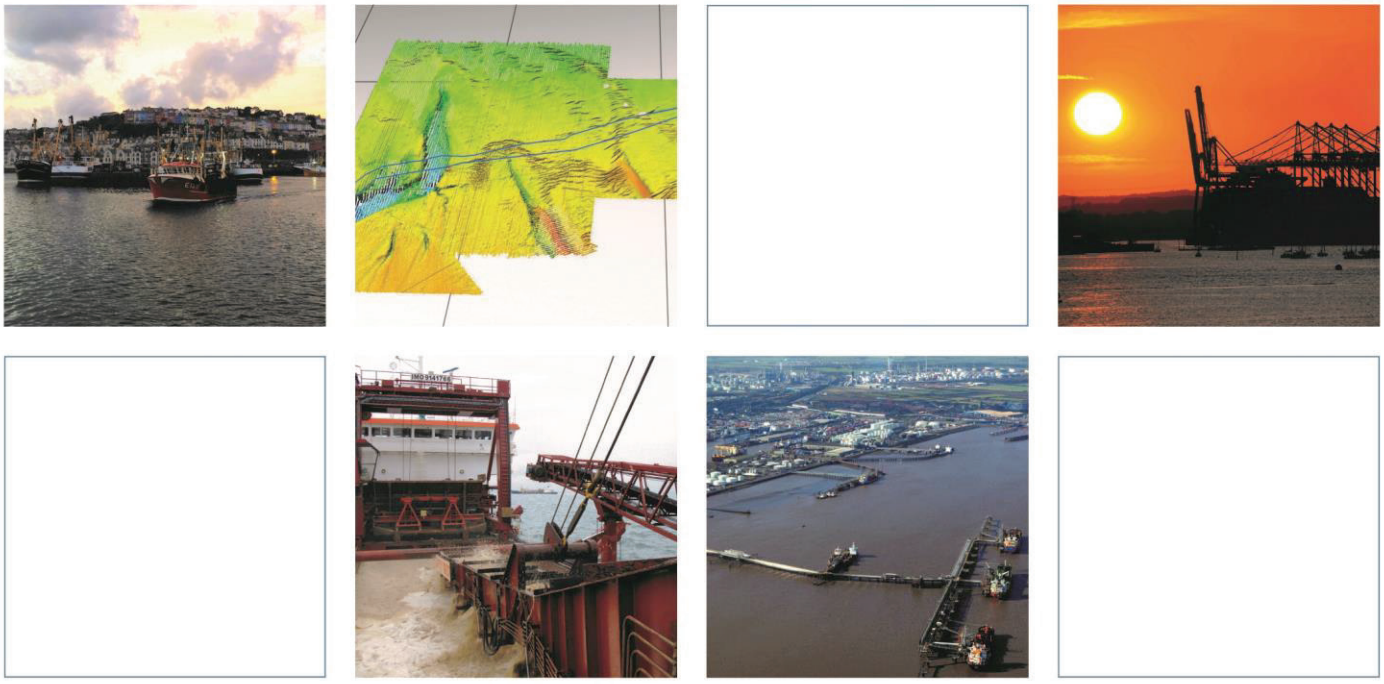
Marine Scotland

Seafood Trade Modelling Research Project - Assessing the Impact of Alternative Fish Trade Agreements Post EU-Exit

Final Report

June 2018



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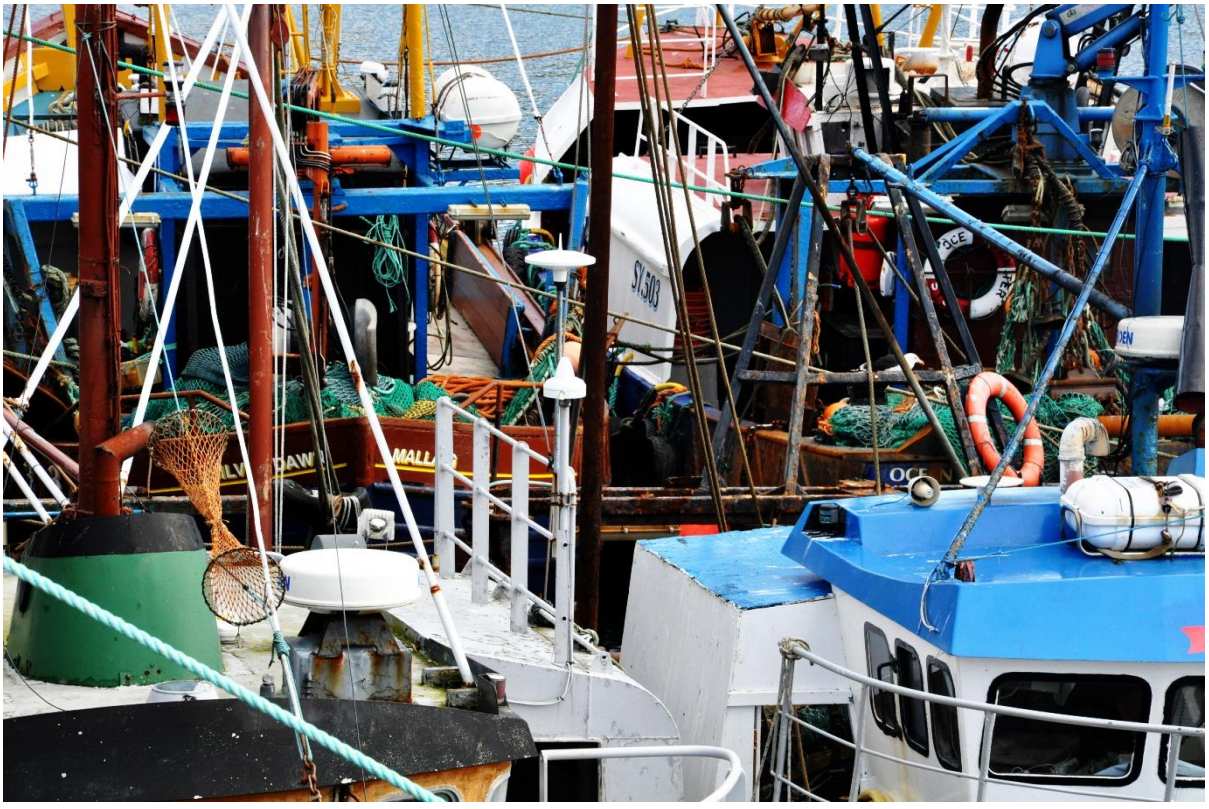

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Executive Summary

Fisheries is one of the sectors that has been flagged as likely to be significantly affected by the UK's exit from the EU. This project provides evidence on the likely impacts of different scenarios for total allowable catch (TAC) or quota sharing and trade arrangements between UK and the EU, to better understand the potential impacts of different arrangements on fishing, aquaculture and processing, and potential knock-on impacts on other sectors of the economy. It has been prepared by ABPmer Ltd, InterAnalysis Ltd at the University of Sussex and Vivid Economics on behalf of Marine Scotland.

Approach

The potential impacts of four scenarios of UK TAC or quota sharing and trade arrangements (tariffs and non-tariff measures) with the European Union (EU) and rest of the world are explored for ten different fish and shellfish species (cod, crab, haddock, hake, herring, mackerel, Nephrops, saithe, salmon and scallop) under four different scenarios.

The scenarios range from more liberal trade and greater fishing opportunities (TAC or quota shares) for the UK to more restrictive trade without growth in fishing opportunity for the UK. They are not predictions of the future and serve only to highlight the relative importance of the international drivers for the UK seafood sector — level of fishing opportunity, tariffs and non-tariff measures (NTMs). The analysis does not discuss the relative likelihood of any of the scenarios, which are modelled for analytical purposes only. The scenarios modelled are:

- **Scenario 1:** Removal of all tariffs on UK exports to all countries and the removal of UK tariffs on imports from all countries, a small reduction of non-tariff barriers between the UK and non-EU trading partners, and a reallocation of fishing quotas in the UK's favour based on the zonal attachment principle.
- **Scenario 2:** Tariffs on UK-EU trade flows which are similar to the current EU–Norway agreement, a modest increase in non-tariff measures between the UK and the EU, and a reallocation of fishing quotas in the UK's favour based on the zonal attachment principle, while maintaining current (baseline) trade arrangements with the rest of the world.
- **Scenario 3:** World Trade Organisation (WTO) 'Most Favoured Nation' tariffs imposed on bilateral trade between the UK and the EU, together with a larger increase (compared to Scenario 2) in non-tariff measures, and a reallocation of the quotas under the zonal attachment principle as in the earlier scenarios, while maintaining current (baseline) trade arrangements with the rest of the world.
- **Scenario 4:** MFN tariffs applied between the UK and EU, and with non-EU countries. Non-tariff measures increase as in Scenario 3, but there is no reallocation of quotas. Quota allocations remain the same as currently between the UK and EU.

The impacts on prices, output, imports and exports are explored for the UK through partial-equilibrium modelling for each species, using a multi-market model including the UK, the 'EU27' (current EU Member States, less the UK), and other key UK trading partners for each species. The wider economic impacts are explored in terms of the potential direct, indirect and induced GVA and employment impacts of the changes in output for Scotland, and an identification of the main sectors of the economy likely to be affected.

Trade impacts

In the absence of reallocation of quotas in line with zonal attachment, the liberalisation of trade modelled in Scenario 1 results in a decrease in the UK price index for all species, which is expected to benefit consumers, and an increase in both UK exports and imports. However, despite this representing a very substantial liberalisation of the UK's trade, the changes in trade are modest, with the largest increase in exports being for salmon at 3.5%.

The impact of increased tariffs and non-tariff measures (under Scenarios 2–4) is negative for the UK (again, without considering reallocation of quotas in line with zonal attachment). Exports decline for all species modelled, and quantity and value of output, and imports, decline for all species except haddock. The reductions in output, exports and imports for the UK are 2.3%, 5.9% and 3.7% respectively under Scenario 4. Prices for all species rise, driven by the increase in tariffs and non-tariff measures.

Both tariffs and non-tariff measures contribute to these trade impacts, with the relative contribution variable across species and scenarios. Under Scenario 2 (EU-Norway level tariffs), non-tariff measures have a bigger impact than tariffs for many species, however in Scenarios 3 and 4 (WTO Most Favoured Nation tariffs), tariffs and non-tariff measures have a similar magnitude of effect, at the levels modelled here.

The reallocation of quotas in line with the zonal attachment principle results in increased UK production and dominates the impacts of other elements of the scenarios (tariffs and non-tariff measures). The impact of increasing UK production on output and exports outweighs the impact of the imposition of tariffs and non-tariff measures for the species and trade codes modelled, resulting in an aggregate increase in output of 10% and increase in exports of 12%, even with the imposition of WTO Most Favoured Nation tariffs on trade with the EU (Scenario 3). There is also a reduction in imports of 5%. For Scenario 1, the aggregate increase in output is 12% and increase in exports is 17%, with a 0.4% reduction in imports.

The impact varies across species, reflecting differential impacts across fleet segments and the aquaculture industry, and associated processing industry, mostly determined by the potential gains (or not) from the reallocation of quotas in line with zonal attachment compared to the current Relative Stability-based quota allocation. Hake, herring, mackerel and saithe all stand to gain significant percentage increases in quota allocation under zonal attachment, resulting in increases in output and exports, and reductions in imports.

Fleet sectors targeting non-quota species (crab and scallop) and the salmon aquaculture industry, which do not stand to gain from quota increases under the zonal attachment principle, suffer the negative impacts of higher tariffs and non-tariff measures without the benefits of a reallocation of quotas. Therefore, they experience a contraction in output value with the imposition of EU-Norway type tariffs (and non-tariff measures), and a greater contraction with WTO Most Favoured Nation tariffs and non-tariff measures. These are of the order of –0.6% for salmon and –4.4% for scallop (under Scenario 4). The impact on salmon is moderated by the large proportion of exports that go to non-EU countries (mainly the USA), and the low level of the EU's Most Favoured Nation tariffs on less processed forms of salmon (2% on fresh and chilled fish and fresh, chilled and frozen fillets). Further, current UK trade with most non-EU countries is not based on preferential trade agreements, thus it already faces the WTO MFN tariffs and higher non-tariff measures.

Differences between species also arise from the proportion of UK exports that go to the EU. Without a change to quota allocations, the largest negative impacts are on cod, hake, herring and saithe, due to

the large proportion of exports of these species that go to the EU, together with the relative increase in the level of tariffs (which are greater for herring) (Scenario 4).

The focus on ten species and the trade codes that relate specifically to those species means that the impact on trade for more mixed and generic categories, including frozen fillet blocks which are used as inputs to the processing industry, are not modelled. The modelling therefore does not reflect the full potential impact on the processing sector, particularly that part of it that relies on imported processed material. However, the UK would be able to set its own tariffs for imports for these trade codes, and frozen products would be less affected by non-tariff measures that might result in border delays.

Wider economic impacts

In terms of the wider economic impacts, the direct impacts in Scotland of Scenario 1 are an increase in economic output of around £320 million from 2015, the majority of which comes from the processing sector. The indirect impacts add a further £170 million and the induced impacts another £50 million. The total impact is a £540 million or 21% increase in output across the Scottish economy. This would be associated with a total increase of 5,000 FTE jobs and £210 million in GVA from 2015, including direct, indirect and induced effects.

In comparison, the direct impacts of facing WTO Most Favoured Nation tariffs and increased non-tariff measures — with no reallocation of quotas (Scenario 4) — would be a decrease in direct economic output in Scotland of around £50 million. Again, most of the impact is on the processing sector. The indirect impacts would subtract a further £27 million from Scotland's economy and the induced impacts another £8 million. The total impact would be an £85 million or 3% decrease in economic output from 2015. This would be associated with a decrease of 429 FTE jobs (direct, indirect and induced), of which 44% would be in the processing sector and 43% to the fishing sector. The total GVA under Scenario 4 decreases by £20 million.

The sectors of the economy that are most affected by the indirect effects (purchases by the sectors directly affected) are fishing, fish and fruit processing, and aquaculture sectors. This is because the sectors purchase from each other and within themselves. Other top ten affected sectors relate to the purchase of items associated with co-processing of fish, such as food and packaging. Transport, power and fuel, and financial services sectors are also in the top ten sectors that are indirectly affected. Together, the top ten affected sectors that are indirectly affected account for 72% of the indirect impact.

Conclusions

Overall, the project successfully developed seafood trade models for ten individual fish and shellfish species. In the scenarios analysed, the gains for the UK economy of a reallocation of quotas between the UK and EU in line with the zonal attachment principle are potentially significant and outweigh the negative impacts of an increase in tariff and non-tariff barriers. However, depending on the level of tariffs imposed, some sectors may be overall negatively impacted, particularly fleet sectors targeting non-quota species and the aquaculture industry. A focus on achieving an agreement with the EU on sustainable fishing and TAC or quota sharing arrangements should therefore be a priority for negotiations, along with considerations for free access to the EU market.

Further development of the seafood trade models is recommended, including updating and refining some of the underlying data, developing models for additional species, and developing models for additional trade codes that are important to parts of the UK seafood processing industry and to increase the coverage.

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1 Introduction

This Final Report for the 'Seafood Trade Modelling Research Project — Assessing the Impact of Alternative Fish Trade Agreements Post EU-Exit' has been prepared by ABPmer Ltd, InterAnalysis Ltd at the University of Sussex and Vivid Economics on behalf of Marine Scotland. It provides the analysis of the potential impacts on prices, output, imports and exports for ten seafood species for four different scenarios for Total Allowable Catch (TAC) or quota sharing and trade arrangements between the UK and European Union (EU) and the rest of the world. The impacts on prices, output, imports and exports are explored for the UK and the EU through partial-equilibrium modelling for each of the ten species, using a multi-market model including the UK, the 'EU27' (current EU Member States, less the UK), and other key UK trading partners for each species. The wider economic impacts of each of the scenarios on Scotland are explored in terms of the potential direct, indirect and induced GVA, employment and output changes, and identification of the main sectors of the economy likely to be indirectly affected.

1.1 Background

Fisheries is one of the sectors that has been flagged as likely to be significantly affected by the UK's exit from the EU. It comprises both wild sea fisheries and aquaculture, which provide inputs to the fish processing industry. The aim of the project was to provide evidence on the likely impacts of different TAC or quota sharing and trade arrangements scenarios, to better understand the potential impacts on fishing, aquaculture and processing, and potential knock-on impacts on other sectors of Scotland's economy.

The total volume of landings by UK vessels (into the UK and abroad) was 708,100 tonnes with a first sale value of £775 million in 2015 (MMO, 2016). UK aquaculture production is dominated by Atlantic salmon, most of which is produced in Scotland, with 171,722 tonnes produced in 2015 with a value of £637 million (Marine Scotland, 2016). The fish processing industry is important in the UK, particularly in the Humberside and Grampian regions, with a total turnover of £4,395 million and £776 million GVA in 2014 (Seafish, 2016). Of this, £2,038 million turnover and £341 million GVA was in Scotland. Further detail on the fishing, aquaculture and processing industries are provided in Appendix A.

Table 1.1 Output, GVA and employment for fishing, aquaculture and processing for Scotland and the rest of UK

	Sector	Scotland	Rest of UK	Total	Source
Output (£m)	Fishing (2015)	437	338	775	MMO, 2016
	Aquaculture (2015)	660	20	680	Cefas; SG 2016a; SG 2016b
	Processing (2014)	2,038	2,357	4,395	Seafish, 2016
GVA (£m)	Fishing (2015)	197	152	349	Calculated from SG 2017, based on output
	Aquaculture (2015)	215	6	221	
	Processing (2014)	341	435	776	Seafish, 2016
Employment	Fishing (2015)	4,828	7,279	12,107	MMO, 2017
	Aquaculture	1,654 (2015)	1,333 (2012)	N/A[1]	HIE, 2017; Cefas, 2015
	Processing (2014)	8,784	9,824	18,608	Seafish, 2016

[1] Not possible to provide total; data are from different years.

Fish and fishery products are one of the most highly traded food commodities internationally, with fish trade representing more than 9% of total agricultural (including fish) exports (excluding forest products) and 1% of world merchandise trade in value terms in 2014. The value of global fish and fishery products exports rose from US$ 8 billion in 1976 to US$ 148 billion in 2014 (FAO, 2016a). Supply chains are complex and globalised, with processing being increasingly outsourced to countries with comparatively low wage and production costs.

In 2016, the UK exported £1,640 million of fish and fish preparations, of which 71% went to EU countries (MMO, 2017) (in 2015, the figure was £1,337 million). Salmon, mackerel, herring, scallops and Nephrops are particularly important species for UK seafood exports, Salmon alone represents 32% of the value of UK seafood exports (Seafish, 2017). The main species imported reflect the UK's consumer tastes, with shrimps and prawns, cod, tuna and salmon dominating (Seafish, 2017).

The rules governing international trade of seafood are negotiated in the World Trade Organisation (WTO)[1], through a series of agreements with the aim of establishing a framework for trade and the liberalisation of international markets for goods, services and investments (FAO, 2009). Whilst tariffs can act as a barrier to trade, increasing costs, non-tariff measures can have as great or a greater effect on trade. For fish and fishery products, these include sanitary and phytosanitary measures, restrictions on fish (e.g. size, presentation); the catch method; and labelling requirements (e.g. origin of the catch, generic marketing names). Further detail on WTO rules for trade relevant to the seafood industry is provided in Appendix B.

Shortly before the UK joined the European Economic Community in 1973, the existing six members established the principle of equal access to waters. Fishing opportunities for Member States' fishing fleets (for species managed through TACs and quotas) are determined by the distribution or allocation of the EU's quota to the individual Member States. This is done according to the principle of 'Relative Stability' which seeks to guarantee the same proportion of the EU's quota each year for a Member State, in relation to a species in a fishing area. The Relative Stability key was established on the basis of historical reported landings over a five-year reference period (1973–1978), and was subject to intense political negotiation during the development of the first Common Fisheries Policy (CFP). The allocation also takes into account the needs of coastal areas heavily dependent on fisheries, lost fishing opportunities arising from the declaration of 200-mile exclusive fishing zones by third countries, and national priorities in terms of target stocks (FAO, 2000).

When the UK leaves the EU and the CFP, it will be considered a coastal state under the United Nations Convention on the Law of the Sea (UNCLOS), responsible for the sustainable management of the resources in its Exclusive Economic Zone (EEZ). This requires cooperation with other states (in particular the EU and Norway) for the management of shared stocks, and a key part of this will be agreeing overall catch limits and their allocation between the coastal states. Zonal attachment[2], as used as the basis for allocation of shared stocks in the EU–Norway agreement, is an alternative approach to the current CFP 'relative stability' allocation based predominantly on historic catch levels.

[1] WTO rules cover tariffs and non-tariff measures (NTMs), technical standards, including food safety and quality, rules of origin, anti-dumping measures, subsidies and safeguards, trade in services, intellectual property and dispute settlement.

[2] Zonal attachment is a way of defining how the amount of fish to be caught from a shared stock should be divided amongst the coastal states in whose waters the stocks occur. The zonal attachment of a stock is the share of the stock residing within a particular country's EEZ, weighted by the time it spends in a country's zone over a year, if necessary.

1.2 Aims and objectives

The aims and objectives of the research as presented in the Invitation to Tender (ITT) were:

a) To develop scenarios for Scotland and the rest of UK's future fish trade and fishing access rights. This will be informed by an analysis of current international trade rules (tariffs and non-tariff measures); evidence on existing trade follows (imports and exports); global consumption and production patterns; the identification of potential new market opportunities for Scotland's and rest of the UK's fishing and seafood industry; and, aspirations for Scotland and different parts of the UK.
b) Adapt existing and tested fish trade analysis frameworks or models to evaluate the impacts of scenarios for alternative fish trade and fishing access rights (see objective (a)) to assess impacts across different fishing and seafood industry sectors and regions of the UK (Scotland, England, Wales and Northern Ireland).
c) For each region of the UK (England, Scotland, Northern Ireland and Wales), use the model to:
    i. Assess the impacts of the alternative scenarios for UK fish trade and fishing access rights on patterns (direction of flows, volume and value) of Scotland and the UK's trade (imports and exports) for different fishing and seafood commodities;
    ii. Assess the wider economic impacts (e.g., turn over, Gross Value Added (GVA) and employment) of changes in UK fish trade patterns and changes to fishing access rights; and
    iii. Identify main sectors of each region and the wider UK economy that will be affected by changes in UK fish trade.

