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### Abstract

Cod and haddock are two of the “big 5” UK supermarket fish species and intrinsic to fish and chip shops nationwide. UK whitefish fleets produce a significant amount, however there is a reliance on imports to maintain supply. The UK is in a strong position to compete for raw material from Iceland and Norway given high prices paid for imports and investment by Icelandic and Norwegian companies in the UK. Regarding UK production of whitefish, the European Common Fisheries Policy landing obligation has introduced significant uncertainty. To avoid discarding of any quota stock, fishing may be stopped before all target stocks quota is reached. For demersal fleets, there is a transition period between 2016-18 where target stocks are introduced according to Advisory Council and EU agreement and Article 15, with all quota stocks from 2019. As the capacity of the fleets balance to the new regulations, supply will likely return and if maximum sustainable yield (MSY) is reached in 2020 then an increase in TACs from current levels is likely too. However, markets and industries can change in a short period. Particularly, most processing companies are small to medium size enterprises and those that concentrate on cod and haddock may have to adjust their business. Fleets could be resilient to such short term reductions in landings however this cannot be assumed. The competitiveness of producers will surely be affected in the short to medium term as a result.

<b>Keywords</b>	value chain analysis, competitiveness, sustainability, bioeconomic modelling, whitefish
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## 1. Introduction

Cod and haddock are by far the largest marine species on the UK seafood market behind salmon, tuna and prawns. Seafish Factsheet [21] reports that sales of cod and haddock in the UK account for over half a billion pounds sterling each year, one fifth of the UK seafood retail market, with the fish and chip foodservice sector worth over one billion pounds sterling per year largely providing cod and haddock [1]. Furthermore, cod and haddock are for the most part sourced from North East Atlantic waters and have significant importance to UK producers, both fleets and processors.

The last European Common Fisheries Policy<sup>1</sup> has introduced some significant challenges to UK fishing fleets to maintain supply of key species in the short term. The two key policies in this regulation are the objective to reach maximum sustainable yield (MSY) for all quota stocks by 2020, and the implement of a landing obligation, essentially a discard ban, for all quota stocks by 2019. A transition period between 2016 and 2019 is being managed to drive fisheries to these positions by the stated years. MSY is calculated at a single species level but the landing obligation operates in a multi-species context. Hence, in 2019, this could mean that fleet's must stop fishing as soon as the quota of a single stock is met. The resulting effort level may be considerably less than fishing at MSY for some stocks. The binding policy is therefore

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<sup>1</sup> Regulation (EU) No 1380/2013 on the Common Fisheries Policy

likely to be the landing obligation, even though fishing below MSY, at levels potentially much lower than those resulting in maximum yield, will have a positive impact on the status of fish stocks. This could however have a severely negative impact on supply. Given this, it is an important statement made by the European PECH Committee which states, “Considering the unclear linkages between MSY and the landing obligation, ... achieving exploitation rates able to produce maximum sustainable yield is likely the most important objective and should be prioritised” (North Sea p.67 of [19]).

Recent studies have indicated that choke species could reduce catching opportunities for fleets if species for which there is low quota held cannot be avoided [2]. Extra-EU imports, which are considerable, will likely remain unaffected by the changes to the CFP. There is however a competition amongst several EU countries for a limited supply of extra-EU sourced whitefish: cod in particular but also haddock. The processing, retail and foodservice sectors will be most affected should the supply of cod and haddock reduce, putting added pressure on margins but also on the need to offer alternative products to satisfy demand for seafood products.

In addition to highlighting potentially conflicting objectives of policy, this paper aims to investigate how supplies and markets for cod and haddock are likely to be affected in the UK in the short to medium term. This could impact the competitiveness of UK producers and processors significantly. Competition in international markets is both an opportunity and a threat, as there is limited international supply of cod and haddock, even so it could be expected to have a positive impact in the supply chain for producers. Fleet adjustment, and the need to balance resource availability with the size and composition of the fleet, continues to happen in UK and other EU fleets. This reduces pressure on stocks (i.e. conservation objective) thus enabling the drive towards MSY and subsequently improves the economic performance of fleets (i.e. economic objective) but at the direct expense of reductions in numbers of vessels (i.e. social objective) and the social cost that brings. The objectives highlighted are of course simplified, but demonstrate the social objective pulling in a different direction to conservation and economy [3,4,5]. This is important with the introduction of the landing obligation as the total demand for fish continues to grow even though average consumption in the UK has decreased slightly in recent years and with that changing prices of fish maintain a healthy market for seafood.

This paper estimates the potential impact of changing regulation to the supply of cod and haddock on UK producers and UK markets. A modelling approach is taken to estimate how the landing obligation might impact fleets. Patterns of trade are analysed to understand the flexibility and complexity of cod and haddock markets. The structure of this paper provides an overview of the whitefish production in the UK and other EU countries, followed by an evaluation of the whitefish value chain, with results from modelled scenarios considering potential impacts on the UK whitefish market, concluding with a discussion and final comments.

## 2. Material and methods

### 2.1 UK Whitefish production

The UK whitefish fleet is for the most part concentrated in the Scottish ports of Peterhead and Fraserburgh, although there are whitefish vessels registered in other ports in England, Wales and Northern Ireland. For the purpose of this study, the following evaluation focuses on

vessels using demersal trawl/seine to target cod, haddock, whiting and saithe predominantly, with revenue from these four species representing more than 50% of these vessels' total fishing income. The vessels selected are split into two length classes: 12 to 24m, and over 24m (Figure 1). There are many other vessels that catch whitefish in addition to other species, for example anglerfish, megrim, plaice, lemon sole etc, however these are not included in this analysis.

### **{FIGURE 1}**

The number of vessels for the over 24m segment have remained stable at between 55-60 vessels across the period. The number of vessels for the 12-24m segment have fluctuated strongly mostly as a result of quota availability and the need to target other stocks to a greater extent for a time. This was evident in 2011-12 as the fishing opportunities for cod and haddock, as well as whiting and saithe, worsened. This is notably due to increasing fuel prices (approximately 34p in 2010 to 46p in 2011) and decreasing TAC particularly for North Sea cod from 40,000 tonnes in 2010 to 32,000 tonnes in 2011. From a level of around 50 vessels in 2008-10, the 12-24m fleet segment has reduced to around 37 vessels in 2014.

Cod, haddock, whiting and saithe contribute over 70% to both fleets total landing value (Figure 2). The remaining 30% of landings value is made up from anglerfish and flatfish and small amounts of hake, cephalopods, ling, plaice and pollack (included in "Others". Income in the most recent two year (i.e. 2013-14) are at their highest by a considerable margin. This indicates that fishing opportunities have increased with greater TACs, particularly North Sea haddock, but also that prices have improved. For example the North Sea and West Coast haddock TAC(IV, IIIa and VIa) increased from an average of 39,413 tonnes in 2011-12 to an average of 49,566 tonnes in 2013-14. Haddock prices rose from an average of £1.14 per kg to £1.26 per kg over the same two periods.

Both fleets have seen increases in income (Figure 2) and profit (Figure 3) in recent years. Income for the 12-24m fleet segment has increased by 50% between 2008 and 2014 and for the over 24m fleet segment by 33% from its lowest in 2009 compared to 2014. In addition, other income reflecting quota trade has increased by approximately 10% over the period for both fleet segments.

