainly in the Norwegian EEZ, while the EU which was a coastal state is now a DWFS.

As noted in chapter 3, it seems useful to distinguish between cooperation at the primary level, e.g. involving science, and cooperation at the secondary level, i.e., the management of the fishery. At the primarily level, there has been – and still is - a great deal of cooperation between the parties. This suggests that all the parties find it beneficial to cooperate at that level.

At the secondary level, by contrast, there is currently only weak cooperation in the sense that the parties agree on the overall TACs, while there is no agreement on quota sharing or even the principles for quota sharing. This is true for all three fisheries. For mackerel, the grand coalition broke down in 2008 (Table 3.2). This was followed by a sub-coalition and singletons. From 2021, there have been singletons only. The story is similar for herring, where there was full cooperation up to 2012 except for the period 2003-6 (Table 3.4). This was followed by a period with a sub-coalition combined with singletons. From 2017 all parties in the NSSH-ASH fishery have operated as singletons with the exception of cooperation between Norway and Russia pertaining to juvenile herring in the Barents Sea. For blue whiting, the grand coalition broke down in 2015. Ever since there has been unilateral quota setting by singletons (Table 3.5).

This suggests that for all three fisheries, the individual rationality constraint for the grand coalition (at least) is not met. It seems that the parties feel they will be better off not joining the grand coalition. Although the sum of harvests exceeds the TACs as suggested by ICES, the stocks are still sustainably harvested. As a consequence, there may be little incentive to cooperate. Importantly this may change if the stocks become overexploited, threatening their future yield. Indeed, the fisheries moratorium in the NSSH-ASH fishery and the subsequent grand coalition were formed following a severe collapse in this fishery.

The breakdown of grand coalitions is also an indication that the fourth condition for cooperation, namely that the agreement must be resilient at all times even in the face of unpredictable shocks, has not been met. This is certainly the case for both mackerel and herring, where shocks in the sense of major changes in the spatial distribution of the stocks seem to have factor in the collapse of the previous grand coalitions.

Despite harvesting considerably more than the TACs recommended by ICES in some years, all three pelagic stocks are nevertheless considered to be harvested sustainably (chapter 3). A consequence of this may be that fishers, their organisations and the national authorities have less faith in ICES advice.

5.2 CONSEQUENCES OF BREXIT

Next, let us consider some of the consequences of Brexit. As part of the EU-UK Trade and Cooperation Agreement (UK and EU, 2020), the two parties agreed on quota shares for 2021-26 for the different stocks. These quota shares will be adjusted over the 2021-26 period. Adjustments vary from stock to stock but overall the UK quota shares increase somewhat.

The period from 1st January, 2021 until 30th June, 2026 is considered the *adjustment period*. During this period, a party can notify the other party of changes in access to its waters. In this event, the other party may respond with a reciprocal change in access rights and suspend the free trade in fishery products (Bjørndal & Munro, 2021).

In case of serious breaches relating to the UK-EU Trade and Cooperation Agreement (TCA), the other party may take measures that suspend not only access and free trade in fish products, but also other aspects of the Agreement including free trade in other goods, aviation and road haulage. This clearly illustrates the strong linkage between fisheries management and trade made by the UK and the EU.

Each party has the right to terminate the fisheries part of the agreement. However, in that event, agreements as to trade, aviation, and road transportation will cease to be in force on the first day of the ninth month following the date of notification.

In sum, the UK cannot unilaterally change the fisheries agreement without potentially incurring severe retaliation in other areas from the EU. Therefore, it may be postulated that there will only be changes if both parties agree (Bjørndal & Munro, 2021). Nevertheless, there is concern in some EU countries as to whether reduction fishing can continue in the British EEZ, whether bottom trawling can continue on the Dogger Bank and about the stability and timeliness of EU quotas in the Norwegian zone.

5.3 STRATEGIC IMPLICATIONS FOR INDIVIDUAL COUNTRIES

We will now consider some strategic implications for individual countries, as these may vary.

Iceland

For the Icelandic fishing industry, the most valuable fisheries are the demersal ones including cod. While these stocks mostly spawn and reside within the Icelandic EEZ, certain stock segment are periodically found outside the EEZ. Thus, they are shared stocks and harvested by other European nations including Greenland, the Faroe Islands, EU nations and Russia. The pelagic fisheries for shared North-East Atlantic stocks; mackerel, NSSH-ASH and blue whiting account, for only 12-14% of the total landed value of the Icelandic fisheries. For these reasons, from the Icelandic perspective, the North Atlantic pelagic fishery game is but a part of the overall fishery game including a range of other species.

Occasional large-scale migrations of pelagic stocks into the Icelandic EEZ for feeding purposes such as that of mackerel that has occurred since 2008 destabilise the Icelandic marine ecosystem, reduce the stocks of many commercial species thus, mostly, negatively affecting other Icelandic fishing opportunities. For that reason, the benefits to Iceland of mackerel fishing in her own waters are substantially greater than just the added income to the mackerel fishery. Much the same applies to large-scale migrations of NSSH-ASH into the Icelandic EEZ. These facts show that arguments in terms of temporal zonal attachment of the stocks, that have been put forward by some and other North-East Atlantic nations, have little meaning to Iceland and perhaps also Greenland and the Faroe Islands.

To the extent that Iceland, Greenland and the Faroe Islands are in a similar position regarding migrations of North Atlantic pelagic stocks into their waters, they may find it beneficial to form a coalition in the pelagic game. This option may be strengthened by the fact that all three nations already cooperate in certain fisheries and have shared fishing agreements.

The Icelandic pelagic fishing industry is highly profitable and increasingly technically advanced. This sector is also very flexible and has streamlined its operations to the available harvesting opportunities. Thus, there is not much overcapacity in the fishing fleet and processing sector. Moreover, in addition to the shared North Atlantic pelagic fisheries, Iceland has significant pelagic fisheries within her own EEZ for Icelandic herring and capelin, as illustrated in ch. 4. These facts somewhat reduce the reliance of the pelagic sector on the shared North Atlantic pelagic fisheries and influences the way Iceland plays this fisheries game.

Iceland exports most of its fish products and much of its value-added from the fishing industry comes from the international marketing arm. As a result, Iceland is highly concerned about its international reputation as a responsible fish harvester. This imposes certain constraints on how Iceland chooses to play the North Atlantic fishery game including the pelagic one.

There is no doubt that Iceland would like to have as large harvests from the shared North Atlantic Sea stocks as possible. Iceland seems to have the efficiency and capacity to substantially increase her share in the total catch. Why Iceland has nevertheless decided to show restraint and largely refrained from taking proactive steps in the game, like some other countries have done, is not clear.

Norway

For Norway, it is important to point out the country's "control" of the NSSH-ASH stock, in the sense that it spawns in Norwegian waters. As juveniles grow up in the Russian EEZ, this has given rise to the bilateral agreement between Norway and Russia which has been in effect for a long period of time.

While Norwegian fishermen harvest herring in the Norwegian EEZ and international waters, there is dependence on the UK zone, in particular for mackerel, and the EU zone for blue whiting. This suggests Norway is dependent on access agreements. For mackerel this dependence has varied over time, as a consequence of variations in the migratory pattern of the stock. Post-Brexit Norway has not had access to harvesting mackerel in the UK zone while access to the EU zone for blue whiting has been maintained.

Fish processing is also an important sector in the Norwegian economy. For this industry, supplies of mackerel by foreign fishermen, in particular British, are important.

Denmark

EU fishers harvest mackerel in the British EEZ, NSSH-ASH mainly in the Norwegian EEZ and blue whiting mainly in the EU EEZ. It is important for EU fishermen that the TCA settled the quota shares for UK and EU fishers. Hence, uncertainty on quota allocations between British and EU fishermen is substantially reduced and essentially removed, since the UK cannot unilaterally change the fisheries agreement without retaliation. However, some fear remains on exclusion from the Norwegian EEZ, as the EU before Brexit exchanged quotas for Norwegian vessels in the British zone with quotas for EU vessels in the Norwegian zone. The access of EU fishers to the Norwegian EEZ is regulated by the EU-Norway agreement, specifying the mutual fishing rights in each other's zone. Although this has been agreed upon for 2021-2022, uncertainty for the future remains, as agreements are for only one year at the time.

Some speculate that there may be a ban on reduction fishing in the British zone and that a more stringent environmental British policy may close the Dogger Bank from bottom trawling and fishing for reduction. Both would have severe consequences for EU fishers. However, according to the TCA, this can only happen in case of agreement between the UK and the EU.

The United Kingdom

British fishermen have achieved increased quota shares and tariff free export to the EU from the TCA. Mackerel is by far the most important commercial species for the UK, more so than for other countries. NSSH-ASH and blue whiting, on the other hand, are of limited value. North Sea herring is important for the British pelagic fleet, but management of this fishery is covered by an EU-UK-Norway agreement (Bjorndal & Munro, 2021). British fishers fish the majority of their blue whiting catches in EU zone, mainly in Irish waters and have an interest in continuing to do so. Moreover, the majority of the mackerel catches of British vessels are landed in Norway, which the fishermen have an interest in continuing with.

The Faroe Islands

According to official records, around 36% of the Faroese NSSH-ASH and 24% of mackerel and blue whiting catches are harvested outside of the Faroese EEZ. In particular, up to 15% of mackerel catches came from UK EEZ. Bearing in mind the importance of such external catches for both the Faroese fishers and the overall Faroese economy, the Faroese Pelagic Industry that has been part of the negotiation team for many years. Historically, due to the Common Fisheries Policy (CFP), the UK does not have a history of making fishery agreements on their own. Post-Brexit, the Faroese pelagic industry would like to negotiate long-term quota allocations that would also include option for the industry to choose where and when to fish allocated quotas so as to maximise the efficiency of the fleet. The industry view is based on a perception of economic attractiveness to execute the mackerel fishery in UK waters (lower costs/higher quality fish, higher prices in Japanese markets), although there is awareness that such agreement would require reciprocity.

The next major issue concerns long-term stock considerations. There are concerns about pelagic processing industry plants (human consumption) as well as availability of certified fishmeal for the Faroese salmon industry. The MSC suspension of certification of the herring and blue whiting fisheries is mentioned as an issue for the salmon industry that wants to ensure continued certification by the Aquaculture Stewardship Council (ASC)[34]. Therefore, there is a negative spillover effect which might have economic consequences not only for the pelagic industry but also the salmon aquaculture industry on the Faroe Islands.

5.4 FUTURE COOPERATION?

The analysis of the three pelagic fisheries clearly indicates the challenges of arriving at cooperative agreements. We will now consider some future scenarios. First, we can identify what might be considered two polar opposites. Actual game paths over time are likely to stay within these extremes.

I. The "Swiss Corporation": Maximising total benefits from the fisheries

The term "Swiss Corporation" (SC) was coined by Anthony Scott (2008) for a situation where all parties involved agree to cooperate in a way that will maximise total benefits, in this case from the three fisheries in question. In a way, the participating countries become "shareholders" of the Corporation and will share the benefits generated.