Due to data constraints, the project was not able to address objective c) for each region of the UK. The Steering Group agreed for the project to look at trade impacts (objective c(i)) at the UK level, and wider economic impacts (objective c(ii) and (iii)) only for Scotland. Further, rather than looking at the scenarios for fishing access rights, the Steering Group agreed that the project should focus on scenarios for TAC or quota sharing arrangements between the UK and the EU.

2 Scenarios

When the UK leaves the EU, a number of aspects of the policy framework will change, potentially radically. The scenarios for TAC or quota sharing and trade arrangements were developed by the Project Steering Group and consider:

- Changes to arrangements for trade in fish and fishery products (tariffs and non-tariff measures (NTMs)); and
- Changes to the distribution of TACs or quotas between the UK and EU27[3], with a move away from Relative Stability[4] (RS) and towards the zonal attachment (ZA) principle.

Changes are likely to be most significant between the EU and the UK, but changes may also occur between the UK and third countries, either as a result of new trade agreements, or because effective UK membership of existing EU Free Trade Agreements (FTAs) with (50+) third countries may lapse.

The baseline for the scenarios is 2015 in terms of the value of landings and the value and volume of trade flows. This was the latest year for which global fishery and aquaculture production data were available. The baseline is that UK and EU27 landings remain at status quo level (2015), the UK remains part of the Single Market and EU Customs Union for fish and fishery products. There are no tariffs and a low level of NTMs (5%) between the UK and EU for fish trade, and no trade defence with the EU. The model does not incorporate bio-economic modelling of fish stocks, and therefore does not account for potential changes to fish stock biomass or productivity in the future. Additionally, macroeconomic factors that may affect fish trade (e.g. exchange rates, economic growth, market demand) are held constant.

The scenarios range from more liberal trade and greater fishing opportunities (i.e. greater TAC or quota allocations, hereafter 'quota allocations' for brevity) for the UK, to more restrictive trade without growth in fishing opportunities for the UK. They are not predictions of the future and serve only to highlight the relative performance of the international drivers for the UK seafood industry – tariffs, non-tariff measures and quota allocations for shared stocks. The analysis does not reflect the relative likelihood of any of the scenarios and they are modelled for analytical purposes only. They are described below and summarised in Table 2.1 (further detail provided in Appendix C).

Scenario 1: this involves three elements: (i) no tariffs on UK exports nor imports with all countries in the world, hence this involves the removal of all tariffs on UK exports to all countries and the removal of UK tariffs on imports from all countries; (ii) a small reduction of non-tariff barriers between the UK and non-EU trading partners, for example arising from future free trade agreements the UK might sign (e.g. global mutual recognition of standards would mean standards and conformity testing would disappear); and (iii) a reallocation of fishing quotas in the UK's favour based on the zonal attachment principle[5]. This involves increasing the UK's quota allocations and decreasing the EU's.

[3] Current EU Member States, less the UK.

[4] Relative Stability seeks to guarantee the same proportion of the EU's quota each year for a Member State, in relation to a species in a fishing area. The Relative Stability key was established based on historical reported landings from 1973-1978, adjusted to take into account the loss of fishing opportunities in third countries' EEZs and areas dependent on fishing.

[5] Where the sharing of TACs for joint stocks is done according to an agreed percentage, based on the spatial distribution of the stock over time and over its various life stages (zonal attachment) for each species.

Scenario 2: This also involves three elements: (a) the UK signing an EU–Norway-style agreement on tariffs with regard to fisheries with the EU, hence there is some introduction of tariffs on UK-EU trade flows but below the level of EU Most Favoured Nation (MFN) tariffs, and continuation of existing FTAs with third countries ('grandfathering') (Gasiorek & Holmes, 2017), such that applied tariffs on non-EU trade remains as currently; (b) a modest increase in non-tariff measures between the UK and the EU arising from the exit of the UK from the Single Market and the consequent increases in regulatory burden and customs procedures therein (e.g. mutual recognition of both standards and testing and certification, rules of origin, catch certificates); and (c) the reallocation of fishing quotas in the UK's favour based on the zonal attachment principle.

Scenario 3: This scenario results in MFN tariffs being imposed on bilateral trade between the UK and the EU[6], and a larger increase in non-tariff measures arising from the UK's exit from the Single Market and the absence of a deal with the EU (e.g. full strength conformity assessment due to no mutual recognition of UK standards or testing and certification procedures, veterinary checks, catch certificates). However, this option retains the reallocation of the quotas under zonal attachment as in the earlier scenarios. In this scenario, the tariffs applied by the UK on imports from non-EU countries, and the tariffs faced by the UK in third country markets, have not been changed from the baseline. Of course, depending on what is negotiated by the UK there may well be tariff changes from a no-deal option with those non-EU countries that the EU has a free trade agreement with.[7] On leaving the EU, the UK will no longer be a party to these agreements and unless they have been rolled over (or 'grandfathered'), MFN tariffs between the UK and these countries may well apply. This possibility is addressed in Scenario 4.

Scenario 4: in this scenario, MFN tariffs are applied between the UK and EU, and non-EU countries, and there is no reallocation of quotas. It suggests that quota allocations remain the same as currently, while the UK leaves the EU with no deal in place on tariffs. It is worth mentioning here that two alternative no-deal scenarios can be envisaged - one which is planned for and known in advance, and a second which involves a last-minute no-deal, which is sometimes referred to as 'crashing out'. These differences have not been modelled here but the latter would clearly involve a bigger change in non-tariff measures and customs procedures. Finally, and as discussed in the context of Scenario 3, the tariff changes that may occur as a result of a no-deal scenario between the UK and the countries that the EU currently has a free trade agreement with are explicitly modelled. For the trade between the UK and these countries, each country's MFN tariff rate is applied.[8]

6 This assumes that the UK inherits the EU's schedules for the purposes of this project, thus the current EU's average MFN tariff is applied bilaterally by the UK and the EU.

7 The EU currently has 37 free trade agreements with over 60 countries.

8 The countries included in our simulations vary from specie to specie and are based on the principal trading partner for the UK for that specie. This means that for some of our modelled species, none of the countries which are individually identified are countries with whom the EU has a free trade agreement. In these cases there is no additional change in the bilateral tariffs applied.

Table 2.1. Summary of scenarios

Scenario	Description	Tariffs	Non-Tariff Measures*	Production (Quota) Changes
Baseline	Current situation	Zero tariffs with EU Existing tariffs with RoW	Base - EU: 5% - RoW: 15%	Relative stability and in-year quota swaps
1	Global Free Trade Agreement and increased UK production	Zero tariffs with EU Zero tariffs on UK imports from RoW	Low - EU: 5% - RoW: 10%	UK and EU quotas based on zonal attachment
2	EU-Norway-type agreement with EU and increased UK production	EU-Norway tariffs with EU Existing tariffs with RoW	Moderate - EU: 10% - RoW: 15%	UK and EU quotas based on zonal attachment
3	MFN tariffs and increased UK production	MFN tariffs with EU Existing tariffs with RoW	High - EU: 15% - RoW: 15%	UK and EU quotas based on zonal attachment
4	MFN Tariffs and no increase in UK production	MFN with EU MFN with RoW	High - EU: 15% - RoW: 15%	No change

* NTM are modelled as *ad valorem* equivalent (AVE) tariffs. The NTM levels used in the scenarios were developed based on an analysis of the types of NTM that will be in place in each scenario, and available information on their magnitude as a tariff equivalent. Further details are provided in Section 3.3.1 and Appendix B.2.

3 Description of the Approach

3.1 Trade model

The modelling framework used is a standard partial equilibrium computable model of international trade - the Trade Analysis Partial Equilibrium Sussex (TAPES) model created at the University of Sussex. The TAPES model is specifically designed to analyse the impact on trade (both imports and exports) and production of changes in trade policies, such as tariffs, quotas or non-tariff measures. The version of the model used is a slightly modified version of Francois *et al.* (1998), and is a perfectly competitive[9] multi-market model with an underlying Armington demand structure[10]: The advantage of a multi-market model is that trade – both exports and imports – can be simultaneously modelled between several partner countries. Hence, in the context of changes in policy arising from Brexit it allows both the change in UK imports from various sources, as well as changes in UK exports to different destinations, to be considered.

Partial equilibrium modelling involves treating each industry/goods/species separately (for the sake of brevity, subsequently referred to as 'goods'), and does not take into account the interactions between goods. Hence, in this report the direct impact of changes in tariffs on trade flows are modelled for ten different fish species, and each of these is modelled independently. Any changes, therefore, in the price of haddock as a result of a change in tariffs, do not impact on the demand for a different species, such as cod. In a similar vein the model does not model factor markets, such as the labour market. Hence, as supply changes in response to a tariff change we do not model any changes in the labour market nor any changes therefore in wages. While to a degree this is clearly unrealistic it is important to note that the main impact of any change in tariffs would be the direct effect, and the interaction effects with other goods where they exist are typically very much second order and much smaller. Modelling the interaction effects between goods/markets is much more complex and much more demanding of the data, and all species or potential substitutes would also be affected by relatively similar shocks. Accounting for interactions between commodities would require a form of modelling known as computable general equilibrium (CGE) modelling, which is only possible where there is a full set of input-output tables. As these are typically only available at a much more aggregated level it is not possible to run a CGE analysis on each individual species. The approach taken in this report therefore is to model the impact on different species at the most disaggregated level that was possible given the data constraints, and then to model the broader economic impacts which take into account inter-sectoral linkages separately. A substantial advantage of this approach is that it is possible to work at a much more detailed level of goods (fish species) than would otherwise be possible.

[9] The assumption of perfect competition means that it does not allow for any monopolistic or imperfectly competitive behaviour by firms. This means markets converge to an equilibrium where no firm is making abnormal profit.

[10] The Armington demand structure is a way of setting up and solving the model, and means that within a given industry (in this case, any given fish species) the products (fish) produced by each country are not identical to each other, but are modelled as imperfect substitutes. Hence products are differentiated by their place of origin and a constant elasticity of substitution is assumed among different products in the same class. The degree of substitutability between, for example, the imports of haddock from Canada and from the EU, is a parameter that is then chosen in the model.

The TAPES model is specified as a non-linear system of equations and numerical methods are used for solving.[11] In order to achieve this, partial equilibrium modelling involves three stages. First the base (or equilibrium) data set needs assembling. For the scenarios ten fish species are modelled and so the data on the actual trade flows between countries for each of these species are needed, as well as information on domestic production (landings and processed output) for all countries, on the tariffs between the countries concerned, and then information on key parameters. The data are described in more detail in Section 3.2. Second, the model needs to be 'calibrated' to the base data. This entails ensuring that when the system of equations is solved, in the absence of any change in policy, the levels of trade and production which are generated replicate exactly the levels of trade and production in the base data set. The final stage is that of 'simulation'. This involves changing a policy parameter – this could be a tariff, a quota, or a non-tariff measure, or some combination of the three – and then to run the model again. The change in policy impacts on prices, which in turn impacts on levels of trade and production which the model solves for. The comparison between the base equilibrium and the simulated equilibrium is therefore the simulated impact of the policy change. Appendix D provides a full description of the model and model equations.

3.1.1 Species

The modelling focusses on ten species (or species groups) (Table 3.1). A separate model was created for each of the species. These species (groups) were selected on the basis of their visibility in the Harmonised System (HS) 6-digit trade codes and their importance in terms of:

- Value of UK landings;
- UK export values; and
- Potential for quota redistribution under the principle of zonal attachment; and
- Significance to the Scottish fleet.

This precluded the inclusion of some species, such as monkfish or anglers, which are grouped with a range of other families in the trade data at 6-digit level across all product types (fresh/chilled, frozen, fillets etc.) and therefore could not be differentiated for the purposes of the modelling. The 6-digit codes were used because data on world trade flows (imports and exports for all countries) were required for the model, and this global coverage is only available at the 6-digit level.

Table 3.1. Species modelled

Species (Group)		Species Included (Based on the Species Included in the Relevant Trade Codes)
1	Cod	*Gadus morhua, Gadus ogac, Gadus macrocephalus*
2	Crab	All crab species
3	Haddock	*Melanogrammus aeglefinus*
4	Hake	*Merluccius* spp., *Urophycis* spp.
5	Herring	*Clupea harengus, Clupea pallasii*
6	Mackerel	*Scomber scombrus, Scomber australicus, Scomber japonicus*
7	Nephrops	*Nephrops norvegicus*
8	Saithe	*Pollachius virens*
9	Salmon	Atlantic salmon (*Salmo salar*), Danube salmon (*Hucho hucho*) and Pacific salmon
10	Scallops	Genera Pecten, Chlamys or Placopecten

[11] The GAUSS programming language is used to implement the model.

For each species, the trade codes that relate exclusively to each species (or species group) were selected for the model[12]. The list of codes used and their descriptions is provided in Appendix E. Because 2015 data are used, it is the HS2012 version of the trade codes that is used. The aim was to ensure that there is no overlap in the trade accounted for in the modelling exercise, but this means that the model may not capture all trade for a species. For example, for hake, the trade categories included (which relate exclusively to hake) are:

- 030254: Fresh or chilled;
- 030366: Frozen; and
- 030474: Frozen fillets.

Hake may also be traded as fresh or chilled fillets; fresh or chilled other meat; dried, salted or in brine or smoked; prepared or preserved. However, for these categories, hake is mixed in a group with various other fish species, or in a general 'other' category. For these, it is impossible to know the proportion attributable to hake, and therefore they have been excluded from the analysis.

The ten species modelled account for 67% of the value of UK landings and 94% of the value of UK aquaculture production. The trade models account for 60% of the value of UK trade (imports and exports) in the 03 category, and 13% of UK trade in the 1604 and 1605 categories. The trade data used in this report (see Section 3.2.2) are taken from the United Nations' (UN) Comtrade database, which provides extremely detailed trade data up to the HS 6-digit level. These data were used as opposed to for example Office of National Statistics (ONS) or Her Majesty's Revenue and Customs (HMRC) data because the modelling requires data on bilateral trade for all countries in the model, for example between Peru and Norway. This is only available from international data sources such as Comtrade. In principle, these data should be highly compatible with the UK official data, as it is supplied to the UN by the UK government, but in practice some differences between datasets do exist.

Of these ten species, mackerel, Nephrops, salmon and scallop dominate the value of UK exports, with cod, haddock and salmon dominating UK imports (Figure 3.1). UK imports of cod and haddock far outweigh exports of these species, whereas for Nephrops and scallops the opposite is true.

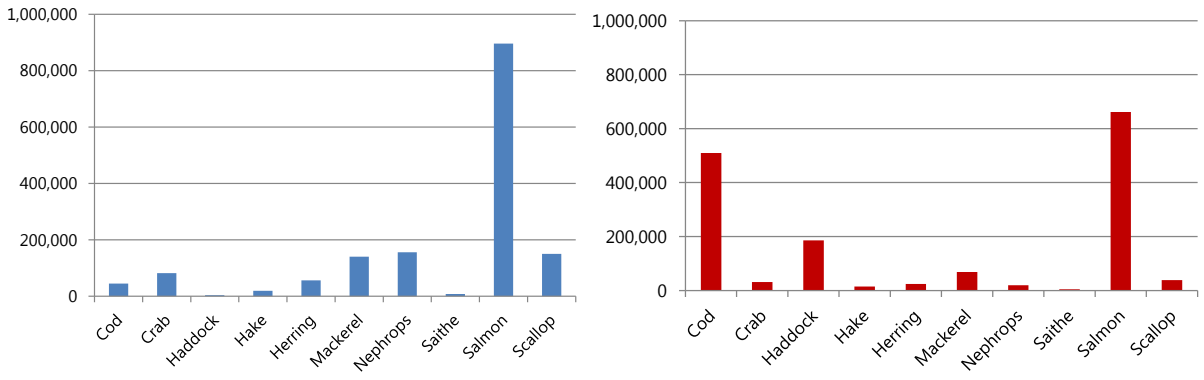

Figure 3.1. UK exports (left) and imports (right) of each species (annual average, 2013–2015), ($000)

[12] Trade data are available at six-digit Harmonised System (HS) level. There are codes specific to different species and species groups, but the grouping of species is not consistent across the different categories. For example, while cod (*Gadus morhua, Gadus ogac, Gadus macrocephalus*) is distinguished at the HS 6-digit level in 030251 (fresh or chilled) and 030363 (frozen), it is grouped together with seven other families (Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae – including species such as haddock, hake, Alaska pollock) in 030444 (fresh or chilled fillets), but treated separately again for frozen fillets (030471).

A large proportion of the exports of these species go to the EU27, although mackerel and salmon have the lowest proportions of exports to the EU. Imports of most species to the UK are dominated by non-EU countries, but over 80% of herring and mackerel imports are from EU27 countries (Figure 3.2).

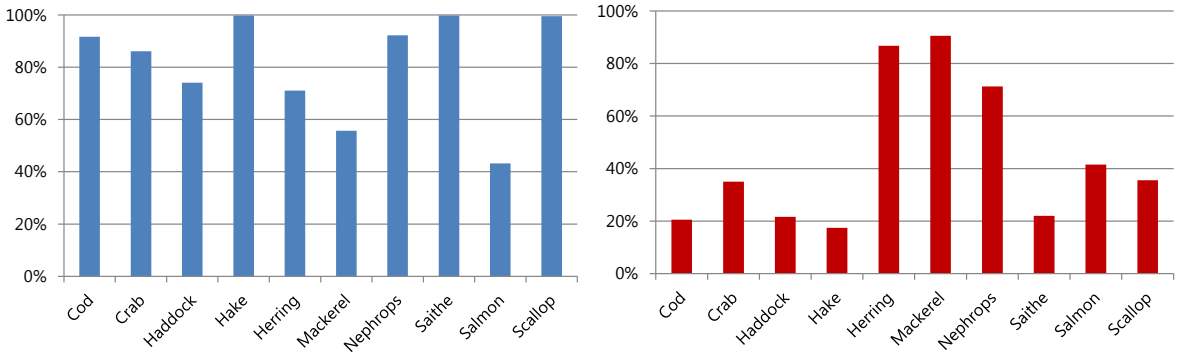

Figure 3.2. Share of UK exports (left) and imports (right) of each species that are traded with the EU27 (2013–2015)

3.1.2 Countries

The UK and EU27 are included in the models for every species. The other individual countries included in each species model account for at least 2.5% of the value of UK exports and of the value of UK imports of the HS2012 codes (on average over the period 2013–2015). The remaining countries are grouped in a 'Rest of World' (RoW) category. The EU27 was treated as a single entity in the model, because all its members have the same external trade policy (tariffs, border controls), which allowed more third countries to be included in the models.

The countries modelled for each species are listed in Table 3.2, and Appendix F lists the share of imports and exports for the top ten trading partners of the UK. By including these countries, over 95% of the UK's trade in each species is accounted for in the model.

Table 3.2. Countries included in each species model

Cod	Crab	Haddock	Hake	Herring
China EU27 Faroe Islands Iceland Nigeria Norway RoW Russian Federation United Kingdom	China EU27 Indonesia RoW United Kingdom Viet Nam Thailand China, Hong Kong SAR	Canada China EU27 Faroe Islands Iceland Norway RoW Russian Federation United Arab Emirates (UAE) United Kingdom USA	Argentina EU27 RoW South Africa United States of America United Kingdom	China EU27 Nigeria Norway RoW United Kingdom
Mackerel	**Nephrops**	**Saithe**	**Salmon**	**Scallops**
China EU27 Nigeria Norway RoW Russian Federation Ukraine United Kingdom	China EU27 India RoW United Kingdom Vietnam	China EU27 Faroe Islands Iceland Norway RoW United Kingdom	Canada China EU27 RoW United Kingdom USA	Argentina Canada EU27 Japan Peru RoW United Kingdom USA

It is important to note that the trade data give us the value of recorded trade, for example between Norway and the UK. Additional complexities to do with boat ownership and rule of origin certifications (e.g. Norwegian-produced salmon that is exported to the UK via Sweden or other EU countries) etc. are implicitly captured in this data but are not explicitly identifiable.

3.2 Data sources

A range of different data types were brought together for the model:

- Production data (value of production for each species, taking into account landings as well as production of processed fish and seafood);
- Trade data (value of imports and exports for each species, between the UK and each of the countries in the model);
- Tariffs for each of the countries in the model, both for the baseline and for each scenario;
- Tariff-equivalents for non-tariff measures, both for the baseline and for each scenario; and
- Other model parameters.

3.2.1 Production

The partial-equilibrium modelling requires data on production of each species modelled. The model for each species combines fresh and chilled fish, as well as processed fish (filleted, frozen, smoked etc.). Estimates of the value of production of each species, for each country, were therefore based on the volume of landings and aquaculture production (from FAO global production database – FAO, 2017) combined with reported data on the production of processed fish (from the FAO commodities and trade database – FAO, 2016b), taking into account conversion factors in processing (from EUMOFA). Full details are provided in Appendix G.1.

3.2.2 Trade

The data on trade in the model are derived from the UN Comtrade database. In order to ensure compatibility with the latest available production data, 2015 data are used. For each species, the bilateral trade flow is required, for example the level of UK imports from the EU and exports to the EU. These bilateral flows are needed for every pair of countries that are included for any given species. Further details are provided in Appendix G.2.