### **{FIGURE 2}**

Average vessel profit is estimated to have increased sharply since 2009 and even more so since 2012. For the 12-24m fleet segment, this could be explained partly by less vessels getting a greater share. For the over 24m, number of vessels has however remained relatively constant. The increase in profitability is likely due to a mix of increased prices, increased TACs and stable costs (mainly energy/fuel costs). These latter costs have on average reduced from £299,000 in 2012 to £269,000 in 2014 for the larger vessels (over 24m). Conversely, all other costs appear to have increased by 10% year-on-year from 2012 to 2014. Smaller vessels (12-24m) have seen costs increasing significantly, with revenues increasing at a greater rate on average.

### **{FIGURE 3}**

Overall, it is apparent that the amount of revenue required to breakeven for the over 24m whitefish fleet has reduced in recent years, mostly as a consequence of reduced costs and lower fuel prices (Figure 4). For the 12-24m whitefish fleet breakeven revenue has remained

fairly stable increasing to a small degree in recent years. For both fleet segments, income per day has steadily increased. Similarly for both fleet segments, the number of days required to breakeven has decreased as income has increased at a greater rate than costs (Figure 4). In 2014, the 12-24m whitefish fleet segment is estimated to have broken even in 50% of the days fished and the over 24m fleet segment in approximately 43% of days.

#### **{FIGURE 4}**

## **2.2 UK Whitefish value chain**

UK whitefish production is important to the UK fishing industry, with cod, haddock, whiting and saithe contributing 14.3% to the total UK landings value (at £122.9 million) [6]. Even so, the strong demand for cod and haddock by UK consumers means that imports of these species are considerable and a magnitude higher than UK production. Total imports for cod and haddock represent in 2014 close to 152,000 tonnes for a value of £649 million, with Iceland, Norway, China and Denmark representing over 75% of the volume of imports (Figure 5). Iceland and Norway supplied 48% of the imports of cod in 2014 and 44% of haddock. China, Denmark, Germany and the Faroe Islands are also large suppliers (41% cod and 35% haddock). Most imports coming from China are processed products, companies taking advantage of Chinese lower costs to process raw material before shipping it back to the UK.

#### **{FIGURE 5}**

Data on nine whitefish value chains were collected for 2014 (Table 1). The majority of whitefish landings by UK registered vessels are at UK ports. The exceptions to this are cod, where 9,500 tonnes were landed in Norway in 2014 and 4,800 tonnes in Germany, and plaice where most landings by UK vessels took place in the Netherlands. This appears mostly due to closeness to port, market and processing requirements. The imports of cod are significant at 116,400 tonnes and a value of over half a billion euros. This is far more than the UK production and is originated mostly from Icelandic waters, the North Sea and the Barents Sea. There are also sizeable imports of haddock at 35,900 tonnes which is slightly less than the UK production, again from the same areas.

#### **{TABLE 1}**

Apparent consumption of whitefish is significant in the UK. Cod and haddock lead but other species contribute quite strongly in the market. The seven other species make up approximately 106,000 tonnes, one third of which is pollack (Table 1). Cod and haddock are part of the “big 5” supermarket fish species along with salmon, tuna and prawns. According to data compiled by Seafish, retail sales for cod in 2014 were approximately 20% of the retail market (see Introduction) [1]. However, with the demand for cod and haddock through fish and chip shops and other fast food outlets, estimated to exceed one billion GBP per year, cod and haddock are the most important wild marine fish on the UK market. Any significant change in supply could therefore affect significantly the UK market and UK fish producers.

## **2.3 EU Whitefish production**

The UK is the largest EU producer of cod and haddock from the North Sea and Norwegian waters (Figure 6), equally for cod in these areas but mostly the North Sea for haddock. Cod is also produced in relatively large quantity by other EU countries, including Denmark, Poland, Spain, Germany and France from the North Sea, Norwegian waters and the Baltic. Haddock is mostly landed by the UK.

## {FIGURE 6}

### 2.4 Modelling and analysis approach

A two stage modelling and analysis approach has been undertaken. The first stage comprises a typical bioeconomic model for scenario analysis that models the fleet and stock interactions of the UK fisheries (i.e. production). The second stage provides an analysis of the downstream impacts by including the results from stage one plus an assessment of imports in the coming years.

The stage one bioeconomic model is based on Fishrent and has been used in a successful study of the economic impact of the landing obligation on UK fisheries [9,10]. The model comprises four key boxes: production, policy, economy and biology (Figure 7). As indicated, the model operates at the fleet and stock level, for all UK fleets, on a yearly level. For those stocks where stock assessments are available (<http://www.ices.dk/marine-data/tools/Pages/stock-assessment-graphs.aspx>), a simple stock biomass approach is taken in the biology box where the next year's (t+1) stock available is calculated from the this year's (t) stock *plus* stock growth (G) *minus* the catch taken. Stock growth is estimated from:  $G_t = \alpha + \text{biomass}_t^\beta$ , with parameters  $\alpha$  and  $\beta$  estimated using published stock assessment data. The policy box implements a harvest control rule that adjusts total allowable catch (TAC) from the previous year by up to +/- 15%. The production box then estimates catch in time t ( $C_t$ ), landings and discards based on constant catchabilities (q), effort in days fished (E) and level of biomass ( $B_t$ ), i.e.  $C_t = qE_t B_t$ . And, from catch and effort indicators, the economy box calculates the performance of each fleet in terms of revenue/income, costs and profit.

## {FIGURE 7}

The stage two value chain analysis takes the results from the bioeconomic model indicating UK supply of whitefish and calculates the impact on the value chain incorporating supply of whitefish from other countries (e.g. EU and Iceland/Norway). A 'status quo' situation is assumed for imports from the rest of the world. However, in addition lower and upper bounds are identified to indicate an area of uncertainty in the results.

## 3. Calculation

Supply of whitefish to the UK market is dependent on UK production and imports. The biggest policy change in recent history in Europe has been the introduction of the landing obligation under the latest CFP reform. This effectively implements a discard ban for all stocks managed under the EU TAC system and has the potential to disrupt significantly the supply of key marine species. A key foundation of the CFP, relative stability was introduced in its current form in the early 1980s [11]. This was before the need to ensure quota available to fleets matched catch composition, even though the latter changes according to stock abundance and tactical fishing practices (i.e. where, when and how fishing is undertaken) on a regular basis.

The landing obligation for demersal stocks is being implemented from 2016 through a transition period to 2019 from when all demersal TAC stocks are subject to the landing obligation. The transition period is designed to introduce only key target stocks to fleets' catch, so there is likely to be a small effect for most fleets. However, if the landing obligation is introduced with full compliance in 2019 then quota in the UK, based on current rules of allocation, will not necessarily be optimised to enable fleets to fish as many days as possible to maximise the use of that quota. Therefore supply of key stocks may be compromised,

especially in the short term, as fleets adjust to quota for “choke” stocks not being readily available. If fleets don’t receive assistance, perhaps through quota adjustment or subsidies, then vessels may quickly go out of business if they cannot attain a level of income that enables them to covers essential costs, a so-called break-even level [2,10].

In this paper, two simulations are tested for the landing obligation for UK fleets: the first (AS-IS) is a baseline which simulates the implementation of the landing obligation and is designed to allow for quota top-up to account for total catch and also allows for small limits of zero-TAC stocks; and the second (TO-BE) builds on this by also considering key mitigation tools (or policy levers) that are documented in the regulation (i.e. Article 15). The policy levers of the latter simulation include the simulation of,

- *de minimis* – an additional 5% of UK quota is available to alleviate the impact of choke stocks only where any catch identified as *de minimis* must be discarded,
- interspecies flexibility – unused quota of a fleet segment from any stock may be transferred to a “choke” stock if that “choke” stock is under safe biological limits up to a limit of 9%, and
- survivability – skate is assumed to have a good chance of surviving being discarded and is therefore exempt from the landing obligation.