The SC outcome is identical to that of the "sole owner" of the fishery who will also maximise the net returns over time (Bjørndal & Munro, 2012). This maximising path involves determining harvest paths for the three species and the associated fishing effort over time. In this scenario, only the most efficient fishing vessels for each fishery would be deployed.[35] Interestingly, this is also the outcome one is likely to see in case of an international ITQ system, where the efficient vessels would buy out the less efficient ones, regardless of country of origin[36]. To be agreeable to all parties, this SC or sole owner arrangement would need to be combined with an acceptable allocation of the economic surplus to the countries that would not obtain benefits from actually fishing.

[34] See www.asc-aqua.org.
[35] Ch 4 contains a cost analysis. Although it is rather rudimentary and incomplete (Table 4.23), due to the kind of data that are available, it does indicate differences in efficiency across national fleets and fleet segments. This is an area for further research.
[36] Efficiency in fish processing would also need to be taken into consideration in this regard.

Although this system has many desirable features, as well as many unknowns. it is not likely to gain political acceptance in a game situation where even an agreement on quota allocations has proven difficult to achieve and relative stability, the core principle of the Common Fisheries Policy, might be compromised.[37] For this reason, we will not consider it any further.

II. A competitive fishery without any cooperation whatsoever

The polar opposite of the Swiss Corporation is unconstrained competition between all the nations. This would involve each nation harvesting to the point where its net marginal benefits from fishing equals zero. At recent stock sizes, this would mean harvesting at full capacity. In any case, as we are dealing with pelagic stocks, this scenario would lead to serious overexploitation, possibly driving one or more stocks to commercial extinction as happened to the herring fishery in the late 1960s. As all nations involved are responsible fishing nations, committed to the sustainable exploitation of resources, we also consider this scenario unlikely.

III. Other possible outcomes

While scenario I seems not socio-politically feasible at the current time, scenario II is also highly unlikely because it would harm all players. Thus, it is most likely that the actual game outcome will be found between these two polar cases. However, within these bounds, there is a very large number of possibilities. Without further in-depth research we are not in a position to predict the most likely game outcome and, since there is no particular reason to expect it to have a stable equilibrium, its possible evolution over time. Therefore, at this stage, the best we can do is to outline scenarios and discuss possibilities. However, we will first look at the issue of stock size and how this may impact on cooperation.

The impact of stock size on cooperation

The historical development of cooperative solutions to the Norwegian Sea pelagic fishery game suggests that the likelihood of cooperation depends on the size of the fish stocks in question. More to the point, it seems that cooperation is easier to achieve when the stocks are small rather than large. This impact of stock size on the likelihood of cooperation may be formalised in a simple manner. Let the perceived benefits of cooperation to player i be expressed by the function $B(x,i)$, where x is stock size. Let us crucially assume that this function is declining in x for all i. The justification of this

[37] A second-best solution may be to agree on quota allocations between countries which can be combined with current national ITQ or ITQ-like management systems.

assumption is that a stock collapse will be extremely harmful to all players and when that outcome threatens, the only way to avoid it is cooperation.

Additionally, let there be a cost to all the nations of entering an agreement. This cost may for instance be the socio-political cost of having to deal with domestic criticisms any such agreement is likely to receive. Let this cost be represented by the function $C(x,i)$ for all i which, it seems reasonable to assume. is non-decreasing in x.

Now, an obvious necessary condition for the grand coalition (see the beginning of this section) is that

$$A(x,i) = B(x;i) - C(x;i) > 0, \text{ all } i.$$

Similarly, the necessary condition for any coalition would be

$$A(x,i) = B(x;i) - C(x;i) > 0, \text{ all } i \text{ in the coalition.}$$

Thus, according to the above, the likelihood of a coalition increases with the function $A(.)$. This function, however, is decreasing in biomass. Therefore, the likelihood of a coalition increases with falling biomass.

III.1 Continuation of present policies

One scenario is that the game will continue to be played in the way it has been over the past few years. There will not be long-lasting agreements, but all major players will show restraint so that the stocks will remain in a "reasonable" condition. There may be occasional probing by one or more players and, if unsuccessful, there will be withdrawal to the previous "arrangement".

In the short run, continuation of present policies looks likely. This involves cooperation about science, information sharing and more, but unilateral quota setting by the different nations where the sum of quotas exceeds the TAC recommended by ICES[38]. The consequences for the sustainability of the stock depend on a number of variables. First, the productivity of the stocks, in particular when it comes to recruitment. Second, the TACs set by ICES, taking into consideration stock size and productivity. Third, the degree to which the sum of unilateral quotas exceeds the TACs, or perhaps rather stock productivity. Various scenarios can be envisaged if the sustainability of the stocks under this arrangement becomes an issue. Another issue is how stable this situation is.

[38] At times concerns have been expressed about the quality of advice from ICES, see e.g. https://www.insider.co.uk/news/scottish-fishermen-launch-survey-north-26178753 relating to the North Sea. This is an important issue, but we will not pursue it any further.

III.2 Renewed Grand Coalitions

All three stocks have in the past at times been managed by Grand Coalitions, and since they are necessary to maximise overall benefits (along the lines of the Swiss Corporation), attempt are being made to restore full cooperation.

It is not unlikely that Grand Coalitions will emerge in one or more of these fisheries in the medium-term future. However, both theory and experience show that they are unlikely to be stable. It should also be kept in mind that Grand Coalitions do not imply full efficiency (as in the Swiss Corporation) while the reverse holds (full efficiency implies a Grand Coalition)[39]. One reason why previous Grand Coalitions have proven unstable may be that they have not been efficient (i.e., maximised total net benefits).

Scaling back "overharvesting"

As shown in chapter 3, there is currently "overharvesting" in all three fisheries in the sense that the sum of unilateral quotas exceeds the TAC as recommended by ICES. One option for a Grand Coalition might be to eliminate this "overharvesting" by agreeing to "scale back" harvesting in a way that the sum of national quotas is equal to the TAC advice, but with relative quotas unchanged. It is important to note that if sticking to the ICES recommendations means that the stocks will get larger, future TACs and, therefore, absolute national quota shares will be higher in the future.

An example for mackerel is given in Table 5.1 where we compare the situation in 2021 (Table 3.3) with a case where all quota shares are reduced proportionally but so that the sum of quotas equals 100% of ICES catch advice[40]. For NSSH-ASH we will consider actual catch shares relative to ICES advice (Table 5.3)[41] as we do blue whiting (Table 5.4), in both cases for 2020.

These ways of scaling back can be based on either announced quotas or actual harvests[42] which typically are different. The method chosen will have an impact on national quota shares and thus influence incentives as to which approach to choose. Furthermore, the time period selected in Tables 5.1-5.3 is somewhat arbitrary. An alternative is to base the quota shares on a longer time period, say five or 10 years, rather than a single year. This allows for changes in zonal attachment, for example due to environmental variability, which in a sense will be averaged out. It must, however, also be noted that the choice of period will affect national quota shares and thus their incentives.

[39] In other words, Grand Coalitions may not necessarily lead to first best outcomes, i.e., they may lead to second best outcomes.
[40] Note that the TAC is often higher than the ICES advice.
[41] This is defined as actual catch for the year relative to ICES advice. When it comes to national TAC for a year, it is important to bear in mind the countries have an opportunity to transfer quotas from one year to the next, i.e., "lending and borrowing" of own quota, within specified limits.
[42] Actual harvest for a country in a given year may differ from its TAC not only because of fishing opportunities, but also because of quota transfers between years, as discussed earlier.

Table 5.1. Mackerel quotas and catches relative to ICES advice. Percent.

Scenario	ICES advice	Total quota	EU	UK	Norway	Russia	Iceland	Faroe Islands	Greenland	Total
2021 actual situation quotas	852,284	1,206,748	23.2	26.1	35.0	14.1	16.5	19.6	7.0	131.5
2021: Scaled back relative shares of the unilateral quotas	-	-	16.4	18.4	24.7	10.0	11.7	13.8	5.0	100.0

Table 5.2. NSSH-ASH quotas (percentages) relative to ICES advice (tonnes) for herring 2020.

Year	ICES Advice	Total quota	EU	Norway	Russia	Iceland	Faroe Islands	Greenland	Sum
2020 actual situation	525,594	740,781	7.1	75.1	14.4	17.6	21.3	5.4	140.9
2020: relative shares of the unilateral quotas	-	-	5.0	53.3	10.3	12.5	15.1	3.8	100.0

Based on ICES Advice on fishing opportunities, catch and effort. Herring. Her.27.1.-24a514a. Published 30th September, 2021.

Table 5.3. Catch shares (percentages) relative to ICES advice (tonnes) for blue whiting 2020.

Year	ICES advice	Total quota	EU	Norway	Russia	Iceland	Faroe Islands	Greenland	Sum
2020 actual situation	1,161,615	1,558,949	36.3	27.7	16.8	20.9	30.9	1.7	134.2
2020: relative shares of the unilateral quotas	-	-	27.0	20.6	12.5	15.54	23.0	1.3	100.0

Based on ICES Advice on fishing opportunities, catch and effort. Blue whiting. whb.27.1.-91214. Published 30th September, 2021.

Although this solution might seem appealing, we have pointed out challenges when it comes to how the quota shares should be determined. Moreover, there is no certainly this solution would be stable. Consider the individual rationality constraint. If scaling back is implemented on the basis of one year, say 2021, all countries would be worse off, and the individual rationality constraint would not be met. However, compliance with TACs may lead to a more sustainable fishery over time so that it might be likely that the individual rationality constraint is met in a dynamic context. When it comes to the collective rationality constraint, there is again no assurance this is met. It is also uncertain whether the solution would stand up to environmental shocks. Thus, overall the solution is likely to be stable only under a very special set of circumstances.

III.3 Cyclical cooperation

The history of the Norwegian Sea pelagic fisheries described in previous chapters exhibits periods of high degrees of cooperation followed by break-downs and periods with relatively little cooperation. Moreover, as discussed above, there are indications that cooperation is more likely to occur when the stocks are depressed. These observations, limited as they are, suggest that the Norwegian Sea pelagic fisheries game may be characterised by cyclical cooperation. In this section we attempt to develop a simple model that is capable of generating cycles of relative cooperation and non-cooperation.

Consider the standard simple fisheries dynamics:

(1) $\dot{x} = G(x) - y$,

where x denotes biomass and y harvest and the function $G(x)$ is the usual biomass growth function (Clark 1976).

Under competitive fishing, y depends only on x (as well as price and production functions which are exogenous in this analysis). Cooperation tempers harvests so we may write a harvest function under cooperation as:

(2) $Y(x,c)$,

where c denotes the degree of cooperation. Obviously, the derivatives are $Y_x>0$ and $Y_c<0$.

Cooperation is, in general, a multidimensional and possibly complicated phenomenon. To make headway in the modelling we represent it here by the one-dimensional, nonnegative real variable c. For further convenience we normalise c as follows:[43]

$c \in [0,1]$,

where c=0 denotes no cooperation, with c=1 denoting full cooperation.