3.2.3 Tariffs

The data on tariffs derives from the UN Trade Analysis Information System (TRAINS) database, which provides information on the 6-digit tariffs levied by each country on each importer. In the absence of a free trade agreement between countries the tariffs will be the Most Favoured Nation (MFN)[13] applied tariffs; where there is a free trade agreement then the tariffs will be the preferential tariffs. As the model combines the trade for the different categories (fresh, frozen, fillets etc.) of a species together, a simple average tariff across the product categories for each species was used[14]. In the case of salmon, this was adjusted to take account of the differentiation between species, to avoid the average being weighted towards the lower tariffs of the fresh/chilled categories, where there is a

[13] MFN tariffs are set by each country through WTO agreements which mean that the lowest tariff offered by a country for a product category must be offered to all WTO members. The exception is Free Trade Agreements, where members can lower tariffs to below the MFN level without extending that tariff to all WTO members.

[14] Simple averages are usually preferable to weighted averages based on the value of trade. This is because the value of trade is endogenously determined by the tariff itself and so can provide a distortionary picture. Hence in the extreme case where a tariff is very high such that no trade takes place, the weight would be zero, and the weighted average tariff would not even take that product into account even though the tariff is clearly impeding trade.

greater level of species differentiation in the 6-digit trade codes. Further details are provided in Appendix G.3.

3.2.4 Non-tariff measures

Reliable estimates of the size of non-tariff barriers are not available, especially at extremely detailed levels of trade codes. A review of the literature (see Appendix G.4) indicates a range of AVEs for different types of NTM, of the order of –3% to +20%. We therefore assume a base level of NTMs of 5% for trade with the EU27 and 15% for trade with non-EU countries, and adjust this to reflect the NTMs in play in each scenario. Further details are provided in Appendix G.4. In choosing these levels of NTMs, if anything the assumptions made are conservative, and these probably represent a lower bound. NTM estimates do not account for the cost of 'doing business' in other countries.

3.2.5 Other model parameters

The model requires information or assumptions about: (a) the elasticity of demand for each species; (b) the elasticity of substitution between countries for any given species; and (c) the elasticity of supply.

The elasticity of demand represents how much demand changes with a change in price. It therefore captures the extent to which a change in price is then reflected in a change in demand for a given fish species. Information on the elasticity of demand is obtained from the detailed econometric estimation undertaken by Kee *et al.* (2008). Their work provides estimates at the HS1988 6-digit level for a range of countries, and for a range of seafood products. As the partial equilibrium model requires a single elasticity which is then applied to all countries, for each of the relevant 6-digit codes for each species the median elasticity as estimated by Kee *et al.* (2008) is used to take the simple average across the 6-digit codes.

The elasticity of supply represents how responsive supply is to a change in demand or price, i.e. how readily supply can be increased or decreased. The elasticity of substitution represents whether a product can be easily substituted by a similar product from a different source (country), for example whether cod from Norway is very similar to cod from Iceland. There are no estimates either of the elasticity of substitution nor of the elasticity of supply for the fish species modelled, so common practice requires some assumption: In the base simulations the elasticity of substitution is assumed to be 5 for fish species and 2.5 for shellfish species (due to fresh product being particularly important for UK–EU trade); and the elasticity of supply 1[15] (see Appendix D.2). Sensitivity analysis on these parameter values was carried out in order to assess the extent to which this impacts on the results (Appendix J)[16] Nevertheless it is important to note that there is considerable uncertainty as to the actual value of all of these elasticities and the best that any model can do is to use best-guess estimates and undertake sensitivity analysis. In turn this means that the results should not be viewed as predictions or forecasts, but more as indicators of the possible orders of magnitude that could occur, while holding all other factors that might impact on trade constant.

[15] Elasticity of substitution: if the elasticity of substitution were equal to 1 then if the price of say UK fish rose then consumers would switch in equal quantities to suppliers from other destinations. If the elasticity of substitution is more than 1 then there will be a bigger switch to purchasing from other suppliers. Generally, one would expect the elasticity of substitution to be higher than the elasticity of demand. We have assumed an elasticity of substitution of 2.5 and 5. Where the elasticity is equal to 5, the species are assumed to be quite highly substitutable. A supply elasticity of "1" means that if prices rose by 10% supply would increase by 10%. Where the supply elasticity is "3" (as in some of our sensitivity analysis), a 10% increase in price would lead to an increase in supply of 30%.

[16] The aim of the sensitivity analysis is to change one of the underlying parameters, such as the supply elasticity, in order to see how sensitive the results are to the change in the parameter. This helps to assess the plausibility and sensitivity of the results.

3.2.6 Corrections to the data

Landings to foreign ports

UK landings to foreign ports for herring and mackerel have been shown to be lacking from the trade statistics for UK exports (Seafish, 2017). A correction to the trade data was therefore made for herring and mackerel landed by UK vessels in non-UK ports, to account for unrecorded exports to Norway and the EU27 (Table 3.3).

Table 3.3. Correction for unrecorded exports landed directly to foreign ports (2015 data)

	Norway	EU27	Non-EU
Herring			
Value of UK landings to foreign ports ($000)	10,521	18,817	0
Value of UK exports (fresh/chilled) ($000)	-	7,806	8,754
Unrecorded exports ($000)	10,521	11,011	n/a
Mackerel			
Value of landings to foreign ports ($000)	106,758	42,083	6
Value of UK exports (fresh/chilled) ($000)	3,495	12,479	15,974
Unrecorded exports ($000)	103,264	29,604	n/a

Faroese salmon trade flows

Sources indicate that Faroese salmon passes through the UK in transit to other countries, but it is not processed or consumed in the UK. Therefore, imports of salmon to the UK from the Faroe Islands, and a corresponding value of UK salmon exports to the EU27, were removed from the trade data, as agreed with the Project Steering Group.

Value of production and exports

In the trade model, the value of production must be greater than the value of exports. In some cases, exports exceeded production, as a result of the combination of different datasets, and imported raw material being used as inputs to the processing industry, and the product subsequently exported. In these cases, the value of production was adjusted to allow for the value of exports and an estimate of domestic consumption. Domestic consumption was calculated based on: FAO per capita fish and seafood supply[17], population size, and an estimate of the significance of the species in question for local diets based on consumer preferences; the average ratio of exports to production from the other countries in the model; or the intra-regional trade flows.

Zero trade flows

In the model, trade flows cannot be equal to zero. Therefore, where the trade data showed there was no trade in a species between two countries, this was set to a very low level ($0.1) in order to allow the model to run.

Lack of trade data

In some cases, such as for the Faroe Islands, no trade data were available. In these instances, the mirror flows were used (i.e. as reported by the partner country importing from or exporting to the Faroe Islands).

[17] From the FAOSTAT Food Balance: Food Supply – Livestock and Fish Primary Equivalent dataset for 2013 (http://www.fao.org/fishery/statistics/global-consumption/en).

3.3 Applying the scenarios

3.3.1 Tariffs and NTMs

The TAPES model is set up to be able to work with both *ad valorem* tariffs, and specific tariffs, as well as quotas and non-tariff barriers. Effectively applied tariffs (AHS) are used for the baseline. A change to tariffs was applied by inputting the new tariff levels in the model.

The treatment of non-tariff measures (NTMs) in the model is stylised and these are modelled as *ad valorem* equivalent tariffs (but without generating any government revenue). For example, suppose that there is an NTM related to standards. For this to be included in the model, and for the model to be able to simulate changes in the non-tariff barrier, then the model needs information on the extent to which this NTM restricts trade if it were equivalent to a tariff. For example, a 10% NTM, assumes that the NTM restricts trade to the same degree as would a 10% tariff. The NTM levels modelled are based on available evidence on existing NTMs.

The level of NTMs in each scenario was based on available literature (see Appendix G.4) and adjusted to reflect the different types of NTM in each scenario. A change to NTMs was applied by adding the AVE NTM level to the new tariff levels and inputting them to the model. The range of NTM AVEs used reflect reasonable levels of NTMs where trade takes place under normal conditions (which is appropriate for the simulated equilibrium of the model, which does not incorporate short-term transitional impacts). It is possible that NTM levels could be much higher in the short-term and for some shipments if there are severe disruptions to trade flows such as significant border delays or trade defence measures imposed.

3.3.2 Zonal attachment

The new level of production for each species was calculated based on the additional UK landings anticipated from a change of TAC or quota distribution to the zonal attachment principle, by stock. The zonal attachment percentage estimate for each stock was taken from University of Aberdeen & SFF (2017), which provides one interpretation of the zonal attachment principle, applied to the 2015 TAC. The change in landings was calculated as the difference between the calculated UK zonal attachment quota estimate for each species, compared to relevant UK landings for 2015. Zonal attachment for Nephrops was estimated based on ICES stock advice for the individual Functional Units (FU) and the proportion of each FU in UK waters. It was assumed that UK production expands to fulfil the quota allocation. The exception was North Sea and West of Scotland Nephrops, where 2015 landings were significantly below the UK's initial quota allocation. However, the increase in Nephrops landings modelled (1,244 tonnes) is comparable to the overall potential increase in quota under the Zonal Attachment principle (1,421 tonnes).

The change in the value of production was calculated based on the anticipated change in landings, and the average value of production per tonne of live weight landings, for each country. The average value of production takes into account the split between fresh and processed categories and the different values per tonne of those categories, and therefore represents potential production value taking into account processing in line with current activity. Full details are provided in Appendix H.

A change in production as a result of a change in the distribution of TACs and quotas between the UK and EU on the basis of the zonal attachment principle was applied by increasing the UK's production value and decreasing the EU's production value by the amounts/percentages indicated by the zonal attachment calculations.

No *a priori* change in production was modelled for the non-quota species crab and scallop, nor for salmon which is produced by aquaculture, although production of these species may change in response to the trade regime.

3.4 Wider economic impacts

Wider economic impacts on Scotland's economy were considered only in relation to the direct, indirect and induced impacts of Scenarios 1 and 4. In order to take the trade modelling outputs (for the UK) and apply multipliers and Input-Output (I-O) analysis, the results for each species were disaggregated to the primary (fishing and aquaculture) and processing sectors, and further disaggregated between Scotland and the UK. Changes in the direct, indirect and induced impacts on output, GVA and employment for Scotland were calculated, and the upstream economic sectors affected were identified.

3.4.1 Applying the model outputs to the primary and processing sectors

The trade model outputs aggregate the impacts on the fishing, aquaculture and processing sectors for each species, combining production of unprocessed and minimally processed fresh/chilled product, as well as processed products such as fillets, smoked, canned and prepared/preserved products. The percentage change in output from the trade modelling (which captures a proportion of output and trade in each species) was applied to the UK output of fishing, aquaculture and processing sectors for each species. This assumes that the percentage changes from the trade modelling will apply to the rest of the sector.

The I-O tables include sectors that relate to the two primary industries of fishing and aquaculture production, as well as the secondary industry of fish processing. To identify the impact on turnover (output), GVA and employment, the change in output from the trade modelling was disaggregated into impact on the primary industries (fishing or aquaculture production) and impact on the processing industry, based on the location of landings and production, and the structure of the supply chain in each case.

The apportionment was based on the output of the fishing sector (value of landings by UK vessels to UK and non-UK ports), the output of the aquaculture sector (value of production), and a calculation of the output of the processing sector for each species (Table 3.4). Further details are provided in Appendix I.

Table 3.4. Disaggregation of change in output to primary and processing industries

Species	Fishing	Aquaculture	Processing
Cod	37%	0%	63%
Crab	16%	0%	84%
Haddock	22%	0%	78%
Hake	27%	0%	73%
Herring	18%	0%	82%
Mackerel	31%	0%	69%
Nephrops	29%	0%	71%
Saithe	11%	0%	89%
Salmon	0%	34%	66%
Scallop	17%	0%	83%

Note: Change in GVA and employment were disaggregated to the primary and processing sectors according to specific percentages based on the processing GVA or employment attributed to each species as a proportion of the total GVA or employment (from processing and fishing/aquaculture for each species).

3.4.2 Identifying impacts on the Scottish economy

The outputs of the trade modelling are for the UK as a whole. In order to determine the proportion of these impacts that might occur in Scotland, the UK-level impacts were apportioned to Scotland for each species, based on the relative geographic footprint of the catching or aquaculture sectors and of the processing sector (Table 3.5). Further details are provided in Appendix I.

Table 3.5. Apportionment of fishing, aquaculture and processing output between Scotland and Rest of UK

Species	Fishing		Aquaculture		Processing	
	Scotland	Rest of UK	Scotland	Rest of UK	Scotland	Rest of UK
Cod	46%	54%	-	-	47%	53%
Crab	37%	63%	-	-	29%	71%
Haddock	83%	17%	-	-	47%	53%
Hake	54%	46%	-	-	47%	53%
Herring	65%	35%	-	-	59%	41%
Mackerel	82%	18%	-	-	59%	41%
Nephrops	74%	26%	-	-	29%	71%
Saithe	62%	38%	-	-	47%	53%
Salmon	-	-	99%	1%	77%	23%
Scallop	59%	41%	-	-	29%	71%

Note: For GVA and employment, modified percentages were used for apportioning between Scotland and the UK, based on Scottish processing turnover, GVA and employment as a proportion of UK (data from Seafish).

3.4.3 GVA and employment

The results of the trade modelling, in terms of the changes in output, were used to calculate the direct, indirect and induced changes in output, GVA and employment. For the direct effects, GVA to output ratios were taken from the Scottish Input-Output (I-O) tables[18]. Employment data were obtained from industry-specific sources (Cefas, 2015; SG, 2016a,b; Seafish, 2016; MMO, 2017; HIE, 2017). For the indirect and induced effects, Type I and Type II multipliers for fishing, aquaculture and processing from the Scottish I-O tables were used. Because GVA will be affected by both output and price, the change in GVA in the scenarios was calculated from the model results by combining the price and output effects. The apportionment of output, GVA and employment between Scotland and the UK for the processing sector was calculated separately for each species group, based on 2014 Seafood Processing Industry Survey data provided by Seafish.

3.4.4 Sectors affected

I--O analysis was used to consider the distribution of indirect impacts across the economy, to identify which sectors are likely to be most affected by changes in output and GVA.

3.5 Key assumptions and limitations

For any modelling study, what is not included can be just as important as what is included. The specific assumptions of the model (beyond those outlined above) and issues excluded from the model, are as follows:

[18] http://www.gov.scot/Topics/Statistics/Browse/Economy/Input-Output

Production sector

- UK-flagged vessels are treated as UK vessels. Issues surrounding beneficial ownership and potential changes to the economic link criteria are not taken into account.
- It is assumed that the UK fleet will be able to catch the increased quota allocations based on the zonal attachment principle. In reality it may be that the industry might not utilise all the additional quota implied by a switch to zonal attachment. This could be due to mixed fishery and landing obligation considerations, as well as industry interest and specialisation for certain target species.

Agreements and quota allocations

- Reciprocal access and landing rights in the UK and EU do not change. The potential change to landings from a change in quota distribution based on the zonal attachment principle is assessed; the potential for changes to landings as a result of restriction of access to fishing grounds is not assessed.
- The EU-Norway agreement is important for Scotland, but how this may change is unclear. Changes to bilateral agreements with other countries in the North East Atlantic region are excluded from the scope and we assume an arrangement is achieved between the UK and Norway that continues the status quo position in relation to fisheries access and quotas.
- Any changes to the distribution of quota allocations between the EU and UK will not change on day 1 of Brexit, but are more likely take place over a longer time period. A partial equilibrium model is typically a static model that does not take into account any adjustment period and does not have an explicit time horizon. The impact of changes in policy which are modelled therefore give the simulated outcomes of each scenario once a new equilibrium has been reached.
- Quota allocation under the zonal attachment principle has been calculated based on University of Aberdeen & SFF (2017). Zonal attachment percentages for individual stocks may differ from the percentages used from this study as a result of: the incorporation of time spent in each jurisdiction, different life history stages, and taking account of the mismatch between survey data coverage and stock assessment units.
- The trade codes included in the models for each species are those which are specifically attributable to the species in question at HS 6-digit level. Not all trade in a species is therefore captured, as trade codes that group the species together with other species in a more generic category are excluded from the analysis.
- The focus of the approach on the ten species means that trade of fish in more generic species categories in the trade codes – including frozen block fillets which are important as inputs for the processing sector – is not captured. This means that the potential impact on these trade flows for the processing sector is not fully captured.

Tariffs, NTMs and tariff rate quotas

- Tariff rate quotas are not explicitly modelled.
- Changes to NTMs have been modelled based on the literature review of tariff equivalent costs of additional border checks, testing and certification requirements, rules of origin and catch certificates. The percentages used do not reflect the complete break-down of trading arrangements and implementation of trade defence measures. In the event of these circumstances arising, potential impacts could be significantly greater than those modelled.
- The changes in the NTMs have been assumed to be the same across all species — in reality this may not be the case.

Macroeconomic and other factors

- The percentage changes in output from the trade modelling are assumed to apply to the wider UK output of fishing, aquaculture and processing sectors for each species. This may overestimate the impact on the processing sector for the trade codes modelled.
- The data used are from 2015, after the Russian trade embargo on European food production (including fish) products was introduced. The trade analysis is therefore based on trade flows with the trade embargo in place. In the event that the UK has a different trading arrangement with Russia, potential trade with Russia could increase. In particular, Russia has the potential to be an important market for mackerel (prior to the embargo, up to 20% of mackerel processed in Scotland went directly to Russia[19]).
- The data used are from 2015, prior to the Referendum vote for the UK to leave the EU, and therefore prior to the change in the Sterling-Euro and Sterling-Dollar exchange rates.
- The potential for a breakdown in negotiations with the EU and UK unilaterally setting their quota levels (which could result in the aggregate quotas being set above the level of scientifically-advised TACs, overfishing occurring and landings subsequently declining, together with the potential implementation of trade sanctions) is beyond the scope of the study.

[19] https://news.gov.scot/news/russian-trade-sanctions

4 Results

The results are presented as follows:

- Section 4.1: UK aggregate impacts (across the ten species) from modelling scenarios for trade and quota sharing arrangements.
- Sections 4.2 to 4.5: the results for each scenario, including details for each of the ten species modelled.
- Section 4.6: the wider economic impacts on Scotland's economy for Scenarios 1 and 4, including the changes in direct, indirect and induced output, gross value added (GVA) and employment for the seafood industry, as well as an identification of other sectors of the economy likely to be affected.

4.1 Aggregate UK and EU trade impacts

Summary results for aggregate changes in UK output, exports and imports are provided in Table 4.1 for each of the scenarios. This is based on aggregating the results of the ten species modelled. The table gives the percentage change for each of the variables. The results indicate a 12% increase in output and 17% increase in exports under Scenario 1, and a 2% contraction in output and 6% reduction in exports under Scenario 4.

Table 4.1. Aggregate impact on UK output and trade value for the ten species for each Scenario (percentage change)

Detail		UK Percentage Change in			EU Percentage Change in		
		Output	Exports	Imports	Output	Exports	Imports
1	Tariff changes only	0.36	0.84	1.08	–0.07	–0.20	0.00
	Tariffs + NTMs	0.88	2.01	2.20	–0.16	–0.49	0.00
	Tariffs + NTMs + ZA	11.62	17.17	–0.40	–8.25	–11.30	1.84
2	Tariff changes only	–0.64	–1.56	–0.61	–0.07	–0.60	–0.09
	Tariffs + NTMs	–1.21	–3.14	–1.37	–0.19	–1.38	–0.18
	Tariffs + NTMs + ZA	10.59	13.57	–3.93	–8.25	–12.04	1.75
3	Tariff changes only	–1.41	–3.01	–1.33	–0.08	–1.22	–0.22
	Tariffs + NTMs	–2.42	–5.89	–2.73	–0.31	–2.67	–0.38
	Tariffs + NTMs + ZA	10.14	11.92	–5.29	–8.29	–13.02	1.63
4	Tariff changes only	–1.31	–3.01	–2.33	–0.08	–1.22	–0.22
	Tariffs + NTMs	–2.32	–5.89	–3.74	–0.31	–2.67	–0.38

There are several features which emerge from these results. The first is that the substantial changes in quota allocation from zonal attachment dominate the results. Hence in all the scenarios with quota allocation changes between the UK and EU, there are substantial increases in the value of UK output of fish, and in UK fish exports, with a more modest decline in imports. This is not surprising as the changes in allocations in favour of the UK are in many cases substantial. Several issues are worth noting with regard to this. The first is that the changes in the quota allocations modelled here correspondingly have a negative impact on EU output and trade. For example, in Scenario 3, where there is an increase in UK output of 10% and an increase in UK exports of 12%, the corresponding change for the EU is a decrease in output of 8% and a decrease in exports of 13%.

The second is in terms of the modelling of the scenarios themselves. For example, Scenario 3 involves the simultaneous modelling of an increase in the UK's quota via the changes in quota allocation and the imposition of MFN tariffs on trade between the EU and the UK. In some cases the current quotas may not be binding[20], and it is therefore possible that production and exports may not increase even where a given quota has increased. This may be because the quota was not (very) binding initially, because there are mixed fishery considerations that are not accounted for in the modelling, because the simultaneous imposition of tariffs reduces trade, or because of other factors that mean that new quota levels are not fulfilled. As we do not know whether this will be the case or not, we have assumed that UK output will expand to fill the quota[21]. This should therefore be seen as an outer-bound estimate and the impact may well be smaller than this.

The third feature which emerges from these aggregate results and from the more detailed results presented later on is that the net effects are driven by changes in trade policy both with regard to UK imports and with regard to UK exports. Suppose tariffs of 10% are introduced on trade between the EU and the UK, hence UK imports and exports now face a tariff of 10%. While the tariff is the same on both imports and exports the net effect on the industry (or species) does not cancel out. This is because the net effects will depend on the underlying pattern of trade. If the UK exports are substantially bigger then UK imports, then the introduction of the tariff will have a much bigger impact on exports, and consequently on net UK production. If tariff (or NTM) changes with other countries are then introduced in the model, then the drivers of the net changes become even more complex.

