FIS012A - Quota management and choke species under the landing obligation

A REPORT COMMISSIONED BY FIS
AND PREPARED BY

CEFAS

Published by: Fisheries Innovation Scotland (FIS)

This report is available at: http://www.fiscot.org.

Suggested Citation: Reeves, S A. Davie, S L. Quota management and choke species under the landing obligation. 2017. A study commissioned by Fisheries Innovation Scotland (FIS) http://www.fiscot.org/ and supported by The European Maritime and Fisheries Fund and The Scottish Government

Title: FIS012A - Quota management and choke species under the landing obligation

ISBN: 978-1-911123-08-8

First published: 2017

Cefas

Cefas contract report C7079

FIS012a: Quota management and choke species under the landing obligation

Authors: Stuart A. Reeves & Sarah L. Davie

Issue date: 27/03/2017

Fisheries Innovation Scotland

Cefas Document Control

Title: Quota management and choke species under the landing obligation

Submitted to:	FIS
Date submitted:	
Project Manager:	SAR
Report compiled by:	SAR
Quality control by:	P. Dolder
Approved by & date:	P. Dolder 11/11/16 (v1)
Version:	3

Version Control History			
Author	**Date**	**Comment**	**Version**
SAR/SLD	8/11/16	Text for review. Some details still to be finalised	1
SAR/SLD	14/11/16	Remaining sections added & PD comments incoporated	2
SAR	27/3/2017	Incorporating reviewer comments	3

Quota management and choke species under the landing obligation

Authors: Stuart A. Reeves & Sarah L. Davie

Issue date: 27/03/2017

Head office
Centre for Environment, Fisheries & Aquaculture Science
Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK
Tel +44 (0) 1502 56 2244 Fax +44 (0) 1502 51 3865
www.cefas.defra.gov.uk

Cefas is an executive agency of Defra

Executive Summary

- Most demersal species are caught together in mixed fisheries. This can cause problems if a vessel does not hold enough quota to legally land all of the species it catches. In the past this has meant that vessels have had to discard their over-quota catches, but with the introduction of a discard ban for EU fisheries, this will no longer be legal. Instead, vessels will be required to stop fishing once they have exhausted one of their quotas. This could 'choke-off' their fishing opportunities for other stocks, hence this is known as the 'choke-species' problem.

- The choke-species problem could have major economic consequences for the Scottish fishing industry. For this reason, it is important to understand the factors that influence the problem so that the issues can be managed in order to mitigate its impacts. One of the factors that could influence choking is the process by which quotas are allocated to vessels. This process was the initial focus of the current project.

- The objectives of the project were to describe the existing quota allocation process then to identify possible alternative approaches and compare their effectiveness using a model of the mixed fisheries of the North Sea. In practice, the focus of the project was expanded so that it considered TAC-setting as well as quota allocation as the initial TAC can also have a major influence on any problems with choke. At the same time, it became apparent that the quota-allocation process is a managed in a very 'hands-off' way without any stated objectives about what it is trying to achieve. This leads to practical difficulties in evaluating alternative approaches, so less emphasis was placed on this aspect of the project.

- A TAC is set to limit the quantity of fish removed from a stock in a given year rather than to provide the vessels exploiting the stock with sufficient fishing opportunities to last the year. With that caveat, it is possible to identify aspects of the TAC-setting process that can contribute to the risk of choking occurring. This project used a detailed review of the TAC-setting process for the main North Sea demersal stocks in order to identify these features.

- TACs are usually based on the results of catch forecasts which, in turn, are based on the results of stock assessments. As a result, there is a greater risk of choke occurring if a stock assessment is of poor quality or if there has been a lot of discarding of the stock concerned as this will also influence the quality of the catch forecast. In addition, if the fishing mortality on a stock is above the sustainability target value for that stock, setting a TAC in order to reduce fishing mortality will also increase the risk of choke occurring.

- Shares of EU stocks are allocated to EU member States on the basis of 'relative stability'. The original basis for these fixed shares was established based on track records of catches from the late 1970s. Within the UK, these quotas are allocated on the basis of 'Fixed Quota Allocations' (FQAs) which, in turn, are based on catch track records from the late 1990s. This means that initial quota allocations are fixed based on fishing practices and stock conditions which may no longer be comparable with current conditions.

- To get around the problems associated with quota allocations being based on past fishing practices, a system of quota trading within the UK, and between the UK and other EU Member States has developed. This allows vessels some flexibility to match

their quota holdings to what they are actually catching. This has led to pattern of quota trading that is relatively consistent from year to year for a given stock.

- A review of the patterns of quota allocation and trading for the main North Sea demersal stocks is used to identify key risk factors for choke that are associated with the quota allocation process. The main risk issues arise where the UK allocation of a given stock is relatively small and/or there have been substantial changes in the stock or fishery since the quota shares were established.

- The hake in the North Sea form part of the widely distributed Northern hake stock and make a useful case study of the risk factors associated with choke. The stock is subject to a full analytical assessment, and is fished at below its sustainability target level, so these factors are low risk in terms of their potential of contributing to choke. On the other hand, the amount of the total catch allocated to the North Sea is relatively small, as is the share allocated to the UK. This is against the background of a large increase in abundance of the stock, a northward shift in its distribution and changes in fishing practice by the fleet so they fish in deeper water than previously. All this means that vessels in the northern North Sea now encounter much higher abundances of hake than would have been the case when relative stability shares were established. This leads to a high choke risk and a high degree of trading-in quota from elsewhere.

- The Fcube mixed-fishery modelling works by translating scientific advice on catches into the amount of effort it would take each fleet to take its quota share of the total catch. The model was adapted so that it could be used to look at the process of quota allocation and trading. Two runs were made to compare the current situation of quota trading against a hypothetical case where no trading occurred. The results of these runs indicate that the current system of quota trading is rather effective in mitigating choke risk.

- The work on the identification of choke risk factors for North Sea stocks summarised here is no being applied more generally to develop a risk framework for the identification of choke risks across all stocks of UK interest. This will allow both the highest risk stocks to be identified as well as the potential causes of any choke problems

- Future research could extend the risk framework by addressing the biological aspects of a stock which influence its potential choke risk. This would be of long-term relevance in relation to issues like fleet capacity and sustainable exploitation.

Table of contents

1 Project overview

1.1 Project details

The following report summarises work done under contract to Fisheries Innovation Scotland, project reference FIS012a "Quota management and choke species in mixed-fisheries".

The project had the following objectives:

1. To describe the current system of quota allocation and trading within Scotland and evaluate the extent of flexibility. This will be completed by the end of month 2 of the project.

2. To develop and implement the Fcube mixed-fishery model for the North Sea in order to permit a detailed evaluation of the potential for managing quota shares to balance fishing opportunities with catches in mixed fisheries. This will be completed by the end of month 4 of the project.

3. To run a number of different quota allocation scenarios in order to evaluate the contribution they could make to reducing the extent of the choke species issue for Scottish vessels. This will be completed by the end of month 6 of the project.

There were some differences between these initial objectives and the project's eventual results. These are discussed in Section 6.3.

1.2 Project timeline

A kick-off meeting was held in Edinburgh on 27 April.

In order to help improve understanding of how the quota allocation and management process operates, both in Scotland and UK-wide, the project leader had meetings with the Marine Scotland quota management team and the Chief Executive of the Scottish Fishermen's Organisation. These took place in Edinburgh on 24 May. He also had a meeting with the Defra quota management team in London on 1 June. The information gained from these discussions forms the basis of Sections 4.2 and 4.3 of this report.

The project leader participated in the FIS Scottish Fisheries Workshop in St Andrews over 22-23 August. There he ran a stakeholder workshop where he presented and discussed some project results and sought input on a number of questions related to quota allocation.

Some results from the project were presented and discussed at the ICES Working Group on Mixed Fisheries Advice Methodology in Copenhagen on 13 October. Results from the project also formed the basis of an invited presentation on 'Identifying choke' at the North Sea Advisory Council symposium on choke avoidance measures in Copenhagen on 2 November.

Comments on the report were received in early February 2017, and the report was amended to take account of these comments and resubmitted at the end of March 2017.

2 Introduction

Most demersal fish species are caught together in mixed fisheries. This often means that the mix of fish species encountered by the vessel doesn't match-up with the quota shares they have for those stocks. Previously, vessels were able to address this by discarding over-quota catches, but the introduction of the landing obligation to EU fisheries (EC, 2013) will remove this possibility for stocks subject to Total Allowable Catches (TACs). Instead, vessels will be required to stop fishing where they may catch a stock for which they have exhausted their quota. In effect, the first quota to be exhausted can 'choke-off' fishing possibilities for other stocks caught in the same fishery, hence this is known as the 'choke-species' problem.

The choke-species problem arises from the mismatch between the mix of species a vessel catches and the quota shares it has for those species. The mix of species that a vessel catches at any one time depends on the spatial and temporal distribution of the different species, which is variable and very difficult to predict on a fine enough scale to be relevant to the operation of fishing vessels. A vessel's quota shares depend both on how the TAC is set and also how it is allocated between and within nations. Broadly speaking, the mix of species a vessel catches can be attributed to operational decisions taken by the vessel skipper, whereas the quota shares it holds are a result of processes related to fishery management, that is TAC-setting and quota allocation. For this reason, the current study considers these latter processes in detail with a view to understanding the contribution they make to the choke species problem.

The intent of this study is to identify the risk factors associated with the choke-species problem for stocks of interest to the UK. This will be done through a detailed study of the TAC-setting and quota allocation processes for subset of these stocks, namely the main demersal stocks of the North Sea. This study will aim to identify the risk factors that are likely to contribute to the overall choke risk of each of these stocks. Mixed-fishery modelling will also be used to evaluate the extent to which the current quota allocation and trading system help mitigate the risk of choke occurring. The results of this study should then help the development of a risk framework that can be applied to further stocks in order to identify likely choke risks and help to manage these as these stocks become subject to the landing obligation.

3 Total Allowable Catches

3.1 Total Allowable Catches as a management measure

The primary purpose of Total Allowable Catch (TAC) in a fisheries management context is to place an upper limit on the amount of fish that can legally be removed from a given stock in a given year. By limiting the catch, the intention is to limit the number of fish killed by fishing, i.e. the fishing mortality. Generally, a TAC will be based on the results of a catch forecast where estimates of the recent population are projected forward under different assumptions about fishing mortality. This means that there is a direct link between a TAC and its estimated consequences for the stock, i.e. the level of fishing mortality it will lead to and the stock size that will result. Management objectives for a given stock will normally involve ensuring that the exploitation of that stock is sustainable in the long term, and this in turn will normally be specified in terms of reference values for fishing mortality and stock biomass. As a result, by setting appropriate TACs it is possible to adjust the level of exploitation on a stock towards the references levels. Within Europe, there is a general policy of ensuring that stocks are exploited in a way that is consistent with obtaining the Maximum Sustainable Yield (MSY) from the stock. In general, this means that management is intended to ensure that the fishing mortality on each stock is at or below the value of fishing mortality that will produce MSY. This value is known as F-MSY. Similarly, management acts to keep the spawning stock biomass (SSB) of each stock above its MSY trigger value (known as MSY B-trigger, or just B-trigger). Overall a TAC will generally be set in order to bring or maintain a stock within these reference points.

3.2 Scientific advice on catches

The starting point for setting TACs for commercial fish stocks is scientific advice on the state of each stock. For most stocks in EU waters, this advice is based on stock assessments which are performed under the auspices of the International Council for the Exploration of the Sea (ICES). Typically, this will involve fitting an assessment model to historic catch and survey data in order to reconstruct the history of the stock in terms of trends in stock biomass and recruitment and the fishing mortality that has been acting on the stock. Once this has been done, the estimated populations for the most recent year for which data are available are projected forward in order to provide a set of catch options for the year in question. The methodology behind these short-term catch forecasts is discussed in detail by Reeves & Pastoors (2007).

The catch options that result from the catch forecast are presented in the form of a table which lists the fishing mortality value used as the basis of each option, the estimated catch that will result from that fishing mortality, and the estimate of the spawning biomass of the stock that will remain at the end of the year. Some of the options included in the table are there to illustrate, for instance, the consequences of not fishing the stock, or fishing at the same level as the previous year. Other options will include, e.g. fishing at a level that corresponds to the agreed or advised MSY reference points or the fishing mortality that results from applying the rules set-out in a management plan that applies to the stock.

Depending on the state of the stock relative to any agreed or advised reference points, ICES will generally advise that the catch during the year in question should be no more than *X* tonnes. This advice is based on stock conservation considerations, usually involved with ensuring the long-term sustainability of the exploitation of the stock. Depending on past fishing practices, the catch forecast may also contain an estimate of the discards. i.e. on the basis of data from discard sampling in recent years, the forecast would estimate that a catch of *X*

tonnes would consist of *Y* tonnes of landings and *Z* tonnes of discards. With the advent of the landing obligation, the terminology used to describe these catch components has now changes so the ICES advice refers to 'wanted catch' and 'unwanted catch'.

3.3 Choke risks from TAC-setting

It is important to note that a TAC is a biological quantity. It is essentially a forecast of the weight of fish that can be removed from a stock in a given year in order that the proportion removed corresponds to the intended fishing mortality. A TAC is set to limit the quantity of fish removed from a stock rather than to provide the vessels exploiting the stock with sufficient fishing opportunities to last the year. The rate at which a TAC will be exhausted depends on how many vessels will be fishing for the stock and on the effectiveness of the gears they use and seasonal patterns in the fishery.

The choke-risk associated with a particular TAC cannot be fully identified in isolation of the TACs for other stocks caught in the same fishery. Nonetheless, a number of circumstances can be identified under which the TAC-setting process in itself may increase the risk of choke occurring. One is if a TAC is set for a given year in order to produce a substantial reduction in fishing mortality when compared to the previous year. As fishing mortality can be interpreted as the proportion of the stock that is removed by fishing each year this would imply that a TAC set to reduce fishing mortality would also mean a TAC that would be lower relative to stock abundance. This, in turn, which would increase the risk of the TAC being exhausted before the year end with the same level of fishing activity, and hence also the associated choke risk. As a result, if a stock is below its biomass trigger point or is currently being exploited above MSY, then there is also likely to be an increased choke risk associated with the stock.

TACs are derived from catch forecasts, which in turn are based on stock assessments which estimate the current state of the stock in terms its abundance and the level of fishing mortality it is subject to. Choking is less likely to occur if these catch forecasts are able to track changes in the abundance of the stock in order that that the relationship between TAC and stock abundance remains reasonably stable. This means that 'quality' of the stock assessment also contributes to choke risk, with a less precise or consistent assessment increasing choke risk. By extension, stocks which are subject to a precautionary TAC (i.e. a TAC which isn't based on an analytical stock assessment) and/or which are classified as data-limited, will also have a higher choke risk.

Discarding is a source of uncertainty in stock assessments as the data on removals from the stock through discarding are generally of lower precision than estimates of landings due to lower sampling coverage. Thus stocks with a record of high or variable discarding are likely to have a higher choke risk. This will partly be due to the greater uncertainty in the input data to the stock assessment, but also because, as an interim measure while the landing obligation is phased in, TACs for some stocks are being adjusted to include 'uplifts' to account for fish that would previously have been discarded, but which now will have to be landed. These adjustments lead to increased uncertainty being incorporated in the resultant TAC, both because of the lower precision of the discard data, and because of potential problems with allocating the uplifts to the relevant fleets, which may not be the case if the uplifts are allocated according to relative stability.

While a TAC is set to limit removals from a given stock, there are sometimes additional constraints on where or when these fish may be caught. In particular, in cases where the total catch from a given stock is partitioned into different TACs to be taken from different areas. Under these circumstances, depending on how the partitioning is made, there can be a risk that the TACs are more restrictive in some areas than in others. An example of this would be

where partitioning is based on relative catches over some historic reference period and subsequent changes to stock distribution mean that the original partitioning is no longer representative of the current stock distribution.

3.4 Setting TACs for North Sea stocks

The annual TAC is the starting point for determining the fishing opportunities available for each stock. For this reason, this section is intended to give some background to the basis for which TACs are set for each of the main North Sea stocks considered here. In all cases, TACs are based on scientific advice provided by ICES, but the background to the advice differs from stock to stock for a variety of reasons. Some of the differences arise from the distribution of the fish populations in relation to the North Sea area. Some stocks are not confined to the North Sea (ICES sub-area IV) but also extend into adjacent waters such as the Skagerrak (ICES Division IIIa North) and the Eastern Channel (ICES Division VIId). Where this is the case, scientific advice is based on a stock assessment covering all of the relevant areas. The assessment leads to an advised total catch that can be taken from the overall stock, hence setting separate area TACs requires that the total catch is partitioned between the different areas. This is typically done using fixed percentages that are based on catches during a past reference period. The specific details for each stock are described below. The status of each stock in these summaries is based on the most recent ICES scientific advice (ICES, 2015, 2016).