By the definition of fishery cooperation, $Y(x,0) = y^{\circ}(x)$ is the harvest under non-cooperation (competitive fishing) and $Y(x,1) = y^{*}(x)$, where $y^*(x)$ is the optimal harvest feedback path (Arnason et al., 2004), i.e., the harvest under full cooperation.

The above is either standard fishery economics or, as regards cooperation, essentially definitions. For our cyclical cooperation model, the following fundamental assumption about fisheries cooperation is adopted:

Equilibrium cooperation, i.e., cooperative game solution, is the function:

[43] All finite real numbers can be mapped into the interval [0,1].

(3) $c = F(x)$, $F_x \leq 0$.

This assumption is crucial for the cooperative game dynamics to be described below. It can be justified by simple behavioural arguments (as we have done above) and it seems to fit the known facts about the fisheries under consideration.

Regarding further specifications of the function $F(.)$, it appears we may assume that $F(\infty)=0$ and $F(0)=1$. Why cooperate in the use of an infinite resource? Why not cooperate fully in the use of nonexistent resource?

Since $c = F(x)$ is supposed to be equilibrium cooperation, it seems reasonable to assume that cooperation is always moving toward this equilibrium for any level of biomass. This assumption defines the dynamics:

(4) $\dot{c} = F(x) - c$.

So, whenever cooperation is less than the equilibrium one, it is increasing and vice versa.

Now, expressions (1), (2) and (4) define the complete dynamic system:

(5) $\dot{x} = G(x) - Y(x,c)$,

$\dot{c} = F(x) - c$.

Equilibrium of this system is defined by:

(6) $G(x^e) - Y(x^e, c^e) = 0$,

$F(x^e) - c^e = 0$.

Note that (6) may define more than one equilibrium.

An interesting implication of (6) is that equilibrium biomass, x^e, can only equal the optimal equilibrium biomass, $x^{e}*$, say if full cooperation prevails, i.e., $c^e=1$**!** Note that $c^e=1$ is necessary for optimality but not sufficient.

Now, it is straight forward to show that:

1. One or more equilibria defined by (6) may exist.
2. These equilibria may or may not be locally stable.
3. Dynamic paths outside of equilibria may be cyclical.

These three results are reasonably intuitive. To prove them rigorously, however, is somewhat tedious. Therefore, instead of doing so, we illustrate them with the help of a standard phase diagram analysis (see e.g. Seierstad and Sydsæter, 1987).

In Figure 5.1, the curves labelled $\dot{x} = 0$ and $\dot{c} = 0$ represent the biomass equilibrium and cooperation equilibrium, respectively. The shape and location of these curves may be inferred from system (5) and the specification of the functions $G(x)$, $Y(x,c)$ and $F(x)$ above. Where these equilibrium curves intersect, equilibria occur. As illustrated in Figure 5.1, in this particular case, two equilibria exist.[44]

The movement of biomass (horizontal direction) and cooperation (vertical direction) outside these curves are indicated by the direction arrows in the diagram. The combined movement of biomass and cooperation at all points in the (x,c)-space must fall between these arrows.

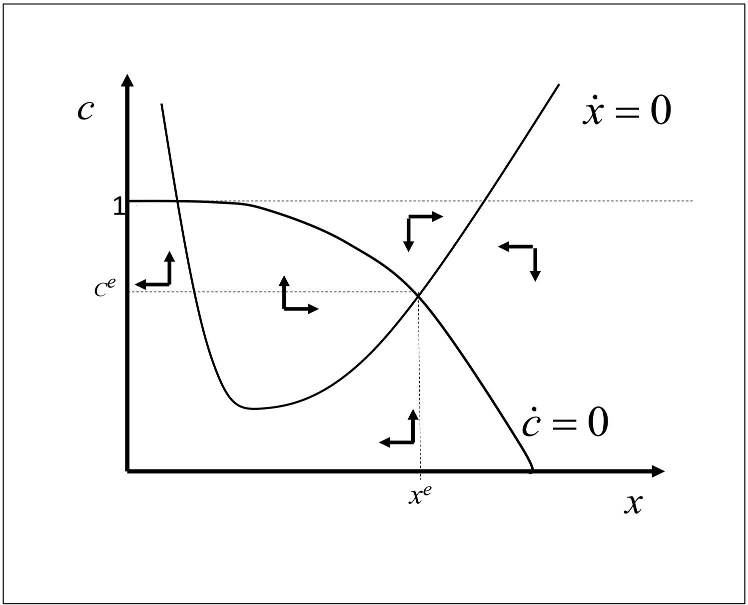


Figure 5.1. Biomass-cooperation dynamics.

The direction arrows in Figure 5.1 clearly show that of the two equilibria, the one at the lower biomass is clearly unstable and the other one, labelled (x^e,c^e), may be locally stable.

The important thing from the perspective of cooperation cycles is that irrespective of the local stability of (x^e,c^e) the dynamic paths around this equilibrium will be cyclical. Moreover, if this equilibrium is not locally stable, a limit cycle (endless biomass-cooperative cycles) may exist.

Starting with an unexploited fishery and therefore no cooperation, Figure 5.1 suggests that biomass will decline followed by emerging cooperation at some point of lower biomass followed by possibly cyclical evolution of biomass and cooperation that will converge to (x^e,c^e) if it is stable or not if (x^e,c^e) is unstable.

[44] Only one or even none may exist if the minimum of the biomass equilibrium curve occurs a relatively high biomass and cooperation level which could be the case for a biologically unproductive but economically valuable resource.

This analysis has demonstrated a potentially useful theorem of international fisheries games: Fisheries cooperative games may evolve cyclically (in the above sense) over time.

5.5 CONCLUSIONS

Based on this analysis, it appears reasonable to expect that the current conditions will continue in the foreseeable future for all three fisheries under consideration. In the final chapter, we will briefly discuss how the game can be changed so as to increase the likelihood of a cooperative solution.

6. SUMMARY

In this report, we have examined the multi-nation management of the three major pelagic fisheries in the Norwegian Sea: mackerel, NSSH-ASH and blue whiting. At the beginning of this century, all the harvesting nations cooperated, in other words, the fisheries were managed by Grand Coalitions. Since then, the Grand Coalitions have broken down. In chapter 2, we outlined necessary conditions for cooperative management. The collapse of the Grand Coalitions can be explained by one or more these conditions for cooperation no longer being satisfied. Currently, all countries set unilateral quotas in all three fisheries with the consequence that the sum of national quotas exceeds the TACs recommended by ICES. This may threaten the long-term sustainability of the stocks.

As noted in the report, when it comes to the management of international fishery resources there are two levels of cooperation, primary and secondary (Gulland, 1980). The primary level involves cooperation in scientific research while the second involves cooperation in management. For all three fisheries under investigation, there is cooperation at the primary level pertaining to issues such as stock assessment, technical regulations and information exchange. At the secondary level, there is at best only weak, tacit cooperation. Thus, while the parties agree on overall TACs there is no agreement on the sharing of this TAC with the consequence that each nation sets its own harvesting quota unilaterally with the total exceeding the ICES advice. Nevertheless, in setting these unilateral quotas, the nations have, for the most parts, showed remarkable restraint, which may be indicative of tacit cooperation. The restraint may at least partly be due to concerns by fisheries and environmental organisations about the situation in these fisheries.

As a consequence of Brexit, there is now an additional player in the Norwegian Sea. In general, it is more difficult to achieve cooperation when more players are involved. The UK is now a coastal state in all three fisheries. The EU is a coastal state for mackerel and blue whiting, and a DWFS for NSSH-ASH. Mackerel is the most important fishery for the UK, while blue whiting and NSSH-ASH are of limited importance. Traditionally, the UK EEZ has been very important for mackerel fishing for the EU, Norway and the Faroe Islands. While the UK and EU have joint access to each other's zone, post-Brexit Norwegian and Faroese fishermen have not had access to mackerel in British waters. Presumably this is because Norway and the Faroe Islands have not been able to come up with fishing rights or other exchanges that are acceptable to the UK.

Our analyses suggest the hypothesis that Grand Coalitions are more likely to form during periods of overharvesting. In a situation with overharvesting, it will be in the interest of all parties to allow the stock to recover. This might give rise to cooperation and the formation of a Grand Coalition. However, after recovery of the stock, the incentives for remaining in the Grand Coalition are reduced. Thus, some countries may choose to leave the Grand Coalition resulting in its collapse. Then we are back in a state of non-cooperation or, at best, partial cooperation. If this leads to a significant stock decline, conditions for a reformation of a grand coalition may be created. In this way, cycles of more and less cooperation may appear. Up to now, a stable cooperation has not manifested itself and according to our analysis it may not appear likely.

The question then arises as to what can be done to increase the likelihood of reaching a Grand Coalition that lasts over time. As stated in chapter 2, game theory suggests that in order to enhance the likelihood for a cooperative agreement, it is important that the scope for bargaining is as wide as possible. This, in effect, is equivalent to increasing the size of the game.

In the pelagic fisheries game under consideration, although there are separate negotiations for all three fisheries, there are obviously also linkages between them. Thus, including all three fisheries in the negotiations at the same time will increase the scope for bargaining and, consequently the likelihood of reaching an agreement. A more radical way to increase the size of the game would be to include other fisheries in the Norwegian Sea and possibly elsewhere. A pertinent example is provided by the 2022 UK-Norway fisheries agreement whereby UK can harvest up to 17,000 tonnes NSSH-ASH in the Norwegian EEZ, while Norway can harvest up to 17,000 tonnes NSH in the UK EEZ.

The size of the games can also be increased by including other fields of economic activity such as trade. By enlarging the game, the probability of reaching an agreement may increase, as the scope for political tradeoffs expands. It may possibly also lead to increased stability of the agreements reached. In this respect, it is relevant that fisheries agreements including access rights and quota exchanges are normally the responsibility of fisheries ministries, while trade is usually the responsibility of a different ministry. As a result, international agreements tend to be made in a compartmentalised manner. One option that may increase the probability of reaching a Grand Coalition would be to adopt a more holistic approach. In a sense, it is a matter of at what level the agreements are negotiated and what is included. In many ways, the 2021 Trade and Cooperation Agreement between the UK and the EU is a relevant example as it included different areas such as fisheries, trade, transportation, aviation and more.

As pointed out in chapter 2, most real life games, be they non-cooperative or cooperative, are not simple “one shot”, static games. First, players usually play sequentially, giving rise to multi-stage games. The sequencing of negotiations may be important and have an impact on the final outcome. In the Norwegian Sea case, it makes sense to start with issues that are not very controversial and where agreements can be reached with relative ease. Thus, assuming holistic negotiations are infeasible, for the three fisheries under consideration, it would make sense not to start with mackerel which appears to be the most challenging of the three.