If we set aside the changes in quota allocations, then we see that all the scenarios, except for Scenario 1, which allows for the greatest reduction in trade barriers, result in a decline in UK output, exports and imports. These changes are largest in the case of Scenario 4, and lead to reductions in output, exports and imports of 2.3%, 5.9%, and 3.7% respectively. These negative impacts arise both from the changes in tariffs, and from the changes in non-tariff measures.

These aggregate results, of course, mask the detailed results by species and these can be seen in Sections 4.2 to 4.5 which provide a more detailed breakdown of the results. The overall picture from these more detailed results is that, as seen with the aggregate results the modelled, changes in quota allocation account for the much bigger changes to the outcomes – typically output and exports increase, imports go down. The impact on the UK price index is more mixed.

With no changes in quota allocation, the impact on the UK with regard to output, trade and prices is more mixed and more muted. In Scenario 1, we see UK output rising in five out of the ten sectors, and in each case by less than 1%. In the 'no deal' scenario (Scenario 4), output declines in all but one sector (haddock) with the biggest decline for hake — a reduction of 15% (since 99% of UK exports of hake currently go to the EU). The UK price index rises for all fish species in this experiment, with the biggest increase for herring at just over 5%.

4.2 Scenario 1

In this scenario, the UK maintains existing access to the EU market (hence no change in tariffs or NTMs); and in addition the UK establishes free trade with the rest of the world, hence there are no tariffs on the imports or exports of seafood products with all countries. Quota allocations (for catch quotas in fisheries) change to being based on the zonal attachment principle rather than the current Relative Stability, resulting in quota increases for the UK and decreases for the EU.

[20] I.e. the quota does not restrict production, as the current level of landings is below the level of the quota.
[21] With the exception of North Sea and West of Scotland Nephrops, see Section 3.3.2 and Appendix H for more details.

In order to show the relative impacts of the different elements of this scenario, the results are set out in three tables which provide results for the UK. Table 4.2 gives the changes in prices, output, export and imports arising from the change in tariffs only. Table 4.3 adds in the changes from the non-tariff measures, and Table 4.4 includes the changes from quota increases.

Essentially the first part of this experiment (Table 4.2) involves a reduction in the UK's tariffs (leading to a decline in the UK price index), and a reduction in the tariffs faced by the UK in its export markets. Those tariff reductions on UK exports lead to an increase in exports and also an increase in imports. As discussed earlier, the net effect on production (output) is therefore variable across species depending on relative changes in exports and imports. For some species, there is an increase while in others a decrease. Haddock is the most negatively affected in terms of output, with herring, salmon and mackerel experiencing the largest increases in output. Despite this representing a very substantial liberalisation of the UK's trade, the changes are modest.

However, when quota redistribution is introduced (Table 4.4), exports increase substantially and imports decline for most species. The change in output is most pronounced for those species that will experience the largest quota gains under the zonal attachment principle, with non-quota species (crab, salmon, scallop) experiencing very small increases or reductions in output value, which are driven by changes in tariffs and NTMs.

Table 4.2. Scenario 1: Percentage change in each variable for the UK from tariff changes

Species	Zero UK Tariffs Levied and Faced with All Countries					MFN Tariffs
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	–0.54	0.54	0.44	0.62	2.55	11.5
Crab	–0.12	0.25	0.20	0.34	1.64	7.8
Haddock	–0.78	–0.56	–1.11	0.21	–0.16	7.5
Hake	–2.57	–0.13	–0.27	0.01	1.10	12.3
Herring	–0.11	1.02	0.80	0.81	0.21	14.3
Mackerel	–0.13	0.70	0.55	0.59	0.25	14.5
Nephrops	–0.70	0.26	–0.15	–0.01	0.60	16
Saithe	–0.02	0.00	–0.01	0.00	0.03	7.5
Salmon	–0.26	0.94	0.72	1.63	0.25	4.9
Scallop	–1.69	–0.22	–0.45	0.02	1.04	16

Table 4.3. Scenario 1: Percentage change in each variable for the UK from tariff changes and change in NTMs

Species	Zero UK Tariffs Levied and Faced with All Countries +Decrease in NTMs Between UK and World					NTM AVE (EU; RoW)*
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	–1.09	0.80	0.66	0.91	5.24	5%; 10%
Crab	–0.23	0.45	0.36	0.60	3.18	5%; 10%
Haddock	–2.60	–1.84	–3.66	1.03	–0.55	5%; 10%
Hake	–4.06	–0.20	–0.42	0.03	1.73	5%; 10%
Herring	–0.19	2.41	1.85	1.88	0.37	5%; 10%
Mackerel	–0.21	2.93	2.02	2.16	0.40	5%; 10%
Nephrops	–0.98	0.37	–0.18	0.02	0.83	5%; 10%
Saithe	–0.74	–0.31	–0.63	0.03	1.53	5%; 10%
Salmon	–0.63	2.03	1.53	3.58	0.60	5%; 10%
Scallop	–2.43	–0.30	–0.64	0.03	1.49	5%; 10%

* Baseline NTMs are EU 5%; RoW 15%, i.e. a reduction in NTMs with RoW of five percentage points is modelled.

Table 4.4. Scenario 1: Percentage change in each variable for the UK from tariff changes, changes in NTMs and changes in quota allocation

Species	Zero UK Tariffs Levied and Faced with All Countries +Decrease in NTMs Between UK and World +Changes in Quota Allocations					Change in Quota*
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	–1.12	8.78	6.99	7.37	5.09	8.8%
Crab	–0.23	0.45	0.36	0.60	3.18	–
Haddock	–4.50	21.17	12.38	26.80	–7.59	21.2%
Hake	–6.60	65.94	61.31	62.59	–5.25	166%
Herring	8.31	118.97	88.92	88.96	–18.10	219%
Mackerel	5.41	53.39	37.68	37.43	–20.84	53.4%
Nephrops	–1.48	4.80	2.99	3.53	–2.53	4.8%
Saithe	–47.21	85.91	37.70	108.64	–67.90	186%
Salmon	–0.63	2.03	1.53	3.58	0.60	–
Scallop	–2.43	–0.30	–0.64	0.03	1.49	–

* Change in quota relates to the calculated change in production value.

The results suggest that:

- With no changes in quota allocation, the price index in the UK goes down for all species, so consumers are expected to benefit. With changes in quota allocation this is not always the case, and this will be driven by the changes in both UK supply and also supply from other markets.
- All species except scallop experience an increase in UK output (when tariffs, NTMs and quota reallocation are included). The reduction in UK scallop output is driven by the increase in imports from non-EU countries (as a result of the reduction of the currently high tariff, the highest of the non-quota species), which leads to a reduction in the price index.
- The changes in quota allocation result in large increases in exports and reductions in imports, (in percentage terms) for those species where the UK stands to gain significant increases in quota allocation compared to the current quota allocation under Relative Stability (hake, herring, saithe).

The trade impacts (tariffs and NTMs, without considering quota reallocation) are highly variable across species. Output increases for some species and decreases for others. This is driven by the changes in both imports and exports and prices; whether output goes up or down depends on the net impacts. When quota reallocation is also considered, there are significant increases in UK output value for those species that will benefit from a redistribution of quotas, with larger impacts seen for those species with greater quota percentage increases. The non-quota species crab, salmon and scallop, and also cod and Nephrops for which the anticipated quota increase is more muted, see much smaller increases in output and exports.

4.3 Scenario 2

In this scenario, it is assumed that the UK enters into an agreement with the EU similar to Norway's EEA membership, in which tariffs are imposed on fish and fishery products, but they are negotiated to be below MFN levels. There is an associated increase in NTMs with the EU, but these are minimised through mutual recognition of standards and testing and certification. Quota allocations (for catch quotas in fisheries) change to being based on the zonal attachment principle rather than the current Relative Stability, resulting in quota increases for the UK and decreases for the EU. Trade

arrangements (tariffs and NTMs) with the rest of the world remain as they are currently – all the changes in trade arrangements are with the EU.

In order to show the relative impacts of the different elements of this scenario, the results are set out in three tables which provide results for the UK. Table 4.5 gives the changes in prices, output, export and imports arising from the change in tariffs only. Table 4.6 adds in the changes from the non-tariff measures, and Table 4.7 includes the quota changes.

The results suggest that:

- With no changes in quota allocation, there is an increase in prices for all species, driven by the increase in tariffs and NTMs. As a result of the introduction of tariffs on EU exports, the price of UK imports from the EU rises. As these prices rise, UK production adjusts as do imports from other suppliers. As the production and imports change, this will also impact on the prices that these suppliers charge. Hence the change in the average price of any given fish species in the UK will be a weighted (by the share of each supplier in the UK market) average of all these price changes. With changes in quota allocation included, the results are more mixed with prices going up for some species (notably herring and mackerel), but down for others (saithe and hake, which are species with significant quota allocation changes).
- With no changes in quota allocation, the quantity and value of output declines for all species, driven by the higher tariffs levied by the EU, except for haddock (which is particularly important for the UK market and so a lower proportion of landings are exported than for other species). When quota allocation changes are included, the output for quota species increase.
- When allowing for the changes in quotas, exports increase for all quota species, driven by the greater levels of UK landings, and decline for all non-quota species as a result of higher tariffs and NTMs. Imports decline across all species.
- As with Scenario 1, where there are positive outcomes for some species; these derive from the substantial changes in quotas which have been modelled. These positive outcomes for quota species are accompanied by negative outcomes for non-quota species, which do not benefit from quota increases under the zonal attachment principle. Both the feasibility of achieving the changes in quotas modelled and the differential impacts across species will need to be weighed up by policy makers as they affect different fleet sectors, processing sectors, and fisheries and aquaculture sectors in a heterogeneous manner.

Table 4.5. Scenario 2: Percentage change in each variable for the UK from tariff changes

Species	EU-Norway Tariffs Between UK and EU					Tariffs
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	0.02	–0.29	–0.23	–0.35	–0.08	0.57
Crab	0.02	–0.54	–0.35	–0.89	–0.31	2.27
Haddock	0.03	0.01	0.03	–0.14	0.01	0.3
Hake	0.25	–2.75	–2.52	–2.71	–0.11	3.3
Herring	1.53	–3.35	–2.66	–2.71	–2.91	6.8
Mackerel	2.03	–2.21	–1.61	–1.84	–3.78	9.7
Nephrops	0.26	–0.65	–0.12	–0.21	–0.22	1.6
Saithe	0.01	–0.10	–0.07	–0.18	–0.02	0.3
Salmon	0.96	–0.67	–0.21	–1.71	–0.92	4.1
Scallop	0.74	–3.26	–1.41	–2.19	–0.46	7.6

Table 4.6. Scenario 2: Percentage change in each variable for the UK from tariff changes and change in NTMs

Species	EU-Norway Tariffs Between UK and EU +Modest Increase in NTMs Between UK and EU					NTM AVE (EU; RoW)*
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	0.16	–2.71	–2.19	–3.25	–0.73	10%; 15%
Crab	0.07	–1.65	–1.08	–2.76	–0.96	10%; 15%
Haddock	0.52	0.18	0.59	–2.37	0.10	10%; 15%
Hake	0.61	–6.63	–6.07	–6.55	–0.26	10%; 15%
Herring	2.60	–5.58	–4.45	–4.53	–4.89	10%; 15%
Mackerel	3.01	–3.22	–2.36	–2.69	–5.56	10%; 15%
Nephrops	1.05	–2.59	–0.50	–0.87	–0.90	10%; 15%
Saithe	0.15	–1.72	–1.24	–3.10	–0.31	10%; 15%
Salmon	2.07	–1.41	–0.42	–3.64	–2.00	10%; 15%
Scallop	1.20	–5.22	–2.27	–3.55	–0.74	10%; 15%

* Baseline NTMs are EU 5%; RoW 15%, i.e. an increase in NTMs with EU of five percentage points is modelled.

Table 4.7. Scenario 2: Percentage change in each variable for the UK from tariff changes, changes in NTMs and changes in quota allocation

Species	EU-Norway Tariffs Between UK and EU +Modest Increase in NTMs Between UK and EU +Changes in Quota Allocation					Change in Quota*
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	0.06	8.78	6.96	6.13	–0.75	8.8%
Crab	0.07	–1.65	–1.08	–2.76	–0.96	–
Haddock	–1.06	21.18	15.78	21.41	–6.40	21.2%
Hake	–2.56	65.94	61.67	61.99	–8.11	166%
Herring	11.96	118.97	88.83	88.76	–23.81	219%
Mackerel	8.48	53.39	37.53	36.77	–27.48	53.4%
Nephrops	–1.40	4.79	3.22	3.29	–6.18	4.8%
Saithe	–47.64	85.91	37.06	107.08	–69.39	186%
Salmon	2.07	–1.41	–0.42	–3.64	–2.00	–
Scallop	1.20	–5.22	–2.27	–3.55	–0.74	–

* Change in quota relates to the calculated change in production value.

4.4 Scenario 3

The main change introduced by this scenario is the imposition of MFN tariffs between the UK and the EU, as well as an increase in NTMs between the UK and the EU as a result of UK exit from the EU Single Market. As in Scenarios 1 and 2, quota allocations (for catch quotas in fisheries) change to being based on the zonal attachment principle rather than the current Relative Stability, resulting in quota increases for the UK and decreases for the EU.

In order to see the relative impact of the different elements of this scenario, the results are set out in three tables which provide results for the UK. Table 4.8 gives the changes in prices, output, export and imports arising from the change in tariffs only. The changes from tariffs and NTMs are shown in Table 4.9. Table 4.10 gives the changes from tariff, non-tariff measures and quota changes.

The results suggest that:

- The picture in relation to prices is quite mixed. Once again, these results will be driven both by the policy changes but also the underlying base structure of trade. The increase in the price index of herring and mackerel reflects the large proportion of imports from the EU. Cod and haddock, two of the species most consumed in the UK, experience small increases and decreases in prices, respectively. Salmon experiences a larger increase in price of 3.3%.
- Output increases significantly for quota species, despite the increase in MFN tariffs and NTMs with the EU, and decreases for non-quota species. Once again this is driven the substantial changes in quotas which have been modelled here.
- In line with the increases in output, exports increase for quota species, and decrease for non-quota species. Imports of all species fall, as a result of a combination of higher tariffs and NTMs and the increase in UK output.
- Crab, salmon and scallop – the non-quota species – do not experience the production increases of quota species from the zonal attachment principle, and output and exports decline, due to the higher tariffs in place. The increase in output and exports for Nephrops (a quota species) is modest because the anticipated change in production from quota reallocation is relatively small, based on an increase in quota from Area VII grounds; quotas in the North Sea and West of Scotland are unlikely to change much under the Zonal Attachment principle and current levels of uptake from these areas are low.

Table 4.8. Scenario 3: Percentage change in each variable for the UK from tariff changes

Species	MFN Tariffs Between UK and EU					MFN Tariffs
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	0.31	–5.34	–4.32	–6.42	–1.45	11.5
Crab	0.07	–1.77	–1.16	–2.96	–1.03	7.8
Haddock	0.72	0.25	0.83	–3.30	0.14	7.5
Hake	0.88	–9.51	–8.72	–9.41	–0.38	12.3
Herring	3.13	–6.65	–5.31	–5.41	–5.84	14.3
Mackerel	2.97	–3.18	–2.33	–2.66	–5.49	14.5
Nephrops	2.42	–5.90	–1.18	–2.06	–2.09	16
Saithe	0.21	–2.38	–1.72	–4.33	–0.44	7.5
Salmon	1.14	–0.79	–0.25	–2.03	–1.09	4.9
Scallop	1.50	–6.48	–2.84	–4.43	–0.93	16

Table 4.9. Scenario 3: Percentage change in each variable for the UK from tariff changes, and changes in NTMs

Species	MFN Tariffs Between UK and EU + Increase in NTMs Between UK and EU + Changes in Quota Allocations					NTM AVE (EU; RoW)*
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	0.55	–9.25	–7.54	–11.20	–2.53	15%; 15%
Crab	0.16	–3.75	–2.48	–6.33	–2.20	15%; 15%
Haddock	1.59	0.56	1.82	–7.19	0.31	15%; 15%
Hake	1.50	–15.94	–14.67	–15.83	–0.64	15%; 15%
Herring	5.14	–10.49	–8.43	–8.59	–9.34	15%; 15%
Mackerel	4.82	–4.99	–3.69	–4.22	–8.77	15%; 15%
Nephrops	3.76	–9.01	–1.88	–3.25	–3.27	15%; 15%
Saithe	0.46	–5.15	–3.76	–9.44	–0.96	15%; 15%
Salmon	3.28	–2.19	–0.61	–5.69	–3.20	15%; 15%
Scallop	2.31	–9.86	–4.40	–6.86	–1.44	15%; 15%

* Baseline NTMs are EU 5%; RoW 15%, i.e. an increase in NTMs with EU of ten percentage points is modelled.

Table 4.10. Scenario 3: Percentage change in each variable for the UK from tariff changes, changes in NTMs and changes in quota allocation

Species	MFN Tariffs Between UK and EU + Increase in NTMs Between UK and EU + Changes in Quota Allocations					Change in Quota*
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	0.32	8.78	6.92	3.71	–2.23	8.8%
Crab	0.16	–3.75	–2.48	–6.33	–2.20	–
Haddock	–0.52	21.17	16.26	15.58	–6.33	21.2%
Hake	–2.27	65.94	61.67	61.42	–9.45	166%
Herring	15.38	118.97	88.69	88.53	–28.66	219%
Mackerel	10.35	53.39	37.44	36.46	–30.97	53.4%
Nephrops	–2.81	4.80	3.17	2.57	–12.32	4.8%
Saithe	–49.30	85.91	35.17	104.25	–71.02	186%
Salmon	3.28	–2.19	–0.61	–5.69	–3.20	–
Scallop	2.31	–9.86	–4.40	–6.86	–1.44	–

* Change in quota relates to the calculated change in production value.

4.5 Scenario 4

In Scenario 4, there is no change to quota allocation, but there is the imposition of MFN tariffs between the UK and EU and Rest of the World, and an increase in the level of NTMs.

The results for the UK of the changes in prices, output, export and imports arising from the change in tariffs only is shown in Table 4.11. The changes from both tariffs and NTMs are shown in Table 4.12. As this experiment involves the imposition of tariffs and NTMs on trade between the EU and the UK it is perhaps not surprising that the effects on output and exports are almost invariably negative.

Table 4.11. Scenario 4: Percentage change in each variable for the UK from tariff changes

Species	MFN Tariffs Between UK and EU + Increase in NTMs Between UK and EU					MFN Tariffs
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	0.95	–5.35	–4.35	–6.42	–4.34	11.5
Crab	0.07	–1.77	–1.16	–2.96	–1.03	7.8
Haddock	2.58	1.62	3.53	–3.30	0.50	7.5
Hake	1.34	–9.48	–8.67	–9.41	–0.57	12.3
Herring	3.24	–6.65	–5.31	–5.41	–6.03	14.3
Mackerel	2.98	–3.18	–2.33	–2.66	–5.51	14.5
Nephrops	2.42	–5.90	–1.18	–2.06	–2.09	16
Saithe	1.20	–1.94	–0.85	–4.33	–2.53	7.5
Salmon	1.14	–0.79	–0.25	–2.03	–1.09	4.9
Scallop	1.56	–6.47	–2.82	–4.43	–0.97	16

Table 4.12. Scenario 4: Percentage change in each variable for the UK from tariff changes and changes in NTMs

Species	MFN Tariffs Between UK and EU + Increase in NTMs Between UK and EU					NTM AVE (EU; RoW)*
	UK Price Index	Output (Quantity)	Output (Value)	Exports (Value)	Imports (Value)	
Cod	1.20	–9.27	–7.57	–11.20	–5.41	15%; 15%
Crab	0.16	–3.75	–2.48	–6.33	–2.20	15%; 15%
Haddock	3.47	1.95	4.58	–7.19	0.66	15%; 15%
Hake	1.96	–15.91	–14.61	–15.83	–0.84	15%; 15%
Herring	5.26	–10.48	–8.43	–8.59	–9.53	15%; 15%
Mackerel	4.84	–5.01	–3.69	–4.22	–8.79	15%; 15%
Nephrops	3.76	–9.01	–1.88	–3.25	–3.27	15%; 15%
Saithe	1.46	–4.71	–2.89	–9.44	–3.07	15%; 15%
Salmon	3.28	–2.19	–0.61	–5.69	–3.20	15%; 15%
Scallop	2.37	–9.85	–4.38	–6.86	–1.48	15%; 15%
Baseline NTMs are EU 5%; RoW 15%, i.e. an increase in NTMs with EU of ten percentage points is modelled.						

The results suggest that:

- Prices for all species rise and these range from less than 1% (for crab), to over 5% (for herring).
- UK output declines for all species except haddock; haddock is extremely important for the UK market and almost all UK production is sold domestically rather than exported. Increasing tariffs on exports therefore do not impact on domestic production, whereas tariffs applied to imports protect the UK industry allowing it to expand.
- Exports also decline for all species, with the greatest decline of 16% for hake, for which nearly all of the UK's exports currently go to the EU, and so this species is relatively more affected by the change in trade regime. Hake experiences a similar decline in overall output. The smallest decline in exports is for Nephrops, of just over 3%. Imports also decline for all species except haddock.
- Differences between quota and non-quota species are less visible in this scenario, as there is no change in quota allocation; the results are driven by the change in tariffs and NTMs. The species that experience the greatest impacts are those with higher tariff levels such as hake, cod and herring. Shellfish species, such as scallop and Nephrops, have relatively smaller impacts despite their high tariff levels, because of the lower substitution elasticity assumed for these species in model, which reflects the importance of fresh or live shellfish in the EU market.

4.6 Sensitivity analysis

In simulation models such as the ones used for this study, certain assumptions are required regarding underlying parameters. In this case, the key parameters are the elasticity of demand, the elasticity of substitution and the elasticity of supply. Inevitably the model results are sensitive to these elasticity parameters, and therefore it is good practice to conduct sensitivity analysis or different runs of the model to establish how changes to these assumptions affect the results. This also helps to give a picture of the broad range of possible outcomes.