3.4.1 Cod

As the most high-profile stock in the North Sea, the cod stock has been a major driver for fisheries management in the North Sea since at least 2000. At that time the stock had fallen to such a low level that ICES advised that no fishery on the stock should take place and that a long-term management plan should be implemented to ensure the rebuilding of the stock. Subsequent to this, a management plan was introduced which involved restrictions on fishing effort and also low TACs which were intended to reduce fishing mortality on the stock to a sustainable level and to allow the stock to increase above its limit biomass reference point. Overall, this initial management plan and its successors have led to a substantial reduction in the number of vessels exploiting the demersal fisheries of the North Sea and to changes in how these vessels operate. The current EU management plan is given in EC (2008), but as the stock is shared between the EU and Norway, the elements of the plan that determine how the TAC is set are also written in to an agreement between the EU and Norway.

Recent stock trends for North Sea cod are shown in Figure 3-1. Management in recent years has been aimed at rebuilding the stock's spawning biomass above the trigger level of 165,000t and reducing fishing mortality to a level of 0.4. Since the latter value was established, ICES has revised its estimate of F-MSY for the stock down to 0.35, but TACs have still been set on the basis of an F of 0.4 as this is the value that is written into the relevant legislation. In recent years fishing mortality has been close to the 0.4 management target, and spawning biomass has increased slowly to just below the trigger value.

Cod in the North Sea and the adjacent waters of the Skagerrak and the Eastern Channel are considered to form a single biological population hence the assessment combines catches from these three areas into one stock area. However, TACs are set separately with an overall forecast catch being split so that 83% of the catch is allocated to the North Sea, 12% to the Skagerrak, and 5% to the Eastern Channel.

Recent discard data for the stock imply an overall mean discard rate of 18.4% by weight.

3.4.2 Haddock

Haddock in the North Sea and Skagerrak (ICES sub-area IV and Division IIIaN) were previously treated as a separate stock from haddock to the west of Scotland (ICES Division VIa), but following a review in 2014, they are now considered to form a single biological unit and are assessed as such. Recent trends in the North Sea and West of Scotland haddock stock are shown in Figure 3-2. The North Sea stock was previously managed under an EU-Norway agreement but this has not been updated since the stock was merged with the West of Scotland component. ICES management advice is based around maintaining the spawning stock above a B-trigger value of 88,000t and maintaining fishing mortality at or below the MSY level of 0.37. Recent stock assessments have indicated that fishing mortality has been below the MSY value since 2008 and spawning stock biomass has been above the MSY trigger level since 2007. However, the stock shows substantial fluctuations due to the influence of occasional strong year classes, and the most recent (2016) stock assessment indicates a recent change in status such that SSB is now below the MSY trigger value and fishing mortality is above the MSY value.

Prior to the combining of the two haddock stock, the TAC for the North Sea stock was split so that 94% was allocated to the North Sea with the remaining 6% allocated to the Skagerrak. For the new, combined-area stock the split of the catches has been agreed as 9.5% allocated to Division VIa, and the remaining 90.5% to the North Sea and Skagerrak, split 94:6 as previously.

The most recent catch forecast for the stock uses a recent mean discard rate of 17.3%

3.4.3 Whiting

Whiting in the North Sea and the Eastern Channel are considered to form a single biological population. Recent trends in this stock are shown in Figure 3-3. As the stock is shared between the EU and Norway it was, until recently, managed under an EU-Norway agreement. However, the model used to assess the stock was reviewed in 2016, in particular, changes were made to the assumptions about natural mortality acting on the stock. Following these changes, the harvest control rule contained within the EU-Norway agreement is considered no longer appropriate.

ICES advice for the North Sea whiting is intended to ensure the spawning stock remains above the MSY trigger level of 242,000t and that fishing mortality is at or below the MSY level of 0.15. In practice, spawning biomass has fluctuated around the MSY trigger level in recent years, and fishing mortality has been slightly above the MSY level.

The overall catch from the stock is partitioned so that 80% is allocated to the North Sea, and the remaining 20% to the Eastern Channel (ICES Division VIId). However, the TAC for whiting in the latter area forms part of a larger TAC-area covering the whole of Sub-Area VII (i.e. the Channel and the Celtic Sea) excluding Division VIIa (the Irish Sea). In practice, this means that the catches of whiting taken in the Eastern Channel could legally exceed the quantity implied by the quantity allocated from the North Sea/Eastern Channel catch forecast.

The recent mean overall discard rate for this stock is 38.4% by weight.

3.4.4 Saithe

Saithe is a relatively large and mobile species and the population that is found from the Skagerrak, across the Northern North Sea and West of Scotland as far as the Rockall Plateau

is regarded as a single biological stock. Recent trends in this stock are shown in Figure 3-4. The stock is managed under an EU-Norway management plan with a target fishing mortality of 0.3 and a spawning biomass trigger value of 200,000t. A recent ICES review of the stock assessment model has resulted in a slightly higher estimate of F-MSY (0.36) and a lower estimate of B-trigger (150,000t). On the basis of these values, fishing mortality on the stock has been below the MSY level since 2013 and spawning biomass has been above the MSY trigger level since 1997.

The total catch of saithe is partitioned between two TAC areas so that 90.6% is allocated to the North Sea and Skagerrak and the remaining 9.4% to the areas West of Scotland.

Discard date for this stock suggest than in recent years an average of 4.8% of the catch has been discarded.

3.4.5 Plaice

The North Sea plaice stock is managed in combination with the North Sea sole stock through an EU plaice and sole management plan (EC, 2007). Since the implementation of the plan, fishing mortality on the stock has shown a steady decline and it is now close to the estimated MSY value of 0.19 (Figure 3-5). This decrease in fishing mortality has resulted in a substantial increase in stock size to well above previously observed levels. Total catches in recent years have been less than the TAC.

There has been a recent change in the way that North Sea plaice are treated for assessment purposes as plaice in the Skagerrak are now considered to form part of the same stock as North Sea plaice. As a result, since 2016 the ICES stock assessment now covers plaice in both of these areas. It is not clear if a fixed partition of the TAC between the two years has been established, but in 2016, the North Sea TAC amounted to 92% of the combined TACs across the two areas.

The recent mean discard rate for this stock is 23.2%.

3.4.6 Sole

As with the plaice stock, the North Sea sole stock is managed through the long-term management plan for plaice and sole documented in EC (2007). Fishing mortality has shown a similar declining trend to that of plaice, to the extent that it is now close to the MSY level of 0.2. Spawning stock biomass has shown a recent increase and has been above the MSY trigger level of 37,000t since 2012. Stock trends are shown in Figure 3-6.

Sole in the North Sea are regarded as a separate stock from sole in adjacent waters so the TAC does not raise any issues of partitioning between areas.

Recent discard data suggest that on average 7% of the sole catch is discarded.

3.4.7 Hake

Hake caught in the North Sea are regarded as part of the Northern hake stock. This stock is found in Atlantic waters from the north coast of Spain up to the Northern North Sea, including waters to the west and south of the British Isles. A recovery plan was implemented for the stock in 2004 (EC, 2004). However, this is no longer considered current as it is based on reference points which have subsequently been revised by ICES. In addition, the stock has

shown a substantial recovery since the late 2000s as fishing mortality has shown a steady decrease to the point where it is now slightly below the MSY level (Figure 3-7). This decrease in fishing pressure has been accompanied by a large increase in spawning biomass to levels well above what had been previously observed for the stock. This increase in abundance has been accompanied by changes in distribution of the stock. In particular, there has been a marked increase in the abundance in the Northern North Sea. This effect is rather seasonal as it is limited to the months from April to September (Baudron & Fernandez, 2015).

The large area occupied by the Northern Hake stock means that the overall total catch resulting from the annual scientific advice needs to be partitioned across a number of different TAC areas. The partitioning is as follows: ICES Division IIIa: 3.01%; North Sea: 3.51%; ICES sub-areas VI, VIII, XII & XIV: 56.08%; ICES sub-area VIII: 37.4%.

In view of the small proportion of the overall catch allocated to the North Sea, it may be useful to look at the catch history in the different areas to try and understand the basis for the partitioning between the different areas for this stock. Figure 3-8 compares officially reported catches of hake for each of the TAC areas with percentages allocated to each of these areas. Based on these data, the percentage of the Northern Hake catch taken in the North Sea only fell below the allocated figure of 3.51% in on year: 1984 when North Sea catches accounted for 3.4% of the total. On average over 1950 to 2010, 5.91% of the total catch of Northern Hake was taken in the North Sea. This brief analysis indicates that the basis for partitioning of the Northern Hake TAC between areas is not clear but it does not appear to have been based on reported catches from the different areas. Further, the result of the partitioning is that the North Sea allocation is lower than it would have been had it have been based on historic catch data.

The recent discard data included in the catch forecast for hake imply that around 8.6% of the catch in weight is discarded.

3.4.8 Norway Lobster

Norway lobster (*Nephrops norvegicus*), which is widely known by its generic name of Nephrops*,* lives in burrows in the seabed so its distribution in the North Sea is limited to areas with appropriate muddy sediment where it can dig these burrows. The animals are sedentary and there is thought to be little or no connection between different populations within the North Sea. For this reason, Nephrops within the North Sea are treated as a set of discrete sub-populations know as Functional Units (FUs – see Figure 3-9). ICES provides scientific advice for each of these separately. Because of the sedentary behaviour and because it is not possible to determine the age of individuals, the stock assessment methodology used for most North Sea stocks cannot be used for Nephrops. The more important FUs are surveyed using remote cameras to survey the grounds so that a count of burrows can be used as an estimate of population abundance, and this information is used as the basis of catch advice for these units. For other FUs, the advice is typically based on maintaining the recent level of landings.

The status of the different sub-populations differs from FU to FU. The Farn Deeps (FU 6), which is the area which has produced the highest landings in recent years, is estimated to be both overfished with respect to MSY, and have an abundance below the MSY trigger level. The harvest rate of the large Fladen Ground unit (FU 7) is estimated to be below the MSY level, although abundance has recently dropped below the MSY trigger level. The opposite situation is the case for the Firth of Forth population, where the harvest rate is close to, but below, the MSY level, whereas stock abundance is relatively high. The Moray Firth population is estimated to be both harvested sustainably and above the trigger biomass level. No quantitative information is available on the states of the populations in other Functional Units.

Reflecting the different states of the Nephrops sub-populations within the North Sea, ICES has long advised that management should be applied at the Functional Unit level in order to minimise the risk of transfer off effort between units leading to over-fishing. This recommendation has not yet been implemented as the North Sea TAC is derived from the sum of the advised catches from each FU, with no restrictions on where the catch may be taken from.

Discarding of Nephrops is variable by Functional Unit, but recent data for the most commercial important FUs show discard rates of between 0.3% and 14%.

3.5 TAC setting for North Sea stocks – conclusions

For most of the North Sea demersal stocks considered above, recent fishing mortality is at or close to the specified MSY value or management plan target value and spawning biomass is close to or above the MSY trigger value. One consequence of this is that future TACs are likely to be set to correspond to a similar level of fishing mortality. As fishing mortality can be interpreted as the proportion of the stock that is removed by fishing each year, setting a TAC on the basis of a fixed fishing mortality has the advantage that the ratio between the TAC and stock abundance should be comparable from year to year. In contrast, if a TAC was set in order to reduce fishing mortality relative to the previous year, then this would also imply a TAC set lower relative to stock abundance, which would increase the risk of the TAC being exhausted before the year end, and hence also the associated choke risk.

The Nephrops populations are an exception to the general trend of North Sea stocks being fished close to MSY. However, as the TAC is set as the sum of the advised catches across the different functional units, the net result is that the overall TAC is not limiting given the concentration of fishing on some of the smaller FUs.

Although the Northern stock of hake is now fished at below its MSY target, a number of other factors contribute to the TAC in the North Sea being set at a low level when compared to the abundance of hake encountered by vessels fishing in the relevant areas of the Northern North Sea. The stock covers a much larger area than just the North Sea, but only 3.5% of the total TAC is allocated to the North Sea, a portion that is low compared to the historic track record. At the same time there has been a clear increase in the relative abundance of hake in the Northern North Sea, beyond what would be expected due to the increasing stock size. The situation is exacerbated by the fact that UK vessels, who constitute the main fleet active in the areas of the Northern North Sea where hake are now abundant, receive a relatively small allocation of the North Sea hake TAC.

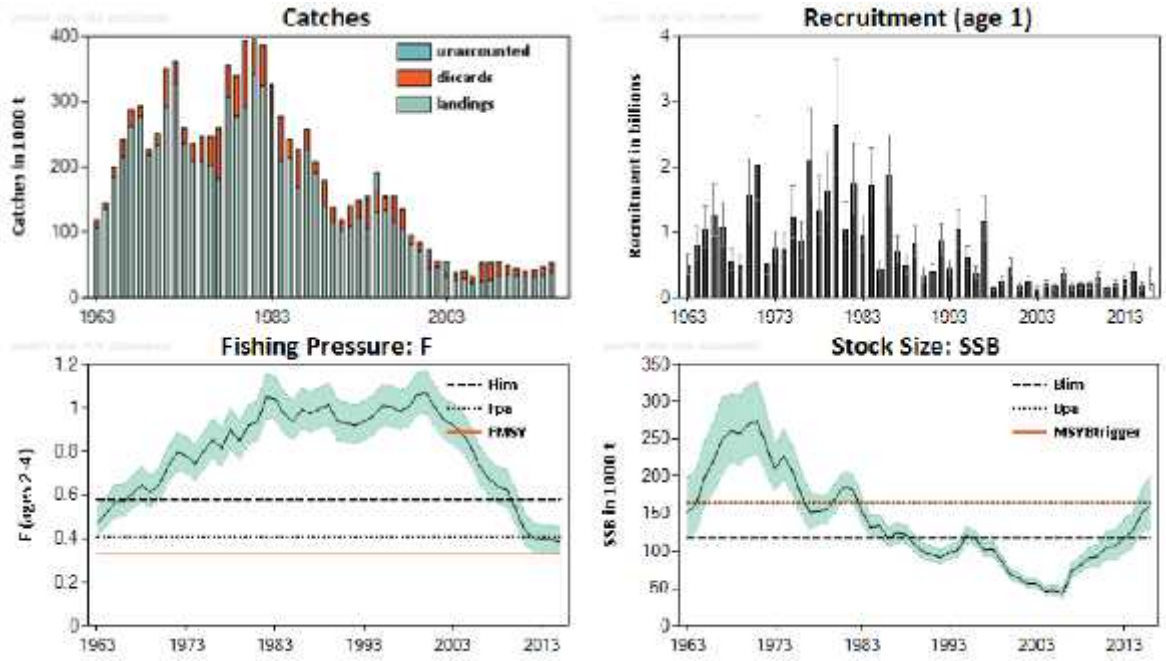


Figure 3-1; Stock trends in North Sea cod. From ICES (2016)

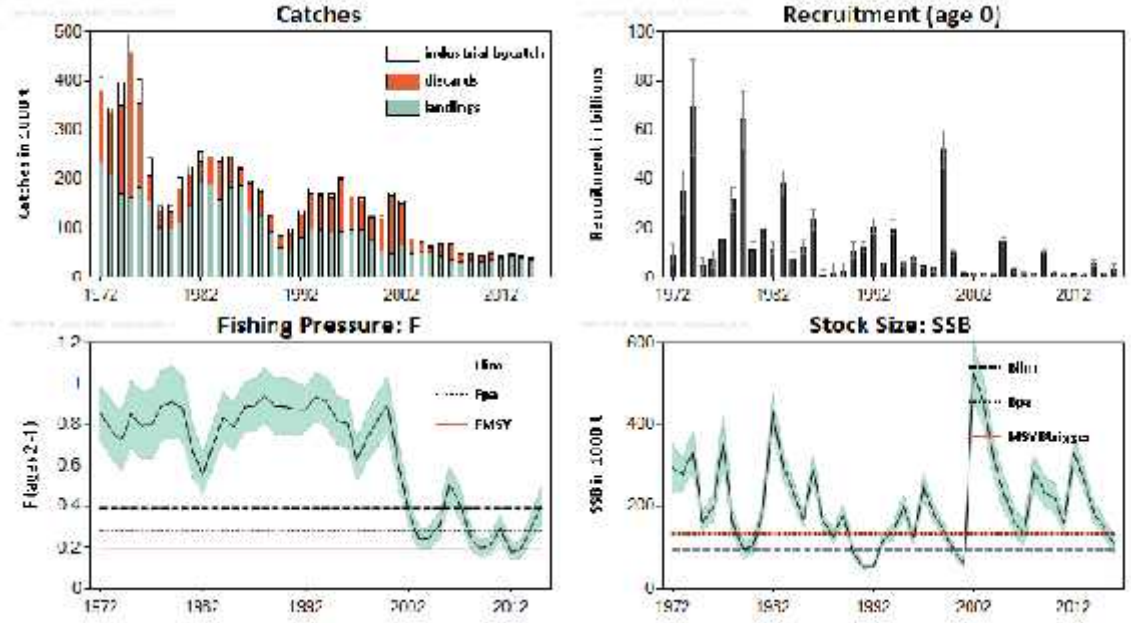


Figure 3-2; Stock trends of North Sea haddock, From ICES (2016).