A key assumption is that quota allocations to fleet segments remain as in 2013 without further quota trade. The results presented for UK production can be considered to be the worst case scenario. Rest of the world imports are assumed to continue as in the base year under ‘status quo’, 2013. Bounds on status quo are provided by best and worst case estimations on rest of the world imports. This percentage bound is estimated based on imports from recent years for cod and haddock (Table 2). Confidence intervals of +/- 10% for imports of cod are taken to be [105k, 127k] and of haddock [33k, 39k] from 2014 levels.

#### {TABLE 2}

Note also that exports are modelled to follow changes in UK production. For cod, given exports are at a similar level to UK production, any changes in UK production are likely offset by changes in exports so as to have a minimal net effect on supply.

## 4. Results

Simulation results for the UK production of whitefish, in particular cod and haddock, under the landing obligation are presented in Figure 8. During the transition period, between 2016 and 2018, as more stocks come under the landing obligation the total landings of cod and haddock are not affected considerably. In fact, with quota top-up, fleets are estimated to have more quota to access in the transition period. In 2019 however, as all quota stocks come under the landing obligation, the fleets are choked relatively early by the quota they are simulated to have available. In the As-Is simulation (Figure 8), this is estimated to result in cod and haddock quota utilisation of less than 40% of base year levels with a significant reduction in supply of cod and haddock versus 2013 levels.

#### {FIGURE 8}

In the To-Be simulation (Figure 8), the situation is marginally better with policy levers implemented (namely *de minimis*, quota flexibility and survivability). It is simulated that cod

and haddock quota utilisation could be up to 50% of base year levels in 2022. However, this is still a significant reduction in supply of UK produced cod and haddock versus 2013 levels.

As discussed in section 2.1, it is apparent that the amount of revenue required to breakeven for the over 24m whitefish fleet has reduced in recent years where the 12-24m whitefish fleet breakeven revenue has remained fairly stable, but with income per day for both fleet segments steadily increasing. In 2014, the 12-24m whitefish fleet segment is estimated to have broken even in 50% of the days fished and the over 24m fleet segment in approximately 43% of days (Figure 4). Results from scenarios presented above indicate that fleet segments may reduce to 35-50% of base year levels of effort, which brings the whitefish fleet segments considered down to breakeven levels. This suggests that these fleets could continue to operate with profits in the short term with quota trade even though some individual vessels may struggle with a much reduced financial position. However, it is supply from UK production that is likely to be affected as fleets adjust under the landing obligation.

Considering the effects that these changes could have on total supply of cod and haddock to UK markets, the simulation results are combined with imports of cod haddock to the UK in 2013-14 and potential total supply projected to 2022. These results are presented in balance sheets in Figure 9.

### {FIGURE 9}

It is estimated that 115,000 tonnes of cod and 90,000 tonnes of haddock were available to the UK market in 2013. In 2019 it is estimated that between 104,000 to 127,000 tonnes of cod and 51,000 to 59,000 tonnes of haddock could be available (As-Is and To-Be simulations respectively). As proportionally more haddock is supplied from UK production, this is the species likely to be impacted the most. It suggests that cod available to UK markets could be relatively similar to that in 2013, but for haddock 27%-40% less in market supply (i.e. lowest to highest simulated result in Figure 9). A drop of 20% in haddock imports between 2013 and 2014 indicates the level of volatility seen (Table 2).

The UK has the largest and most competitive seafood processing industry in the EU, “the highest GVA in absolute terms in 2012 (27% of the EU total)” and “the highest net profit in absolute terms in 2012 (66% of the estimated total)” [13,14]. Compared to Iceland and Norway with 4,200 workers [22] and 9,600 FTEs [23] respectively, UK fish processing is reported to have 17,855 FTEs in fish processing (Spain with 17,399) in 2012 [13] and 19,511 FTE jobs in 2014 [14]. With 403 fish processing units (i.e. company locations) reported, an average of 48 FTE per unit even though 57% of units have greater than 100 FTEs, 83% of which specialise in sea fish and 15% salmon [14]. With regard to whitefish, the wholesale and processing sectors supply fish and chip shops that typically rely on cod and haddock. Total value to this part of the value chain is reported to amount to over £1 billion per year<sup>2</sup>. This implies that the processing/wholesale sectors will likely seek to make up any short fall from UK production in imports.

## 5. Discussion

It is reported that around 70% of all seafood sold in the UK are the “big 5” species, i.e. salmon, cod, haddock, tuna, prawns [1]. Of these salmon is mostly farmed in Europe, prawns and tuna are mostly imported from outside Europe with only cod and haddock originating mostly from

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<sup>2</sup> <http://www.federationoffishfriers.co.uk/pages/facts-and-figures-603.htm>

European and neighbouring seas. The UK's share of North Sea cod EU TAC amounted to approximately 40% in 2015 and for North Sea haddock approximately 70% in 2015. In addition, quota was available to UK fleets fishing in Norwegian waters (ICES area II). Supply of cod and haddock from UK fleets is limited and with the introduction of the landing obligation UK production will likely be reduced in the short term placing more reliance on imports, particularly from Iceland and Norway. If exports reduce as a result of UK landings decreasing then there'll be additional competition from other countries, possibly also increased by the landing obligation in those countries also.

From the analysis undertaken here, cod appears to be relatively secure especially as imports have increased by 15% in the three year period from 2012 to 2014. Haddock on the other hand is likely to see decreasing supply on the UK market in the short term as imports have decreased by 41% over the same period, with the landing obligation also potentially resulting in decreased supply.

The UK competes with Spain and other parts of Europe for cod and haddock supplies from Iceland [20], particularly Spain's demand for expensive Icelandic salt cod. Cod and haddock TACs in Iceland have been increasing in recent years<sup>3</sup> [15]. The UK is historically a strong market for exporting unprocessed cod and haddock to. Conversely, in 2015, ICES published recommendations to reduce the TAC of Barents Sea cod in 2016 by 10%. However, Norway and Russia kept 2016 TAC the same as in 2015. Even so, TAC for Barents Sea cod has reduced from 1m tonnes in 2013 to 894 thousand tonnes in 2015 and 2016, with a further decrease to 805 thousand tonnes advised by ICES for 2017 [16]. Haddock on the other hand was recommended to increase by 25%. Thus imports of cod, with such competition and reducing supplies may not be able to increase significantly in the short term. One website reported "Barents Sea cod quota cut will cause a fight for raw material" between the various processing sectors [17]. In their analysis, increases in fresh cod with higher prices, given recent increases in demand, appeared to be the conclusion.

Retail is apparently becoming more demanding on the need to provide sustainable fish products. This has resulted in the Marine Stewardship Council (MSC) label becoming the most commonly used. As a result for example, Icelandic cod and haddock has been certified under the MSC scheme. It is estimated that approximately half of UK cod supply is MSC and the majority of haddock. Supermarkets vary hugely with MSC labelled product lines with MSC.org reporting that Sainsbury's have 76% seafood products labelled MSC with Waitrose and LIDL approximately 50% and other supermarkets from 2% to 37%. Policy that could impact such labelling is the EU's objective to ensure that all quota stocks are fished at maximum sustainable yield (MSY) by 2020. This would imply that stocks at this level are sustainable and may not necessarily require a label to indicate sustainability. In addition, the EC has recently completed a study considering the demand for a public sustainable label [18]. It is often surmised that a price premium is attached to sustainably certified seafood, however there appears little general evidence to support this. Such labelling is less clearly used (or apparently required) in the fish and chips sector that has annual sales of fish and chips in the UK of around £1.2 billion (see footnote 2).