The sensitivity analysis focussed on changes in the supply elasticity and the elasticity of substitution. This is because these are the elasticity parameters for which underlying econometric estimates from the literature were not available. With regard to the elasticity of supply, in the base this is set equal to 1. For the sensitivity, simulations were run where it is set to 3, and to 0.5 respectively. For the

elasticity of substitution, the assumed elasticity is probably at the upper end, so for the sensitivity analysis the implications of halving this are explored.

Table 4.13 shows the aggregate impact on UK output, imports, and exports, and also on EU output for the sensitivity analysis. This is presented for both Scenario 1 and for Scenario 4 as these can be thought of as comprising the extremes of the scenarios modelled. Partly for comparative purposes and partly because the changes in quota allocations dominate the results, the experiments we run here involve the combined impact of changes in tariffs and non-tariff measures only (i.e. no change to quota allocation). The full sets of results of the sensitivity experiments including quota allocation changes for Scenario 1 can be found in Appendix J.

Table 4.13. Sensitivity analysis – aggregate impact for Scenarios 1 and 4 for output, export and import value (percentage change)

Scenario	Detail	UK			EU		
		Output	Exports	Imports	Output	Exports	Imports
1 (Tariff and NTM changes only)	Base	0.88	2.01	2.20	-0.16	-0.49	0.00
	Supply elasticity = 3	2.51	5.30	5.54	-0.39	-1.19	0.00
	Supply elasticity = 0.5	0.43	1.04	1.12	-0.09	-0.27	0.00
	Substitution elasticity is halved	0.77	1.62	1.96	-0.09	-0.26	0.00
4	Base	–2.32	–5.89	–3.74	–0.31	–2.67	–0.38
	Supply elasticity = 3	–4.93	–12.86	–9.07	–1.01	–6.43	–0.85
	Supply elasticity = 0.5	–1.25	–3.24	–1.92	–0.12	–1.41	–0.20
	Substitution elasticity is halved	–1.22	–3.72	–3.27	–0.42	–2.11	–0.22

From the table it can be seen that, relative to the base:

- Increasing (decreasing) the supply elasticity increases (decreases) the magnitude of the impact on output, exports and imports, but less than proportionately. Hence tripling the supply elasticity leads to changes which are less than three times bigger. Halving the supply elasticity leads to changes which are approximately half the size.
- Reducing the substitution elasticity moderates some of the output changes, so if EU countries are more dependent on the purchase of UK fish and shellfish, the impacts on UK output and exports will be reduced.
- The aggregate impact on output for the UK ranges from an increase of 0.88% to 2.51% for the first scenario; and a contraction in output of between 1.2% to 4.9% with regard to Scenario 4.

4.7 Wider economic impacts

The assessment of wider economic impacts focuses on the impacts on the Scottish economy of changes in production and trade patterns under Scenarios 1 and 4. The results presented are the resulting changes to current estimated[22] output, GVA and employment in Scotland – see Table 4.14. This section does not take into account the effects of EU-Exit on labour availability, the cost of finance, or any other non-fish trade economic effects, therefore results are likely to overstate the wider economic impacts.

[22] For consistency, the current levels of output, GVA and employment were derived from UK-wide data based on the apportionment methodology described in Appendix I – Wider Economic Impacts Method.

The trade model outputs, in the form of percentage changes in prices, output quantity, output value, imports and exports are used to estimate absolute changes in output, GVA and employment in Scotland's fishing, aquaculture and processing sectors, and in the sectors supplying them. The estimations make use of input-output tables from which multipliers have been derived; accounting tables which show the relationship between GVA and output; purchasing tables, showing purchases by the fishing and fish processing sectors; data sources on employment in fishing, aquaculture and processing; and data on processing by fish type (demersal, pelagic and shellfish) (see Section 3.4). Note that the trade model does not capture all trade in each species, due to the exclusion of trade codes that relate to mixed species groups (see Section 3.5).

Table 4.14. Estimated current levels of output, GVA and employment in Scotland for species in the trade models

Species	Total Output, £1,000s	Total GVA £1,000s	Total Employment FTEs
Cod	61,105	19,373	466
Crab	82,791	23,207	860
Haddock	114,287	35,168	557
Hake	52,394	15,858	321
Herring	107,505	22,892	926
Mackerel	343,607	91,685	2,849
Nephrops	119,641	41,486	1,071
Saithe	50,505	13,564	216
Salmon	1,591,174	205,123	3,586
Scallop	131,986	39,556	1,230
Total	**2,654,995**	**507,912**	**12,084**

In the tables that follow, the indirect and induced impacts have been estimated for Scenarios 1 and 4, and the results are reported in terms of changes in output, GVA and employment. For output and GVA, a breakdown of the indirect effect across the ten sectors experiencing the greatest impacts is also given.

Two aspects of this approach to assessing wider economic impacts should be noted:

- The Scottish and UK input-output (I-O) tables include sectors that relate to the two primary industries of fishing and aquaculture production, as well as the secondary industry of fish processing. The outputs of the trade model were apportioned between the relevant primary industries and the processing industry, so that they could be mapped to the lines of the I-O tables and associated multipliers. Details of the apportionment methodology can be found in Appendix I.
- A standard criticism of multipliers is that they over-estimate wider impacts because they do not adequately account for the response of other sectors and potential constraints in the labour and other factor markets. For example, if jobs are lost in the original sector, the labour market adjusts and re-employs some of those out of work, perhaps after a period of transition. In this example, there might be less of a change in employment than the multiplier suggests, and wages might fall, which the multiplier does not record.

4.7.1 Wider output impacts

The UK value of fishing, aquaculture and processing output of the ten species modelled is around £4.1 billion per year, of which Scotland accounts for £2.7 billion. Salmon accounts for around half of UK output (by value) of the ten species (production and processing). The next largest by value is mackerel, at around an eighth of output. UK GVA for fishing, aquaculture and processing of the ten

species is around a quarter of the output, at £1 billion. Scotland accounts for about half of the GVA. Total employment in Scotland in fishing, aquaculture and processing related to the ten species modelled is around 12,000 persons (from a total of 14,500 persons, Marine Scotland 2017).

Table 4.15 shows that under Scenario 1, the overall wider output impacts are positive at £546 million. This figure is composed of mostly positive effects across the ten modelled species. The largest wider output impacts are attributed to mackerel (£218 million) and herring (£162 million), while the only negative change is to scallops (–£1.4 million).

Under Scenario 4, the majority of effects on species are negative. The aggregate wider output impacts for the 10 species under Scenario 4 is a fall in output of £85 million. In Table 4.16, haddock a species that is very important to the UK market and with a smaller proportion of landings exported compared to other species, is the only species that makes a positive change to the wider output of Scotland's economy of £9 million. This follows on from the outputs of the trade model in which increasing tariffs on exports under scenario 4 do not impact on domestic production (as most production is not exported), whereas tariffs applied to imports protect the UK industry allowing it to expand.

Table 4.15. Wider output impacts, Scenario 1

Species	Direct, £1,000s	Indirect, £1,000s	Induced, £1,000s	Total, £1,000s
Cod	4,271	2,264	661	**7,196**
Crab	298	162	48	**508**
Haddock	14,149	7,545	2,210	**23,904**
Hake	32,123	17,185	5,041	**54,349**
Herring	95,594	51,872	15,322	**162,788**
Mackerel	129,471	68,545	20,005	**218,021**
Nephrops	3,577	1,860	538	**5,975**
Saithe	19,041	10,408	3,085	**32,534**
Salmon	24,345	14,382	3,658	**42,385**
Scallop	–845	–453	–133	**–1,431**
Total	**322,023**	**173,770**	**50,436**	**546,229**

Table 4.16. Wider output impacts, Scenario 4

Species	Direct, £1,000s	Indirect, £1,000s	Induced, £1,000s	Total, £1,000s
Cod	–4,625	–2,452	–716	**–7,793**
Crab	–2,050	–1,113	–329	**–3,492**
Haddock	5,234	2,791	817	**8,842**
Hake	–7,657	–4,096	–1,202	**–12,955**
Herring	–9,063	–4,918	–1,453	**–15,434**
Mackerel	–12,691	–6,719	–1,961	**–21,370**
Nephrops	–2,245	–1,167	–338	**–3,750**
Saithe	–1,459	–797	–236	**–2,492**
Salmon	–9,680	–5,718	–1,455	**–16,852**
Scallop	–5,785	–3,102	–911	**–9,798**
Total	**–50,021**	**–27,291**	**–7,782**	**–85,095**

The wider output effects can be split into effects arising from changes in the processing sector, the fishing sector and the aquaculture sector. Table 4.17 shows that, under Scenario 1 and Scenario 4, the largest share of impact is attributed to the processing sector – 71% and 69%, respectively. Overall impacts are positive under Scenario 1, representing an increase in wider economic output of

£546 million across Scotland's economy (compared to the current situation or baseline), and negative under Scenario 4, representing a decrease in wider economic output of £85 million across Scotland's economy, compared to the current situation or baseline.

Table 4.17. Wider output impacts, by sector experiencing direct changes

Sector	Scenario 1		Scenario 4	
	Total Impact £1,000s	Percentage of Total Impact	Total Impact £1,000s	Percentage of Total Impact
Fishing	143,193	26%	–20,011	24%
Aquaculture	17,056	3%	–6,782	8%
Processing	385,980	71%	–58,302	69%
Total	**546,229**		**–85,095**	

4.7.2 Wider GVA impacts

Under Scenario 1, the wider GVA impact of fishing, aquaculture and fish processing, which includes direct, indirect and induced effects, increases by £212 million (Table 4.18). Under Scenario 1, most species contribute to increasing the wider GVA impacts. The largest wider GVA impacts under Scenario 1 are attributed to mackerel and herring. Only saithe and scallop make negative contributions to wider GVA impacts. The negative impact of scallops arises from negative impacts on price and output under the scenario, while the negative impact of saithe arises from falling price index, despite an increase in output under the scenario.

Scenario 4 would reduce the wider GVA impact of fishing, aquaculture and fish processing by £17 million, as shown in Table 4.19. All species, except for haddock and salmon, contribute to the reduction in GVA impacts under this scenario. Salmon makes a positive contribution to wider GVA impact (of £4.3 million), due to the increase in the price index (despite a decline in output), as both volume and price changes contribute to GVA. Haddock makes a positive contribution to wider GVA impacts of £4 million under this scenario because of increased output and prices. Scallop contributes the largest fall in economy-wide GVA of £6.4 million.

Table 4.18. Wider GVA impacts, Scenario 1

Species	Direct, £1,000s	Indirect, £1,000s	Induced, £1,000s	Total, £1,000s
Cod	1,465	1,043	435	**2,942**
Crab	51	42	18	**111**
Haddock	5,527	4,084	1,706	**11,318**
Hake	8,720	6,576	2,751	**18,047**
Herring	31,400	24,245	10,158	**65,802**
Mackerel	56,559	36,651	15,172	**108,382**
Nephrops	1,348	858	355	**2,561**
Saithe	–252	–220	–93	**–565**
Salmon	2,845	2,332	658	**5,835**
Scallop	–1,077	–824	–345	**–2,246**
Total	**106,587**	**74,788**	**30,814**	**212,188**

Table 4.19. Wider GVA impacts, Scenario 4

Species	Direct £1,000s	Indirect £1,000s	Induced £1,000s	Total £1,000s
Cod	–1,585	–1,128	–470	**–3,183**
Crab	–835	–693	–292	**–1,820**
Haddock	1,932	1,428	596	**3,957**
Hake	–2,261	–1,705	–713	**–4,680**
Herring	–1,323	–1,021	–428	**–2,772**
Mackerel	–366	–237	–98	**–701**
Nephrops	–2,319	–1,476	–610	**–4,405**
Saithe	–450	–393	–166	**–1,009**
Salmon	2,080	1,705	481	**4,265**
Scallop	–3,050	–2,334	–977	**–6,361**
Total	**–8,176**	**–5,855**	**–2,677**	**–16,709**

Under Scenario 1, all the three sectors fishing, aquaculture and processing contribute to increasing the wider GVA impacts on Scotland's economy (Table 4.20). Fish processing accounts for the largest share of the increase in wider economic impact – 53% of the wider GVA impacts. Under Scenario 4, the fishing and processing sectors contribute to reducing the wider GVA impacts on Scotland's economy, while aquaculture makes a positive contribution.

Table 4.20. Wider GVA impacts, by sector experiencing direct impact

Sector	Scenario 1		Scenario 4	
	Total Impact £1,000s	Percentage of Total Impact	Total Impact £1,000s	Percentage of Total Impact
Fishing	93,095	44%	–8,048	38%
Processing	113,258	53%	–12,926	62%
Sub-Total			**–20,974**	
Aquaculture	5,835	3%	4,265	100%
Total (Overall)	**212,188**		**–16,709**	

4.7.3 Wider employment impacts

Under Scenario 1, the wider employment impacts (direct, indirect and induced), are positive, as shown in Table 4.21. Under this scenario, employment in Scotland could increase by up to 5,000 full time equivalent (FTE) jobs. The largest proportion of the increase in wider employment would stem from mackerel (2,122 FTE jobs), followed by herring (1,622 FTE jobs) and hake, (377 FTE jobs). Scenario 4 has an overall negative impact on wider employment in Scotland. Wider employment could decrease by 429 FTE jobs. Mackerel would contribute the largest fall in wider employment in Scotland – 118 FTE jobs.

The sectoral breakdown of wider employment impacts exhibits a similar pattern to wider GVA and output impacts, as shown in
Table 4.23. Under Scenario 1, the largest contribution to increasing wider employment across Scotland derives from the fish processing sector – 63%. Under Scenario 4, the fishing and processing sectors both make similar contribution to the reduction in wider employment across Scotland – 43% and 44%, respectively.

Table 4.21. Wider employment impacts, Scenario 1

Species	Direct, FTEs	Indirect FTEs	Induced FTEs	Total FTEs
Cod	38	22	9	**69**
Crab	2	1	1	**4**
Haddock	112	77	32	**221**
Hake	198	127	52	**377**
Herring	743	618	260	**1,622**
Mackerel	1,060	750	312	**2,122**
Nephrops	37	26	11	**74**
Saithe	184	146	61	**391**
Salmon	54	50	19	**123**
Scallop	–1	–1	–0	**–3**
Total	**2,426**	**1,817**	**757**	**5,000**

Table 4.22. Wider employment impacts, Scenario 4

Species	Direct FTEs	Indirect FTEs	Induced FTEs	Total FTEs
Cod	–18	–13	–5	**–37**
Crab	–5	–4	–2	**–10**
Haddock	6	4	2	**12**
Hake	–23	–18	–7	**–49**
Herring	–31	–23	–10	**–64**
Mackerel	–65	–38	–15	**–118**
Nephrops	–33	–21	–9	**–63**
Saithe	–5	–4	–2	**–11**
Salmon	–27	–22	–6	**–56**
Scallop	–17	–13	–5	**–35**
Total	**–218**	**–151**	**–60**	**–429**

Table 4.23. Wider employment impacts, impact by sector

Sector	Scenario 1		Scenario 4	
	Total Impact FTEs	Percentage of Total Impact*	Total Impact FTEs	Percentage of Total Impact
Fishing	1,810	36%	–184	43%
Aquaculture	40	1%	–56	13%
Processing	3,150	63%	–189	44%
Total	**5,000**		**–429**	

* Total does not sum to 100 due to rounding.

4.7.4 Sectors affected

Table 4.24 shows the ten sectors that account for the largest indirect output effects under Scenario 1. Fishing, fish and fruit processing, and aquaculture account for the largest increase in purchases from the direct impacts from the trade and quota increases modelled – 19%, 16% and 9%, respectively. This is because the fish and fruit processing sector purchases both from the fishing and aquaculture sectors, as well as from itself. Other sectors in the top ten relate to the purchase of items associated with co-processing of fish, such as food and packaging. Transport, fuel and financial services are also in the top ten sectors indirectly affected.

Under Scenario 4, the fishing sector would have the largest decrease in purchases, followed by fish and fruit processing, and aquaculture. The other sectors affected are similar in Scenario 4 to Scenario 1, although land transport replaces the financial services sector in the top ten.

Table 4.24. Top 10 most affected sectors under Scenario 1, indirect output effect

Rank	Sector	Changes in Purchases, £1,000	% of Total Changes from Top 10 Sectors
1	Fishing	40,851	19%
2	Fish & fruit processing	34,686	16%
3	Aquaculture	20,734	9%
4	Other food	13,060	6%
5	Other transport equipment	10,572	5%
6	Rubber & Plastic	10,059	5%
7	Paper & paper products	9,024	4%
8	Coke, petroleum & petrochemicals	8,150	4%
9	Dairy products, oils & fats processing	6,066	3%
10	Financial services	5,683	3%
Total		**220,294**	

Table 4.25. Top 10 most affected sectors under Scenario 4, indirect output effect

Rank	Sector	Changes in Purchases, £1,000	% of Total Changes from Top 10 Sectors
1	Fishing	–6,171	18%
2	Fish and fruit processing	–5,242	15%
3	Aquaculture	–3,611	11%
4	Other food	–1,976	6%
5	Rubber and Plastic	–1,539	4%
6	Other transport equipment	–1,529	4%
7	Paper and paper products	–1,364	4%
8	Coke, petroleum and petrochemicals	–1,163	3%
9	Other land transport	–1,014	3%
10	Dairy products, oils & fats processing	–916	3%
Total		–34,319	

Table 4.26 shows changes in purchases, due to the indirect GVA effect, from sectors across the Scottish economy that are part of the seafood supply chain supplying fishing, aquaculture and seafood processing. As with the output effect, the three sectors in Scenario 1 that have the largest increases in purchases are fishing, fish and fruit processing and aquaculture. Other sectors in the top ten relate to the purchase of items associated with co-processing with fish, such as food and packaging. Transport and fuel are also in the top ten sectors.

Under Scenario 4, the fall in GVA for fishing, aquaculture and seafood processing results in decreases in purchases from the relevant supply chains (see Table 4.27). The fishing sector has the largest decrease in purchases, of £2 million, followed by fish and fruit processing and other food. The other sectors affected are similar in Scenario 4 to Scenario 1, with the dairy products, oils & fats processing sector replacing electricity in the top ten.

Table 4.26. Top 10 most affected sectors under Scenario 1, indirect GVA impacts

Rank	Sector	Changes in Purchases, £1,000	% of Total Changes from Top 10 Sectors
1	Fishing	15,337	17%
2	Fish & fruit processing	13,022	14%
3	Aquaculture	7,786	8%
4	Other transport equipment	6,280	7%
5	Other food	5,019	5%
6	Coke, petroleum & petrochemicals	4,615	5%
7	Rubber & plastic	3,827	4%
8	Paper & paper products	3,395	4%
9	Electricity	2,678	3%
10	Financial services	2,549	3%
Total		**92,254**	

Table 4.27. Top 10 most affected sectors under Scenario 4, indirect GVA effect

Rank	Sector	Changes in Purchases, £1,000	% of Total Changes from Top 10 Sectors
1	Fishing	–1,750	22%
2	Fish and fruit processing	–1,482	19%
3	Other food	–553	7%
4	Other transport equipment	–482	6%
5	Rubber and Plastic	–404	5%
6	Coke, petroleum and petrochemicals	–397	5%
7	Paper and paper products	–386	5%
8	Aquaculture	–270	3%
9	Dairy products, oils & fats processing	–260	3%
10	Financial services	–224	3%
Total		–7,849	

5 Key Messages

The results presented in this report relate to the ten species and trade codes specific to each species modelled, under a set of scenarios developed for analytical purposes. The scenarios are not predictions of what will happen in the future, but they are stylised alternative worlds that have been developed for analytical purposes. Not all trade in each species is covered, and not all trade in fish and fishery products is included. The key assumptions in Section 3.5 should be referred to.

The key messages that emerge from the analysis are summarised below.

Impact of trade measures

- The liberalisation of trade modelled in Scenario 1 (zero tariffs and a reduction in NTMs) results in an increase in both exports and imports, and a decrease in the UK price index for all species, which is expected to benefit consumers. Despite this scenario representing a very substantial liberalisation of the UK's seafood trade, the changes are modest, with the largest increase in exports being for salmon at 3.5%.
- In the absence of changes to TAC or quota allocation in line with the zonal attachment principle, the impact of increased tariffs and non-tariff measures (under Scenarios 2–4) is negative for the UK. Exports decline for all species modelled, and quantity and value of output, and imports, decline for all species except haddock. The aggregate reductions in output, exports and imports for the UK are 2.3%, 5.9% and 3.7% respectively under Scenario 4, for MFN tariffs and an increase in NTMs. Prices for all species rise, driven by the increase in tariffs and non-tariff measures, ranging from less than 1% (for crab), to over 5% (for herring) under Scenario 4.
- Both tariffs and NTMs contribute to these trade impacts, with the relative contribution variable across species and scenarios, according to the magnitude of the change relative to the baseline. Under Scenario 2 (EU-Norway level tariffs), NTMs have a bigger impact than tariffs for many species, however in Scenarios 3 and 4 (MFN tariffs), tariffs and NTMs have a similar magnitude of effect at the levels modelled, reflecting the higher level of tariffs in this scenario compared to scenario 2.

Impact of zonal attachment

- The results suggest increases in production from a reallocation of quotas in line with the zonal attachment principle dominate the results and outweigh the impact of the imposition of tariffs and NTMs for the species and trade codes modelled. This results in an aggregate increase in output of 10% and increase in exports of 12%, even with the imposition of MFN tariffs on trade with the EU (Scenario 3). There is also a reduction in imports of 5%. For Scenario 1, the aggregate increase in output is 12% and increase in exports is 17%, with a 0.4% reduction in imports.
- The sensitivity analysis indicates that if fisheries production and landings do not respond as readily to changes in demand, the changes in output and trade are more muted, reducing the magnitude of impacts of each of the scenarios modelled. If UK fish and seafood products are a prime product in the EU market (less substitutable with similar products from other sources), the output changes are moderated (lower gains in Scenario 1, and smaller losses in Scenario 4). This is likely to be the case for fresh fish and shellfish for European markets.