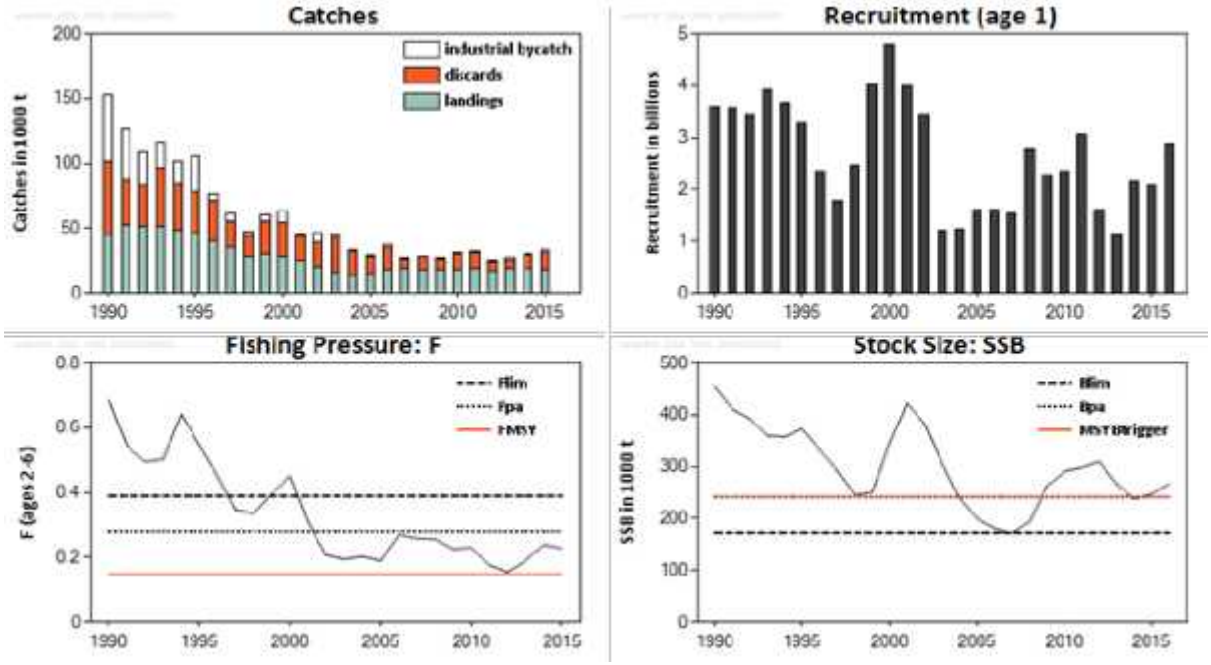


Figure 3-3; Stock trends in North Sea whiting. From ICES (2016).

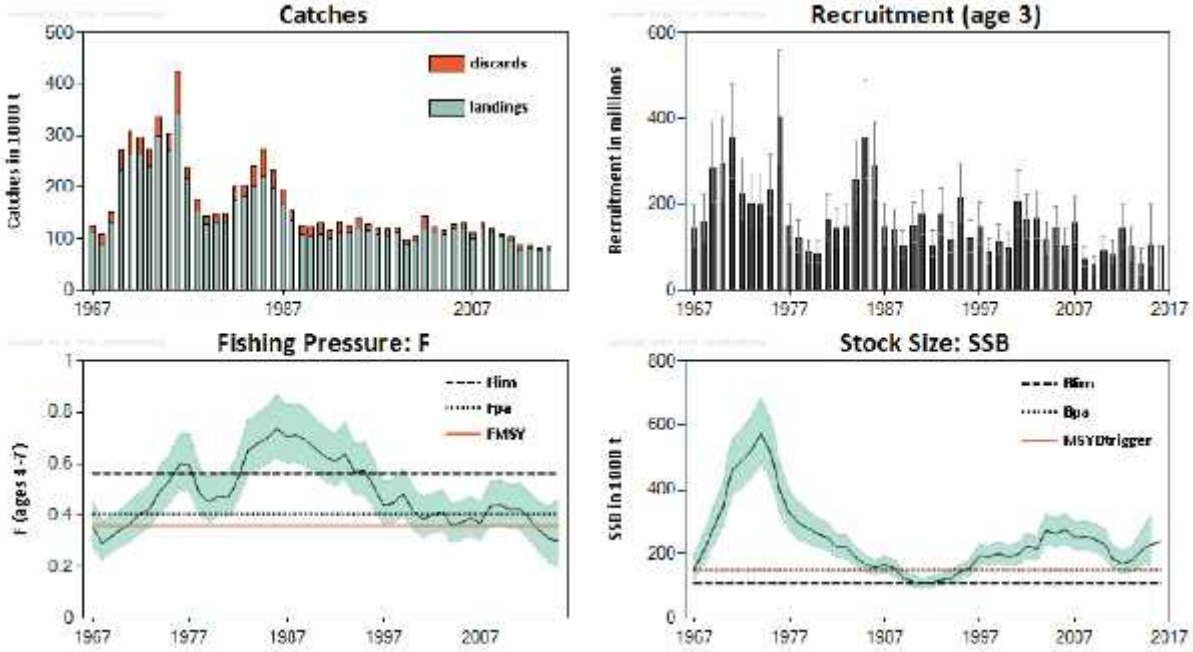


Figure 3-4; Stock trends in North Sea saithe. From ICES (2016).

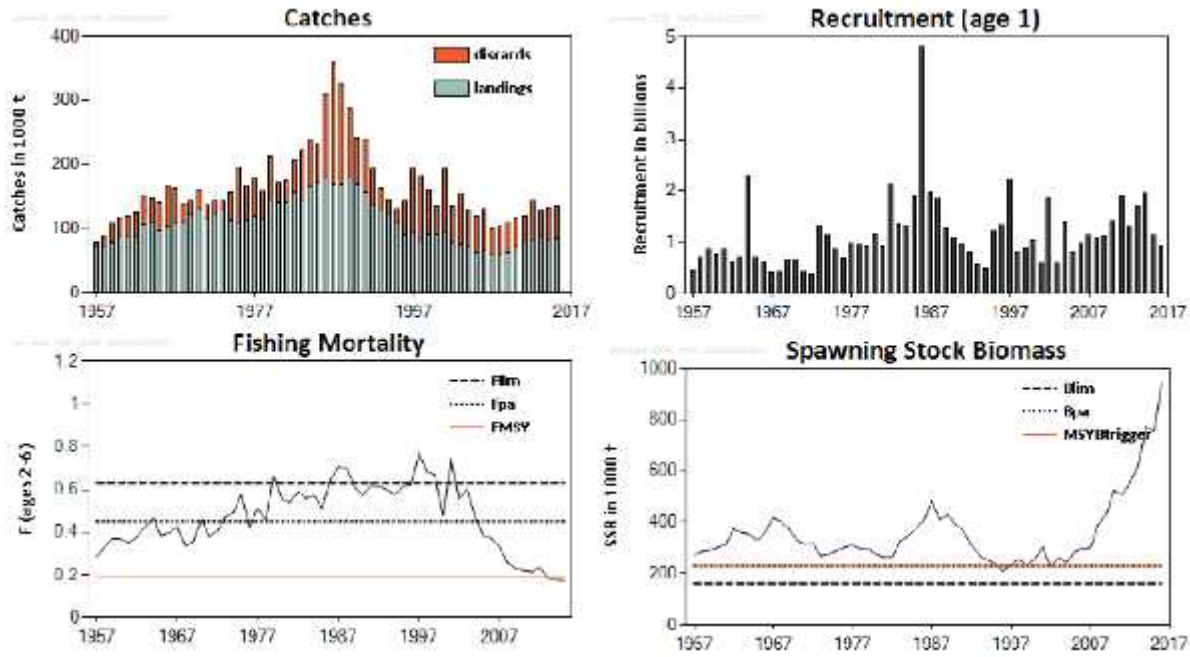


Figure 3-5; Stock trends in North Sea plaice. From ICES (2016).

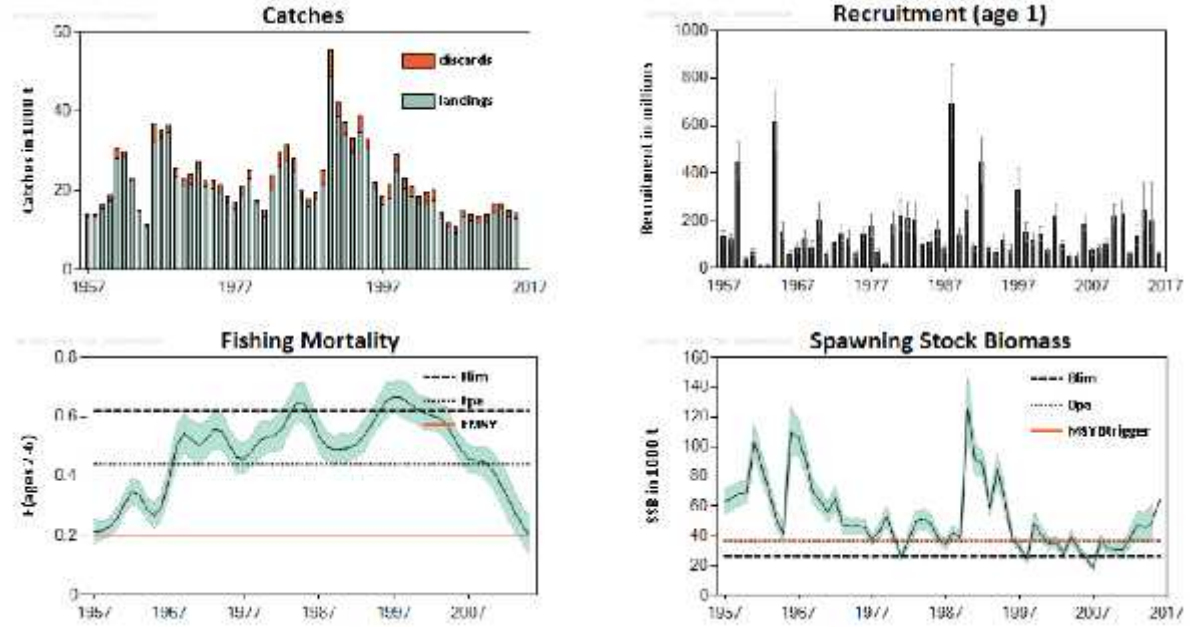


Figure 3-6; Stock trends in North Sea sole. From ICES (2016).

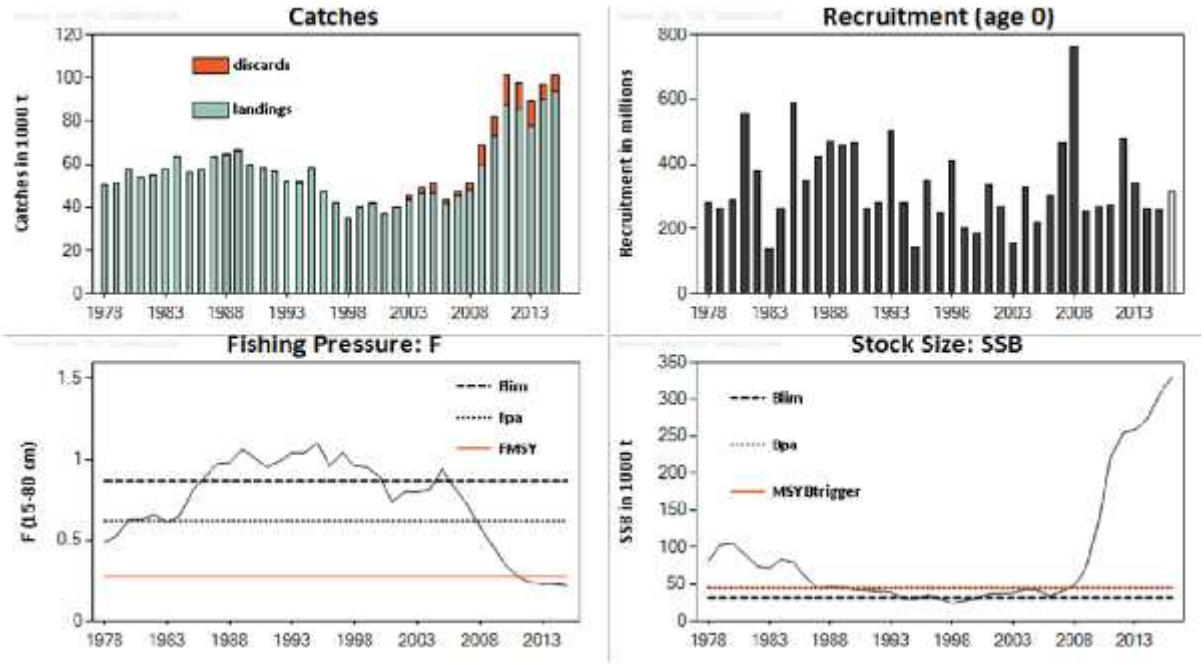


Figure 3-7; Stock trends in Northern Hake. From ICES (2016).

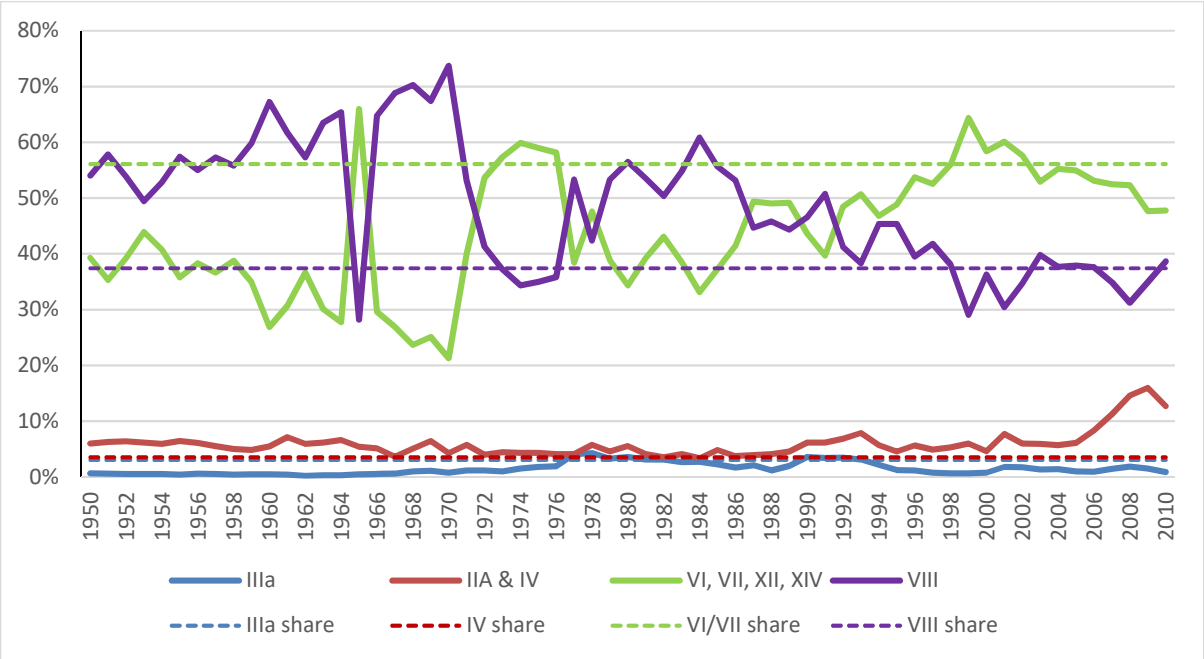


Figure 3-8; Northern Hake. Breakdown of catches showing percentage reported from each TAC area and the share of the TAC allocated to each area. Based on data on reported catches downloaded from www.ices.org.

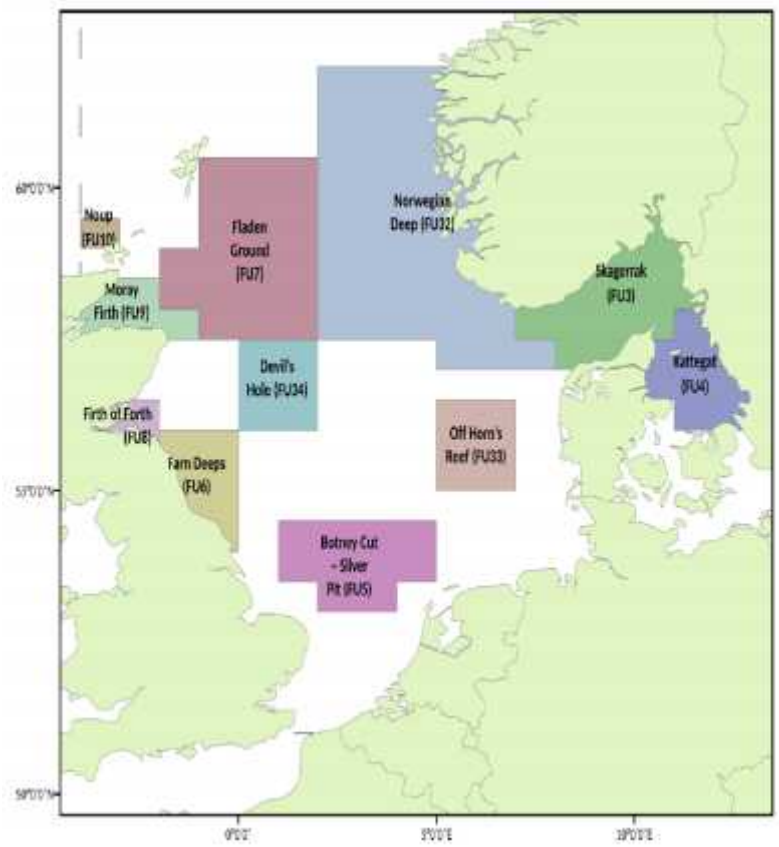


Figure 3-9; The North Sea showing Nephrops Functional Units. From ICES (2016).