There are several risks that could impact the competitiveness of producers in the short term. These include the landing obligation, fishing to levels of MSY and fuel prices. The first two issues could have a direct impact on supply, particularly reduced supply in the short term as

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<sup>3</sup> see <http://www.fiskistofa.is/>

quotas reduce to achieve MSY and the landing obligation (potentially) hinders the ability of fleets to land all of the quota allocated. Fuel prices will impact profit as costs in what is a high energy use business increase. In the medium term of course, as stocks reach MSY, quotas increase and quota trade enables more effective use of quota under the landing obligation fleets will be more resilient and likely to supply the markets with cod and haddock at current amounts or even greater. Sustainability and traceability are important issues and will like add to the competitiveness of producers, even though at present much of the cost of certification falls on producers and not on other parts of the value chain. Balancing fleet capacity and catch composition with quota available is particularly important and may take time.

## 6. Conclusion

The UK has traditionally been a significant market for cod and haddock and as such has in recent years seen significant investment by Icelandic and Norwegian companies in the marketing, wholesale and processing sectors (e.g. Icelandic Seachill, Seagold (Samherji), Carisma UK and links with UK Fisheries Ltd). Important quantities of cod caught in Iceland and Norway are reaching the UK domestic market, either by direct landings or by export of fresh and frozen fish that is mostly filleted. The UK is the destination of more than half of the fresh cod exports from Iceland (57% of the value in 2015) and of close to a third of the cod fillet exports from Iceland (31% of the value in 2015).

The demand for cod and haddock in the UK is strong and is likely to remain so given the importance of the retail market and fish and chip shop market for these species. Supply of cod is estimated to be relatively stable, however haddock has been declining and unless haddock can be sourced in the short term there will likely be a gap in supply as UK fleets adjust to the landing obligation. The UK imports more fresh / frozen cod and haddock than any other EU country, estimated 27% cod and 55% haddock in 2016 (EUMOFA trade data). The next largest importers, Netherlands (24%) and Denmark (15%), appear to import fresh / frozen cod in particular for re-export to Spain, Portugal and France, which also appears from trade data to be a similar phenomenon in the value chain for salted cod.

Of the main importing countries for fresh / frozen cod and haddock in the EU , the UK is estimated to pay the highest prices. On average prices were 35% higher than Netherlands and 29% higher than Denmark between 2015-17. Therefore, the UK is in a strong position to compete for raw material from Iceland and Norway. It may be possible that increased imports for these species will be able to fill the gap but also other substitutes could appear. Pangasius and salmon appears to compete on the retail market with fresh/frozen cod and haddock fillets and pollack competes strongly with cod and haddock in processed seafood (e.g. fish fingers and other battered/breaded fish).

In the medium to long term, as the capacity of the fleets balance to the new regulations supply will likely return and if MSY is reached in 2020 then an increase in TACs from current levels is likely too. However, markets and industries can change in a 5-10 year period. Particularly, most processing companies are small to medium size enterprises (SMEs)<sup>4</sup> [14] and some that concentrate on cod and haddock processing may not survive a shock to their supply or at least may have to adjust how they operate. It appears that fleets could be resilient to such short term reductions in landings however this cannot be assumed. The competitiveness of

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<sup>4</sup> Medium <250 employees and <€50m turnover; Small <50 employees and <€10m turnover; Micro <10 employees and <€2m turnover. Note balance sheet limits are also used. (See EU recommendation 2003/361)

producers will surely be affected in the short to medium term as a result as fleets adapt to supply the market.

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Figure 1. Whitefish fleet segments 12-24m and over 24m vessels (source: estimated from [20])

Figure 2. Whitefish fleet segments 12-24m and >24m landings in value, GBP (source: estimated from [20] and [6])

Figure 3. Whitefish fleet segments 12-24m and > 24m profit, GBP (source: estimated from [20] and [6])

Figure 4. Breakeven revenue and days fished for whitefish fleet segments

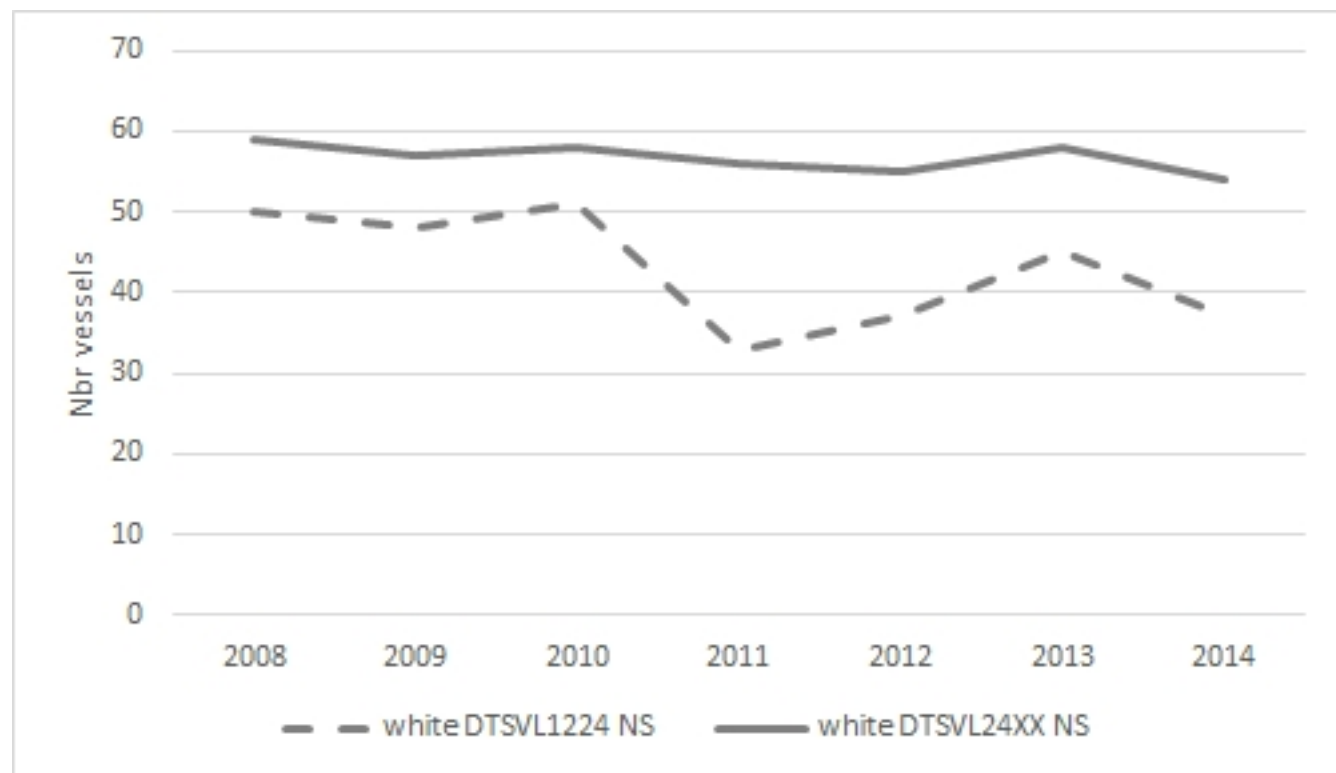
Figure 5. Countries from which cod and haddock (in total) are imported to the UK in 2014 [7]