Observations on species and sectors

- The impacts on prices, output, imports and exports vary across species, reflecting differential impacts on different fleet sectors and the aquaculture industry, mostly determined by the potential gains (or not) from zonal attachment reallocation of quotas.
- For the scenarios that include reallocation of quotas based on the zonal attachment principle, the resulting increases in output and exports, and reductions in imports, are most significant (in percentage terms) for those species where the UK stands to gain significant increases in quota compared to the current Relative Stability-based allocation. Hake, herring, mackerel and saithe all stand to gain significant percentage increases in quota allocation under zonal attachment.
- Fleet sectors targeting non-quota species (crab and scallop) and the salmon aquaculture industry, which do not stand to gain from zonal attachment quota increases, suffer the negative impacts of higher tariffs and NTMs without the benefits of an increase in production. Therefore, they experience a contraction in output value with the imposition of EU-Norway type tariffs (and non-tariff measures), and a greater contraction with MFN tariffs and non-tariff measures. These are of the order of –0.6% for salmon and –4.4% for scallop (under Scenario 4).
- The impact on salmon is moderated by the large proportion of exports that go to non-EU countries (mainly the USA), and the low level of EU MFN tariffs on less processed forms of salmon (2% on fresh and chilled fish and fresh, chilled fillets and frozen fillets). Trade with most of the non-EU countries are already on the basis on MFN tariffs, therefore it is not affected by the move from Scenario 3 to Scenario 4.
- Without a change to quota allocations, the largest negative impacts are on cod, hake, herring and saithe, due to the large proportion of exports that go to the EU, together with the relative increase in the level of tariffs (which are greater for herring) (Scenario 4).
- The focus on ten species and the trade codes that relate specifically to those species means that the impact on trade for more mixed and generic categories, including frozen fillet blocks which are used as inputs to the processing industry, are not modelled. The modelling therefore does not capture the impact on the processing sector from changes to trade in these categories. However, the UK would be able to set its own tariffs for imports of these trade codes, and as a frozen product it would be less affected by non-tariff measures that might result in border delays.

Wider economic impacts

- The direct impacts in Scotland of Scenario 1, for the ten species modelled, would be an increase in economic output of around £320 million, of which the majority comes from processing. The indirect impacts add a further £170 million and the induced impacts another £50 million. The total impact is a £540 million or 21% increase in economic output linked to the seafood sector. This would be associated with a total increase of 5,000 FTE jobs including direct, indirect and induced effects.
- The direct impacts of MFN tariffs and increased NTMs, with no changes to quota allocation (Scenario 4) on Scotland's economy are a decrease in economic output of around £50 million. Again, it is the processing sector that accounts for most of the impact. The indirect impacts subtract a further £27 million and the induced impacts another £8 million in economic output from the Scottish economy. The total impact is an £85 million or 3% decrease in economic output linked to the seafood sector. This would be associated with a decrease of 218 direct FTE jobs. The total decrease in FTE jobs, including indirect and induced jobs, is 429, of which 44% is attributable to changes in the processing sector and 43% to the fishing sector.

- Under Scenario 1, total Scotland economy-wide GVA (direct, indirect and induced) would increase by £210 million, and under Scenario 4 it would fall by £20 million.
- The sectors of the economy that are most affected by the indirect effects (purchases by the directly affected sectors) are the fishing, fish and fruit processing, and aquaculture sectors themselves (as fish and fruit processing purchases both from the fishing and aquaculture sectors as well as from itself). Other sectors in the top ten relate to the purchase of items probably associated with co-processing with seafood, such as food and packaging. Transport, power and fuel, and financial services sectors are also in the top ten sectors. Together, the top ten affected sectors represent 72% of the indirect impact.

Areas for future improvements to seafood trade modelling

- This project has successfully developed seafood trade models for ten individual fish and shellfish species. However, a number of data limitations were encountered which offer the potential for future improvements to the seafood trade models.
- Changes to quota allocation need further detailed scientific assessment of zonal attachment and the full extent of the quota increases modelled may be difficult to achieve for a variety of reasons.
- The FAO Fisheries Commodities Production and Trade data have recently (November 2017) been released up to 2015 (previously they were only available to 2013), and these could be used to update the underlying production data for the trade codes in the models.
- Worldwide average prices for each trade code have been used, these could be refined to country-specific prices.
- Models for additional species could be developed, to further broaden the applicability of the approach. Additionally, the development of models that incorporate trade codes that are important to parts of the processing industry (e.g. frozen block fillets) could be explored, to increase the coverage of the 1604 category. An alternative approach to modelling these categories may be required, due to the lack of production data for such codes.
- Additional scenarios could be modelled, to increase understanding of the potential outcome of different trade and access arrangements.

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7 Abbreviations/Acronyms

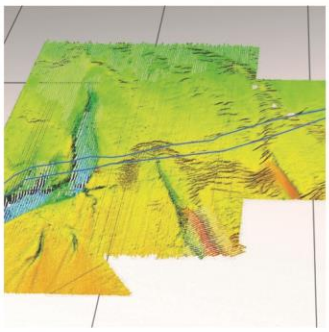
ACP	African, Caribbean and Pacific
AHS	Effectively Applied (Tariffs)
AVE	*ad valorem* Equivalent
c.i.f.	Cost, Insurance and Freight
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CES	Constant Elasticity of Substitution
CFP	Common Fisheries Policy
CoO	Certificates of Origin
EEA	European Economic Area
EEZ	Exclusive Economic Zone
Es	Elasticity of Supply
EU	European Union
EU27	European Union Countries involved in Brexit negotiations (EU except for the UK)
EUMOFA	European Market Observatory for Fisheries and Aquaculture Products
f.o.b.	Free on Board
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FI	Faeroe Islands
FTA	Free Trade Agreement
FTE	Full-time equivalent
FU	Functional Unit
GATT	General Agreement on Tariffs and Trade
GAUSS	Matrix programming language for mathematics and statistics
GBP	British Pounds Sterling
GTAP	Global Trade Analysis Project
GVA	Gross Value Added
HIE	Highlands and Islands Enterprise
HMRC	Her Majesty's Revenue and Customs
HS	Harmonised System
ICES	International Council for the Exploration of the Sea
I-O	Input-Output
ITT	Invitation to Tender
IUU	Illegal, unregulated and unreported
MFN	Most Favoured Nation
MMO	Marine Management Organisation
n/a	Not Applicable
nes	Not Elsewhere Specified
NS	North Sea
NTM	Non-Tariff Measure
OECD	Organisation for Economic Cooperation and Development
ONS	Office for National Statistics
PE	Partial Equilibrium
PSG	Project Steering Group
RoO	Rules of Origin
RoW	Rest of World
RS	Relative Stability
SAR	Special Administrative Region
SFF	Scottish Fishermen's Federation

SPS	Sanitary and Phytosanitary
TAC	Total Allowable Catch
TAPES	Trade Analysis Partial Equilibrium Sussex
TBT	Technical Barriers to Trade
TRAINS	Trade Analysis Information System
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
US	United States
USA	United States of America
USD	US Dollars
USITC	United States International Trade Commission
WS	West of Scotland
WTO	World Trade Organization
ZA	Zonal Attachment

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Appendices


Innovative Thinking - Sustainable Solutions

ABP mer

A UK Fisheries, Aquaculture and Processing Sectors

The following provides a summary of UK and Scottish fisheries, aquaculture production and the fish processing industry.

A.1 UK landings and production

A.1.1 Landings

In 2015, the total volume of landings by UK vessels (into the UK and abroad) was 708,100 tonnes with a first sale value of £775.1 million (MMO, 2016). The total volume of these landings into the UK was 415,700 tonnes with a total first sale value of £552.4 million. These landings comprised of 118,300 tonnes of demersal species (with a value of £208.8 million), 156,400 tonnes pelagic species (value £79.6 million) and 141,000 tonnes of shellfish (value £264 million). Scottish vessels contributed over 400,000 tonnes of UK landings as a result of relatively large amounts of mackerel landings (MMO, 2016).

The total volume of the landings outside of the UK was 292,000 tonnes (134,000 tonnes of mostly mackerel were landed into Norway; 72,000 tonnes were landed into the Netherlands and 39,000 tonnes into Denmark) (MMO, 2016).

Non-UK vessels also land into the UK, which may provide material for the UK processing sector. Non-UK vessels landed 46,000 tonnes of fish into the UK in 2015 with French and Irish-registered vessels landing the largest quantity (17,000 and 7,000 tonnes respectively). The majority of fish landed into the UK by foreign registered vessels were demersal (69 %) (MMO, 2016).

The main demersal, pelagic and shellfish species of importance for the UK fleet, in terms of historic volumes and value of landings, are shown in Figure A.1. Key demersal species are cod, haddock and plaice (monks or anglers also make an important contribution in terms of value), while mackerel and herring are the main pelagic species landed and *Nephrops*, scallops and crabs are the three main species of shellfish landed. Of these species, mackerel and herring are of particular importance to the Scottish fleet.

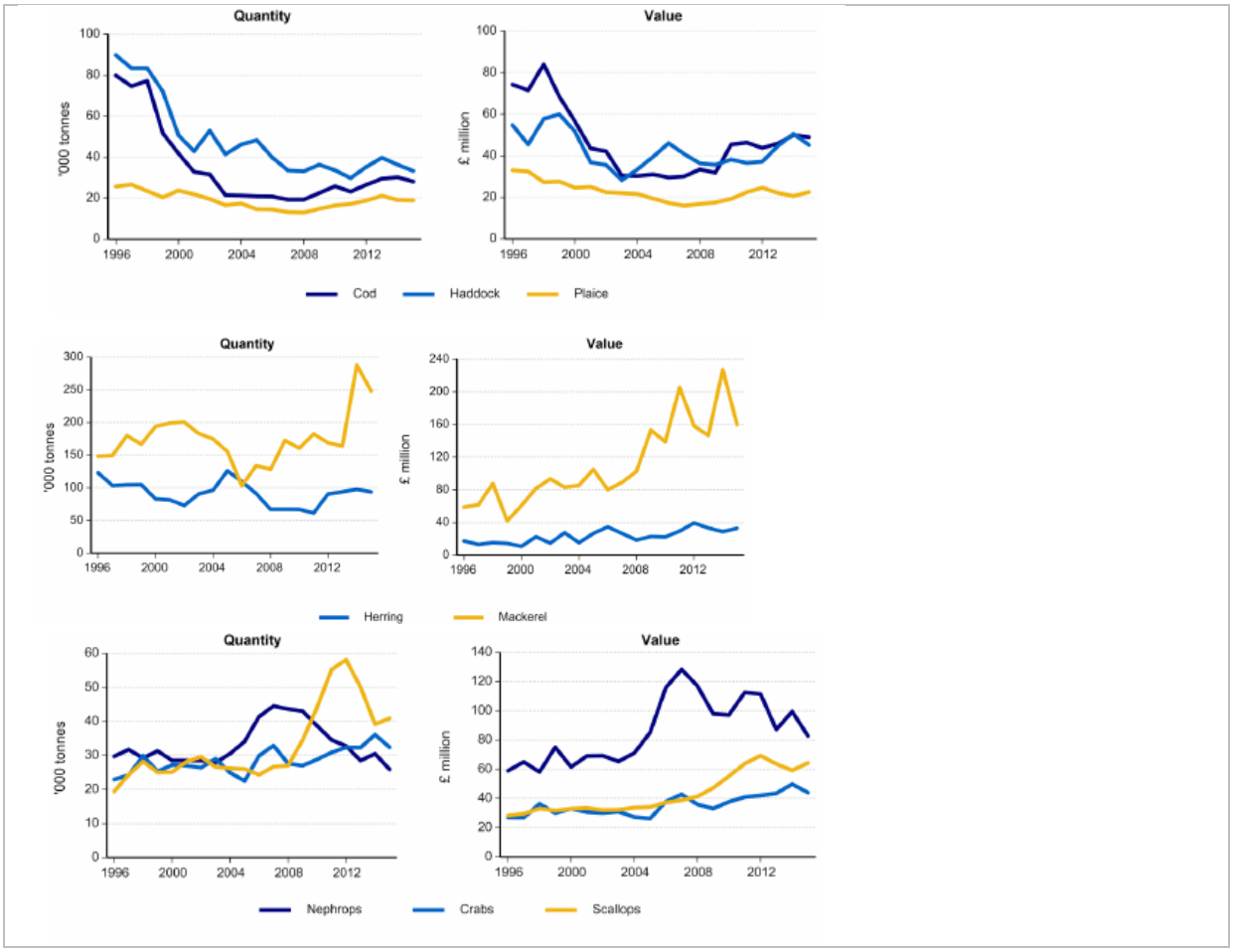


Figure A.1. **Landings of key demersal (top), pelagic (middle) and shellfish species (bottom) into the UK and abroad by UK vessels, by volume and value, between 1996 and 2015**

A.1.2 Aquaculture production

The UK aquaculture industry produces salmon, trout and shellfish for table trade (consumption) as well as ornamental fish and trout and coarse fish (particularly carp) for restocking for sport angling. This overview will focus on sea-based finfish and shellfish species production for the table.

Finfish species farmed for the table in the UK include Atlantic salmon (*Salmo salar*), rainbow trout (*Oncorhynchus mykiss*), halibut (*Hippoglossus hippoglossus*) and Arctic charr (*Salvelinus alpinus*). Scotland dominate finfish production in the UK (currently there is no sea-based marine finfish production in England or Wales, whilst there are a few marine salmon farms in Northern Ireland) and the Scottish industry is dominated by Atlantic salmon production, with 171,722 tonnes produced in 2015 with a value of £637 million (Marine Scotland, 2016a).

Shellfish species farmed in the UK, include mussels (*Mytilus edulis*), native oyster (*Ostrea edulis*), Pacific oyster (*Crassostrea gigas*), King scallop (*Pecten maximus*) and Queen scallop (*Aequipecten opercularis*). In Scotland, mussels are the main shellfish species produced in terms of both volume and value, followed by Pacific oysters (Marine Scotland, 2016b). The total volumes of finfish and shellfish produced between 2011 and 2015 by each Devolved Administration is shown in Table A.1.

Table A.1. UK aquaculture production (tonnes) (2011-2015)

Country	Aquaculture Type	Year				
		2011	2012	2013	2014	2015
Scotland	Finfish (Atlantic salmon)*	158,018	162,223	163,234	179,022	171,722
	Shellfish	7,285	6,525	6,935	7,980	7,506
Northern Ireland	Finfish (Atlantic salmon)*	c	c	c	c	c
	Shellfish	7,715	4,920	3,464	3,238	3,527
Wales	Finfish	-	-	-	-	-
	Shellfish	8,376	8,999	8,344	7,945	7,129
England	Finfish	-	-	-	-	-
	Shellfish	3,660	6,902	5,061	2,456	5,996

* Finfish production volumes only shown for Atlantic salmon and not other species (e.g. rainbow trout, halibut);
c Confidential due to the low number of producers;
\- No sea-based production

Sources: Marine Scotland 2012a, b; 2013a, b; 2014a, b; 2015a ,b; 2016a, b;
Cefas, 2015; unpublished data provided by Cefas

A.2 Fish processing in the UK

In 2014, turnover in the fish processing sector in the UK was £4,395 million and GVA was £776 million (of which £2,269 million turnover and £418 million GVA was in England, £2,038 million turnover and £341 million GVA was in Scotland and £84 million turnover and £17 million GVA was in Wales) (Seafish, 2016).

A.2.1 Sea fish

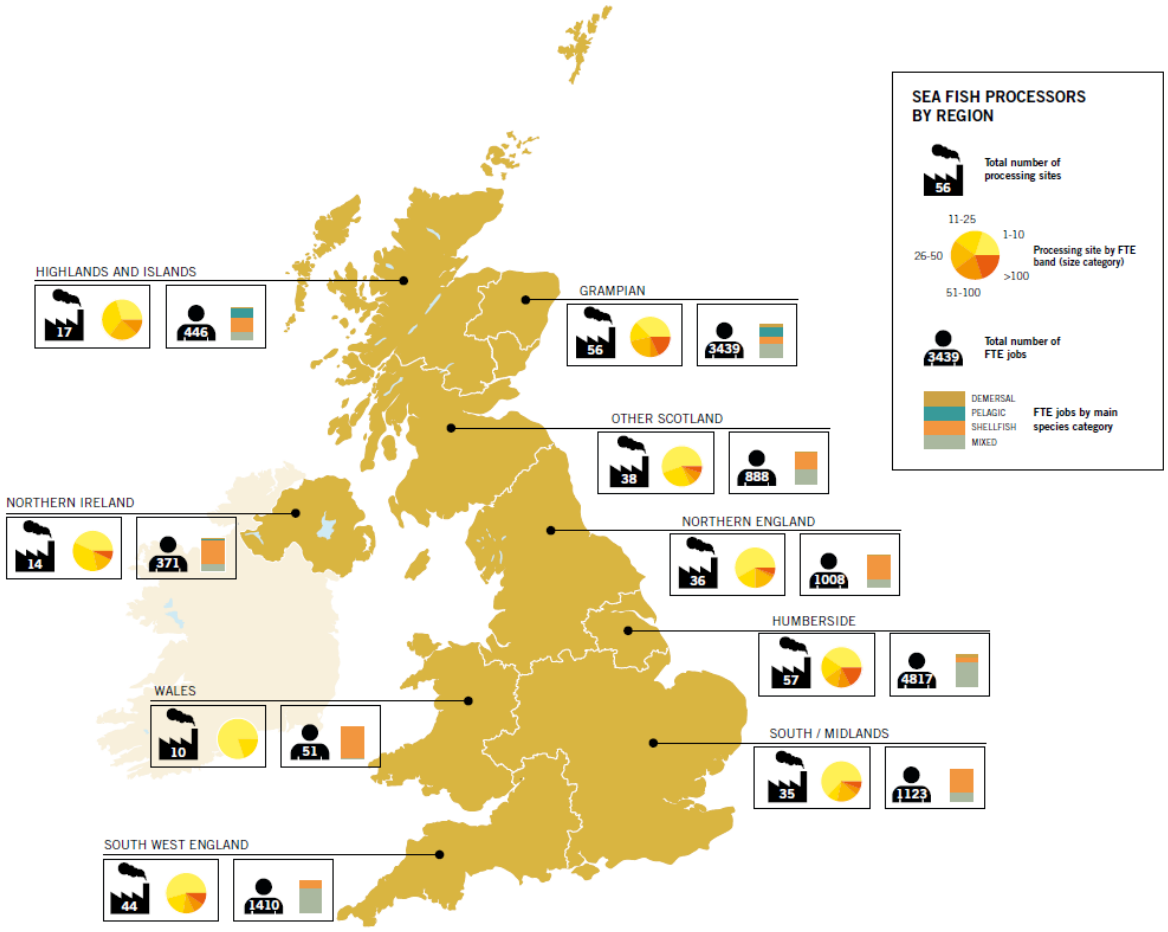
In 2014, turnover in the sea fish processing sector in the UK was £3,128 million and Gross Value Added (GVA) was £554 million. £1,083 million turnover and £169 million GVA was in Scotland (Seafish, 2016)).

In 2016, there were 307 sites processing sea fish[23] (saltwater fish) in the UK, supporting a total of 13,554 FTE jobs. England accounted for 62% of the UK's sea fish processing FTE jobs, while Scotland accounted for 35%, Northern Ireland 3% and Wales less than 1%. In 2016, the three regions with the highest proportion of sea fish processing FTE jobs were Humberside (36%), Grampian (25%) and South West England (10%) (Seafish, 2016). The lowest levels of processing activity were in Wales, Northern Ireland and the Highlands and Islands of Scotland. The regional distribution of processing sites and FTE jobs is shown in Figure A.2.

The majority of sea fish processing companies in the UK process a mixture of species[24] (49%), with 26% specialised in processing shellfish, 21% processing demersal species and 4% processing pelagic species. In the Highlands and Islands, Northern Ireland, Wales and Northern England and the South/Midlands, the majority of FTE jobs were related to shellfish processing in 2016, whereas in Humberside and South West England the majority of FTE jobs were related to processing of mixed species (Figure A.2).

[23] Sea fish is defined as all saltwater (marine) species, including whitefish, pelagic fish, flatfish, saltwater shellfish and saltwater exotics. It excludes diadromous and freshwater species (such as salmon and trout).

[24] Fish from more than one of the fish type categories which comprise demersal, shellfish, pelagic, saltwater exotics, salmon, trout and other freshwater fish.



Reproduced from Seafish, 2016

Figure A.2. Sea fish processing: regional and home nation distribution

A quarter of processing sites reported using imported raw materials, and although other sites may source material domestically some of it may be of imported origin (Seafish, 2016). Of 63 sites that provided information on the origin of raw material processed, 40 sites reported using over 50% imported raw material in value terms. Third countries are important for sourcing raw material for processing: 30 sites reported using ≥50% raw materials imported from the rest of the World (RoW), compared to 16 sites that reported using ≥50% raw material imported from the European Union (Seafish, 2016).

In Scotland, whitefish processing mainly takes place in the north-east. Pelagic processing, like whitefish processing, centres around the north-east but also takes place in Shetland, while shellfish processing takes place across all fishing areas and in the central belt (Scottish Government, 2012).

A.2.2 Salmon and freshwater fish[25]

Salmon is an increasingly large part of UK fish processing industry. The majority of salmon produced in Scotland is also processed in Scotland (Highlands and Islands Enterprise (HIE) and Marine Scotland, 2017). The majority of sites (38) and FTE jobs (3,279) related to salmon and freshwater fish processing in the UK are based in Scotland, while England had 23 sites and 733 FTE jobs and Wales had under 5 sites and hence, due to confidentiality, statistics were not available. In contrast, large-scale processors in Grimsby use Norwegian and Chilean salmon to ensure continuity of supply to their customers largely due to constrained supply of Scottish salmon volumes. Salmon processing in Scotland is concentrated in the regions classified as 'Other Scotland' and 'Highlands and Islands', with 55% and 18% respectively of total salmon and freshwater processor FTE jobs (Seafish, 2016).