4 From TACs to fishing opportunities – allocation and relative stability in EU fisheries

In addition to their role as a fishery management measure, within the context of the European Union (EU), TACs also serve as a measure of fishing opportunities which can then be divided among the various member states with an interest in the relevant fishery. The original intention was as much as possible to allow states stability of fishing opportunities from one year to the next. However, it was also recognised that fish populations were subject to natural variation so that it would not be possible to guarantee fixed quantities of fish each year, so fishing opportunities were set as fixed percentages of TACs rather than as fixed tonnages. This has led to the principle of 'relative stability' whereby each EU stock subject to a TAC has a fixed allocation key which determines what percentage of the annual TAC different member states receive.

The principle of relative stability dates from 1983 (EC, 1983; Holden, 1994) and the starting point for the establishment of the allocation keys that were established at that time were the historic catches by each member state over the reference period 1973-1978. An additional complexity arose from the agreement to make special provisions for areas considered to be heavily dependent on fishing. This applied to Ireland, 'Northern Britain' (see below), and at that time also Greenland. This required the allocation of additional quantities of fish to these areas to reflect their 'vital needs' in this respect. These became known as 'Hague preferences', after negotiations that took place in The Hague in 1976 during the early stages of the development of the EU's Common Fisheries Policy (CFP). The additional catches allocated due to Hague preference were based on reported landings in the reference year of 1975. For Ireland the Hague preference was defined as twice the country's reported landings of a given stock in 1975, whereas for 'Northern Britain' the Hague preference was based on reported landings by vessels of up to 24 metres in length in ports in Northern Ireland, Scotland and the English East coast as far south as Bridlington. Holden (1994) gives a detailed description of how the allocation process worked at that stage, but in short the Hague preference system meant that the UK and Ireland received higher shares of some TACs than would otherwise have been the case. The allocation calculations were done on the basis of groups of species using the value of each species relative to cod (the 'cod-equivalent' approach) as an exchange rate. This meant that there was some negotiation of the extent to which the increased quota allocations would apply to different stocks, with a tendency to push for increase shares of stocks that were considered desirable at the time at the expense of other stocks.

The original intention of Hague preferences was to make special provisions for areas that were heavily dependent on fishing, and this provision still exists for the UK and Ireland through the possibility to claim higher proportions of the TAC of certain stocks, if the TAC falls below a specified threshold level. The precise origin of the threshold values in use is unclear, but the threshold TACs are generally high relative to recent levels, so they presumably date from the late 1970s when most stocks were at much higher levels than are currently observed. This means that in principle it would have been possible for the UK and Ireland to invoke Hague preference in most recent years, and in recent years the UK has routinely invoked Hague Preference for North Sea haddock and whiting. One complication is that the Irish Hague preference share is often larger than the UK one for stocks that both nations exploit. This means that if both the UK and Ireland invoke Hague preference, this can lead to the UK receiving a small quota share than would otherwise have been the case. This may have contributed to the reluctance to invoke this option.

In summary, the UK shares of the TACs on the main North Sea stocks are based on the shares of the catches taken in the late 1970s, with some uplift due to the relative importance of fisheries to parts of the UK. The negotiation process meant that this additional component would have been allocated to stocks that were considered most desirable at that time, including the traditional North Sea stocks.

4.1 From scientific advice to fishing opportunities

Historically, the scientific advice provided by ICES has been used as the starting point for negotiations which lead to the final agreement on the TAC for a given stock. For the North Sea stocks this negotiation takes place either in meetings between the EU and Norway (for shared stocks) or within the meetings of the EU Council of Ministers. While some element of negotiation remains for some stocks, the introduction of a policy of achieving MSY and the increasing implementation of multi-annual management plans has meant that the TACs for most stocks are now determined using pre-agreed algorithms based on the state of the stock relative to its MSY reference points.

The negotiations that take place between the EU and Norway to establish TACs for shared stocks sometimes also involve the trading of quota between the two parties. In recent years at least this has involved relatively small quantities of fish. The quantities vary from year but since 2012 these swaps have resulted in the EU receiving up to 2600t of haddock and 750 tonnes of whiting from Norway (EU/Norway, 2015). In return Norway has received between 250 and 300 tonnes of saithe. These quantities have amounted to up to 6.8% of the overall TAC for haddock, 5.5% of the overall whiting TAC and 0.5% of the saithe TAC.

The overall effect of this trading is to change the total amount of each of these stocks available to the EU. This quantity is then divided between Member States according to the fixed allocation key that results from relative stability. These figures are published annually as EU regulations which specify the overall TACs for each stock and how these are divided between Member States as national quotas. The regulations are described as “fixing the fishing opportunities” for the relevant stocks – see, for example, EC (2015) for 2015 TACs - hence the use here of the term ‘fishing opportunities’.

4.2 Allocation within the UK

While the UK share of any TAC is the main source of quota for a given stock, in a few cases this is augmented with additional quota from other sources. The so-called ‘banking and borrowing’ provisions (EC, 1996) apply in the case of under-utilised quota from the previous year, and allow up to ten percent of that year’s quota to be transferred to the following year. In addition, some vessels, known as ‘flag vessels’ are licensed in the UK but are foreign-owned. These vessels are required to meet certain local connection requirements i.e. using local crew or landing into the UK or donating quota to the UK. North Sea sole is the main stock where there is a contribution through donated quota.

The basis for the allocation of quota to vessels and fishing operators is a system known as Fixed Quota Allocations or FQAs. These are based on a track record period which in most cases was 1994 to 1996 so that vessels were allocated one FQA unit for a given stock for each kg they landed of that stock during the reference period. Only limited trading of FQAs has been possible since 2002, as any trading has required buying the licence of the vessel holding the FQAs.

Since 2012 the allocation of quota within the UK has reflected increased devolution with quota shares first being allocated to the Fisheries Administrations (FAs, i.e. Defra in England, the

Scottish and Welsh Governments and the Department of Agriculture and Rural Development in Northern Ireland) in order to allow these administrations some independence in how they allocate quota. For some specific fisheries, typically small scale pelagic fisheries such as the southwest mackerel handline fishery, an initial allocation is made before the split between FAs, and there are also under-pinning arrangements in place to ensure minimum allocations of quota for some stocks to under-10 metre vessels and to non-sector vessels (i.e. vessels that are not members of a PO). Once these initial allocations have been made, the quota share for a given stock allocated to each FA is based on the proportion of FQAs for that stock that are either held by vessels administered through the ports of that administration, or allocated to dummy licences that are held by Producers' Organisations (POs) under that administration. At this stage each FA then has the option to further top-slice the quota, e.g. to make additional allocations to its own non-sector vessels, before allocating the remaining quota to its POs.

4.3 Producers' Organisations and quota trading

Under the existing UK system, quotas are allocated to Fish Producers' Organisations on the basis of the FQAs held by vessels that are members of that PO or held against dummy licenses held by that PO. How the quotas are then allocated to the member vessels varies from PO to PO. In some cases, the initial quota is allocated according to the FQA holdings of each vessel; in other cases, the quota is pooled and then allocated to each member vessel, typically on a monthly basis. Intermediates between these two approaches also exist. However, the key to how POs operate is the existence of an active system of trading of quota both within the UK and between the UK and other EU Member States.

The EU CFP permits trading of quota between Member States (EC, 2013) and while this trading is administered by the relevant Fisheries Administrations, in practice the trading operates between POs and the equivalent organisations in other Member States. A similar situation applies within the UK. The FAs administer the system on a 'hands-off' basis, with the idea being to permit the fishing industry to solve their problems between themselves as much as possible. The result has been the evolution of a trading system which allows POs some flexibility to adapt their fishing opportunities to their catches. This is an active and dynamic process with most POs employing one or two full-time quota traders to ensure their vessels have sufficient quota to continue fishing throughout the year if possible.

4.4 Choke risks from quota allocation

The background and history of the existing quota sharing and allocation process means that the system has a lot of inertia as the share of the TAC allocated to the UK is based on fishing practices and political priorities during the late 1970s as enshrined in the principle of relative stability, and the initial allocation to vessels is based on the system of FQAs which in turn are based on what vessels caught during the mid-1990s. North Sea demersal stocks have shown substantial changes in abundance and, in some cases, also distribution since the late 1970s, and there have also been changes in the nature and activities of the fishing fleets that exploit those stocks which means that allocations based on the situation in the late 1970s are unlikely to reflect the current situation.

The legacy of having fixed allocation systems based on historic reference periods means that the risk of choking is inherent to the system. However, the possibility of trading quota both between POs within the UK and between Member States within the EU offers a mechanism which allows for some flexibility for vessels to match their quota holdings to their catches. In effect, this trading allows vessels to mitigate the risk of choking by trading-in additional quota to match what they are catching.

Figure 4-1 gives a schematic representation of the TAC-setting and quota allocation and trading process for North Sea stocks.

4.5 Quota allocation and trading at the stock level: North Sea demersal stocks

4.5.1 Data

To gain a more detailed understanding of the issues associated with quota availability and allocation, the following sections consider key North Sea stocks with particular regard to quotas and their allocation. The following analysis is based on data provided by the UK Marine Management Organisation (MMO). The data consist of the initial and 'adapted' quota allocations for each UK PO for the years 2012 to 2015. The initial allocations are the allocations made to each PO at the beginning of the TAC year based on their FQA holdings. The 'adapted' quota allocations are the quota allocations held by each PO at the end of the year, i.e. they are the result of the initial holdings as modified by any subsequent trading and transfers. The data are annual totals; no detail was provided on individual transactions. Where the total adapted UK quota for a given stock differs from the initial total the difference (the 'adaptation') is here assumed to be mainly due to trading with other EU Member States; exceptions to this are mentioned in the individual stock accounts. The data also allow estimation of the extent of trading within the UK.

As a background to the following sections, Figure 4-2 shows the agreed quota allocations (i.e. EU relative stability shares plus the agreed allocation to Norway where relevant, of the main North Sea demersal stocks. Figure 4-3 shows the 'adaptations', i.e. the difference between initial and adapted UK quotas for these stocks, expressed as a percentage difference from the initial quota. Figure 4-4 shows the composition of the adapted 2015 quotas for the major North Sea demersal stocks. This shows the extent of trading for each stock both within the UK and with other EU Member States. Figure 4-5 shows the same information in percentage terms.

4.5.2 Cod

The UK allocation of cod quota amounts to 39% of the overall North Sea cod TAC. This means that the UK holds the largest share. The next largest shares are held by Denmark and Norway who each have around 17% of the TAC. Over 2012 to 2015 the initial UK allocation of North Sea cod quota ranged from 10,300t to 11,400t. After trading, this was increased to between 12,200 and 14,800t. On average, over 2012-1215, trading with other EU Member States led, on average, to a 25.5% increase in the UK cod quota. There is also some trading of quota within the UK; 6.8% of the 2015 UK landings were made against quota that had been traded within the UK. At the same time, about 70% of landings were made against quota that remained with the PO it was initially allocated to. Most of the trading-in of quota (i.e. obtaining quota from other EU Member States) is made by POs that are based in Scotland and there is also a net movement of quota from POs based in England to POs based in Scotland, though the extent of this varies from year to year.

4.5.3 Haddock

The UK relative stability share for North Sea haddock amounts to 77.6% of the EU catch; the result of invoking Hague Preference is to increase this figure to 84.2% bringing the total UK allocation to 64.8% once the Norwegian share is accounted for. Norway holds a further 23% with no other state holding more than 5%. Over 2012-2015, the UK quota was increased by an average of 7.9% due to trading-in of quota. In some years, including 2015, the EU share

of the haddock TAC is increased by trading with Norway. As the UK is allocated 84.2% of the EU share, in effect most of the quota traded-in from Norway come to the UK. In 2015, the level of trading within the UK was comparable with the level of trading with other EU Member States. The trading within the UK involves a net movement of quota from POs based in England to those based in Scotland. Similarly, most of the trading-in of quota is made by POs based in Scotland.

4.5.4 Whiting

The UK relative stability share of the North Sea whiting is 52.74% rising to 66.9% when Hague Preference is included. Overall this leads to a total share of 60.2% of the North Sea whiting TAC, with the next largest shares held by France (12.5%) and Denmark (8.3%). On average over 2012 to 2015, the UK quota was increased by 8.1% due to trading-in of quota, though in 2015, the increase due to trading was rather higher at 16.2%. As with haddock, the EU share of the whiting TAC is sometimes increased through trading with Norway, and in effect the UK receives 67% of this uplift. Most of the trading involves POs based in Scotland trading in quota from other EU Member States although there is also a net movement of quota from English to Scottish POs.

4.5.5 Saithe

Norway is the main holder of quota for North Sea saithe, with 52%, followed by France with 24.6% and Germany with 10.5%. The UK is allocated 8.4% of the overall TAC. In some years the EU trades-out saithe quota to Norway and receives haddock and whiting in return. As the UK relative stability share of the stock is small, this implies a net loss to the UK of around 50 tonnes of saithe quota, a quantity that is too small to be apparent in Figure 4-4. The UK fleet trades-in a substantial quantity of saithe quota from other EU Member States; in 2015 39.1% of UK landings of North Sea saithe were made against quota that had been traded-in in this way. Both English and Scottish POs are involved in this trading. Trading of quota within the UK is minimal.

4.5.6 Plaice

The largest share of the North Sea plaice quota is held by the Netherlands who hold 35.9%. This is followed by the UK with 26.5% then Denmark with 18.7%. For this stock the trading is largely outwards, with a net movement of quota from the UK to other EU Member states. Over 2012 to 2014, between 11.5% and 16% of the UK quota was traded-out in this way. In 2015 the corresponding figure was rather higher as 29.3% of the UK quota was traded out.

4.5.7 Sole

The Netherlands holds the large majority of the North Sea sole quota with 75.2%. The UK share is 4.3%. On average, over 2012 to 2015, the UK quota was increased by 48% through trading-in of quota from other Member States. There is also some trading within the UK that leads to a net movement of quota from Scottish to English POs.

4.5.8 Hake

Denmark is the major holder of North Sea hake quota, with 57.8%, followed by the UK with 18%, the France with 12.8%. The origin of the UK share is not clear; over the relative stability reference period of 1973 to 1978 the UK took 24.8% of the catch reported by states that were members of the EU at that time. This was reflected in the allocation of the first TAC that was established in 1982, when the UK received 25.45% of the total. Further work is required to establish when and why the UK allocation has changed.

Quota transfers that take place during the year lead to the adapted UK quota for hake in the North Sea being substantially higher than the initial quota. Over 2012 to 2015 the adapted quota was between 2.8 and 3.1 times higher than the initial quota. In this case the available data do not make it possible to say where the additional quota has come from as in the case of the widely-distributed Northern Hake stock, the TAC and quota regulations (e.g. Regulation 2015/104 for 2015 TACs) allow transfer of hake quota into the North Sea from the adjacent waters of Division IIIa and Division VIa, providing any such transfer is notified in advance to the European Commission. In addition, EU vessels fishing for cod, haddock and saithe in Norwegian waters of the North Sea also hold quota for 'Norway others', to cover other species they catch in Norwegian waters. It is understood that hake can form a substantial part of this catch. Overall, it seems likely that trading-in of quota from other member states is not the only mechanism whereby the initial quota for hake in the North Sea is increased.

4.5.9 Norway Lobster

The Nephrops fishery in the North Sea is very much a UK fishery as the UK receives an allocation of 86.6% of the TAC. There is net outward trading of quota for this stock; over 2012-2014, the adapted UK quota was between 6% and 8% lower than the initial quota. In 2015 however, there was much more quota traded out as the adapted quota was 35% lower than the initial quota. The amount of trading within the UK is negligible.