Zonal attachment is often suggested as the principle for quota sharing (chapter 2). Working groups have been established for all three stocks to study their geographical distribution before the negotiations about quota sharing in 2022. This indicates that the zonal attachment principle may be seen as a basis for such discussions. Based on history, it is not likely that this principle, by itself, will make agreements possible. One condition for cooperation is that the cooperative agreement must be resilient, even in the face of unpredictable shocks, be they environmental, economic, or political. There is every reason to expect further environmental changes in the future (Barange *et al.,* 2018), in the Norwegian Sea as elsewhere. This suggests zonal attachment may be quite a volatile basis for an agreement. A lasting agreement has to provide both stability and a responsive management. The question is how this can be achieved based on historical and current conditions and what kind of flexibility there should be when it comes to adjustments of national quota shares.

The Norwegian Sea pelagic games are repeated every year, i.e., they are dynamic. As pointed out in chapter 2, if games are repeated over an extensive period of time, non-cooperation may evolve into cooperation. The period of non-cooperation may of course endanger the sustainability of the fish stocks, which will, in turn, affect the way the game is played and the likelihood of cooperation.

References

Agreed Record (2021a). Agreed record on conclusions of fisheries consultations between the Faroe Islands, the European Union, Greenland, Iceland, Norway and the United Kingdom on the management of mackerel in the North-East Atlantic in 2022. London, 26th October, 2021.

Agreed Record (2021b). Agreed record on conclusions of fisheries consultations between the Russian Federation, the Faroe Islands, Iceland, Norway and the United Kingdom on the management of the Norwegian spring-spawning (Atlanto Scandian) herring in the North-East Atlantic in 2022. London, 26th October, 2021.

Agreed Record (2021c). Agreed record on conclusions of fisheries consultations between Norway, the European Union, the Faroe Islands, Iceland and the United Kingdom on the management of the Norwegian spring-spawning (Atlanto Scandian) blue whiting in the North-East Atlantic in 2022. London, 25th-26th October, 2021.

Agnarsson, S. & Arnason, R. (2007). The Role of the Fishing Industry in the Icelandic Economy. In T. Bjorndal, D. V. Gordon, R. Arnason & U. R. Sumaila (Eds.): *Advances in Fisheries Economics*. Blackwell, Oxford.

Arnason, R., Sandal, L. K., Steinshamn, S. I. & Vestergaard, N. (2004). Optimal feedback controls: comparative evaluation of the cod fisheries in Denmark, Iceland, and Norway. *American Journal of Agricultural Economics*, *86*(2), 531-542.

Bjørndal, T., Gordon, D. V., Kaitala, V. & Lindroos, M. (2004). International management strategies for a straddling fish stock: a bio-economic simulation model of the Norwegian spring-spawning herring fishery. *Environ Resource Econ*, 29: 435-457.

Bjørndal, T. & Munro, G. R. (2012). *The Economics and Management of World Fisheries*. Oxford University Press.

Bromley, D. W. & Ellefsen, H. (2021). The quest for fisheries governance: Lessons from the Faroe Islands. *Elementa: Science of the Anthropocene*, 9(1): 00115.

Clark, C.W. (1976). *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*. John Wiley & Sons.

Danish Directorate of Fisheries (2021a). Quota statistics and quota utilization 2010-2020, available at: https://fiskeristyrelsen.dk/fiskeristatistik/kvotestatistik-og-kvoteudnyttelse/#c82836.

Danish Directorate of Fisheries (2021b). Catch and landing statistics, available at: https://fiskeristatistik.fiskeristyrelsen.dk/SASVisualAnalytics/?reportUri=%2Freports%2Freports%2F3207ff0a-4f3c-4adb-a9ca-e8f45f15e3ae&sso_guest=true&sas-welcome=false.

FAO (2020). *The State of World Fisheries and Aquaculture 2020. Sustainability in Action.* Rome. https://doi.org/10.4060/ca9229en.

Faroese Economic Council (2014). Búskaparrenta og tilfeingisrenta í føroyska búskapinum

Faroese Parliament regulations No 150 from Dec 2016

Faroese Parliament regulations No 172 from Dec 2017

Faroese Parliament regulations No 77 from May 2021

Fiskistofa (2021). Quota status and catches of species by vessels. Directorate of Fisheries. Hafnarfjörður.

Gulland, J. A. (1980). *Some Problems of the Management of Shared Stocks*, FAO Fisheries Technical Paper No. 206, Rome.

Gullestad, P., Sundby, S. & Kjesbu, O. S. (2020). Management of transboundary and straddling fish stocks in the Northeast Atlantic in view of climate-induced shifts in spatial distribution. *Fish and Fisheries* 21: 1008-1026. https://doi.org/10.1111/faf.12485.

Hegland, T. J. & Hopkins, C. C.E. (2014). Towards a new fisheries effort management system for the Faroe Islands? – Controversies around the meaning of fishing sustainability. *Maritime Studies* 13(1).

ICES (2011). *Historical nominal catches 1950-2010. Version 26-06-2019. Catch statistics.* Copenhagen. Retrieved from https://www.ices.dk/data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx

ICES (2020). Working Group on Widely Distributed Stocks (WGWIDE), *ICES Scientific Reports*, 2(82).

ICES (2020a). *Blue whiting (Micromesistius poutassou) in subareas 1-9, 12, and 14 (Northeast adjacent waters)*. Copenhagen. Retrived from https://standardgraphs.ices.dk/stockList.aspx

ICES (2020b). *Herring (Clupea harengus) in subareas 1, 2, 5 and divisions 4.a and 14.a, Norwegian spring-spawning herring (the Northeast Atlantic and Arctic Ocean)*. Copenhagen.

ICES (2020c). *Mackerel (Scomber scombrus) in subareas 1-8 and 14 and Division 9.a (the Northeast Atlantic and adjacent waters)*. Copenhagen.

ICES (2020d). *Official nominal catches 2006-2018. Version 22-06-2020. Catch statistics.* Copenhagen. Retrieved from https://www.ices.dk/data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx

International Council for Exploration of the Sea (2020). ICES Advice on fishing opportunities, catch, and effort Ecoregions of the Northeast Atlantic and Arctic Ocean. Published 30 September 2020, advise on mackerel (available at: https://ices.dk/sites/pub/Publications%20Reports/Advice/2020/2020/mac.27.nea.pdf) Norwegian Spring-Spawning herring (available at: https://www.ices.dk/sites/pub/Publications%20Reports/Advice/2020/her.27.1-24a514a.pdf) and blue whiting (available at: https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/whb.27.1-91214.pdf

International Council for Exploration of the Sea (2020). *ICES Advice on fishing opportunities, catch, and effort Ecoregions of the Northeast Atlantic and Arctic Ocean.* Published 30 September 2020, advise on Norwegian Spring-Spawning herring. Retrieved from https://www.ices.dk/sites/pub/Publications%20Reports/Advice/2020/2020/her.27.124a514a.pdf

Marine Management Organisation (2015). *UK Sea Fisheries Statistics 2015.* Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/598208/UK_Sea_Fisheries_Statistics_2015_full_report.pdf

Marine Management Organisation (2018). *UK Sea Fisheries Statistics 2018 full report*. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/920110/UK_sea_fisheries_statistics_2018_002.pdf

Marine Management Organisation (2020). *National Statistics: Monthly Sea Fisheries Statistics 2020.* Retrieved from https://www.gov.uk/government/statistics/monthly-sea-fisheries-statistics-december-2020

Marine Management Organisation (2021). *United Kingdom commercial sea fisheries catches by Exclusive Economic Zone of capture 2012-2019.* Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/923599/2020-UK_Commercial_Sea_Fisheries_Landings_by_EEZ_2012_2019_report.pdf

Marine Management Organisation (2021a). *United Kingdom commercial sea fisheries catches by Exclusive Economic Zone of capture 2012-2019.* Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/923599/2020-UK_Commercial_Sea_Fisheries_Landings_by_EEZ_2012_2019_report.pdf

Marine Management Organisation (2021b). *Statistical data set quota use statistics 2010-2020.* Retrieved from https://www.gov.uk/government/statistical-data-sets/quota-use-statistics.

Munro, G., Van Houtte, A. & Willmann, R. (2004). The conservation and management of shared fish stocks: legal and economic aspects. *FAO Fisheries Technical Paper*. No. 465. Rome, FAO. 69p.

NFD (2019). Meld. St. 13 (2019-2020) Melding til Stortinget. Noregs fiskeriavtalar for 2020 og fisket etter avtalane i 2018 og 2019. Oslo.

NFD (2020). Meld. St. 26 (2020-2021) Melding til Stortinget. Noregs fiskeriavtalar for 2021 og fisket etter avtalane i 2019 og 2020. Oslo.

Nielsen, M., Dalskov, J., Andersen, J. L., Nielsen, R., Koed, A., Pedersen, J. K., Rindorf, A., Vinther, M., Olesen, N. J., Pedersen, P. B., Sveistrup, U., Phillips, A., Eriksen, J. V., Krestyanska, M., Agerskov, P.E. & Olesen, E. A. (2020). *Situationsbeskrivelse af den danske fiskeri-, akvakultur og fiskeindustrisektor: Den Europæiske Hav- og Fiskerifond 2021-2027* (Description of the situation for the Danish fishery, aquaculture and fishing industry sector: The European Maritime and Fisheries Fond 2021-2027, IFRO Udredning 2019/26).

Nøttestad, L., Salthaug, A., Johansen, G. O., Anthonypillai, V., Tangen, Ø., Utne, K. R., Sveinbjörnsson, S., Óskarsson, G. J., Jónsson, S., Debes, H., Mortensen, E., Smith, L., Ólafsdóttir, A., Jacobsen, J. A. & Jansen, T. (2014). Cruise report from the Coordinated Ecosystem Survey (IESSNS) with M/V "Brennholm", M/V "Vendla", M/V "Finnur Fríði" and R/V "Árni Friðriksson" in the Norwegian Sea and surrounding waters, 2 July - 12 August 2014. Working Document to Working Group of Widely Distributed Stocks, ICES, Copenhagen, Denmark, 26 August - 1 September 2014. 49 pp.

Nøttestad, L., Utne, K. R., Óskarsson, G. J., Jónsson, S. Þ., Jacobsen, J. A., Tangen, Ø., Anthonypillai, V., Aanes, S., Vølstad, J. H., Bernasconi, M., Debes, H., Smith, L., Sveinbjörnsson, S., Holst, J. C., Jansen, T. & Slotte, A. (2016). Quantifying changes in abundance, biomass and spatial distribution of Northeast Atlantic (NEA) mackerel (*Scomber scombrus*) in the Nordic Seas from 2007 to 2014. *ICES Journal of Marine Science* 73(2): 359-373. https://doi.org/10.1093/icesjms/fsv218.

Nøttestad, L., Anthonypillai, V., Salthaug, A., Høines, Å., Ólafsdóttir, A. H., Kennedy, J., Homrum, E., Smith, L., Jansen, T., Post, S. & Wieland, K. (2020). Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 1st July – 4th August 2020. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE, No. 5), ICES HQ, Copenhagen, Denmark, (digital meeting) 26. August - 1. September 2020. 55 pp.

Roy, N., Arnason, R. & Schrank, W. E. (2009). The Identification of Base Industries with an Application to the Newfoundland Fisheries. *Land Economics* 85(4):675-691.