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[25] Information relating to salmon processing is grouped together with other 'freshwater' fish in Seafish (2016), hence it is not possible to disaggregate the statistics specifically for salmon. In addition, no turnover or GVA data were available for salmon and freshwater fish processing in Seafish (2016).

B International Trade Issues

B.1 Tariffs

A tariff is a tax on imports or exports, this can either be levied as a fixed fee per item, or as *ad valorem*, based on a percentage of the value of the goods being traded. Tariffs are used to raise government revenue, and to protect domestic industries from cheaper imports from other countries, by effectively increasing the cost of imports. The level of applicable tariff depends on the type of good being traded, often with higher tariffs on more processed products. This can facilitate the import of raw material at low tariff rates to supply the processing industry in the country. Higher tariffs on more processed goods protect the domestic processing industry and have the effect of discouraging value addition in the source countries. This is often seen in fish and fishery tariffs, for example unprocessed tuna has low tariffs to import to the EU, in order to supply raw material for the French and Spanish processing industries, with canned tuna attracting a tariff of 24%.

Tariffs discourage international trade and raise prices for consumers, and there have been international efforts to reduce trade barriers and promote international trade. The General Agreement on Tariffs and Trade (GATT) was a legal agreement with the aim of promoting international trade by the "substantial reduction of tariffs and other trade barriers and the elimination of preferences, on a reciprocal and mutually advantageous basis." Various negotiating rounds have taken place, with the creation of the World Trade Organization (WTO) in 1994 as part of the Uruguay Round.

Under the WTO agreements, countries cannot normally discriminate between their trading partners. The principle of Most-Favoured Nation (MFN) treatment requires that a country must provide its lowest customs duty rate for all WTO members. However, there are exceptions – lower tariffs are permitted for Free Trade Agreements (FTAs) that applies only to goods traded within the group of member countries; and developing countries can be granted preferential access.

Bound tariffs are specific commitments made by individual WTO member governments, as the maximum MFN tariff level that will be applied for a given commodity line. However, members have the flexibility to decrease their tariffs (on a non-discriminatory basis) below the bound level.

MFN tariffs are what countries promise to impose on imports from other members of the WTO, unless the exporting country is part of a preferential trade agreement (such as a free trade area or customs union). This means that, in practice, MFN rates are the highest (most restrictive) that WTO members charge one another.

Due to the existence of various preferential trade agreements, the Effectively Applied (AHS) tariff is often below the MFN rate. Effectively applied tariff is the lowest available tariff for a good traded between two specific countries.

B.2 Non-tariff measures

Non-tariff measures (NTMs) are measures applied at the border, which have the potential to change the quantity of imports (positively or negatively) of specific goods from some or all origins, and which are not tariffs. They are not necessarily set up to exclude imports and in some cases compliance with these measures may increase trade. The United Nations Conference on Trade and Development (UNCTAD) has produced a standard classification for NTM (Table B.1).

While various trade round agreements since 1948 have led to a substantial reduction in tariffs - which were seen as the major barrier to trade - non-tariff measures have the potential to be used as a form of protection and to act as barriers to trade. In an effort to reduce the trade-restricting aspects of these regulations, two agreements were reached under the Uruguay Round negotiations and adopted by WTO members in 1995:

- Application of Sanitary and Phytosanitary Measures (the SPS Agreement); and
- Agreement on Technical Barriers to Trade (TBT).

Details on these are explored further in the sections below.

Table B.1. UNCTAD Classification of NTM (2012)

Imports		
Technical Measures	A	Sanitary and Phytosanitary Measures (SPS)
	B	Technical Barriers to Trade (TBT)
	C	Pre-shipment inspection and other formalities
Non-Technical Measures	D	Contingent trade-protective measures
	E	Non-automatic licensing, quotas, prohibitions and quantity-control measures other than for SPS or TBT reasons
	F	Price-control measures, including additional taxes and charges
	G	Finance measures
	H	Measures affecting competition
	I	Trade-related investment measures
	J	Distribution restrictions
	K	Restrictions on post-sales services
	L	Subsidies (excluding export subsidies under P7)
	M	Government procurement restrictions
	N	Intellectual property
	O	Rules of Origin
Exports		
	P	Export-related measures

Source: Fugazza, 2017

Currently UK firms face only minimal NTM when exporting to the EU27 as the UK is a full member of the EU. In particular UK goods are not subject to Sanitary and Phytosanitary (SPS) or Technical Barriers to Trade (TBT) conformity checks or contingent protection, as a result of the direct effect of EU law on standards (SPS and TBT), membership of the Common Commercial Policy (Contingent protection) and the Customs Union (Rules of Origin, RoO). Categories C, E-N and P are covered in whole or part by Single Market rules and do not attract measures in intra-EU trade, or if they do UK goods will attract similar measures after Brexit.

B.2.1 Sanitary and phytosanitary measures

As a result of concerns over food safety there are increasingly complex requirements for food safety assurance and traceability, both in developed and developing countries. Major markets impose complex food safety assurance and traceability requirements, especially the EU and USA. These requirements present a threat to existing exporters and a 'barrier' to new entrants. Strict quality standards create a bias in favour of countries with a highly developed infrastructure and larger suppliers with greater resources.

The SPS Agreement applies only to measures covering food safety, animal and plant life and human health. Other technical measures outside this area come within the scope of the TBT Agreement. The SPS and TBT Agreements are thus complementary and mutually reinforcing.

These agreements have given a new direction to the international food trade, including fisheries products. The agreements are intended to ensure that requirements such as food quality, labelling and methods of analysis applied to internationally-traded goods do not mislead the consumer or discriminate in favour of domestic producers or goods of different origin. They also try to ensure a balance between the trade-facilitating aspects of standards and their trade-distorting potential.

Some key principles of the SPS Agreement include:

- The sovereign right of a country to put protective measures in place, but these measures should not be more restrictive than necessary to achieve the appropriate level of protection.
- The Agreement stresses that SPS measures should be scientifically based as well as the importance of risk assessment in determining the appropriate levels of SPS measures.
- Of crucial importance are transparency in the development and implementation of measures and the adoption of international standards.
- The SPS Agreement gives status and legal force to the standards set by the Codex Alimentarius Commission. The Codex Alimentarius - or food code - was created in 1963 by FAO and WHO and has become a global reference point for consumers, food producers and processors, national food control agencies and the international food trade.

B.2.2 Technical barriers to trade

The WTO Agreement on Technical Barriers to Trade (TBT) seeks to ensure that:

- Technical standards and regulations do not create unnecessary obstacles to trade;
- Code of good practice is used;
- Procedures for testing should be fair and equitable;
- There is no unfair advantage for domestic products as a result of standards; and
- There is transparency (i.e. notifications).

Examples of technical import requirements may include restrictions on fish (e.g. size, presentation); the catch method (e.g. use of turtle excluder devices in shrimp fisheries; dolphin-safe tuna fishing), and labelling (e.g. origin of the catch, generic marketing names) including the use of eco-labels. In this context, findings from research in India show that SPS measures introduced in the 1990s had far more impact at the macro-level than TBT measures related to the turtle/shrimp dispute with the USA. Nevertheless, at the micro-level the latter also had some negative impacts on the livelihoods of poor fishing communities (Salagrama and Koriya, 2006).

B.2.3 Trade defence measures

Trade defence measures are considered a legitimate means to defend producers against unfairly traded or subsidised imports, if applied using WTO rules. There are three types:

- Anti-dumping measures: the addition of customs duties to products where it can be shown that goods are being traded internationally at below the 'normal value' in their domestic market, or below the cost of production. Anti-dumping measures have been applied within the European Economic Area (EEA) agreement, when the EU imposed additional duty on Norwegian salmon;

- Anti-subsidy (countervailing) measures: the addition of customs duties on products that have been produced with financial assistance (subsidy) from the government, resulting in trade-distorting effects; and
- Safeguard measures: short-term measures to regulate a sharp increase in imports of a certain product that means that domestic producers cannot adapt immediately to the change in the trade situation.

B.2.4 Rules of origin

Rules of Origin (RoO) specify the tariff applicable to products originating from different places and are required to ensure accurate tariff assessment (OECD, 2003). They are important because only fish that is considered to 'originate' from a country can be exported at preferential tariff rates under Free Trade Agreements. Given that fish are caught in many parts of the world and are traded in different forms (e.g. raw, semi-processed and processed) rules of origin present a particular challenge. As a consequence, the proper use and interpretation of rules of origin enhances the predictability and transparency in international fisheries trade. At the same time, from the point of view of exporters, rules of origin can be viewed as a trade impediment.

In general, to obtain duty-free access to the EU market, fishery products must be 'wholly obtained' in the State concerned. The main criteria for defining 'originating products' are registration and flag, ownership and crewing arrangements on the fishing vessels and factory ships, which must be either of the State concerned or European.

There is often a value tolerance (i.e. derogation) to the RoO, in that the value of non-originating fish can be up to a certain percentage of the ex-works price of the product (on a per shipment basis). In the case of African, Caribbean and Pacific (ACP) countries exporting to the EU, this value is 15% (Campling, 2006).

B.2.5 Certification and accreditation

The implementation of product standards requires the verification that such standards have been met. Where countries have their own testing arrangements for ensuring that products meet mandatory standards, but do not recognise each other's arrangements for ensuring compliance, trade barriers continue to exist and there are increased costs (and potential delays) for customs clearance whilst good are checked to verify conformity with the standards. These checks can range from inspections at the border to the testing of samples to ensure compliance.

Certification and accreditation are means of facilitating recognition of systems for testing and ensuring products meet the relevant standards, reducing border delays. Accredited certification bodies in the country of origin may be recognised by the importer as providing effective assurance that goods have been produced in line with the required product standards. If so, a certificate of compliance from an accredited certification body is sufficient to demonstrate that the goods meet the importer's standards and further border checks can be minimised.

Within the EU and the wider EEA, there is mutual recognition of conformity assessment procedures, and standards are harmonised across member states. All EU and EEA member states must have an EU-accredited competent body to guarantee testing and certification processes. This means that there is no need for any further customs checks to ensure conformity with standards, and the relevant certification and accreditation bodies (and the outcome of their inspection procedures) in member states are automatically recognised by other member states.

B.2.6 Catch certificates

Catch certificates are not trade measures but are used to certify the origin of fish to confirm that it has been caught in line with the relevant regulations. The EU's Regulation on preventing illegal, unreported and unregulated (IUU) fishing (EC 1005/2008) requires that fish landed to or exported to the EU from third countries is accompanied by a catch certificate, issued by the flag state's Competent Authority, that certifies that the catches were made with the relevant permissions (i.e. from an area for which the vessel has a valid fishing authorisation, within relevant quota limits and in compliance with technical management measures)[26]. As a third country, the UK will need to comply with this requirement to export fish to the EU, as Norway is required to[27]. This is unlikely to represent a significant burden, but represents additional administration that will be required in order to land in or export to the EU.

B.3 References

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[26] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:pe0005 and https://www.gov.uk/guidance/catch-certificates-for-non-eu-imports-and-exports-of-fish

[27] http://www.catchcertificate.no/om-catch-certificate-sa.aspx.

C Scenarios

Detail on the scenarios is provided in Table C.1 (Scenario 1), Table C.2 (Scenario 2), Table C.3 (Scenario 3) and Table C.4 (Scenario 4) below.

Table C.1. Scenario 1 detail

Scenario 1	Trade Flow	Tariffs and NTMs		UK and EU Production (Catches, Based on Quota Distribution)	
		EU	Non-EU	UK	EU
Global Free Trade Agreement and increased UK production	Imports (to UK) from	Zero tariffs (no change)	Zero tariffs (eliminate current trade barriers)	UK production adjusts based on Zonal Attachment	EU production adjusts based on Zonal Attachment
		Minimum level of non-tariff measures (equal to baseline): ▪ Catch certificates ▪ Trade defence Modelled at 5%	Minimum level of non-tariff measures (below baseline): ▪ Catch certificates (no change) ▪ Trade defence (no change) Modelled at 10%		
	Exports (from UK) to	Zero tariffs (no change)	Zero tariffs (eliminate current trade barriers)		
		Minimum level of non-tariff measures (equal to baseline): ▪ Catch certificates ▪ Trade defence Modelled at 5%	Minimum level of non-tariff measures (below baseline): ▪ Trade defence Modelled at 10%		

Table C.2. Scenario 2 detail

Scenario 2	Trade Flow	Tariffs and NTMs		UK and EU Production (Catches, Based on Quota Distribution)	
		EU	Non-EU	UK	EU
EEA-type agreement with EU (based on Norway's), current trade arrangements with non-EU (grandfathering to UK, EU trade arrangements with RoW) and increased UK production	Imports (to UK) from	Tariff based on Norway EEA Agreement	Maintain baseline tariffs	UK production adjusts based on Zonal Attachment	EU production adjusts based on Zonal Attachment
		Non-tariff measures based on Norway EEA Agreement (moderate NTMs): ▪ Mutual recognition of standards, testing and certification (light-touch customs and veterinary checks) ▪ RoO ▪ Catch certificates ▪ Trade defence Modelled at 10%	Maintain baseline level of non-tariff measures (equal to baseline): ▪ Testing and certification requirements (no change) ▪ RoO (no change) ▪ Catch certificates (no change) ▪ Trade defence (no change) Modelled at 15%		
	Exports (from UK) to	Tariff based on Norway EEA Agreement	Maintain baseline tariffs		
		Non-tariff measures based on Norway EEA Agreement (moderate NTMs) ▪ Mutual recognition of standards, testing and certification (light-touch customs and veterinary checks) ▪ RoO ▪ Catch certificates ▪ Trade defence Modelled at 10%	Maintain baseline level of non-tariff measures (equal to baseline): ▪ Testing and certification requirements (no change) ▪ RoO (no change) ▪ Trade defence (no change) Modelled at 15%		

Table C.3. Scenario 3 detail

Scenario 3 – Slightly Pessimistic	Trade Flow	Tariffs and NTMs		UK and EU Production (Catches, Based on Quota Distribution)	
		EU	Non-EU	UK	EU
MFN tariffs on both EU and non-EU trade (default to WTO trade rules) and increased UK production	Imports (to UK) from	MFN tariffs	Existing tariffs	UK production adjusts based on Zonal Attachment	EU production adjusts based on Zonal Attachment
		Default WTO rules on non-tariff measures (high level of NTMs): ▪ Full strength conformity assessment procedures and veterinary checks ▪ Catch certificates ▪ Trade defence Modelled at 15%	Default WTO rules on non-tariff measures (high level of NTMs, equal to base): ▪ Full strength conformity assessment procedures and veterinary checks ▪ Catch certificates (no change) ▪ Trade defence (no change) Modelled at 15%		
	Exports (from UK) to	MFN tariffs	Existing tariffs		
		Default WTO rules on non-tariff measures (high level of NTMs): ▪ Full strength conformity assessment procedures and veterinary checks ▪ Catch certificates ▪ Trade defence Modelled at 15%	Default WTO rules on non-tariff measures (high level of NTMs, equal to base): ▪ Full strength conformity assessment procedures and veterinary checks ▪ Trade defence (no change) Modelled at 15%		

Table C.4. Scenario 4 detail

Scenario 4 – Highly Pessimistic	Trade Flow	Tariffs and NTMs		UK and EU Production (Catches, Based on Quota Distribution)	
		EU	Non-EU	UK	EU
MFN Tariffs on both EU and non-EU trade (default to WTO trade rules) and no increase in UK production	Imports (to UK) from	MFN tariffs	MFN tariffs	No adjustment in UK production to reflect zonal attachment (current quota allocations maintained) No change for model, i.e. production based on current (2011-15) annual average landings	No adjustment in EU production to reflect zonal attachment (current quota allocations maintained) No change for model, i.e. production based on current (2011-15) annual average landings
		Default WTO rules on non-tariff measures (high level of NTMs): ▪ Full strength conformity assessment procedures and veterinary checks ▪ Catch certificates ▪ Trade defence Modelled at 15%	Default WTO rules on non-tariff measures (high level of NTMs, equal to base): ▪ Full strength conformity assessment procedures and veterinary checks ▪ Catch certificates ▪ Trade defence (no change) Modelled at 15%		
	Exports (from UK) to	MFN tariffs	MFN tariffs		
		Default WTO rules on non-tariff measures (high level of NTMs): ▪ Full strength conformity assessment procedures and veterinary checks ▪ Catch certificates ▪ Trade defence Modelled at 15%	Default WTO rules on non-tariff measures (high level of NTMs, equal to base): ▪ Full strength conformity assessment procedures and veterinary checks ▪ Catch certificates ▪ Trade defence (no change) Modelled at 15%		

D Trade Model Details

D.1 Model equations

We begin by firmly grounding the model in standard consumer theory. Consider a market with *n* products from different countries: $X_1,\ldots,X_n$. We can introduce composite good made from all of the competing products:
$X = u\left(X_1,\ldots,X_n\right)$.

This gives as a quantity-index of consumption in given market, which can be viewed as a utility function of a representative consumer. We assume that *u* has generalised CES form:

$$X = u\left(X_1,\ldots,X_n\right) = \left(a_1 X_1^{\rho} + \ldots + a_n X_n^{\rho}\right)^{\frac{1}{\rho}} \tag{0.1}$$

where a_n are called CES weights and ρ is a constant less than one.

If we combine it with budget constraint $Y = \sum_{i=1}^{n} P_i X_i$,

we can set up a dual-viewing consumer as choosing a consumption bundle that minimises the level of expenditures while retaining specific level of utility. The problem then becomes:

$$\min_{X_1,\ldots,X_n} \quad Y = \sum_{i=1}^{n} P_i X_i \quad \text{s.t.} \quad u\left(X_1,\ldots,X_n\right) = X \tag{0.2}$$

To solve it we set up the Lagrangian:

$$L\left(X_1,\ldots,X_n,\lambda\right) = \sum_{i=1}^{n} P_i X_i + \lambda\left(u\left(X_1,\ldots,X_n\right) - X\right) \tag{0.3}$$

Differentiating the above expression, we can obtain the conditions for an optimal solution:

$$\frac{\frac{\partial u}{\partial X_j}}{\frac{\partial u}{\partial X_k}} = \frac{P_j}{P_k}, \qquad k = 1,\ldots,n \tag{0.4}$$

This means that the marginal rate of substitution between two goods equals their price ratio. In our case, the marginal utility for good X_i equals:

$$\frac{\partial u}{\partial X_i} = a_i X_i^{\rho-1}\left(a_1 X_1^{\rho} + \ldots + a_n X_n^{\rho}\right)^{\frac{1}{\rho}-1} \tag{0.5}$$

Which gives us:

$$\frac{\frac{\partial u}{\partial X_j}}{\frac{\partial u}{\partial X_k}} = \left(\frac{a_j}{a_k}\right)\left(\frac{X_j}{X_k}\right)^{\rho-1} = \frac{P_j}{P_k}, \qquad k = 1,\ldots,n \tag{0.6}$$

Solving for X_k we obtain:

$$X_k = \left(\frac{a_j P_k}{a_k P_j} \right)^{\frac{1}{\rho - 1}} X_j, \qquad k = 1, \ldots, n \tag{0.7}$$

The elasticity of substitution between X_k and any other product competing in the market is constant and equal to $\frac{1}{\rho - 1}$:

$$\frac{X_k}{X_j} = \left(\frac{a_j}{a_k} \right)^{\frac{1}{\rho - 1}} \left(\frac{P_k}{P_j} \right)^{\frac{1}{\rho - 1}}, \qquad k = 1, \ldots, n \tag{0.8}$$

We assume $\sigma = \frac{1}{\rho - 1}$, then the preceding simplifies to:

$$X_k = \left(\frac{a_j P_k}{a_k P_j} \right)^{\sigma} X_j, \qquad k = 1, \ldots, n \tag{0.9}$$

We can now use the final equation arising from using Lagrange method:

$$\frac{\partial L}{\partial \lambda} = X - u\left(X_1, \ldots, X_n \right) = 0 \tag{0.10}$$

Substituting and rearranging gives us:

$$X = \left[\sum_{k=1}^{n} a_k \left(X_j \left(\frac{a_j P_k}{a_k P_j} \right)^{\sigma} \right)^{\frac{\sigma - 1}{\sigma}} \right]^{\frac{\sigma}{\sigma - 1}} = X_j a_j^{-\sigma} \left[\sum_{k=1}^{n} a_k^{\sigma} \left(\frac{P_k}{P_j} \right)^{\sigma - 1} \right]^{\frac{\sigma}{\sigma - 1}} \tag{0.11}$$

Solving for the X_j we obtain the Hicksian demands:

$$X_j = X \cdot a_j^{\sigma} \left[\sum_{k=1}^{n} a_k^{\sigma} \left(\frac{P_k}{P_j} \right)^{\sigma - 1} \right]^{\frac{\sigma}{1 - \sigma}} \tag{0.12}$$

This can be simplified using the property arising from Armington (1969) assumptions:

$$P = P_1 / \frac{\partial u}{\partial X_1} = \ldots = P_n / \frac{\partial u}{\partial X_n} \tag{0.13}$$

where *P* is an exact price index corresponding to the cost of a unit of utility. Substituting the relevant derivatives leads to:

$$P = P_j a_j^{-1} X_j^{\frac{1}{\sigma}} X^{-\frac{1}{\sigma}}, \qquad j = 1, \ldots, n \tag{0.14}$$

Substituting for X_j and rearranging:

$$\left(\frac{P}{P_j}\right)^{\sigma} = \left[\sum_{k=1}^{n} a_k^{\sigma}\left(\frac{P_k}{P_j}\right)^{\sigma-1}\right]^{\frac{\sigma}{1-\sigma}} \tag{0.15}$$

That along with the linear homogeneity of the utility function permits us to write the demand in a more compact form:

$$X_j = X \cdot a_j^{\sigma}\left(\frac{P}{P_j}\right)^{\sigma} = \left(\frac{a_j}{P_j}\right)^{\sigma} Y \cdot P^{\sigma-1}, \qquad j = 1,\ldots,n \tag{0.16}$$

To obtain the price index P we need to calculate the expenditure function for a unit of utility:

$$PX = e(p, X) = \left(\sum_{i=1}^{n} P_i^{1-\sigma} a_i^{\sigma}\right) P^{\sigma} X, \qquad X = 1 \tag{0.17}$$

$$P = \left(\sum_{i=1}^{n} P_i^{1-\sigma} a_i^{\sigma}\right)^{1-\frac{1}{\rho}} \tag{0.18}$$

We then assume a supply function with a constant supply elasticity, and setting this equal to demand, we obtain excess demand conditions for each of the products:

$$\begin{gathered}\left(\frac{a_1}{P_1}\right)^{\sigma} Y \cdot P^{\sigma-1} - k_1\left(\frac{P_1}{(1+t_1)}\right)^{\varepsilon_1} = 0 \\ \vdots \\ \left(\frac{a_n}{P_n}\right)^{\sigma} Y \cdot P^{\sigma-1} - k_n\left(\frac{P_n}{(1+t_n)}\right)^{\varepsilon_n} = 0\end{gathered} \tag{0.19}$$

where: k_i are supply constants, t_i are aggregated trade barriers and ε_i are supply elasticities. Adding the excess demand condition for composite good:

$$Y - k_a P^{1-NA} = 0 \tag{0.20}$$

and the price index equation:

$$P - \left(\sum_{i=1}^{n} P_i^{1-\sigma} a_i^{\sigma}\right)^{1-\frac{1}{\rho}} = 0 \tag{0.21}$$

The model is summarised in Table D.1.