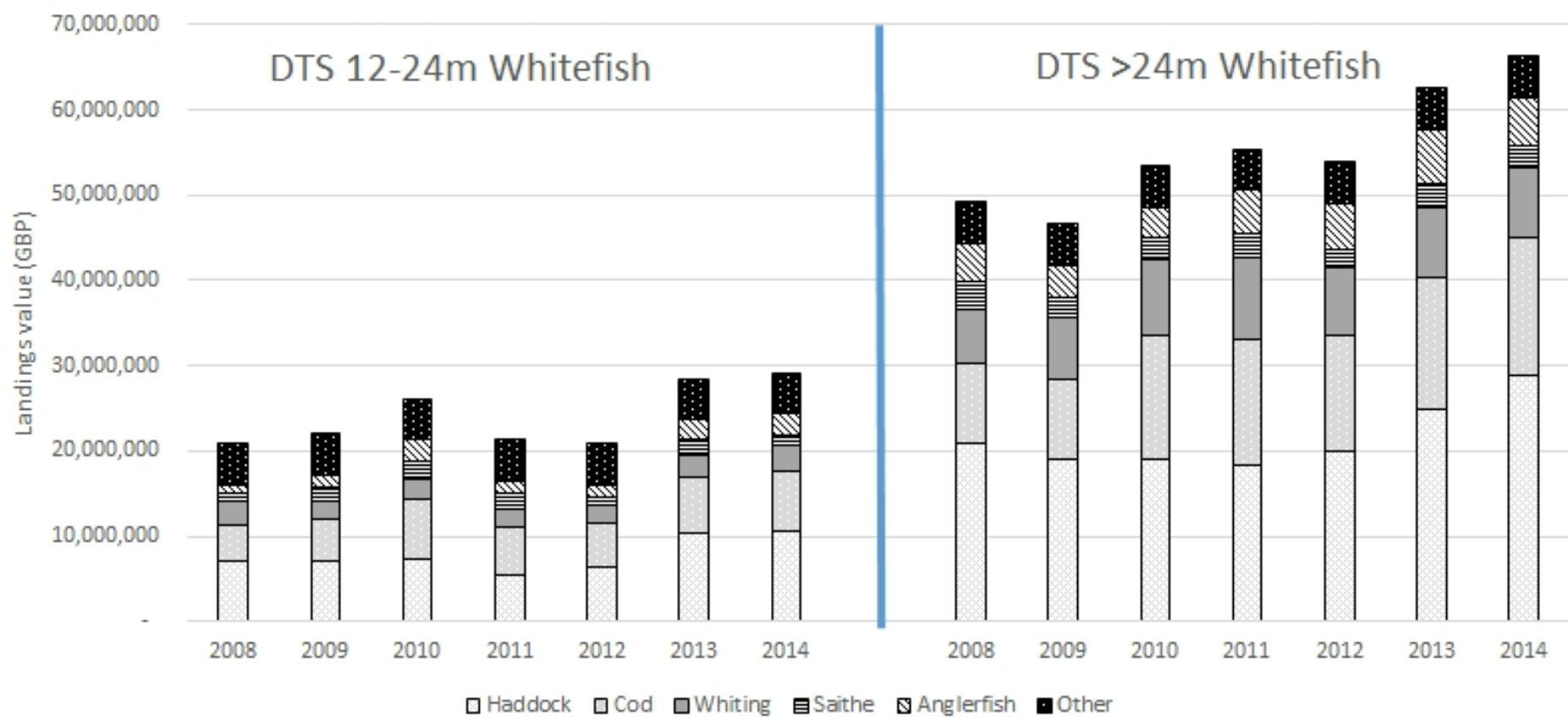
Figure 6. Production of cod and haddock by EU countries in 2013 by main sea area [8]

Figure 7. Model process based on yearly time-step to simulate production in UK fisheries

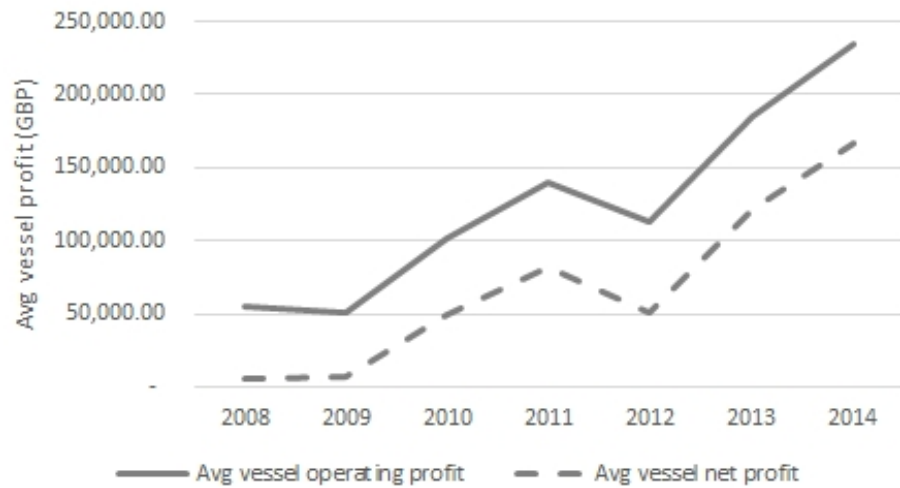
Figure 8. As-Is (left) and To-Be (right) simulation results for cod and haddock production from 2013-22.

Figure 9. Balance sheets for cod and haddock, including lower and upper bounds on to-be scenarios