4.6 Quota allocation for North Sea stocks - conclusions

The analysis of quota allocation and trading in relation to the main North Sea demersal stocks has highlighted that the ability to trade quota within the EU is important in giving vessels some flexibility to adjust their landing opportunities to their catches. In effect, it could be interpreted that, instead of stopping fishing when one or more of their quotas are exhausted, the current system means that vessels are able to adjust their quotas in order to continue fishing. However, the information summarised here is not sufficient to determine how effective the system is in this respect. In particular, until the landing obligation is fully implemented in 2019, it will still be legal for vessels to discard at least some of their catches. As a result, over the period summarised here, vessels have still been able to discard over-quota catches. This means that it is not possible to determine whether vessels were able to obtain sufficient quota to avoid a 'choking' situation. Similarly, given that the amount of quota for a given stock is finite, it is not possible to determine whether vessels were able to obtain sufficient quota to meet their requirements in all cases. These considerations will become more important as the landing obligation is implemented. The landing obligation is also likely to change the pattern of quota availability and trading as vessels may need to retain a full portfolio of quotas to cover species they would previously have discarded.

The data on quota adaptations and trading indicate rather consistent patterns from year to year. In terms of quota trading, this is the case both within the UK and also between the UK and other EU Member States. On the basis of these patterns, a case could be made for

changing the allocation keys in order to account for these structural imbalances. However, while such a change would have economic implications for the quota holders, it is not clear whether this would have any impact on potential choking once the landing obligation is in place.

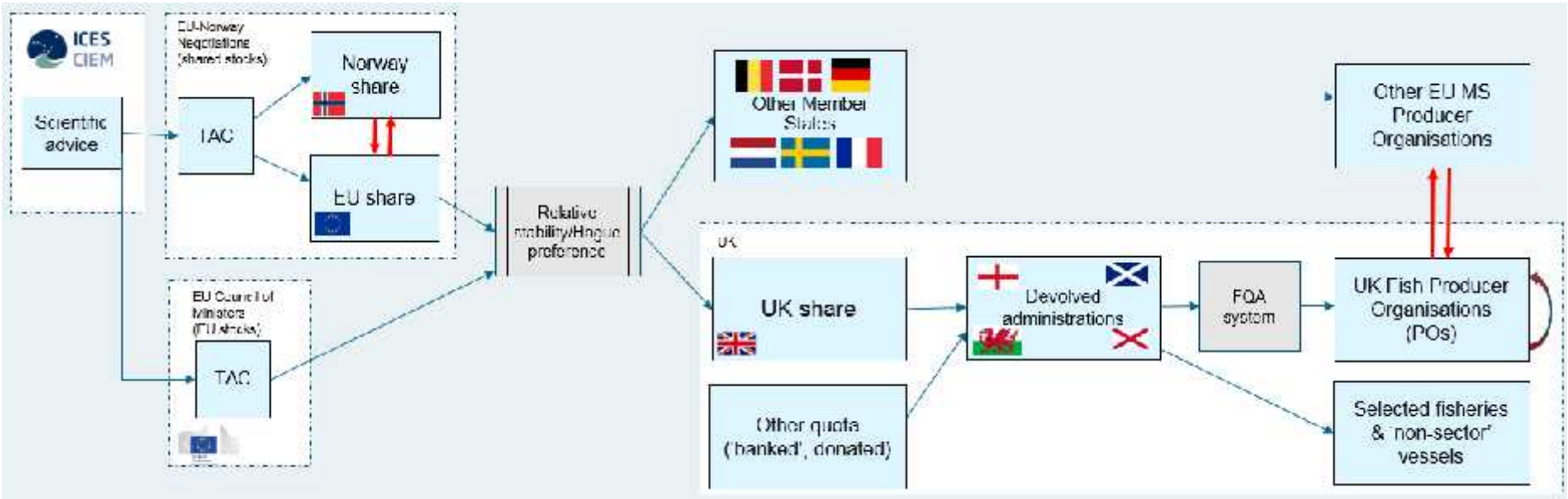


Figure 4-1; A diagrammatic representation of the TAC-setting and quota allocation process for North Sea stocks. Red arrows indicate points where quota trading occurs.

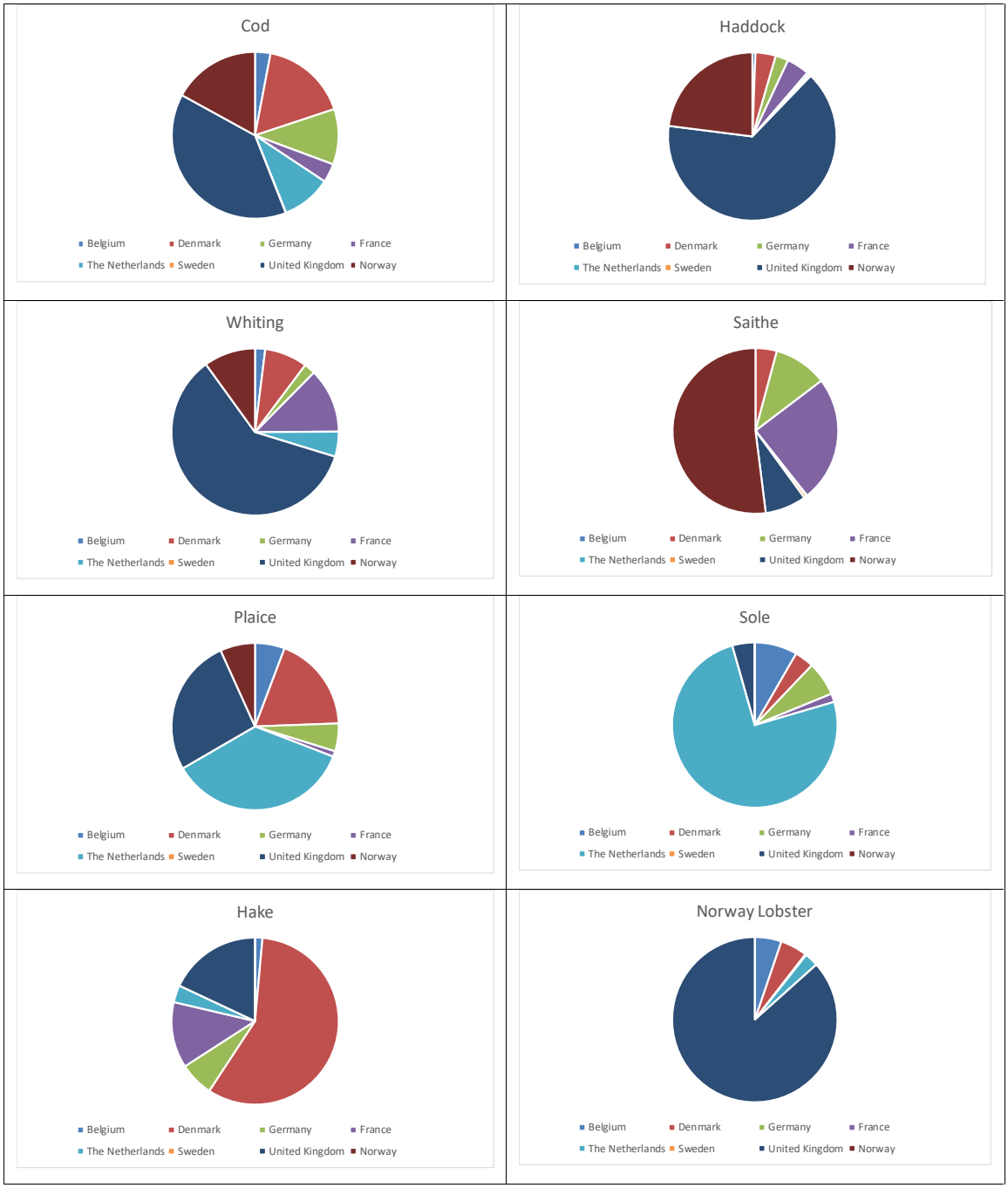


Figure 4-2; Agreed allocations of TACs for North Sea demersal stocks. Figures shown are relative stability shares plus agreed allocations to Norway of North Sea TACs for the species concerned.

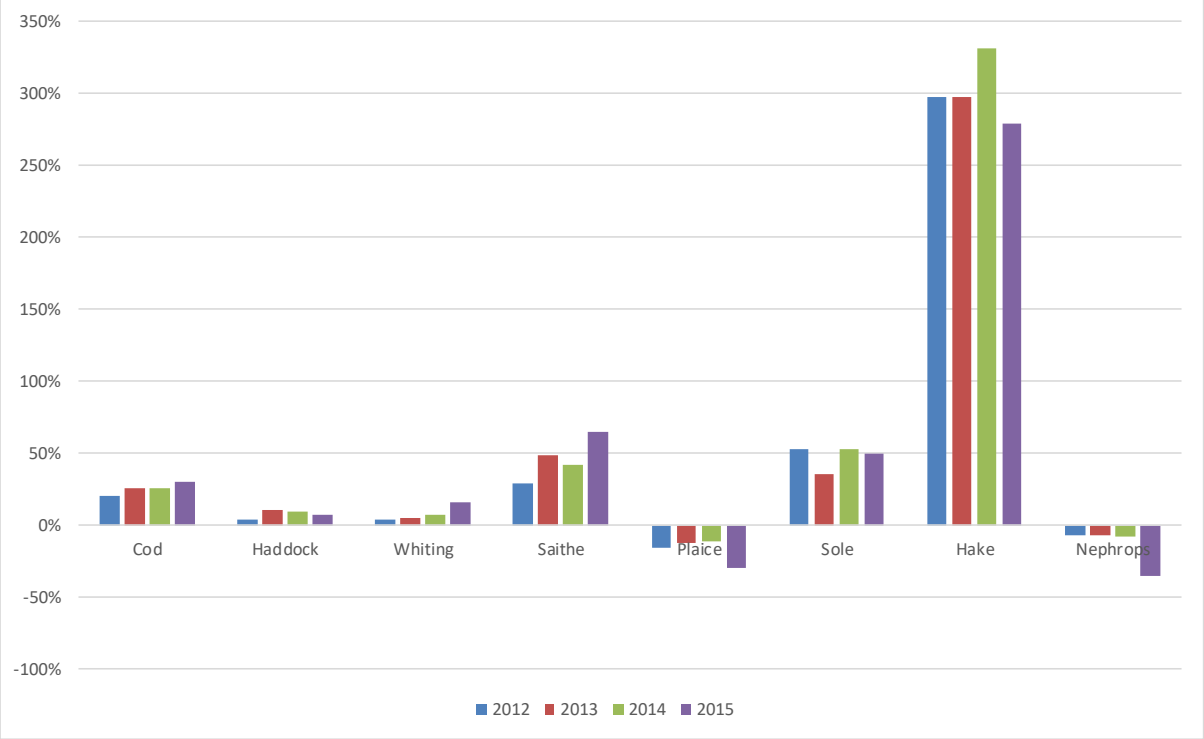


Figure 4-3; UK Quota adaptations for North Sea demersal stocks. Figures shown are the differences between the initial and adapted UK quotas for North Sea demersal stocks for the years 2012 to 2015 expressed as a percentage of the initial quotas.

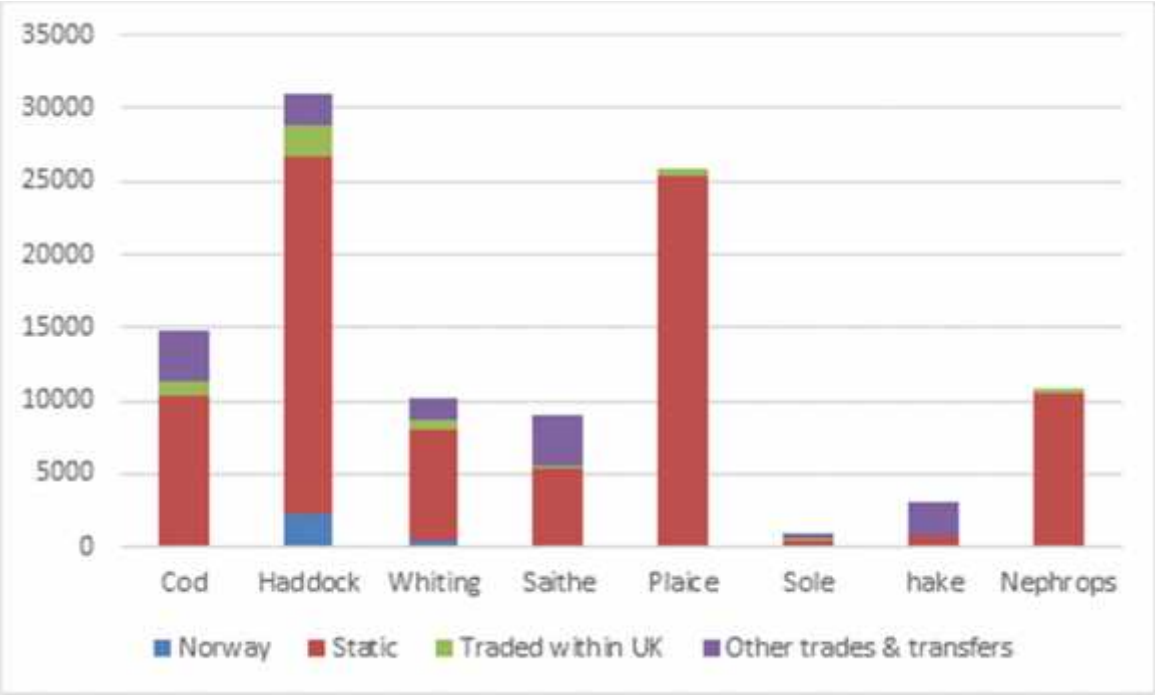


Figure 4-4; Origins of adapted 2015 UK quotas for North Sea demersal stocks. 'Static' indicates quota used by the PO to which it was initially allocated. 'Norway' indicates the contribution to the UK quota that originated from swaps with Norway.

Figure 4-5; Origins of adapted 2015 UK quotas for North Sea demersal stocks as a percentage of the adapted quota.

5 Mixed-fishery Modelling

5.1 Methods

Choke is an issue that is specific to mixed fisheries that are managed by TACs so the issue is here explored using a mixed fishery model of North Sea demersal fisheries. The model used is Fcube (from Fleet and Fishery Forecast; Ulrich et al, 2011). The model was developed in order to take account of mixed fishery effects in fishery management advice, and it is now used by ICES to provide routine advice on this issue (ICES, 2016). As input data, the Fcube approach uses an extensive dataset of catch and effort data for the fleets exploiting the relevant stocks. Thus for the North Sea demersal fisheries the input data include catches and effort by all fleets from all of the eight nations involved in the fisheries. The fleets are based on vessel size categories and gear type as well as nationality, hence fleets include, for instance, Dutch beam trawlers between 24 and 40 metres, and Scottish otter trawlers less than 24 metres. Information is also included on catches and effort within the different metiers these fleets exploit. For instance, Scottish otter trawlers less than 24 metres in length can fish for whitefish with 120mm mesh gear (known as TR1 gear from the categories in the EU cod management plan – EC, 2008) or fish for Nephrops using 80mm mesh (TR2) gear. Data compilation before the model is used involves combining some of the minor fleet-metier combinations into an 'others' category for simplicity, but even after this stage, the input data for the North Sea Fcube still includes around 110 fleet-metier combinations. This is illustrative of the high complexity of the demersal fisheries of the North Sea.

In addition to fleet catch and effort data, the Fcube approach also uses information on the recent state of the fish stocks that are included in the model. The information included is estimates of the population numbers in the most recent year as well as fishing mortalities and weight at age. These population parameters are the same as are used in the catch forecasts for each stock that are used to provide TAC advice. In effect, this allows those catch forecasts to be rerun, with the catch from the stock broken down by fleet and metier. The idea behind this is that TACs are normally set on a single-stock basis without any recognition that they are caught alongside other species. As a management measure, a TAC is assumed to limit catches. This in turn requires that vessels stop fishing once they have exhausted their quota for that stock. This may not be the case in a mixed fishery, hence Fcube is intended to look at what the consequences of a given set of TACs may have for all of the stocks caught in the fishery.

In order to use Fcube to look at the consequences of a given set of TACs may have for all of the stocks caught in the fishery, forecasts are run for a range of different scenarios for how vessels may respond to their fishing opportunities. These scenarios are expressed in terms of the amount of effort each fleet might expend during the forecast year. The scenarios explored generally include the following:

- SQ_Effort – Status quo effort, i.e. vessels use the same amount of effort as in recent years
- Min – Minimum, i.e. vessels stop fishing once they have exhausted one of their quotas.
- Max – Maximum, i.e. vessels continue fishing until they have exhausted all of their quotas.
- Cod – Vessels stop fishing once they have exhausted their quota for cod.

Numerous other scenarios are possible, including individual scenarios for all other stocks within the North Sea Fcube model. However, the scenarios listed here are of interest as the 'Min' and 'Max' scenarios represent hypothetical lower and upper bounds on removals from

each stock, with 'Min' being the extreme case of all vessels being choked by one of their quota stocks – Figure 5-1. Similarly, if it is assumed that fleets were not choked in the preceding year, then the 'SQ_Effort scenario indicates what they might catch if similarly unconstrained in the following year, and any scenario which leads to less effort than the status quo level implies a degree of choke.