Samgöngustofa (2021). Skipaskrá 2021. Icelandic Transport Authority. Reykjavik.

Samró, H. (2015). Stríðið um Makrelin – Tá Føroyar slitu strandarlandaavtaluna of kravdu sín sjálvsagda ræt, Føroyaprent.

Seierstad, A. & Sydsæter, K. (1987). *Optimal Control Theory with Economic Applications*. Northe Holland. Amsterdam.

Statistics Denmark (2021a). Industry's sale of product of own processing. Available at: https://www.statistikbanken.dk/statbank5a/default.asp?w=1920.

Statistics Denmark (2021b), Foreign Trade Statistics. Available at: https://www.statistikbanken.dk/statbank5a/default.asp?w=1920.

Statistics Denmark (2021c), Account Statistics for Fisheries and Aquaculture. Available at: https://www.statistikbanken.dk/statbank5a/default.asp?w=1920.

Statistics Iceland (2021). Gross Domestic Product by industries, percentage breakdown, 1997-2020. Statistics Iceland, Reykjavik.

Statistics Faroe Islands (2021). National Accounts - Gross Domestic Product 2010-2020. Statistics Faroe Islands, Tórshavn.

Statistics Faroe Islands (2021). International Trade in Goods 2010-2020. Statistics Faroe Islands, Tórshavn.

Statistics Iceland (2021b). Fisheries. Statistics Iceland, Reykjavik.

Teyggjan (2021). Ship's statistics, www.teyggjan.fo

The European Commission (2013). "Commission implementing regulation (EU) No 793/2013", *Official Journal of the European Union.*

The Faroe Islands Ministry of Fishery (Bergen, 29 November 2018). "Agreed record on a Fisheries Arrangement between the Faroe Islands, the European Union and Norway on an Extension of the 2014 Mackerel Arrangement to 2020".

The Faroe Islands Ministry of Fishery (2020). “Protocol of the Forty Fourth Session in the Joint Faroese – Russian Fisheries Commission”.

Totland, O. A. (2020). Makrellkonflikten og strategisk klimafornekting. *Internasjonal Politikk*, 78(2), 142-166. https://dx.doi.org/10.23865/intpol.v78.1453

The UK and the EU (2020). Trade and cooperation agreement between the European Union and the European Atomic Energy Community, on the one part, and the United Kingdom of Great Britain and Northern Ireland, on the other part. London and Brussels. 1246 pp.

Vørn – the Faroese Fisheries Directorate (2021). Historical Catches 2010-2020, www.vorn.fo

William, J. H. (2021). Norsk pelagisk fiske: Stø kurs mot grunna! *Norsk Fiskerinæring* 2: 24-28.

APPENDIX: REPORT ON UNILATERAL QUOTAS IN NORTH-EAST ATLANTIC PELAGIC FISHERIES

By Trond Bjørndal and Rannva Danielson

Table of contents

MACKEREL

Data

Data on unilateral quotas for the period 2010-2020 was gathered from the annual ICES WGWIDE reports (2009-2020). Data on unilateral quotas for 2021 was taken from the Faroese national broadcasting corporation (kvf.fo). Data on scientific advice was gathered from the ICES advice on North-East Atlantic mackerel from 2020.

In the period 2005-2015, the scientific advice from ICES for mackerel was given in a range with an upper and lower limit. The upper limit is used throughout this report. If the lower limit had been used, the excess catch (i.e., catch above scientific advice), would naturally be larger. The results, as reported below, should be interpreted with this in mind.

Results

Figures 1 and 2 show the advised catch (upper limit) on mackerel and total catch by all participants in the fishery in the period 2010-2021.

There are two differences between Figures 1 and 2: Figure 1 includes inter-annual transfers by participants (i.e., if participants exceed their quota, they can subtract it from the following year's quota. If they do not fish their entire quota, they can transfer it to the following year). Figure 1 also includes discards and overcatch, as estimated by ICES.

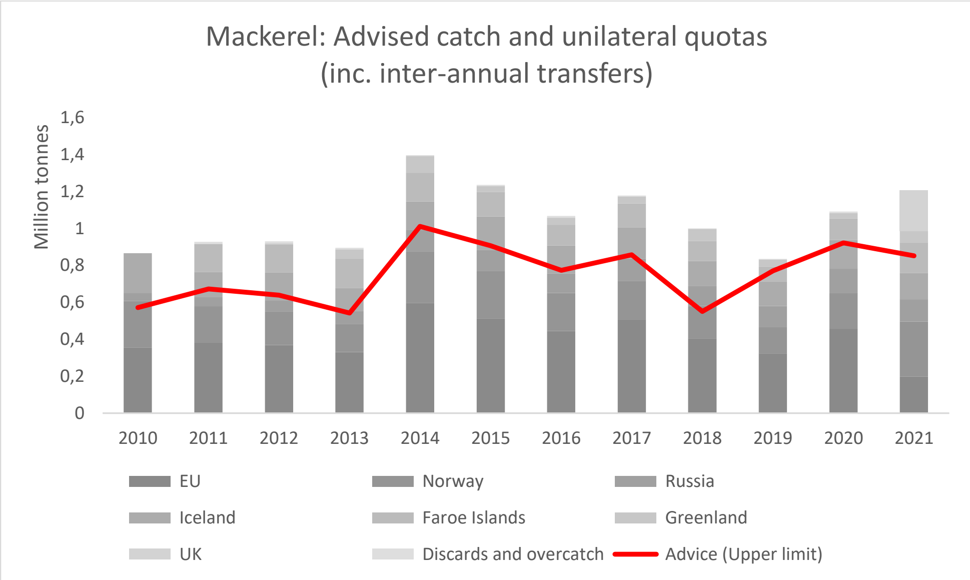


Figure 1. Mackerel: Unilateral quotas as set by participants in the fishery (including inter-annual transfers by participants) and the scientific advice on how much to take out of the stock (upper limit), 2010-2021.

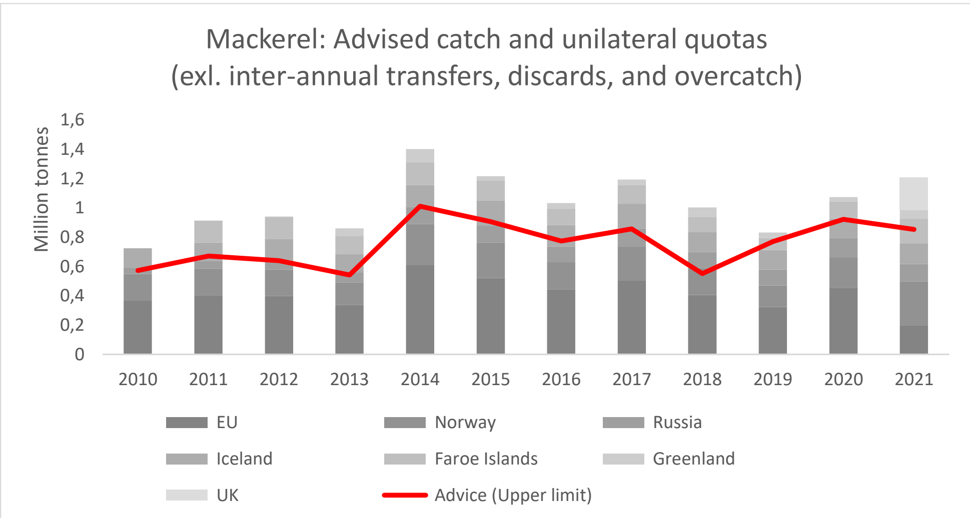


Figure 2. Mackerel: Unilateral quotas as set by participants in the fishery (excluding inter-annual transfers by participants, discards and overcatch) and the scientific advice on how much to take out of the stock (upper limit).

Figure 3 shows the upper limit of the advised mackerel catch in the period 2010-2021 (grey) and the excess catch (red), i.e., how much the total catch by all participants in the fishery exceeded the advised catch. The percentages show by how much the advised catch was exceeded. The lowest excess was 8% in 2019 and the highest was 82% in 2018. In 2018, the advised catch was 550,948 tonnes and the actual catch by all participants was 1,000,559 tonnes. Excess catch increased from 18% in 2020 to 42% in 2021, the year the UK became an independent participant in the fishery following Brexit.

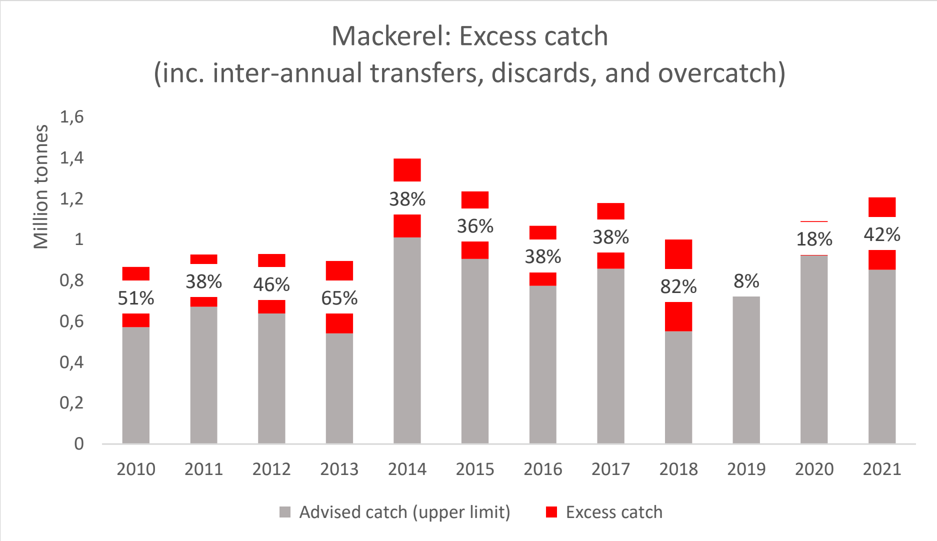


Figure 3. Mackerel: The advised catch (upper limit of the range) and how much the total catch by all participants in the fishery has exceeded scientific advice. This includes inter-annual transfers by participants, as well as discards and estimated overcatch.

Figure 4 shows the relative share of unilateral quotas by each participant in the fishery over time. The UK set a unilateral quota of 222,288 tonnes in 2021, equal to 18% of the total quota set by participants in the fishery in 2021. The EU reduced their relative share of the total quota from 42% in 2020 to 16% in 2021 (from 454,482 tonnes to 198,063 tonnes).