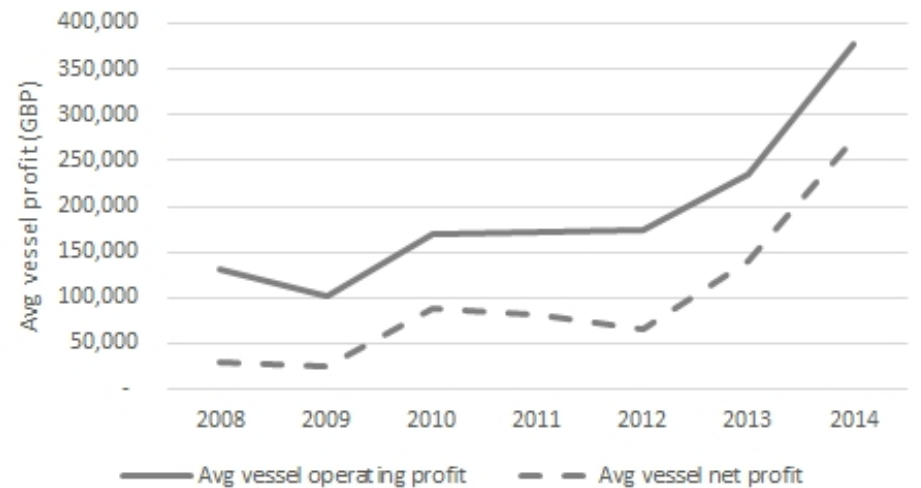




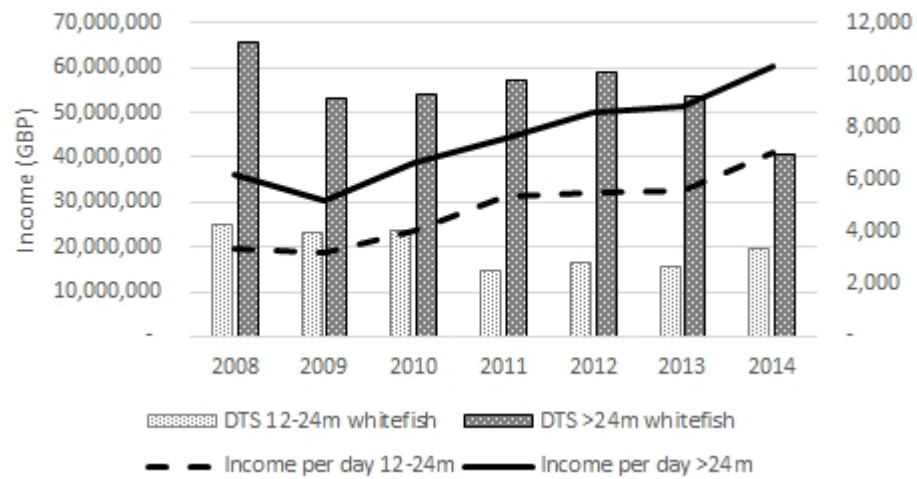
### DTS 12-24m whitefish



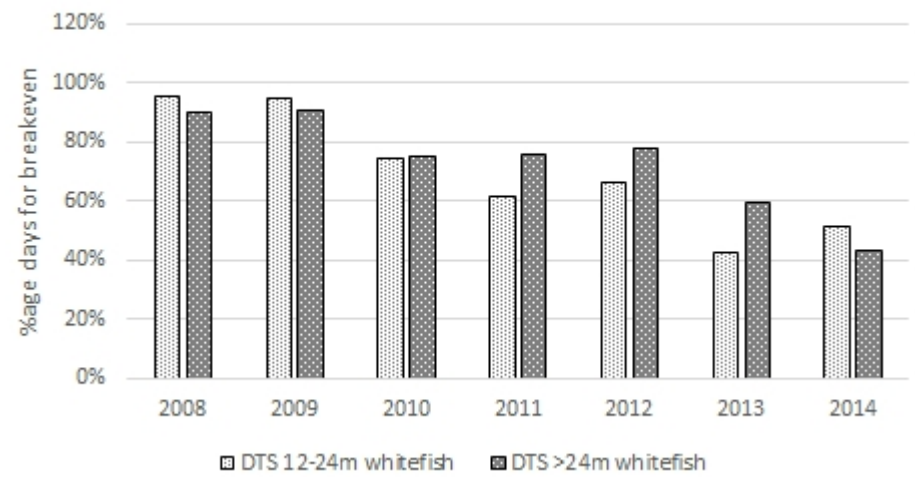
### DTS >24m whitefish

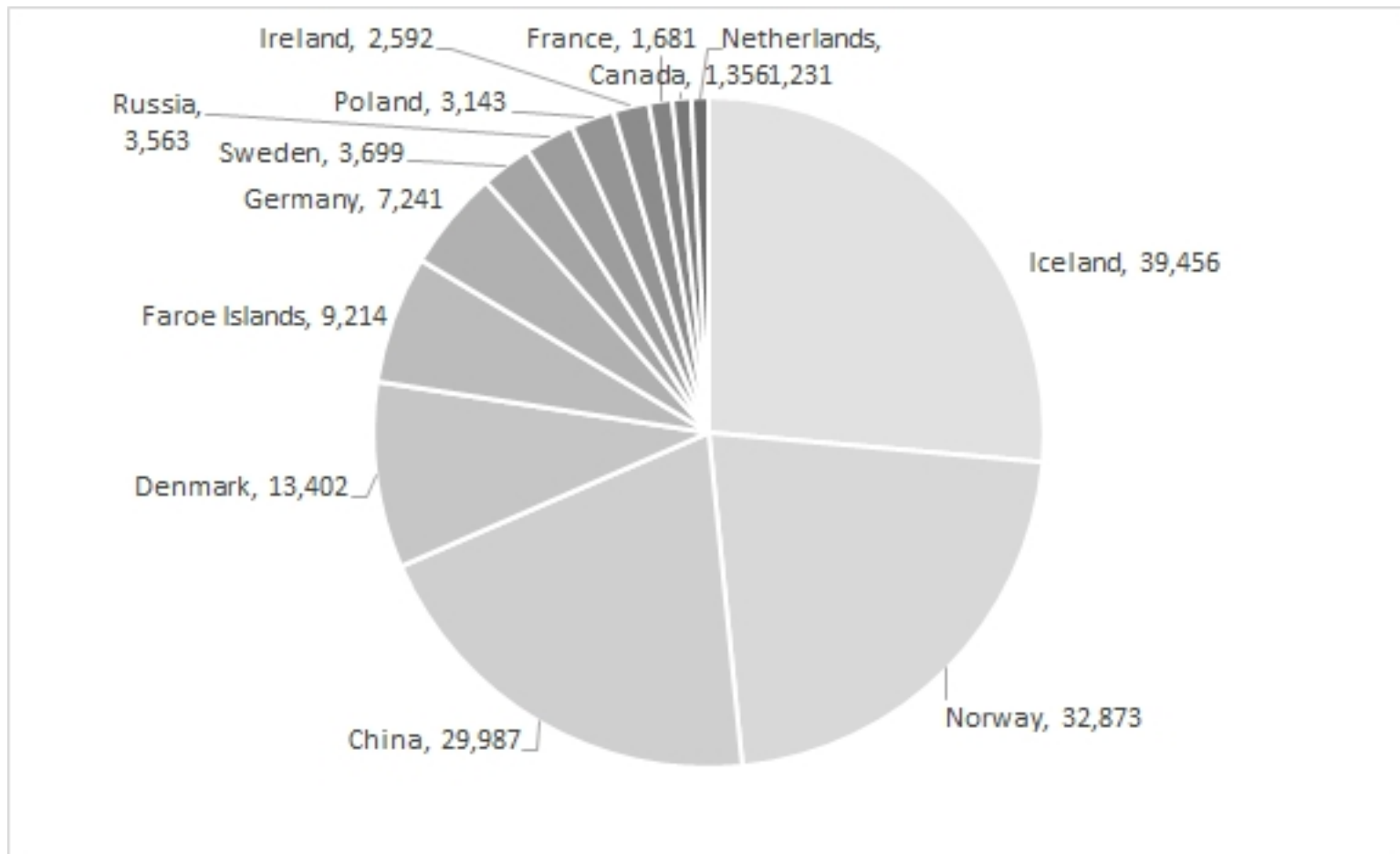


### Breakeven revenue

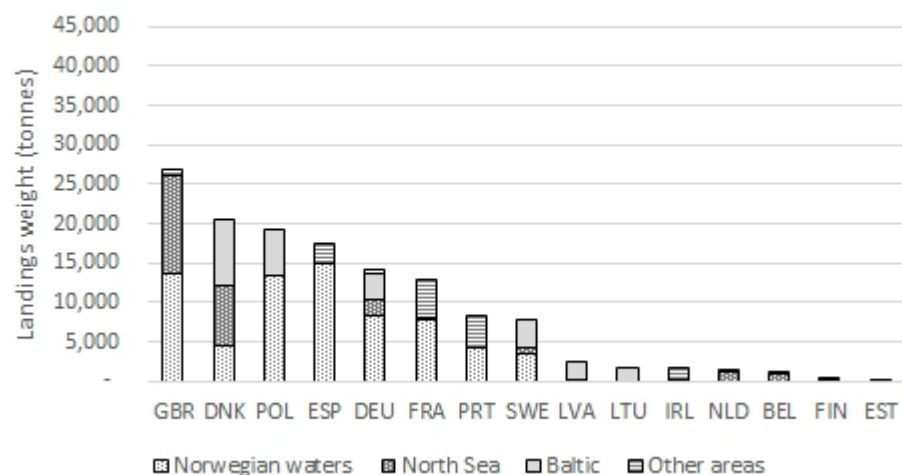


### Breakeven days

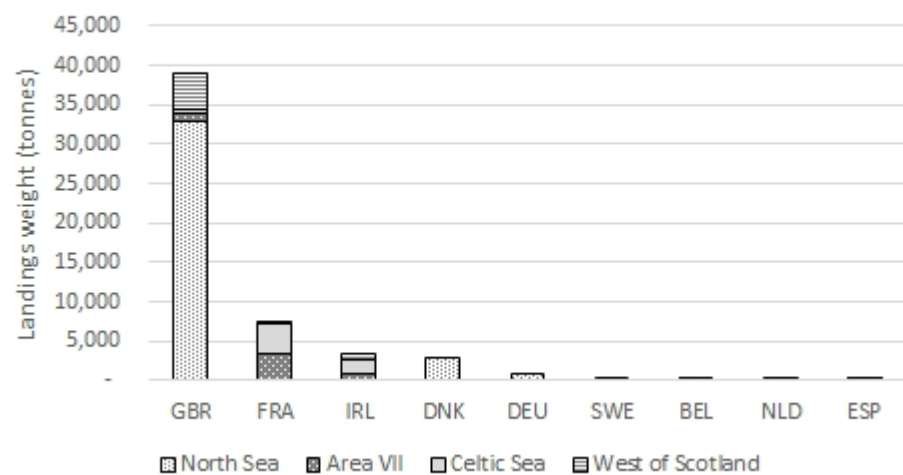


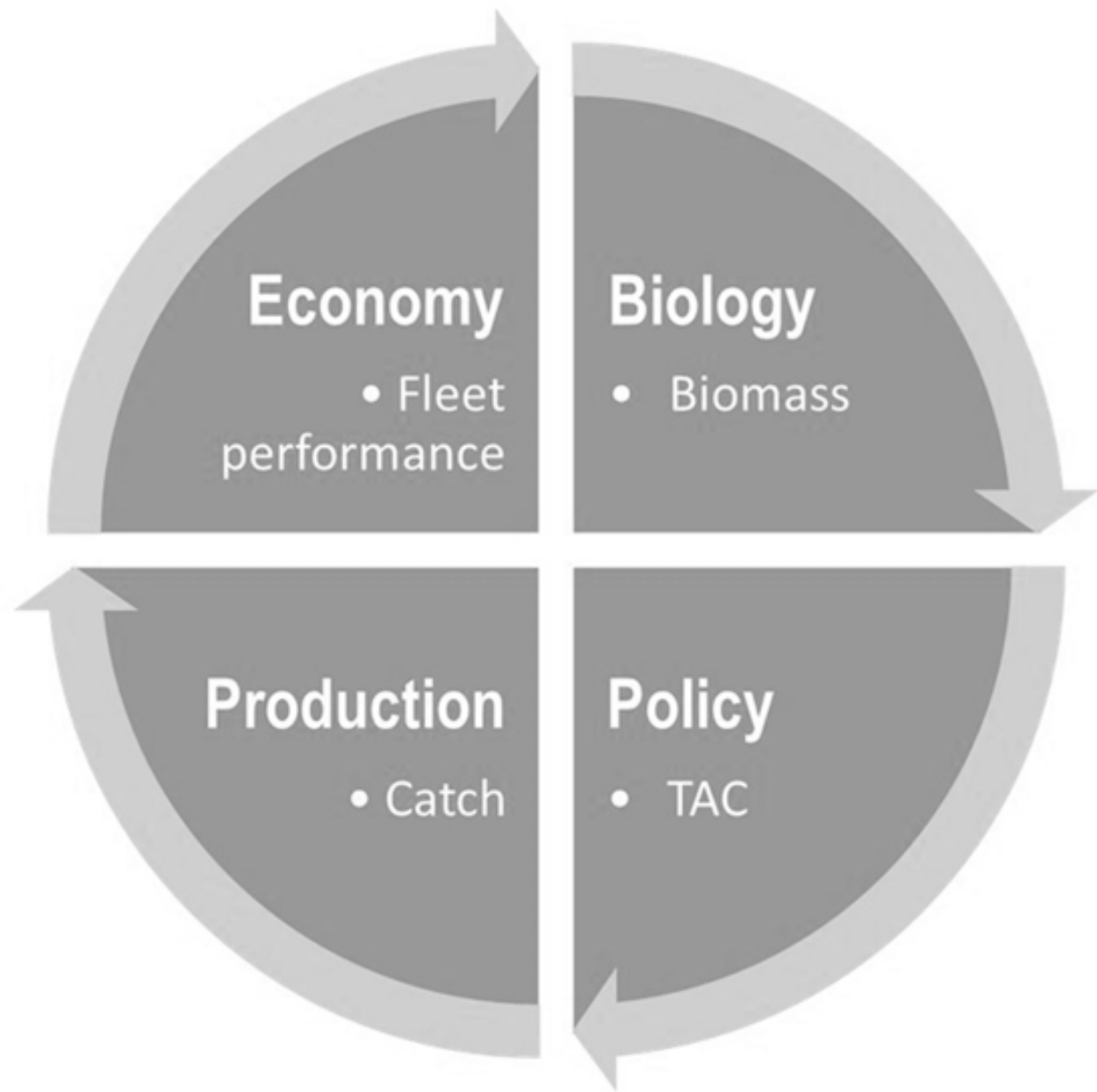


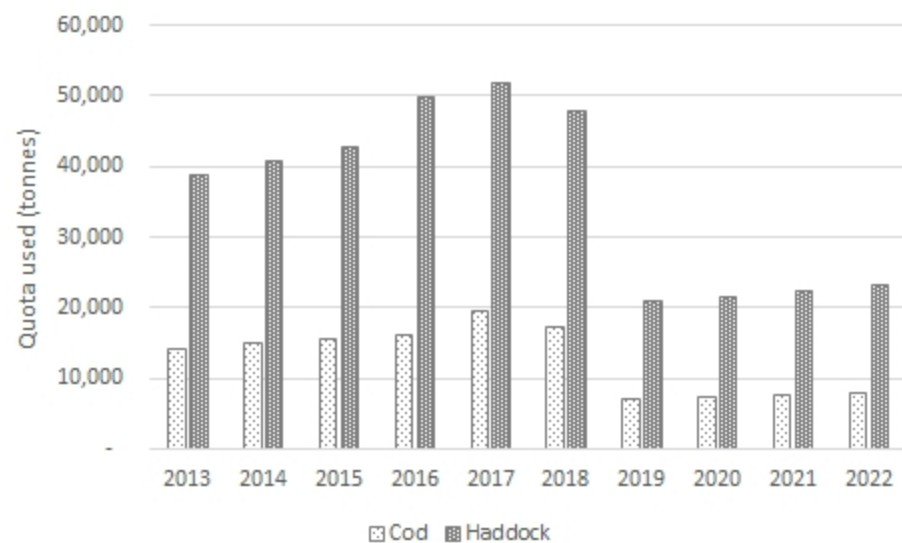
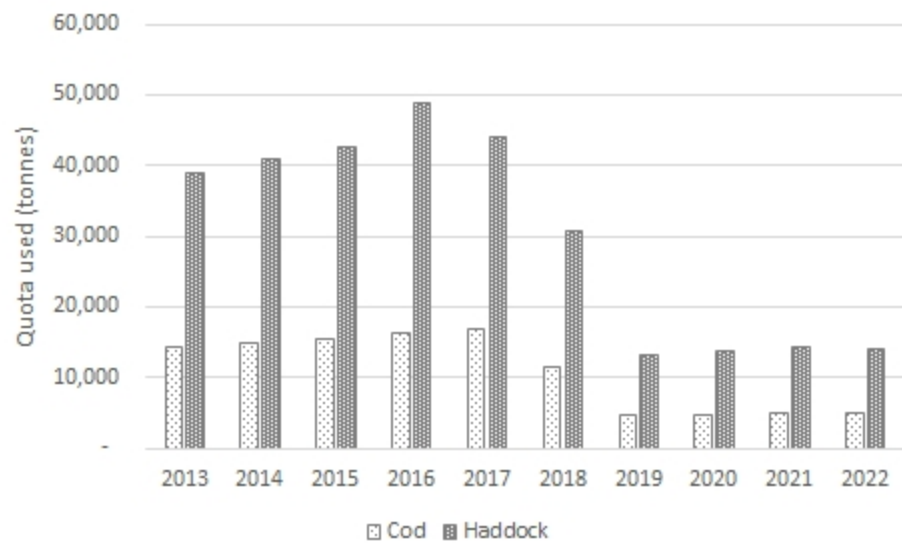
### Cod



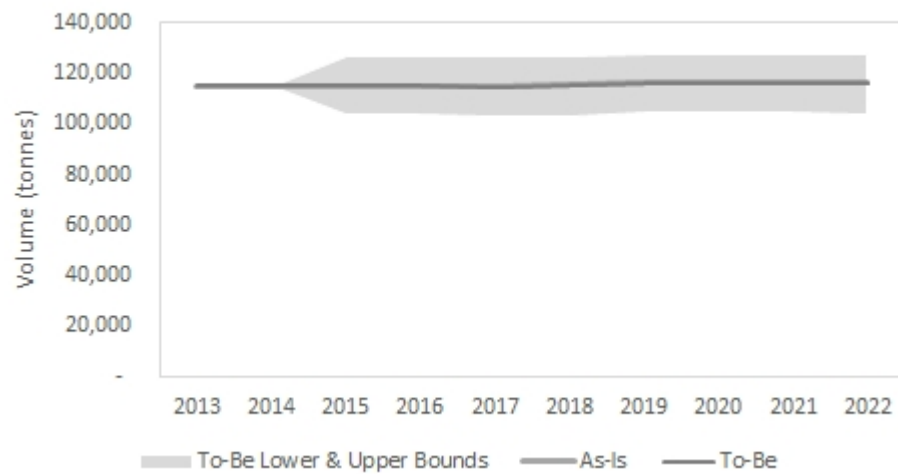
### Haddock







### Total Cod available



### Total Haddock available

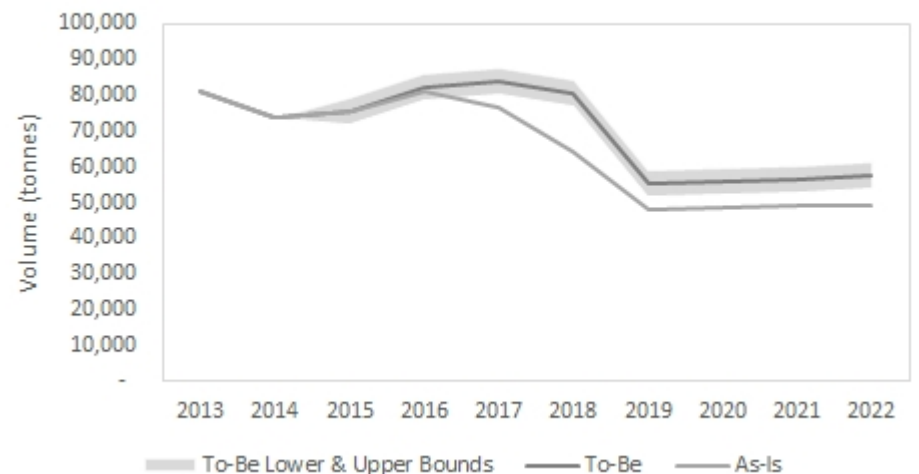


Table 1. Whitefish value chain in the UK in 2014, quantity and value [6]