A key principle underlying Fcube is that A TAC can be translated into the amount of fishing effort each fleet will need to expend in order to take its quota for each stock. This is based on assumptions about the catch share held by each fleet, how that fleet allocates its effort between different metiers, and the availability of each fish stock to each fleet. The catch share is based on recent data on the catches by each fleet. As such, this shares reflect catches after any trading of quota has taken place, rather than initial allocations based on Relative Stability and national allocation processes. The rate of uptake of a TAC will also depend on the metiers which a fleet exploits. In Fcube, the proportion of effort allocated to each metier in the forecast is usually based on recent data for that fleet. The availability of each stock to the gear of each fleet is termed the catchability. This is estimated from recent catch rate date for each stock in each fleet-metier combination. The result of this is that a metier where, for instance, cod, is a target species will have a higher catchability for cod than a metier where it is a bycatch. Taken together, this means that it is possible to estimate how much effort each fleet will need to expend in order to take its catch share of each stock. The stock which implies the least effort for the fleet to catch its share will then be the choke-stock for that fleet, unless the amount of effort implied is greater than the status quo level.

For the current study, the area of interest was the allocation of quota shares and the extent of trading of these and how much influence this can have on relieving choke for UK fleets. As to a large extent the processes of allocation and trading happen at the PO level, it was necessary to allow for this within the Fcube model. To do this, a set of input data was compiled based on the data used in the 2016 ICES Fcube run for the North Sea demersal fisheries. In this, the existing UK fleet data were replaced by corresponding data where the fleets were further disaggregated to include PO information. To give an example, in the ICES data Scottish otter trawlers less than 24m in length had constituted a single fleet, whereas the new data included separate fleets for each PO that had such vessels among its membership.

The catch data compiled for use in the Fcube model are based on reported catches at the end of the year by the relevant fleets. As a result, they represent catches that have been made after all the quota trading has taken place. In order to explore the degree that quota trading can contribute to mitigating choke, a second dataset was constructed which was intended to approximate catches if no trading had taken place. This was done by calculating a correction factor for each PO-stock combination based on the ratio between the reported catches by that PO and the initial quota allocation for each stock held by the PO. These correction factors were applied to the reported catches by each PO-fleet-metier combination to give an adjusted dataset corresponding to the situation where vessels were not able to trade quota so were limited to their initial quota allocations.

Two Fcube runs were made; a baseline run which differed only from the 2016 ICES Fcube run in the inclusion of PO information for UK fleets, and an adjusted run, where the UK fleet-PO catches were changed to correspond to initial allocations as if no quota trading had taken place. The intention of this approach was to compare the detailed results of the two runs in order to evaluate the extent to which the existing quota trading contributes to mitigating the risk of choke occurring.

5.2 Results

In ICES mixed-fishery advice the results from an Fcube run are normally presented in terms of the results for each stock. This is illustrated in Figure 5-1 which shows the results from the ICES 2016 forecast for the 'Min' and 'Max' scenarios as well as the single stock catches as advised by ICES. For the current study the focus is more on results at the level of Fleet-PO, and to a lesser extent, country. This focus requires the presentation of substantial amounts of information in order to cover the results for all fleets and stocks of interest. To do this the results are here presented as 'radar' plots. Each spoke of a plot corresponds to a stock and the length of the spoke is proportional to the amount of effort required to take the quota for that stock. This provides a way of visualising which are the most and least restrictive stocks in each case. As an additional piece of information, some radar plots also include information on the relative importance of each stock to each fleet in terms of its contribution to fleet landings. This is done by making the width of the spoke proportional to the landings.

Figure 5-2 and Figure 5-3 show radar plots of results from the baseline run for each country that participates in the North sea demersal fisheries. Figure 5-2 shows only effort by stock while Figure 5-3 also incorporates information on the catch by each nation. The plots suggest that, in general the least restrictive TACs will be those for North Sea haddock or plaice in the North Sea or Eastern Channel. The most restrictive stocks are indicated to be either North Sea sole or one of the Nephrops functional units. When the catches are taken into account (Figure 5-3) it is apparent that the major target stocks for each fleet are among the least restrictive of their quotas, while the most restrictive stocks are generally a minor component of their catches. The similarities across different countries suggest that the extent to which given stocks are likely to prove restrictive suggest that these results arise from the TACs for each stock rather than the allocation of those TACs between countries. Given that the results are based on catches after quota trading has been taken into account, this result is not unexpected.

Figure 5-4 to Figure 5-7 present more detailed output for the Scottish fleet-PO combinations. Figure 5-4 presents the results from the baseline Fcube run in terms of effort for each stock, and Figure 5-5 also incorporates information on the relative importance of the landings. Figure 5-6 and Figure 5-7 present the corresponding information for the Fcube run using the adjusted UK data, i.e. assuming that no quota trading had taken place. The results from the adjusted run (Figure 5-6) indicate that, in the absence of quota trading, each fleet-PO's quota holdings tend to be dominated by a single stock as the effort implied by that stock is much greater than that for any other stock. The landings data (Figure 5-5 and Figure 5-7) indicate that the stock that dominates tends to be the fleet's main target stock. Despite this, these results suggest that, in some cases at least, the quota holdings by this fleets may be well in excess of what they are able to catch in a year. The results from the baseline run, where quota trading has occurred, indicate much less variation in the effort implied by the catch shares held by the fleet after trading. In effect, the probability of choke occurring increases with the variation in effort implied by the different quota shares a fleet holds. As a result, the substantial reduction in variation that occurs as a result of quota trading indicates that this process is effective in helping reduce the risk of choke occurring.

5.3 Discussion

The comparison of Fcube forecast results with and without quota trading summarised above suggests that the existing system of quota trading is reasonably effective at mitigating choke risk as the process leads to most of the relevant fleets having a good spread of quota shares so that the variation in the amount of effort implied by each of their quota shares is much lower

than if the trading hadn't taken place. This is a qualitative evaluation, which raises the question of how a more quantitative evaluation could be made. This is not straightforward to define, partly because of the nature of the model, but mainly because of uncertainty about what an optimum allocation of quotas would look like.

The two Fcube runs used the same set of assumptions and settings but differed only in the catch shares held by each UK Fleet-PO combination. It would be possible to use different assumptions and settings with each dataset, which would produce different results, but this would require a clear objective for the allocation/trading process so that relative effectiveness of different approaches could be quantified against that objective. The objective could be stated in terms of , for instance, maximising quota uptake, or keeping all boats fishing as long as possible or maximising overall revenue, or minimising choke. All of these approaches are inter-related but raise different issues. For instance, if the objective is defined in terms of minimising choke, how would this be traded-off across different stocks, different fleets and different POs? While it may be of scientific interest to identify a hypothetical optimum, it would be unrealistic to try and put that into practice, given that the existing system of quota trading is a bottom-up process based on an informal network of business contacts rather than a structured, top-down process.

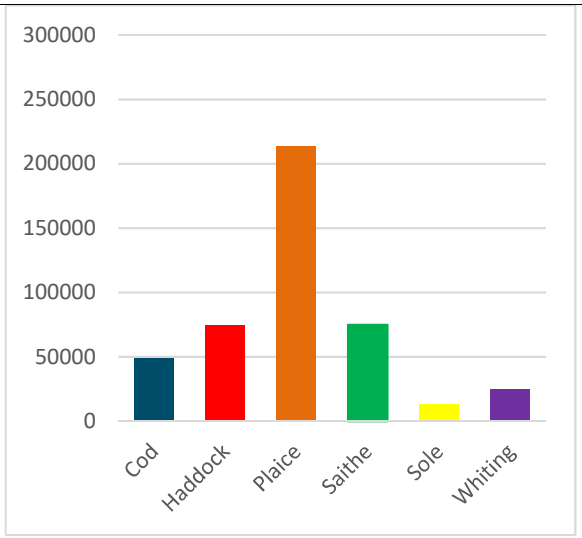
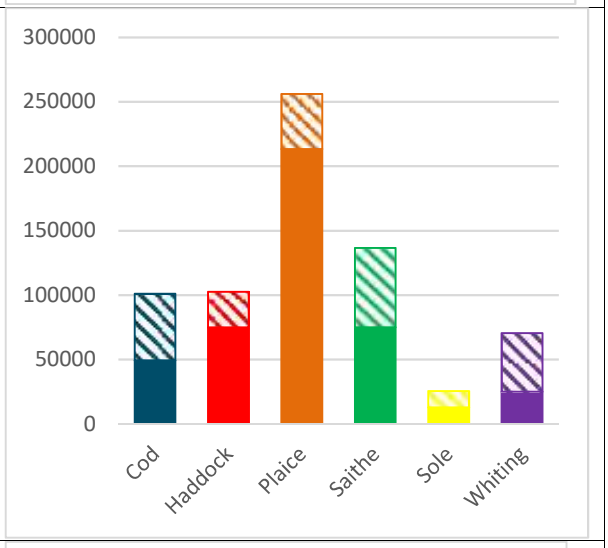
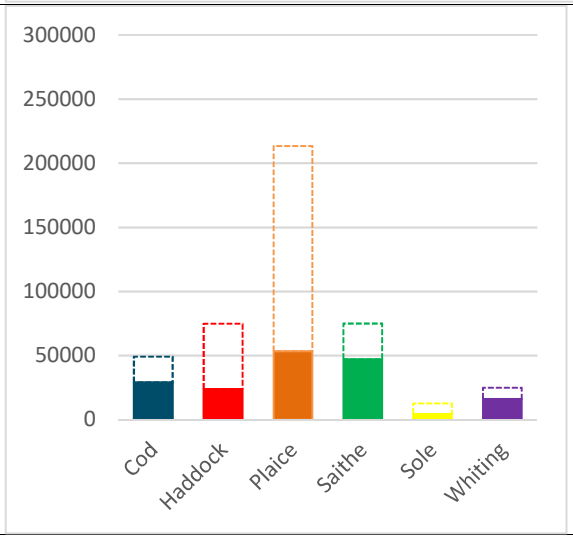
A, ICES advised catches for North Sea demersal stocks in 2016. Assumes that all stocks are caught independently of each other.	
B, Catches assuming that all vessels fish until they have exhausted all of their quotas. Over-quota catches leading to discards The Fcube 'Max' scenario	
C, Catches assuming all vessels stop fishing once they have exhausted one of their quotas. Quotas under-utilised, leading to fishing opportunities being 'choked-off' The Fcube 'Min' scenario	

Figure 5-1, Fcube results for major North Sea stocks from the 2016 ICES Fcube run.

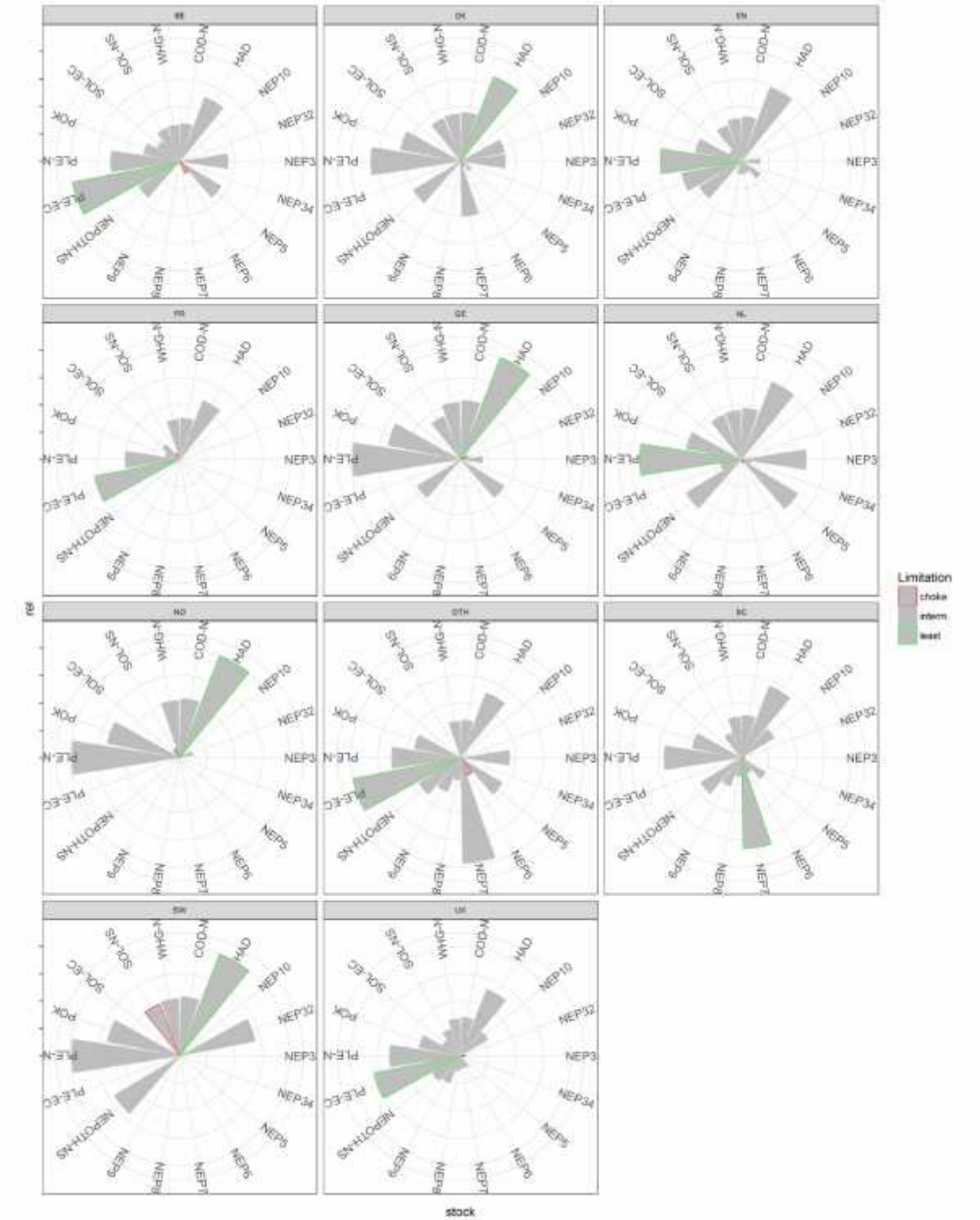


Figure 5-2, 'Radar' plot of results from the baseline Fcube run showing results in terms of the effort implied for each catch share held by national fleets.

The length of each 'spoke' is proportional to the fleet effort that would be required to take the catch share for each stock in 2016.

'OTH' = Aggregate category for minor fleets across all states
'UK' = Aggregate category for minor fleets from England, Scotland and other parts of the UK.

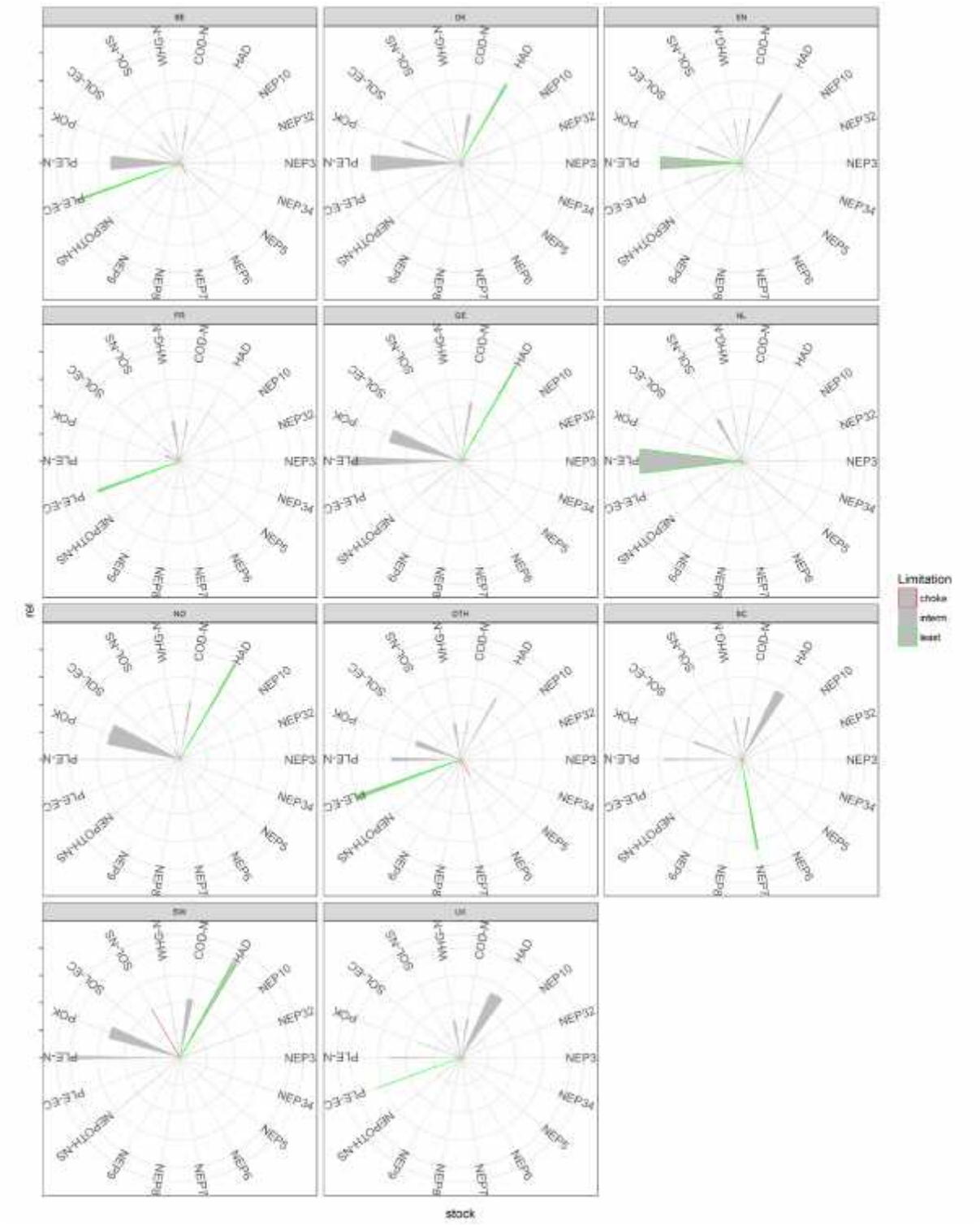


Figure 5-3, 'Radar' plot of results from the baseline Fcube run showing results in terms of the effort implied for each catch share held by national fleets.