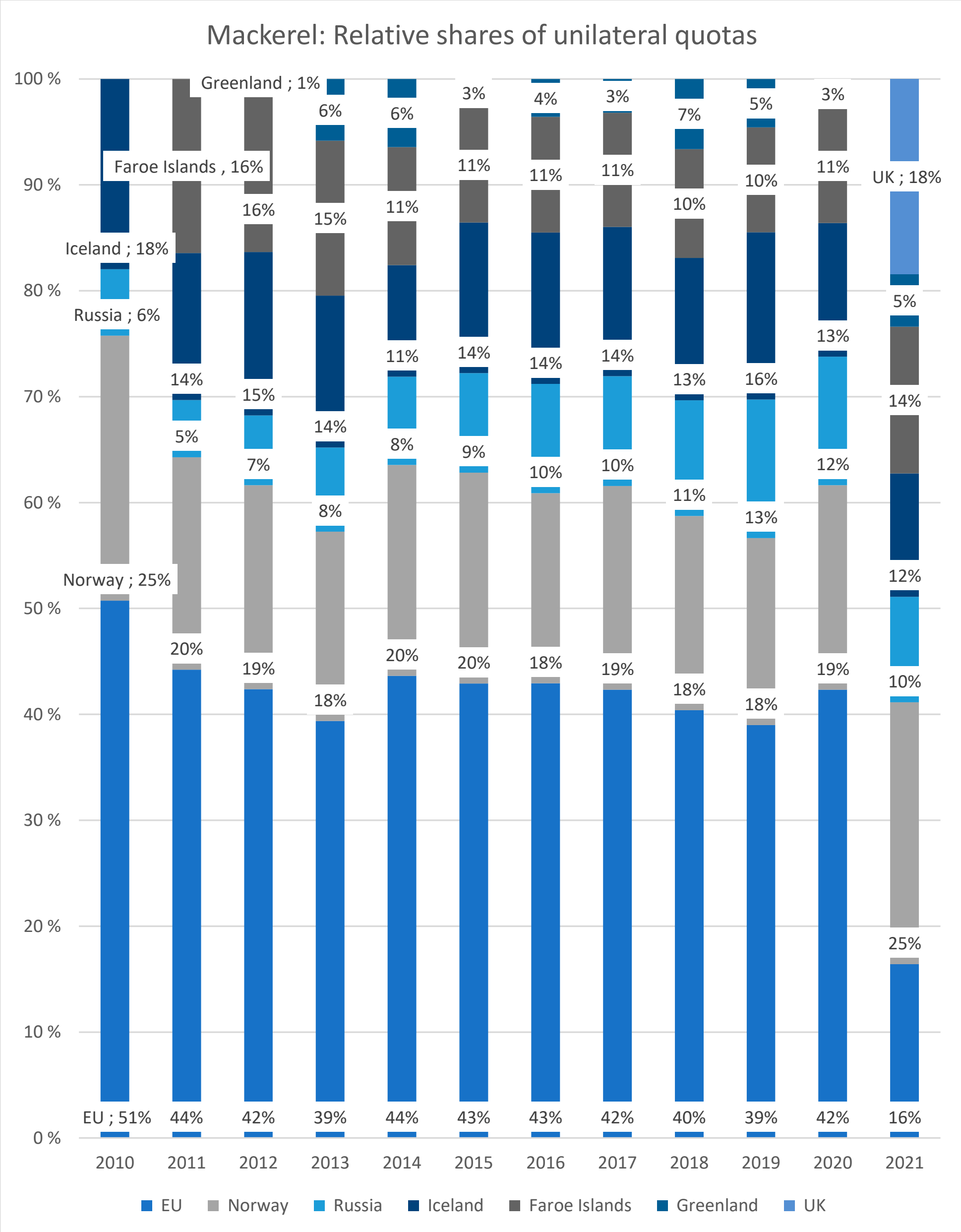


Figure 4. Mackerel: Relative shares of unilateral quotas, 2010-2021.

Table 1 shows unilateral quotas, the sum of unilateral quotas, advised catch in 2020 and 2021. The sum of unilateral quotas exceeded the advised catch by 181,000 tonnes (20%) and 354,000 tonnes (42%) in 2020 and 2021, respectively.

Table 2 shows the relative shares of the unilateral quotas set by participants in the fishery in 2020-2021. The UK entered the fishery as a participant following Brexit and set a unilateral quota equal to 18% of the total mackerel quota.

Table 3 shows the size of unilateral quotas if all participants had same relative share of the total quota but adhered to scientific advice on catch.

Table 1. Mackerel: Unilateral quotas, the sum of unilateral quotas, and advised catch in 2020-2021.

Year	EU	Norway	Russia	Iceland	Faroe Islands	Greenland	UK	Total	Advised catch[45]	Excess
2020	454,482	207,551	130,282	135,428	116,188	59,934	-	1,103,865	922,064	181,801
2021	198,063	298,299	120,423	140,627	167,048	60,000	222,288	1,206,748	852,284	354,464

Table 2. Mackerel: Relative shares of the unilateral quotas in 2020-2021.

Year	EU	Norway	Russia	Iceland	Faroe Islands	Greenland	UK	Sum
2020	41%	19%	12%	12%	11%	5%	-	100
2021	16%	25%	10%	12%	14%	5%	18%	100

Table 3. Mackerel: Unilateral quotas if the participants had same relative quota share as listed in Table 2 but adhered to advised catch limit.

Year	Advised catch (upper limit)	EU	Norway	Russia	Iceland	Faroe Islands	Greenland	UK
2020	922,064	379,631	173,368	108,825	113,124	97,052	50,063	-
2021	852,284	139,885	210,678	85,051	99,320	117,980	42,376	156,994

[45] Upper limit.

NORWEGIAN SPRING SPAWNING HERRING – ATLANTO SCANDIAN HERRING

Data

Data on unilateral quotas for the period 2016-2020 was gathered from coastal states agreements on NSSH-ASH as published by the Pelagic Advisory Council.[46] The Pelagic Advisory Council provides advice on how to manage pelagic stocks on behalf of industry and stakeholders.

Data on scientific advice was gathered from the ICES advice on Norwegian spring-spawning herring from 2020. The scientific advice from ICES for herring in the period is given as less than or equal to (indicated by ≤). The results, as reported below, should be interpreted with this in mind.

Results

Figures 5 and 6 show the advised catch on herring and total catch by all participants in the fishery in the period 2016-2020.

There is one difference between Figures 5 and 6: Figure 5 includes inter-annual transfers by participants (i.e., if participants exceed their quota, they can subtract it from the following year's quota. If they do not fish their entire quota, they can transfer it to the following year). Figure 6 does not include inter-annual transfers.

[46]Available here: https://www.pelagic-ac.org/coastal-states-agreements.

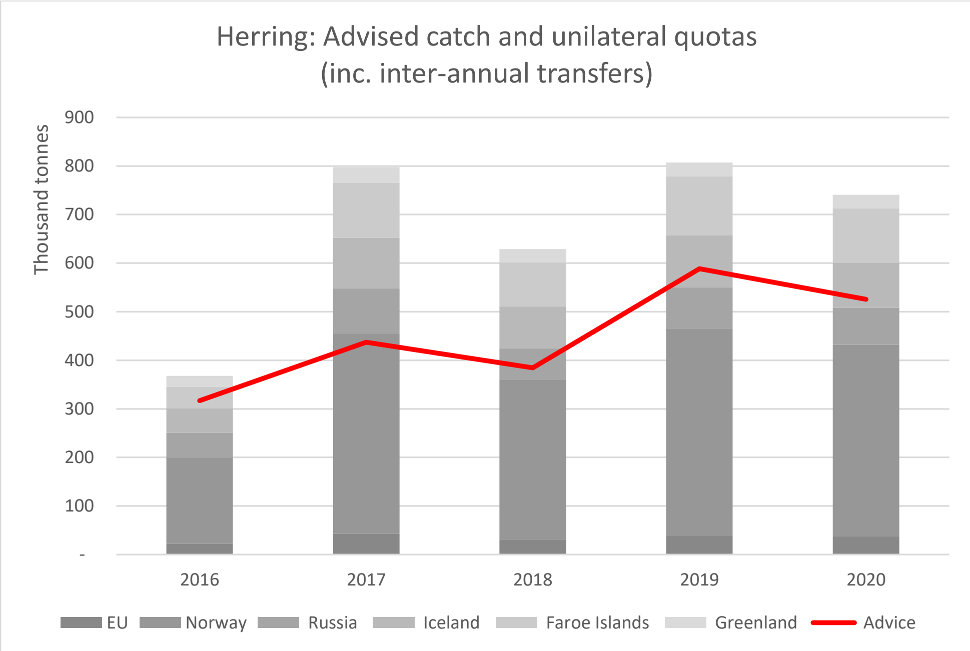


Figure 5. Herring: Unilateral quotas as set by participants in the fishery (including inter-annual transfers by participants) and the scientific advice on how much to take out of the stock, 2016-2020.

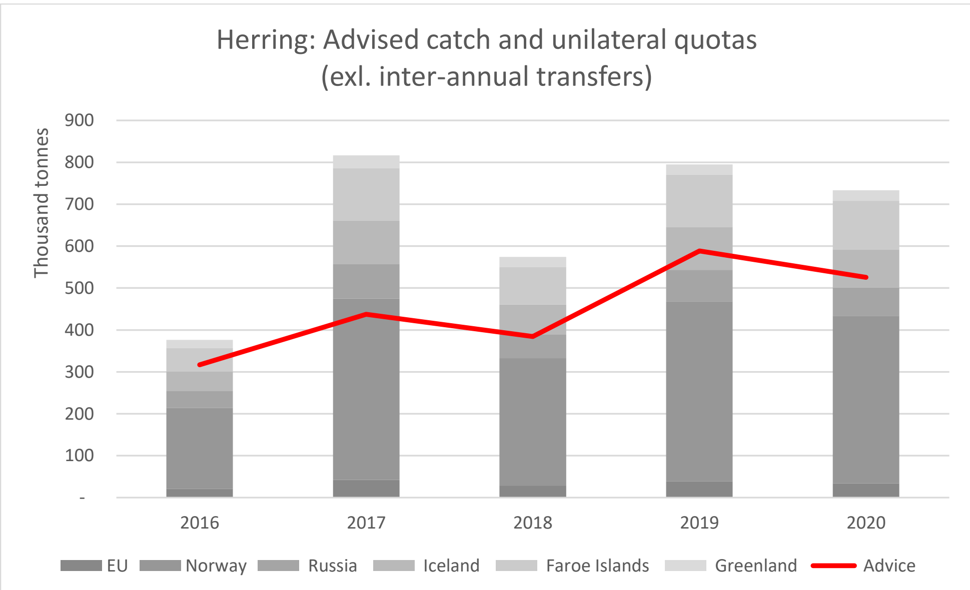


Figure 6. Herring: Unilateral quotas as set by participants in the fishery (excluding inter-annual transfers by participants) and the scientific advice on how much to take out of the stock.

Figure 7 shows the advised herring catch in the period 2016-2020 (grey) and the excess catch (red), i.e., how much the total catch by all participants in the fishery exceeded the advised catch. The percentages show by how much the advised catch was exceeded. The lowest excess was 16% in 2016 and the highest was 82% in 2017, more than 360,000 tonnes.