2014	Landings outside UK by UK vessels	Landings in UK by UK vessels	Imports	Exports	Apparent consumption*
Cod	14.9 kt (M€25.1)	14.0 kt (M€34.7)	116.4 kt (M€510.8)	15.5 kt (M€65.4)	115.7 kt
Haddock	0.7 kt (M€1.3)	35.4 kt (M€61.5)	35.9 kt (M€138.4)	1.0 kt (M€3.2)	72.1 kt
Hake	2.8 kt (M€7.8)	8.5 kt (M€24.6)	4.7 kt (M€13.8)	3.9 kt (M€16.3)	16.4 kt
Ling	0.4 kt (M€0.7)	4.4 kt (M€6.7)	1.2 kt (M€1.5)	2.3 kt (M€5.9)	5.0 kt
Anglerfish	4.5 kt (M€17.9)	11.4 kt (M€39.2)	1.7 kt (M€7.8)	2.8 kt (M€17.6)	11.6 kt
Plaice	15.6 kt (M€21.3)	3.5 kt (M€4.4)	4.2 kt (M€16.0)	0.3 kt (M€0.6)	8.1 kt
Pollack	0.6 kt (M€0.8)	1.9 kt (M€4.3)	38.3 kt (M€89.5)	3.9 kt (M€12.9)	36.4 kt
Saithe	1.6 kt (M€2.5)	11.1 kt (M€12.7)	3.2 kt (M€11.9)	4.7 kt (M€10.7)	15.9 kt
Whiting	0.7 kt (M€0.8)	11.1 kt (M€14.8)	3.3 kt (M€3.2)	1.6 kt (M€1.5)	13.4 kt

\*Apparent consumption = [(total catches – industrial catches) + aquaculture + imports] – exports

Table 2. Changes in rest of world imports to UK for supply of cod and haddock, 2012-14 [6,12]

	Cod imports			Change (2012-14)	Haddock imports			Change (2012-14)
	2012	2013	2014		2012	2013	2014	
Iceland	28,722	36,211	32,747	+14%	10,936	9,289	6,710	-39%
Norway	17,111	20,036	23,757	+39%	23,675	11,386	9,115	-61%
China	14,780	20,339	24,761	+68%	7,946	6,550	5,226	-34%
Denmark	10,255	12,342	9,386	-8%	6,030	6,058	4,016	-33%
Faroe Islands	6,592	7,226	6,353	-4%	2,504	3,110	2,861	+14%
Germany	8,879	7,599	6,802	-23%	1,912	657	439	-77%
Others	15,194	12,591	12,595	-17%	7,708	7,857	7,515	-3%
TOTAL	101,533	116,343	116,401	+15%	60,711	44,907	35,882	-41%