The length of each 'spoke' is proportional to the fleet effort that would be required to take the catch share for each stock in 2016 and the width of each spoke is proportional to the proportion of that stock in the fleet's catch.

'OTH' = Aggregate category for minor fleets across all states
'UK' = Aggregate category for minor fleets from England, Scotland and other parts of the UK.

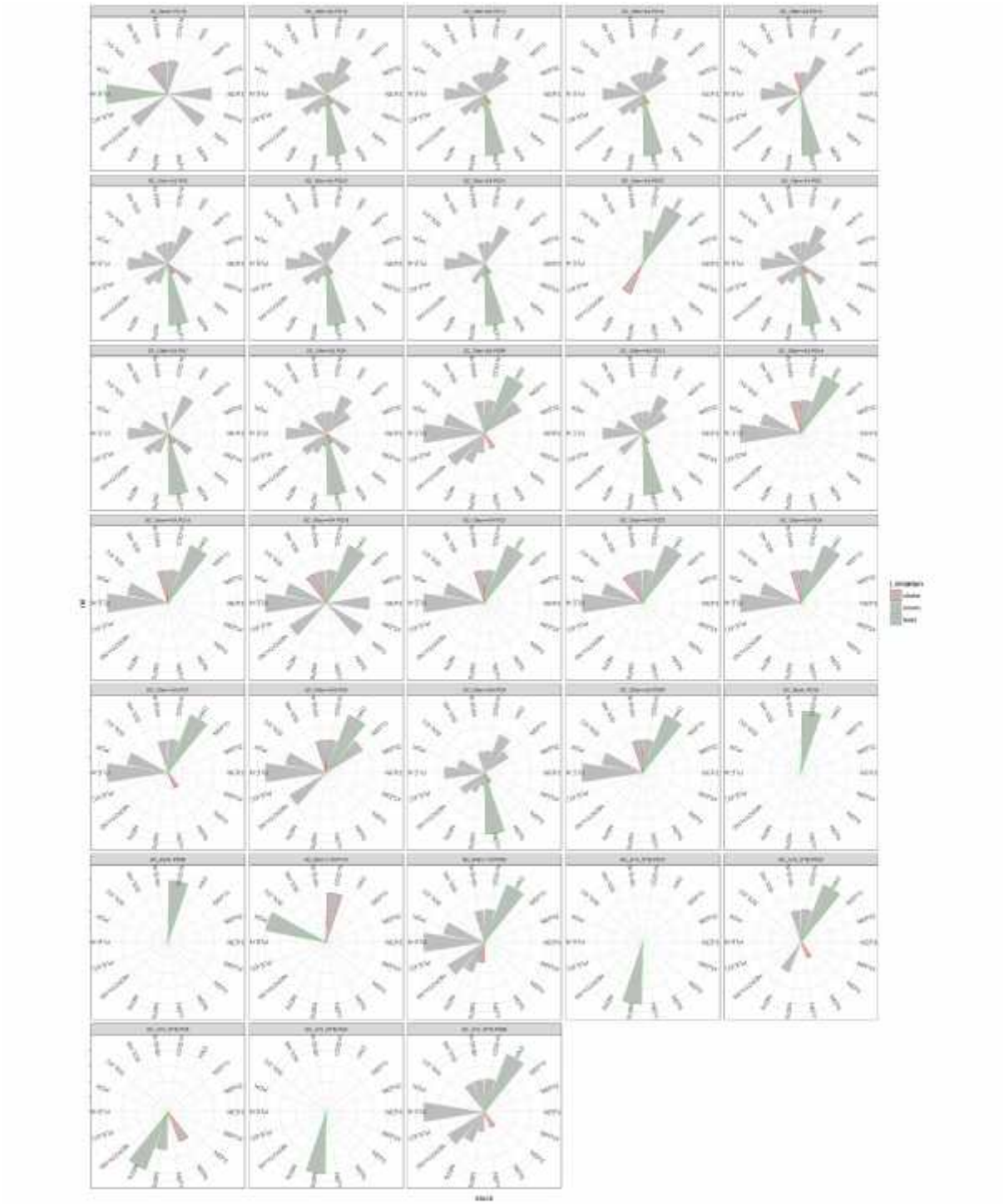


Figure 5-4, 'Radar' plot of results from the baseline Fcube run showing results in terms of the effort implied for each catch share held by Scottish fleet-PO combinations.

The length of each 'spoke' is proportional to the fleet effort that would be required to take the catch share for each stock in 2016.

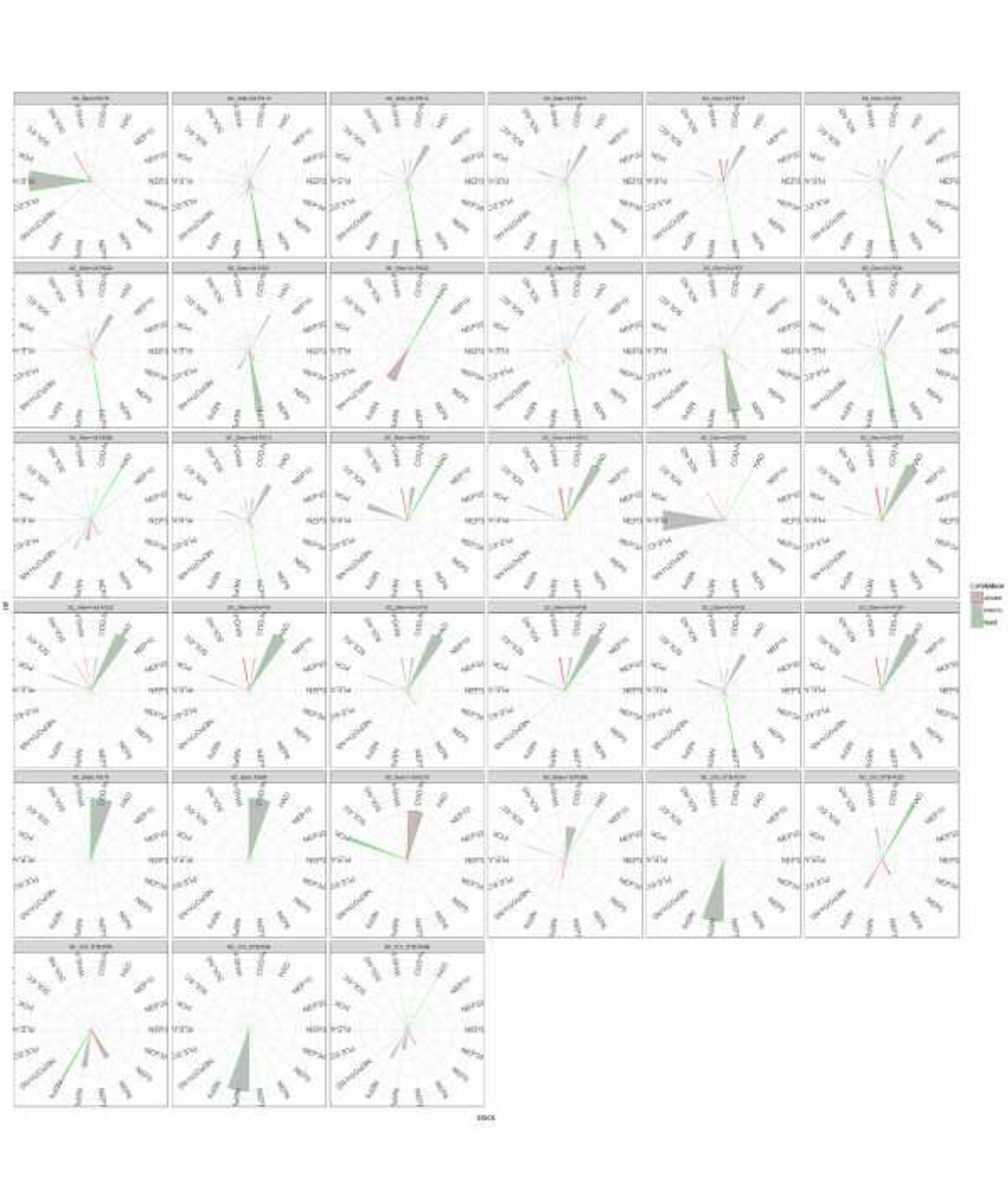


Figure 5-5, 'Radar' plot of results from the baseline Fcube run showing results in terms of the effort implied for each catch share held by Scottish fleet-PO combinations.

The length of each 'spoke' is proportional to the fleet effort that would be required to take the catch share for each stock in 2016 and the width of each spoke is proportional to the proportion of that stock in the fleet's catch.

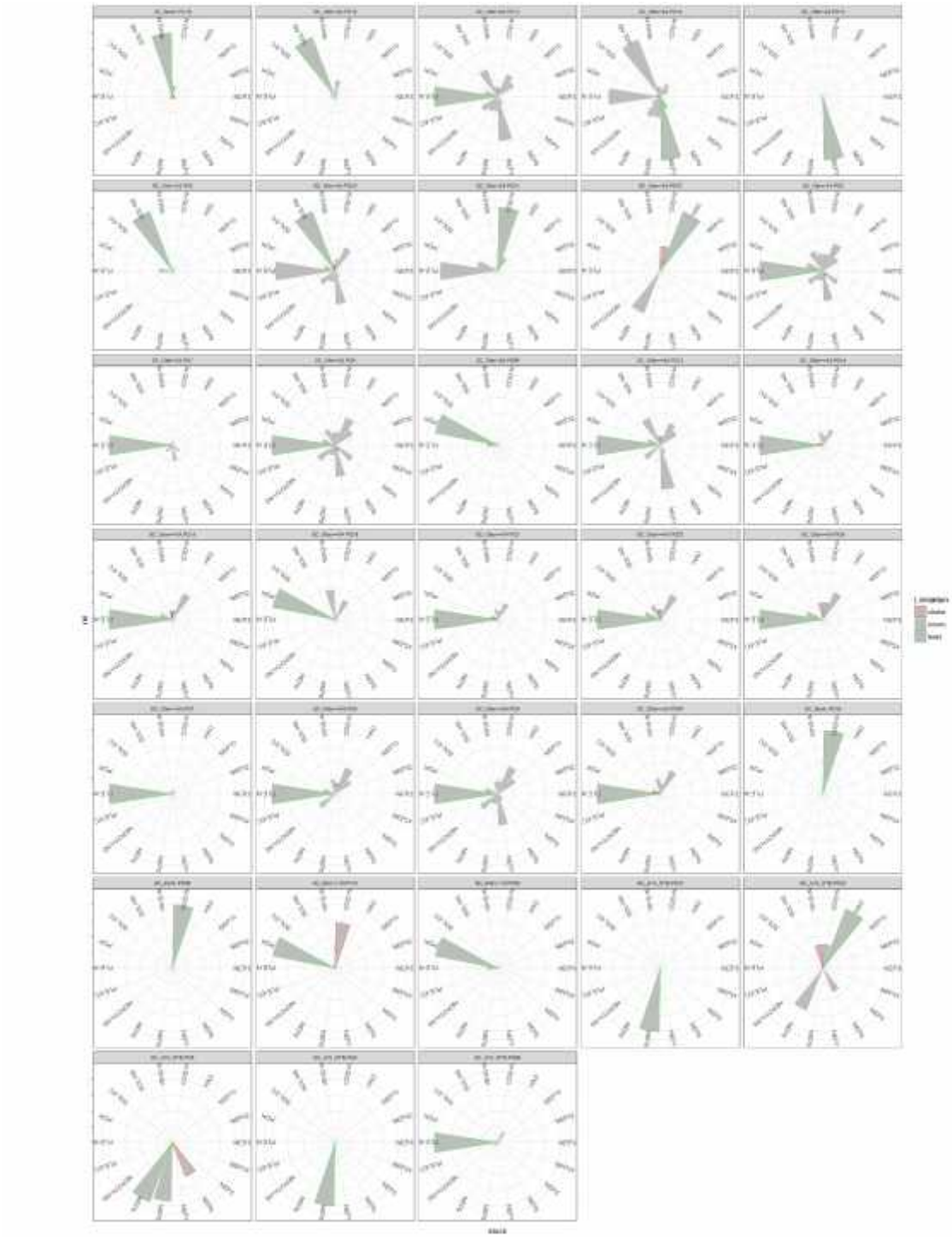


Figure 5-6, 'Radar' plot of results from the adjusted Fcube run showing results in terms of the effort implied for each catch share held by Scottish fleet-PO combinations in the absence of quota trading.

The length of each 'spoke' is proportional to the fleet effort that would be required to take the catch share for each stock in 2016.

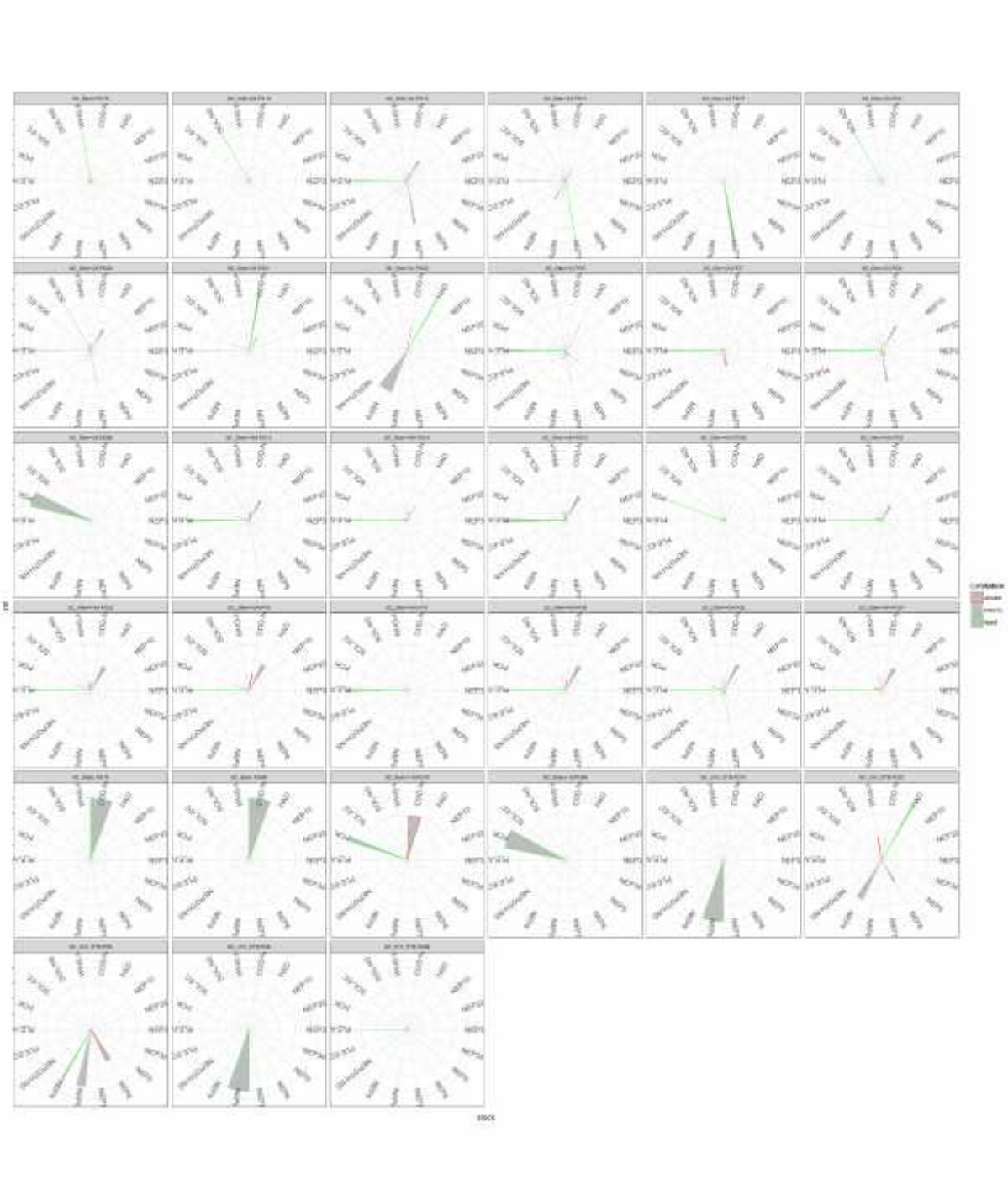


Figure 5-7, 'Radar' plot of results from the adjusted Fcube run showing results in terms of the effort implied for each catch share held by Scottish fleet-PO combinations in the absence of quota trading.