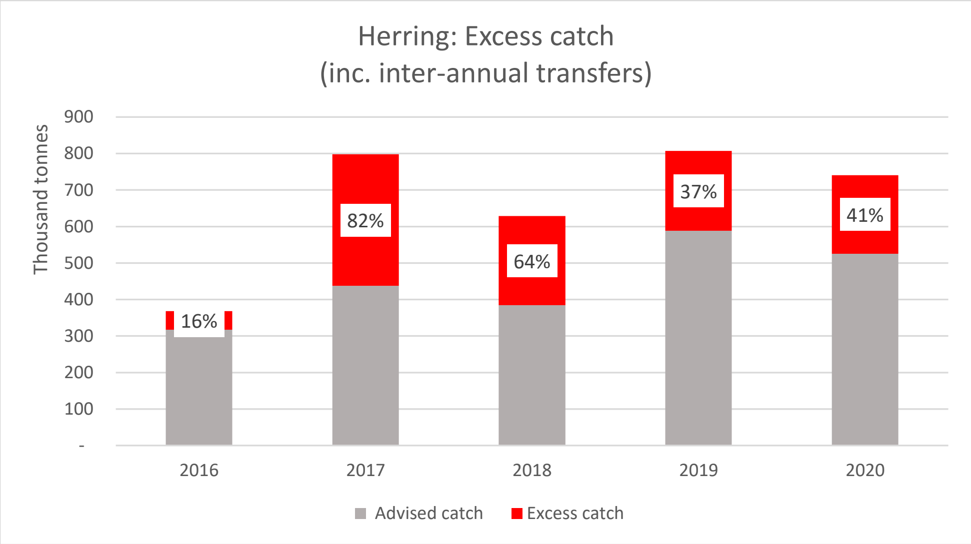


Figure 7. Herring: The advised catch and how much the total catch by all participants in the fishery has exceeded scientific advice. This includes inter-annual transfers by participants.

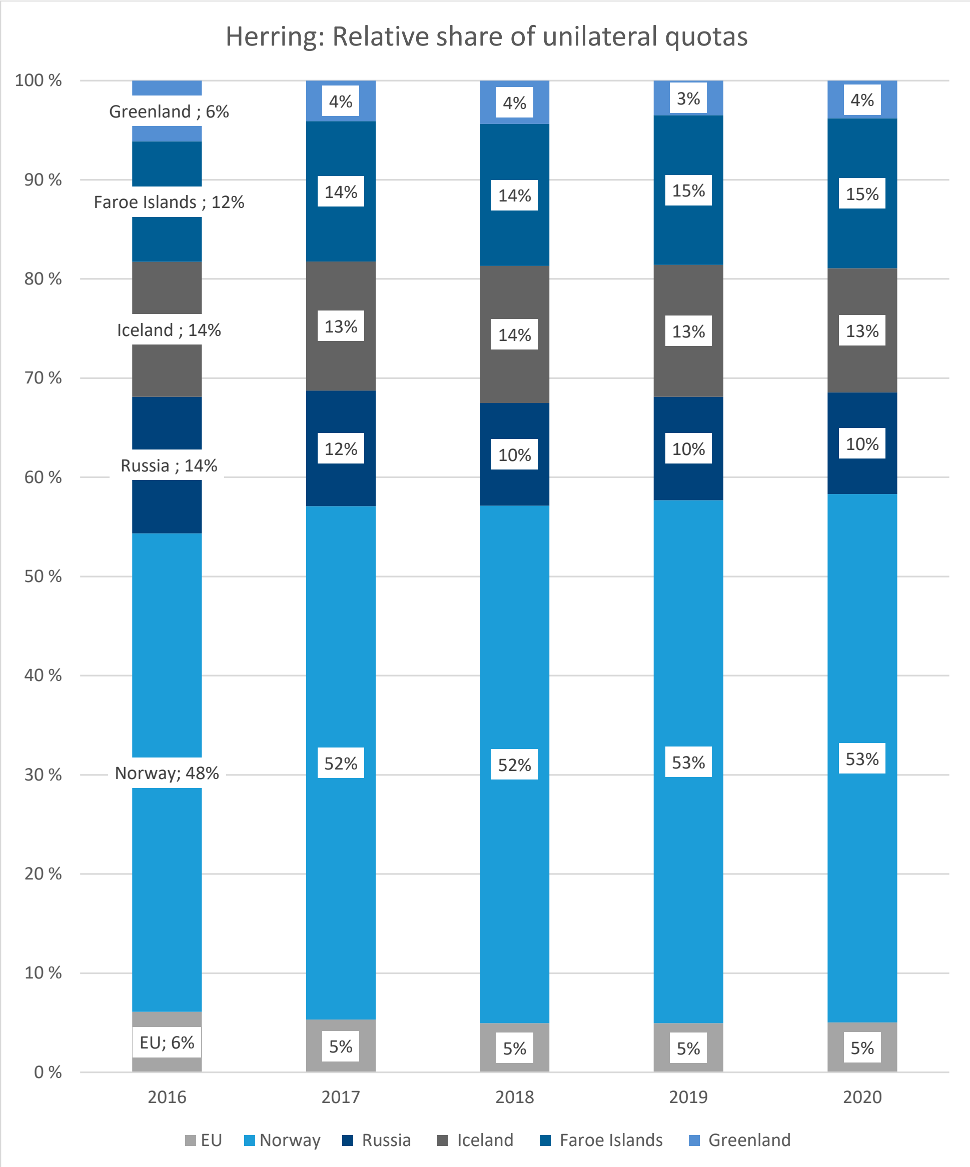


Figure 8. Herring: Relative shares of unilateral quotas, 2016-2020.

Figure 8 shows the relative share of unilateral quotas by each participant in the fishery over time.

Table 4 shows unilateral quotas, the sum of unilateral quotas, advised catch, and excess catch in the period 2016-2020. Table 5 shows the relative shares of the unilateral quotas set by participants in the fishery in 2016-2020. Table 6 shows the size of unilateral quotas if all participants had same relative share of the total quota but adhered to scientific advice on catch.

Table 4. Herring: Unilateral quotas, the sum of unilateral quotas, advised catch, and excess catch in 2016-2020.

Year	EU	Norway	Russia	Iceland	Faroe Islands	Greenland	Total	Advised catch	Excess
2016	22,471	177,662	50,702	50,085	44,767	22,500	368,187	316,876	51,311
2017	42,340	413,031	92,957	103,890	112,914	32,500	797,632	437,364	360,268
2018	31,208	328,148	65,090	86,846	90,030	27,500	628,822	384,197	244,625
2019	39,974	425,770	84,361	107,295	121,821	28,200	807,421	588,562	218,859
2020	37,255	394,717	75,936	92,654	112,019	28,200	740,781	525,594	215,187

Table 5. Herring: Relative shares of the unilateral quotas in 2016-2020.

Year	EU	Norway	Russia	Iceland	Faroe Islands	Greenland
2016	6%	48%	14%	14%	12%	6%
2017	5%	52%	12%	13%	14%	4%
2018	5%	52%	10%	14%	14%	4%
2019	5%	53%	10%	13%	15%	3%
2020	5%	53%	10%	13%	15%	4%

Table 6. Herring: Unilateral quotas if the participants had same relative quota share as listed in Table 5 but adhered to advised catch limit.

Year	Advised catch	EU	Norway	Russia	Iceland	Faroe Islands	Greenland
2016	316,876	19,339	152,903	43,636	43,105	38,528	19,364
2017	437,364	23,216	226,476	50,971	56,966	61,914	17,821
2018	384,197	19,067	200,492	39,769	53,061	55,006	16,802
2019	588,562	29,139	310,361	61,494	78,212	88,800	20,556
2020	525,594	26,433	280,057	53,878	65,739	79,479	20,008

BLUE WHITING

Data

Data on unilateral quotas for the period 2016-2020 was gathered from coastal states agreements on blue whiting as published by the Pelagic Advisory Council.[47] The Pelagic Advisory Council provides advice on how to manage pelagic stocks on behalf of industry and stakeholders.

Data on scientific advice was gathered from the ICES advice on blue whiting from 2020. The scientific advice from ICES for blue whiting in the period is given as less than or equal to (indicated by ≤). The results, as reported below, should be interpreted with this in mind.

Results

Figures 9 and 10 show the advised catch on blue whiting and total catch by all participants in the fishery in the period 2016-2020.

There is one difference between Figures 9 and 10: Figure 5 includes inter-annual transfers by participants (i.e., if participants exceed their quota, they can subtract it from the following year's quota. If they do not fish their entire quota, they can transfer it to the following year). Figure 10 does not include inter-annual transfers.

[47]Available here: https://www.pelagic-ac.org/coastal-states-agreements .

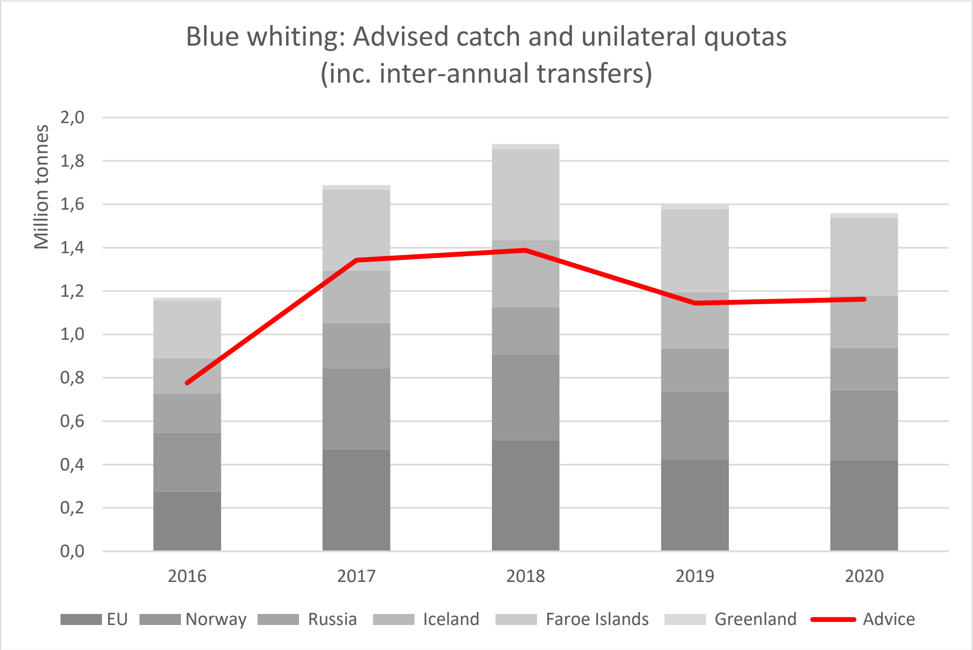


Figure 9. Blue whiting: Unilateral quotas as set by participants in the fishery (including inter-annual transfers by participants) and the scientific advice on how much to take out of the stock, 2016-2020.

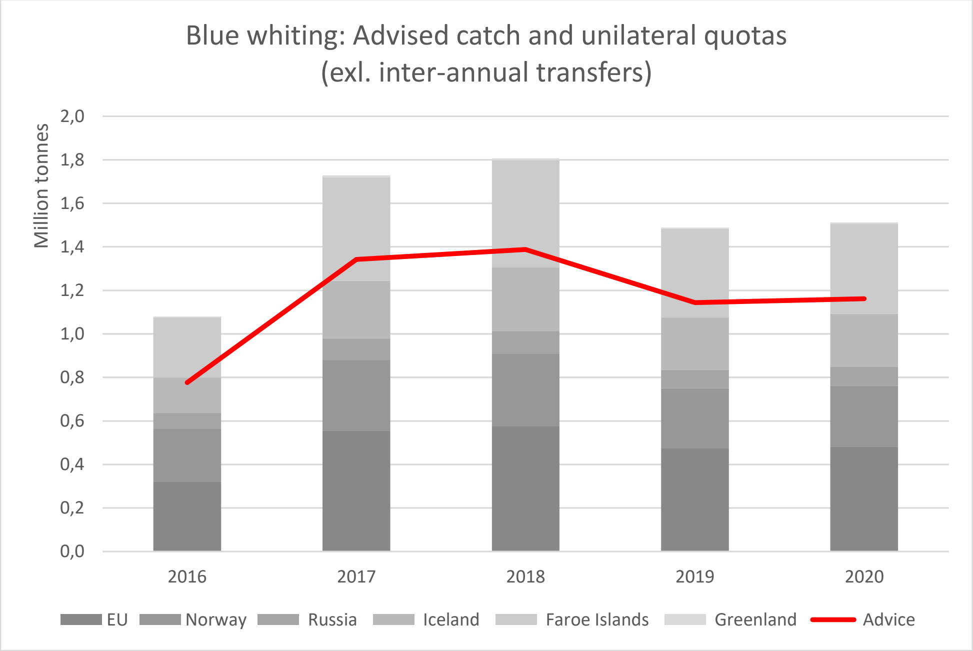


Figure 10. Blue whiting: Unilateral quotas as set by participants in the fishery (excluding inter-annual transfers by participants) and the scientific advice on how much to take out of the stock.

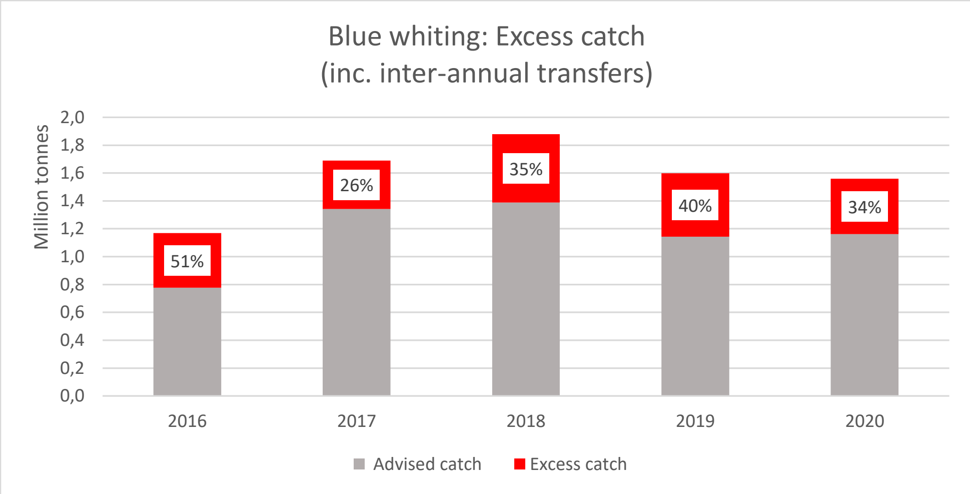


Figure 11. Blue whiting: The advised catch and how much the total catch by all participants in the fishery has exceeded scientific advice. This includes inter-annual transfers by participants.

Figure 11 shows advised catch of blue whiting in the period 2016-2020 (grey) and excess catch (red), i.e., how much the total catch by all participants in the fishery exceeded the advised catch. The percentages show how much catch exceeded advice. The lowest excess was 26% in 2017 and the highest was 51% in 2016.

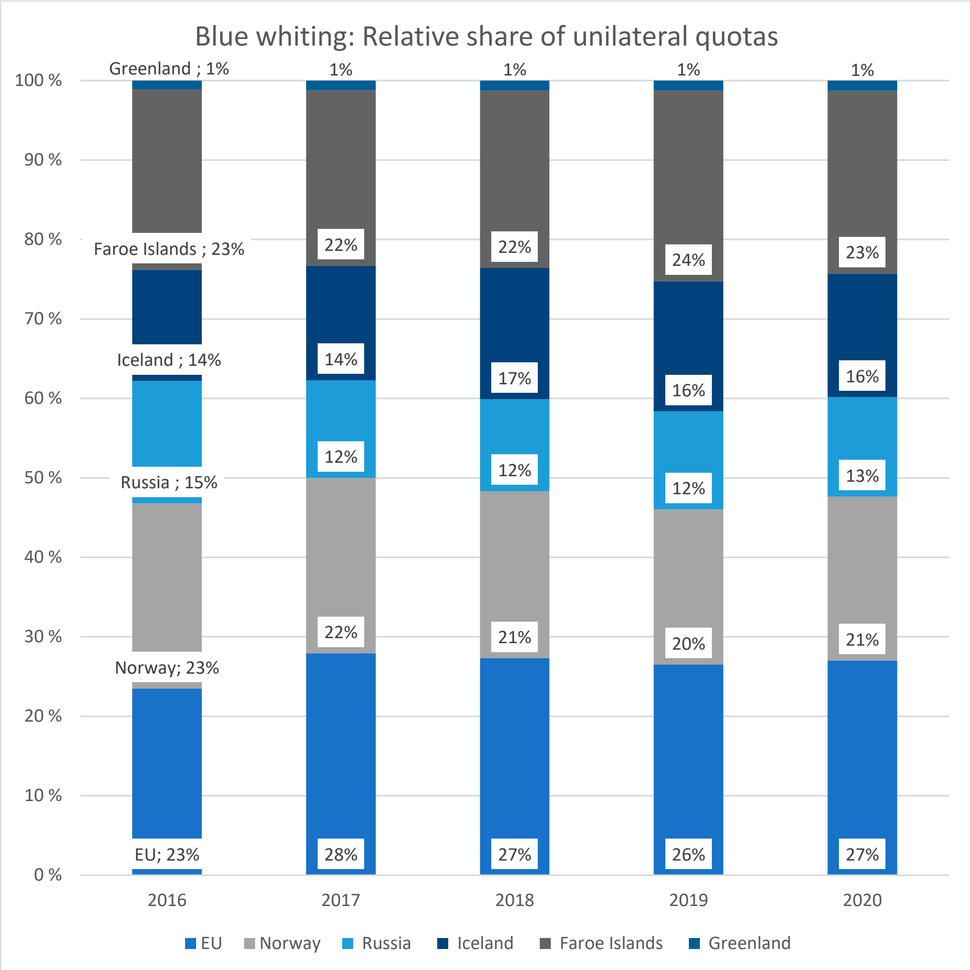


Figure 12. Blue whiting: Relative shares of unilateral quotas, 2016-2020.

Figure 12 shows the relative share of unilateral quotas by each participant in the fishery over time.

Table 7 shows unilateral quotas, the sum of unilateral quotas, advised catch, and excess catch in the period 2016-2020. Table 8 shows the relative shares of the unilateral quotas set by participants in the fishery in 2016-2020. Table 9 shows the size of unilateral quotas if all participants had same relative share of the total quota but adhered to scientific advice on catch.

Table 7. Blue whiting: Unilateral quotas, the sum of unilateral quotas, advised catch, and excess catch in 2016-2020.

Year	EU	Norway	Russia	Iceland	Faroe Islands	Greenland	Total	Advised catch	Excess catch
2016	274,779	272,477	180,105	163,858	264,807	13,247	1,169,273	776,391	392,882
2017	471,630	372,957	207,379	243,179	373,025	20,652	1,688,822	1,342,330	346,492
2018	512,933	394,694	217,529	310,321	419,180	23,667	1,878,324	1,387,872	490,452
2019	423,775	312,517	197,258	262,227	383,371	20,026	1,599,174	1,143,629	455,545
2020	421,110	321,826	195,189	242,344	358,455	20,025	1,558,949	1,161,615	397,334

Table 8. Blue whiting: Relative shares of the unilateral quotas in 2016-2020.

Year	EU	Norway	Russia	Iceland	Faroe Islands	Greenland
2016	23%	23%	15%	14%	23%	1%
2017	28%	22%	12%	14%	22%	1%
2018	27%	21%	12%	17%	22%	1%
2019	26%	20%	12%	16%	24%	1%
2020	27%	21%	13%	16%	23%	1%

Table 9. Blue whiting: Unilateral quotas if the participants had same relative quota share as listed in Table 8 but adhered to advised catch limit.

Year	Advised catch	EU	Norway	Russia	Iceland	Faroe Islands	Greenland
2016	776,391	182,452	180,923	119,589	108,801	175,830	8,796
2017	1,342,330	374,867	296,438	164,831	193,286	296,492	16,415
2018	1,387,872	379,000	291,635	160,730	229,293	309,727	17,487
2019	1,143,629	303,057	223,493	141,067	187,528	274,163	14,321
2020	1,161,615	313,780	239,801	145,441	180,577	267,095	14,921

The Norwegian Sea is home to three large pelagic fisheries for mackerel, Norwegian spring spawning – Atlanto Scandian herring and blue whiting. In 2019, the total catch of these three species was 3,113,000 tonnes with a total value estimated at EUR 2.011 billion. This means they represent some of the largest fisheries in the North Atlantic and are important in terms of income and employment for the participating countries. The purpose of this report is to analyse post-Brexit management of the fisheries. A number of countries including the EU, Norway, the Faroe Islands, Iceland, Greenland and Russia have traditionally fished these stocks and have internationally recognised fishing rights in the area.

As the United Kingdom has left the EU, the legal status of both the UK and the EU has changed: while the UK is now a coastal state in all three fisheries, the EU is coastal state in the fisheries for mackerel and blue whiting while a distant water state in the herring fishery. The more countries involved, the more difficult to arrive at a cooperative agreement. Thus, with a new player post-Brexit, it may become even more difficult than before to agree to cooperate.

The report takes a game theoretic perspective to the management of the fisheries in question. In a cooperative game, all parties cooperating is referred to as the grand coalition and there have been periods when the fisheries have been managed by grand coalitions. However, for mackerel, the grand coalition broke down in 2008; for herring, where there was full cooperation up to 2012, while for blue whiting, the grand coalition broke down in 2015. Currently, although the parties agree on TACs as recommended by ICES, national quotas are set unilaterally with the consequence the sum of quotas exceed ICES quota advice. The report analyses developments in the fisheries over time as well as conditions that must be met for renewed cooperation.

SNF

Samfunns- og næringslivsforskning AS
Centre for Applied Research at NHH

Helleveien 30
NO-5045 Bergen
Norway

P +47 55 95 95 00
E snf@snf.no
W snf.no

Trykk: Allkopi Bergen