The length of each 'spoke' is proportional to the fleet effort that would be required to take the catch share for each stock in 2016 and the width of each spoke is proportional to the proportion of that stock in the fleet's catch.

6 Discussion and conclusions

6.1 Risk factors in TAC-setting and quota allocation.

Of the two processes considered here which contribute to choke risk, the risks that arise at the TAC-setting stage apply to all EU member states that exploit the North Sea stocks, whereas the risks associated with quota allocation are UK-specific, in that they reflect the UK share of the relevant TACs, and the capacity of the UK fleet to take those quotas. With regard to TAC-setting, most of the stocks considered here are subject to full analytical assessments, and are currently exploited close to their MSY fishing mortality targets. As a result, these factors are low risk for most of the stocks considered here. The exception is Nephrops, where a single TAC covers a number of functional units, some of which are being exploited above F-MSY and others of which are classified as data-limited. In this case the use of a single TAC covering multiple populations has the side effect of mitigating the choke risk that might be the case if each Functional Unit was subject to a separate TAC. The information on quota trading indicates a net outward trade of Nephrops quota, which suggests that overall, the choke risk for Nephrops is relatively low.

For most of the stocks considered here, the area-partitioning of the TAC does not present an obvious choke risk. In most cases the stock definition includes the North Sea as the main area, sometimes also including adjacent waters such as the Skagerrak in the Eastern Channel. In these cases, the large majority of the TAC is allocated to the North Sea. The exception is hake. In this case the North Sea is part of the range of the Northern Hake stock which also extends as far south as the north coast of Spain and includes the waters to the west of the British Isles. However, the issue is not the wide distribution of the stock, but the way the overall catch is partitioned across the different areas within the stock distribution. Only 3.5% of the overall catch from the stock is allocated to the North Sea, a figure which is low when compared to the historical track record of reported catches. As a result, this aspect of the TAC setting represents a choke risk for hake in the North Sea.

In some ways the situation with hake in North Sea represents a ‘perfect storm’ of choke risk. In addition to the low North Sea allocation, the UK receives around 18% of the North Sea TAC, which is low compared to a track record of taking around 25% of the EU catch during the late 1970s over the period on which relative stability shares were based. This has been exacerbated by changes in both the stock and the fishery since that period. The stock has recently increased to a high level compared to historic trends, and this has been accompanied by a change in distribution so that a higher proportion of the stock now occurs in the Northern North Sea (Baudron & Fernandez, 2015). In addition, UK fisheries in the Northern North Sea have undergone substantial changes since the relative stability shares were established. The development of a fishery for anglerfish from the mid-1980s, primarily prosecuted by Scottish vessels, has meant more fishing activity in deeper waters on the edge of the continental shelf to the north and west of the UK (Hislop *et al*, 2000). As well as anglerfish, this change in activity meant that vessels also started to catch more hake and saithe than was previously the case, as these species also occur in greater abundances around the edge of the continental shelf. The combination of a change in fishing activity to areas more favoured by hake, coupled with an increase in abundance of hake and an associated northward shift distribution of the stock, means that vessels fishing in these areas are likely to encounter much higher abundances of hake than is implied by the area TAC and their relative stability share. This leads to a high choke risk and this is apparent from the very high degree of trading & quota transfer for hake in the North Sea. The next highest degree of trading occurs for saithe, which is another case where the development of a fishery in deeper waters means that vessels now

encounter higher abundances of the species than was the case at the time that relative stability shares were established.

The work here has used the main North Sea demersal stocks as example stocks to use as the basis of a risk framework that can be applied more widely to try and evaluate the choke risk for stocks of UK interest that will become subject to the landing obligation. In this respect, the North Sea stocks make a useful case study of risk factors associated with quota allocation not least because these stocks are shared with a relatively high number of other states, hence there is more scope for quota trading. As the hake example shows, choking can arise from the combination of a number of inter-related factors from both TAC-setting and quota allocation, but the available information on quota trading, particularly the difference between initial and 'adapted' UK quotas appears to provide a useful indicator of overall choke risk. The North Sea demersal stocks considered here are less useful as an example of choke risks from the TAC-setting process as the relatively high quality of the stock assessments, and the fact that most stocks are close to their MSY targets, means that these sources of choke risk are less represented in these stocks. Further work will be required to evaluate risk factors for TAC-setting, particularly for data-limited stocks, and also to identify indicators for these risk factors.

As part of the work involved in implementing the landing obligation, technical groups which have met to discuss the issue have identified a number of categories of choke. These are, as follows:

1. Sufficient quota at MS level
2. Sufficient quota at TAC level
3. Insufficient quota at TAC level

In principle, Category 1 choke situations could be addressed by reallocation of quota within the relevant member state and Category 2 through exchange of quota between member states. In practice the existence of active trading of quota both within the UK and with other member states, and the absence of information on the extent to which this trading is limited by the availability of quota, means that it is not straightforward to allocate stocks to these categories. The available information on trading does highlight which stocks have the highest degree of dependence on obtaining quota through trading-in, and also which stocks where there is sufficient quota to permit trading-out. In practice the trading means that little distinction is made between quota obtained from within the UK or from another Member State, hence the problems in distinguishing between categories 1 and 2. In contrast, Category 3 arises largely from the choke risks identified in relation to TAC-setting.

To give an indication of the risk framework that is being developed as a result of this work, Table 6-1 shows an example risk table for North sea demersal stocks. It can be seen that this approach helps to identify which problems are linked to which stocks and which stocks have the highest overall risk. Such an approach should also help to identify which mitigation measures are likely to be the most appropriate for each stock. For instance, where the main issues are at the TAC setting stage, approaches which change the way TACs are set, e.g. through flexibility in multi-annual plans, may be appropriate. There are a number of tools and flexibilities available to help manage the landing obligation, whether at the TAC-setting stage, or through decisions on how a stock will be phased-in to the landing obligation, or the flexibilities to transfer catches between stocks or years that the regulation allows. In general these tools apply at a stock level hence the requirement for stock-based information to aid the application of these tools.

6.2 Mixed fishery modelling

The mixed fishery modelling conducted here used a modified version of the Fcube model used by ICES to provide mixed fishery advice for North Sea Demersal stocks. The modifications

were applied to the UK data so that it was possible to allocate catches at the PO-level in order to reflect the fact that this is the level at which quota allocation and trading operates. Modifying and using Fcube in this way proved technically challenging although the problems were eventually resolved. One issue with using Fcube to look at questions related to quota allocation is that the model uses catch data as the basis to estimate catch shares, hence the shares are based on catches that have happened after quota trading has taken place. For this reason, this study derived a dataset for UK fleets based on correcting their catches back to their initial allocations before any quota trading. This was used to provide insight into the extent to which the existing quota trading process acts to redistribute quota allocations in a way that helps mitigate choke risk. On a qualitative level, the process seems to be rather effective in mitigating choke, but it is difficult to make a more quantitative evaluation of this contribution, given the lack of clear objectives for any allocation process.

While Fcube is routinely used to give mixed-fishery advice on a stock basis, the complexity of the data underlying the model means that there is considerable scope for looking at results at other levels, including nation and fleet. This study has illustrated the potential for making greater use of the output from Fcube in this way. At the same time, the complexity of the data also means that it is necessary to develop novel graphic approaches to try and aid comprehension of the results.

6.3 Project objectives and results.

Objective 1 of the project was: “To describe the current system of quota allocation and trading within Scotland and evaluate the extent of flexibility”. The quota allocation system is described in Section 4 which also given an indication of the flexibility of the current system. During the course of this work it became apparent that quota allocation was only part of the story as the ways in which TACs are set also contributes to the choke species issue. Reflecting this, this part of the project work was expanded to also cover TAC-setting.

Objective 2 of the project was: “To develop and implement the Fcube mixed-fishery model for the North Sea in order to permit a detailed evaluation of the potential for managing quota shares to balance fishing opportunities with catches in mixed fisheries”. This was done as described in Section 5 and discussed in Section 6.2.

Objective 3 of the project was: “To run a number of different quota allocation scenarios in order to evaluate the contribution they could make to reducing the extent of the choke species issue for Scottish vessels.”. As well as the mixed-fishery model described under objective 2, this objective required the identification of a number of scenarios of different approaches to quota allocation, so their relative performance could be evaluated. From discussion with the Scottish and English quota management teams it became apparent that there are no clearly stated objectives for the existing quota management system, but rather it has been allowed to evolve in a way which allows the industry flexibility to trade-in quota as and when they need it. Further, it is apparent that the availability of quota from other EU Member States is at least as important as the movement of quota within the UK. In addition, discussions at the stakeholder workshop in August did not identify any clear scenarios that could be tested.

In the absence of clear objectives for the allocation process it is not possible to identify performance measures to compare different allocation systems, and the availability of quota from other EU Member States anyway lessens the influence of the UK allocation system. As noted in section 4.6, there are some consistent patterns of quota trading both within the UK and between the UK and other EU Member States, and while resolving these could have economic implications, it is by no means clear that this would either increase the overall degree of quota uptake or decrease any potential choke issues.

Overall, from the work of the study it became apparent that the basic premise of objective 3, i.e. that different allocation approaches might be more appropriate, was not relevant given how the allocation and trading system works in practice. As a result the mixed-fishery model runs that were performed were limited to two runs, a baseline run representing the existing system, and an adjusted run representing the hypothetical situation that no quota trading takes place.

Reflecting the limited extent to which it was possible to address objective 3, the work of the project has developed in a different direction, but one which still focuses on the contribution that the quota allocation system can make to the choke species problem. By looking in detail at the patterns of quota trading for key North Sea stocks, and coupling this with a similarly detailed analysis of the TAC-setting processes for each of these stocks, the project has established the basis for a risk-based approach to evaluating the choke risk for all stocks of UK interest. This work is continuing outside the framework of the current project and is being used to support the Scottish Government and Defra in their implementation of the landing obligation. As a result, it is considered that the resultant project is of substantial relevance to the Scottish fishing industry.

6.4 Future research

As noted above, the work from this project is being used in the development of a risk-based framework for identifying potential choke issues. This will include risk factors associated with both the TAC-setting and quota-allocation processes. However, another key element which could potentially influence choke risk is the biology of the species concerned. In a mixed fishery, it is likely that the TAC for one species will be exhausted before the others, even if all stocks are exploited at MSY and there are no allocation issues. This will reflect the balance between the MSY target fishing mortality for each stock, and the capability of the fleet to catch the species in question. If the fleet's capacity and capability to catch a stock is not consistent with the MSY targets of one or more of its target stocks, then this imbalance leads to a risk that choke will be a long-term issue. The MSY target reflects aspects of the stock's biology such as its growth and reproductive characteristics, whereas the fleet's ability to catch the species depends on other biological characteristics such as the stock's habitat, behavioural response to fishing gear and geographical distribution. From this it can be seen that the biological characteristics of a stock, specifically what might be considered the balance between its productivity and its catchability, are important for both short-term considerations like estimating choke risk and developing avoidance measures, and longer-term issues like the balance between fleet capacity and sustainable exploitation.

Overall, the contribution that biological factors may have to choke risk suggests that research into this topic would make a useful extension of the current work. The main areas to be investigated would be the relationship between stock productivity and sustainability targets coupled with the factors influencing the availability of the relevant species to fishing gears. Reviews of each of these topics could then be used to identify choke risk factors similar to the current analysis of TAC setting and quota allocation. Such an analysis would also help to gain a more general understanding of the biological factors influencing sustainable exploitation, and in turn this could contribute, for example, to the development of sustainability reference points for data-limited stocks.

Table 6-1, An example risk table for some North Sea stocks. A score of 1 is low risk and a score of 3 is high risk

	Major risks					Minor risks				
TAC_stock	F state	B State	Discards	Uptake & trading		SA Quality	Distrib	Stock change	Fishery change	Total
NS Anglers	1	2	1	1		2	3	1	1	6
NS Cod	2	2	3	3		1	3	1	1	20
NS Dabs & Flounders	2	1	3	1		2	1	1	1	10
NS Haddock	3	1	3	2		1	3	1	1	17
NS Hake	1	1	1	3		1	3	3	3	12
NS Lems & Witches	2	2	3	1		2	1	1	1	13
NS Megrim	1	1	3	1		1	3	1	1	8
NS Nephrops	1	1	1	1		1	1	1	1	0
NS Plaice	1	1	3	1		1	3	3	1	10
NS Saithe	2	1	1	3		1	3	1	3	13
NS Skates & Rays	2	2	2	1		2	1	1	1	10
NS Sole	1	1	1	3		1	2	1	1	7
NS Turbot & Brill	3	3	1	1		2	1	1	1	13
NS Whiting	3	1	3	2		1	3	1	1	17

7 Acknowledgements

The authors of this report would like to thank Grieg Chalmers, Lynda Gateley, Paul McCarthy and Ross Parker of the Scottish Government; Guy Ellis and Kevin Williamson of the Marine Management Organisation and John Anderson of the Scottish Fishermen's Organisation for their highly informative discussions on how quota management and trading operates within the UK.

8 References

Baudron, A.R. & Fernandez, P.G. 2015. Adverse consequences of stock recovery: European hake, a new “choke” species under a discard ban? Fish and Fisheries, 16, 563–575.

EC, 1983. Council Regulation (EEC) No 170/83 of 25 January 1983 establishing a Community system for the conservation and management of fishery resources. Official Journal of the European Communities No L 24/1.

EC, 1996. Council Regulation (EC) No 847/96 of 6 May 1996 introducing additional conditions for year-to-year management of TACs and quota. Official Journal of the European Union, L115/3

EC, 2004. Council Regulation (EC) No 811/2004 of 21 April 2004 establishing measures for the recovery of the northern hake stock. Official Journal of the European Union, L185/1

EC, 2007. Council Regulation (EC) No 676/2007 of 11 June 2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea. Official Journal of the European Union, L 157/1

EC, 2008. Council Regulation (EC) No 1342/2008 of 18 December 2008 establishing a long-term plan for cod stocks and the fisheries exploiting those stocks and repealing Regulation (EC) No 423/2004. Official Journal of the European Union, L 348/20

EC, 2013. Regulation (EU) No 1380/2013 of the European Parliament and of The Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002. Official Journal of the European Union, L 354/22

EC, 2015. Council Regulation (EU) 2015/104 of 19 January 2015 fixing for 2015 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union vessels, in certain non-Union waters, amending Regulation (EU) No 43/2014 and repealing Regulation (EU) No 779/2014. Official Journal of the European Union, L 22/1

EU/Norway, 2015. Agreed Record of Fisheries Consultations Between Norway and the European Union for 2016. Bergen, 4 December 2015. From: http://www.swfpa.com/site/assets/files/3055/eu-norway_agreed_record_for_2016__201512041951.pdf

Holden, M., 1994. The Common Fisheries Policy: Origin, Evaluation and Future. Fishing News Books, Oxford, 288pp.

ICES, 2015, ICES Advice on fishing opportunities, catch, and effort, Greater North Sea and Celtic Seas ecoregions. From www.ices.org

ICES, 2016, ICES Advice on fishing opportunities, catch, and effort, Greater North Sea and Celtic Seas ecoregions. From www.ices.org

Reeves, S.A. and Pastoors, M.A. 2007, Evaluating the science behind the management advice for North Sea cod ICES Journal of Marine Science 64, 671-678

Ulrich, C., Reeves, S.A., Vermard, Y., Holmes, S.J., and Vanhee, W. 2011. Reconciling single-species TACs in the North Sea demersal fisheries using the Fcube mixed-fisheries advice framework ICES Journal of Marine Science: Journal du Conseil 68, 1535-1547

Cefas

Head office
Centre for Environment, Fisheries & Aquaculture Science
Pakefield Road, Lowestoft,
Suffolk NR33 0HT UK

Tel +44 (0) 1502 56 2244
Fax +44 (0) 1502 51 3865

Web www.cefas.defra.gov.uk

Centre for Environment, Fisheries & Aquaculture Science
Barrack Road, The Nothe
Weymouth, DT4 8UB

Tel +44 (0) 1305 206600
Fax +44 (0) 1305 206601

Fisheries Innovation Scotland

Scottish Charity Number SC045119

Company Number SC477579

FIS MEMBER ORGANISATIONS

marinescotland

The Scottish Government

SFF SERVICES LIMITED

SWFPA The Scottish White Fish Producers Association Ltd

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

SEAFISH the authority on seafood

Young's SEAFOOD LIMITED

Sainsbury's