Table D.1. Model summary

Aspect	Detail	
Variables:	$P_1, \ldots, P_n$	Product prices
	Y	Total expenditure
	P	Composite good price index
Parameters (calibrated):	$a_1, \ldots, a_n$	CES weights
	$k_1, \ldots, k_n$	Supply constants
	k_a	Demand for composite constant
Parameters (data):	$X_1, \ldots, X_n$	Base trade flows
	$t_1, \ldots, t_n$	Base tariffs
Parameters (assumed):	σ	Elasticity of substitution
	NA	Composite elasticity of demand
	$\varepsilon_1, \ldots, \varepsilon_n$	Elasticises of supply

D.2 Key parameters of the model

The price elasticity of demand for the aggregate product (Na), tells you, for a given fish species such as cod, how responsive demand for cod is, as the price of cod changes.

The elasticity of substitution (Sig) between individual product varieties from different sources tells you if the price of (for example) UK cod changes, the extent to which cod from other sources (e.g. Russia) is a substitute. The higher the elasticity of substitution, the easier it is for consumers to switch to other sources. In the model the elasticity of substitution is treated as being the same across different sources. Hence the degree of substitutability between e.g. UK and EU sources, is the same as between UK and Chinese sources. For the elasticity of substitution there are no detailed information available. We have assumed that this is equal to 5 for most of the species, except for crab, Nephrops, and scallops where we have assumed 2.5, as EU imports of these species from the UK focus on fresh product.

Note that in the work of the United States International Trade Commission (USITC) (Donnelly *et al.*, 2004), which bases much of its work on the Global Trade Analysis Project (GTAP) dataset, the elasticities they use are:

- "prepared fresh or frozen fish and seafoods" = 1.7; and
- "canned and cured fish and seafoods" = 5

The price elasticity of supply (Es) captures how easy it is for supply to respond to changes in price. The higher the elasticity the easier it is for supply to increase for any given change in price. Another way of putting this is that the higher is the elasticity, as supply changes the price changes by less. The elasticity of supply could be set differentially for each supplier. The elasticity has been set = 1 for all suppliers and all species. Note that Pascoe and Mardle (1999) estimate supply elasticities for a range of fish species and find short- and long-run supply elasticities of less than one for each of the species, with the highest long-run elasticity being for Haddock (0.86), and the lowest for Cod (0.11).

Data on each of the above are limited, especially with regard to fish. There are a few papers that give some estimates for the price elasticity of demand for fish in aggregated form with numbers typically around 1.5 (e.g. Andreyeva *et al.*, 2010; Muhammad *et al.*, 2013), but with some variability. One of the few papers that provides detailed estimates is the work of Kee *et al.* (2008). Hence for the overall elasticity of demand we are using this work. They provide extremely detailed estimates of import demand elasticities at the HS 6-digit level, and by country. We have taken their median elasticity (across countries) for each of the relevant HS 6-digit fish categories for each of our species. The average elasticity is then a weighted average, where the weights are the shares of total trade of each category in UK trade.

Detail of the parameter values used in the model are provided in Table D.2.

Table D.2. Parameters used in the model

Species	Summary Information					
	MFN Tariffs	EU-Norway Tariffs	Changes in Quotas	Elasticity of Demand	Elasticity of Substitution	Elasticity of Supply
Cod	11.5	0.57	8.8%	5.43	5	1
Crab	7.8	2.27	-	4.14	2.5	1
Haddock	7.5	0.3	21.2%	0.44	5	1
Hake	12.3	3.3	166%	1.14	5	1
Herring	14.3	6.8	219%	2.83	5	1
Mackerel	14.5	9.7	53.4%	2.24	5	1
Nephrops	16	1.6	4.8%	0.64	2.5	1
Saithe	7.5	0.3	186%	0.41	5	1
Salmon	4.9	4.1	-	0.71	5	1
Scallop	16	7.6	-	0.72	2.5	1

D.3 References

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E Trade Codes for each Species

The HS2012 6-digit codes, and their descriptions, that are used in the trade model for each species are shown in Table E.1.

Table E.1. HS2012 codes and descriptions for the ten species

HS2012	Form	Description
Cod		
030251	Fresh/chilled	Fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae, excluding livers and roes : -- Cod (*Gadus morhua, Gadus ogac, Gadus macrocephalus*)
030363	Frozen	Fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae, excluding livers and roes : -- Cod (*Gadus morhua, Gadus ogac, Gadus macrocephalus*)
030471	Fillets and other meat	Frozen fillets of fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae : -- Cod (*Gadus morhua, Gadus ogac, Gadus macrocephalus*)
030551	Dried, salted, smoked	Dried fish, other than edible fish offal, whether or not salted but not smoked : -- Cod (*Gadus morhua, Gadus ogac, Gadus macrocephalus*)
030562	Dried, salted, smoked	Fish, salted but not dried or smoked and fish in brine, other than edible fish offal : -- Cod (*Gadus morhua, Gadus ogac, Gadus macrocephalus*)
Crab		
030614	Crustaceans	Frozen : -- Crabs
030624	Crustaceans	Not frozen : -- Crabs
160510	Prepared/ preserved	Crab
Haddock		
030252	Fresh/chilled	Fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae, excluding livers and roes : -- Haddock (*Melanogrammus aeglefinus*)
030364	Frozen	Fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae, excluding livers and roes : -- Haddock (*Melanogrammus aeglefinus*)
030472	Fillets and other meat	Frozen fillets of fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae : -- Haddock (*Melanogrammus aeglefinus*)

HS2012	Form	Description
Hake		
030254	Fresh/chilled	Fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae, excluding livers and roes : -- Hake (*Merluccius* spp., *Urophycis* spp.)
030366	Frozen	Fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae, excluding livers and roes : -- Hake (*Merluccius* spp., *Urophycis* spp.)
030474	Fillets and other meat	Frozen fillets of fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae : -- Hake (*Merluccius* spp., *Urophycis* spp.)
Herring		
030241	Fresh/chilled	Herrings (*Clupea harengus, Clupea pallasii*), anchovies (*Engraulis* spp.), sardines (*Sardina pilchardus, Sardinops* spp.), sardinella (*Sardinella* spp.), brisling or sprats (*Sprattus sprattus*), mackerel (*Scomber scombrus, Scomber australasicus, Scomber japonicus*), jack and horse mackerel (*Trachurus* spp.), cobia (*Rachycentron canadum*) and swordfish (*Xiphias gladius*), excluding livers and roes : -- Herrings (*Clupea harengus, Clupea pallasii*)
030351	Frozen	Herrings (*Clupea harengus, Clupea pallasii*), sardines (*Sardina pilchardus, Sardinops* spp.), sardinella (*Sardinella* spp.), brisling or sprats (*Sprattus sprattus*), mackerel (*Scomber scombrus, Scomber australasicus, Scomber japonicus*), jack and horse mackerel (*Trachurus* spp.), cobia (*Rachycentron canadum*) and swordfish (*Xiphias gladius*), excluding livers and roes : -- Herrings (*Clupea harengus, Clupea pallasii*)
030486	Fillets and other meat	Frozen fillets of other fish : -- Herrings (*Clupea harengus, Clupea pallasii*)
030542	Dried, salted, smoked	Smoked fish, including fillets, other than edible fish offal : -- Herrings (*Clupea harengus, Clupea pallasii*)
030561	Dried, salted, smoked	Fish, salted but not dried or smoked and fish in brine, other than edible fish offal : -- Herrings (*Clupea harengus, Clupea pallasii*)
160412	Prepared/ preserved	Fish, whole or in pieces, but not minced : -- Herrings
Mackerel		
030244	Fresh/chilled	Herrings (*Clupea harengus, Clupea pallasii*), anchovies (*Engraulis* spp.), sardines (*Sardina pilchardus, Sardinops* spp.), sardinella (*Sardinella* spp.), brisling or sprats (*Sprattus sprattus*), mackerel (*Scomber scombrus, Scomber australasicus, Scomber japonicus*), jack and horse mackerel (*Trachurus* spp.), cobia (*Rachycentron canadum*) and swordfish (*Xiphias gladius*), excluding livers and roes : -- Mackerel (*Scomber scombrus, Scomber australasicus, Scomber japonicus*)
030354	Frozen	Herrings (*Clupea harengus, Clupea pallasii*), sardines (*Sardina pilchardus, Sardinops* spp.), sardinella (*Sardinella* spp.), brisling or sprats (Sprattus sprattus), mackerel (*Scomber scombrus, Scomber australasicus, Scomber japonicus*), jack and horse mackerel (*Trachurus* spp.), cobia (*Rachycentron canadum*) and swordfish (*Xiphias gladius*), excluding livers and roes : -- Mackerel (*Scomber scombrus, Scomber australasicus, Scomber japonicus*)
160415	Prepared/ preserved	Fish, whole or in pieces, but not minced : -- Mackerel

HS2012	Form	Description
Nephrops		
030615	Crustaceans	Frozen : -- Norway lobsters (*Nephrops norvegicus*)
030625	Crustaceans	Not frozen : -- Norway lobsters (*Nephrops norvegicus*)
Saithe		
030253	Fresh/chilled	Fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae, excluding livers and roes : -- Coalfish (*Pollachius virens*)
030365	Frozen	Fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae, excluding livers and roes : -- Coalfish (*Pollachius virens*)
030473	Fillets and other meat	Frozen fillets of fish of the families Bregmacerotidae, Euclichthyidae, Gadidae, Macrouridae, Melanonidae, Merlucciidae, Moridae and Muraenolepididae : -- Coalfish (*Pollachius virens*)
Salmon		
030213	Fresh/chilled	Salmonidae, excluding livers and roes : -- Pacific salmon (*Oncorhynchus nerka, Oncorhynchus gorbuscha, Oncorhynchus keta, Oncorhynchus tschawytscha, Oncorhynchus kisutch, Oncorhynchus masou* and *Oncorhynchus rhodurus*)
030214	Fresh/chilled	Salmonidae, excluding livers and roes : -- Atlantic salmon (*Salmo salar*) and Danube salmon (*Hucho hucho*)
030311	Frozen	Salmonidae, excluding livers and roes : -- Sockeye salmon (red salmon) (*Oncorhynchus nerka*)
030312	Frozen	Salmonidae, excluding livers and roes : -- Other Pacific salmon (*Oncorhynchus gorbuscha, Oncorhynchus keta, Oncorhynchus tschawytscha, Oncorhynchus kisutch, Oncorhynchus masou and Oncorhynchus rhodurus*)
030313	Frozen	Salmonidae, excluding livers and roes : -- Atlantic salmon (*Salmo salar*) and Danube salmon (*Hucho hucho*)
030441	Fillets and other meat	Fresh or chilled fillets of other fish : -- Pacific salmon (*Oncorhynchus nerka, Oncorhynchus gorbuscha, Oncorhynchus keta, Oncorhynchus tschawytscha, Oncorhynchus kisutch, Oncorhynchus masou* and *Oncorhynchus rhodurus*), Atlantic salmon (*Salmo salar*) and Danube salmon (*Hucho hucho*)
030481	Fillets and other meat	Frozen fillets of other fish : -- Pacific salmon (*Oncorhynchus nerka, Oncorhynchus gorbuscha, Oncorhynchus keta, Oncorhynchus tschawytscha, Oncorhynchus kisutch, Oncorhynchus masou* and *Oncorhynchus rhodurus*), Atlantic salmon (*Salmo salar*) and Danube salmon (*Hucho hucho*)
030541	Dried, salted, smoked	Smoked fish, including fillets, other than edible fish offal : -- Pacific salmon (*Oncorhynchus nerka, Oncorhynchus gorbuscha, Oncorhynchus keta, Oncorhynchus tschawytscha, Oncorhynchus kisutch, Oncorhynchus masou* and *Oncorhynchus rhodurus*), Atlantic salmon (*Salmo salar*) and Danube salmon (*Hucho hucho*)
160411	Prepared/preserved	Fish, whole or in pieces, but not minced : -- Salmon
Scallop		
030721	Molluscs	Scallops, including queen scallops, of the genera Pecten, Chlamys or Placopecten : -- Live, fresh or chilled
030729	Molluscs	Scallops, including queen scallops, of the genera Pecten, Chlamys or Placopecten : -- Other
160552	Prepared/ preserved	Molluscs : -- Scallops, including queen scallops

F List of Key Trade Partners by Species

The UK's key trade partners for each species are shown in Table F.1 below. These show the **sum** of trade values over the period 2013–2015 in $000, from the UN Comtrade database. The countries included in the model for each species are shown in **bold**.

Table F.1. Key Trade Partners by Species

Export			Import		
Country	Value ($000)	Share	Country	Value ($000)	Share
Cod					
EU27 Members	123,894.13	91.67%	**Iceland**	408,138.43	26.69%
Nigeria	7,348.05	5.44%	**EU27 Members**	313,325.20	20.49%
China	850.27	0.63%	**China**	310,498.65	20.30%
UAE	785.11	0.58%	**Russian Fed.**	172,846.75	11.30%
Norway	707.66	0.52%	**Norway**	172,833.14	11.30%
Canada	445.04	0.33%	**Faeroe Islands**	114,450.26	7.48%
Australia	315.03	0.23%	Greenland	14,153.20	0.93%
Faeroe Islands	177.97	0.13%	Canada	11,649.91	0.76%
Saudi Arabia	119.19	0.09%	Viet Nam	7,223.93	0.47%
Iceland	118.60	0.09%	Thailand	3,829.89	0.25%
Total	**134,761.03**	**99.71%**		**1,528,949.36**	**99.98%**
World	**135,149.88**	**100.00%**	**World**	**1,529,237.47**	**100.00%**
Countries in model as % of total trade		**97.11%**			**97.57%**
Crab					
EU27 Members	212,425.69	86.11%	**EU27 Members**	32,772.19	35.04%
China	21,675.35	8.79%	**Indonesia**	23,204.73	24.81%
China, Hong Kong SAR	7,078.07	2.87%	**Viet Nam**	17,888.78	19.13%
Viet Nam	1,338.61	0.54%	**Thailand**	9,405.35	10.06%
Norway	1,220.99	0.49%	**China**	2,595.48	2.77%
Other Asia, nes	941.14	0.38%	Norway	2,093.73	2.24%
UAE	427.45	0.17%	Sri Lanka	1,866.08	2.00%
Australia	271.50	0.11%	India	1,807.55	1.93%
New Zealand	265.14	0.11%	Canada	1,089.35	1.16%
Rep. of Korea	247.93	0.10%	USA	413.88	0.44%
Total	**245,891.87**	**99.67%**	**Total**	**93,137.13**	**99.58%**
World	**246,694.46**	**100.00%**	**World**	**93,531.03**	**100.00%**
Countries in model as % of total trade		**97.76%**			**91.81%**
Haddock					
EU27 Members	8,497.10	74.04%	**Iceland**	147,361.76	26.48%
China	819.16	7.14%	**EU27 Members**	120,284.73	21.62%
Canada	607.83	5.30%	**Norway**	110,952.94	19.94%
Norway	352.67	3.07%	**China**	80,065.19	14.39%
USA	331.57	2.89%	**Russian Fed.**	58,307.28	10.48%
UAE	330.17	2.88%	**Faeroe Islands**	35,228.88	6.33%
Iceland	324.24	2.83%	Greenland	2,791.22	0.50%
Singapore	98.73	0.86%	Canada	740.22	0.13%
Australia	82.49	0.72%	Viet Nam	325.04	0.06%
Japan	12.20	0.11%	USA	316.15	0.06%
Total	**11,456.14**	**99.82%**	**Total**	**556,373.41**	**99.98%**
World	**11,477.05**	**100.00%**	**World**	**556,460.22**	**100.00%**
Countries in model as % of total trade		**98.13%**			**99.23%**

Hake					
EU27 Members	58,870.31	99.77%	**South Africa**	20,191.39	45.34%
Saudi Arabia	76.73	0.13%	**USA**	9,121.04	20.48%
UAE	40.30	0.07%	**EU27 Members**	7,756.70	17.42%
Ukraine	18.20	0.03%	**Argentina**	4,228.73	9.49%
Argentina	0.00	0.00%	Namibia	1,074.70	2.41%
Canada	0.00	0.00%	Norway	680.40	1.53%
China	0.00	0.00%	Peru	588.79	1.32%
Ecuador	0.00	0.00%	China	432.13	0.97%
Faeroe Islands	0.00	0.00%	Uruguay	167.98	0.38%
Mauritania	0.00	0.00%	Mauritania	157.71	0.35%
Total	**59,005.55**	**100.00%**	**Total**	**44,399.57**	**99.69%**
World	**59,005.55**	**100.00%**	**World**	**44,536.79**	**100.00%**
Countries in model as % of total trade		**99.77%**			**92.73%**
Herring	(Note: Does not include adjustment for UK landings to foreign ports.)				
EU27 Members	120,619.27	71.02%	**EU27 Members**	63,329.98	86.77%
Nigeria	29,148.95	17.16%	**Norway**	8,258.29	11.31%
China	5,102.67	3.00%	Iceland	722.34	0.99%
Egypt	3,212.84	1.89%	Faeroe Islands	517.64	0.71%
Ghana	2,520.71	1.48%	Canada	102.09	0.14%
USA	2,174.89	1.28%	Myanmar (Burma)	42.00	0.06%
Russian Federation	1,227.33	0.72%	Turkey	6.22	0.01%
Japan	1,002.34	0.59%	India	4.44	0.01%
Nicaragua	695.38	0.41%	Thailand	3.58	0.00%
Cote d'Ivoire	652.91	0.38%	Australia	0.00	0.00%
Total	**166,357.30**	**97.95%**	**Total**	**72,986.57**	**100.00%**
World	**169,831.70**	**100.00%**	**World**	**72,986.57**	**100.00%**
Countries in model as % of total trade		**91.19%**			**98.08%**
Mackerel	(Note: Does not include adjustment for UK landings to foreign ports.)				
EU27 Members	234,483.56	55.72%	**EU27 Members**	187,549.39	90.58%
Nigeria	57,391.40	13.64%	**Norway**	13,200.13	6.38%
Russian Fed.	46,844.74	11.13%	Morocco	3,143.47	1.52%
China	23,345.95	5.55%	Thailand	1,370.56	0.66%
Ukraine	19,433.83	4.62%	China	848.83	0.41%
Norway	12,413.54	2.95%	Iceland	476.31	0.23%
Japan	7,825.23	1.86%	India	190.13	0.09%
Other Asia, nes	3,730.74	0.89%	Ecuador	76.44	0.04%
Australia	3,320.79	0.79%	Greenland	69.33	0.03%
Egypt	2,065.12	0.49%	Viet Nam	47.71	0.02%
Total	**410,854.88**	**97.62%**	**Total**	**206,972.30**	**99.96%**
World	**420,861.14**	**100.00%**	**World**	**207,058.96**	**100.00%**
Countries in model as % of total trade		**93.60%**			**96.95%**
Nephrops					
EU27 Members	432,122.87	92.18%	**EU27 Members**	41,393.70	71.30%
China	15,829.41	3.38%	**China**	11,209.65	19.31%
India	9,489.03	2.02%	**Viet Nam**	3,207.05	5.52%
Rest of World	6,754.32	1.44%	**India**	1,491.84	2.57%
Viet Nam	3,910.45	0.83%	Faeroe Islands	379.44	0.65%
Japan	285.83	0.06%	Iceland	274.26	0.47%
Myanmar (Burma)	181.63	0.04%	Norway	59.41	0.10%
Rep. of Korea	68.96	0.01%	Myanmar (Burma)	41.24	0.07%
Switzerland	44.52	0.01%	China, Hong Kong SAR	0.00	0.00%
Mexico	38.49	0.01%	Japan	0.00	0.00%
Total	**468,725.52**	**99.99%**	**Total**	**58,056.58**	**100.00%**
World	**468,794.88**	**100.00%**	**World**	**58,056.58**	**100.00%**
Countries in model as % of total trade		**95.55%**			**98.70%**

Saithe					
EU27 Members	24,380.45	99.74%	**Iceland**	8,777.34	62.10%
Canada	33.07	0.14%	**EU27 Members**	3,105.37	21.97%
Faeroe Islands	25.93	0.11%	**Norway**	913.07	6.46%
Norway	4.29	0.02%	**Faeroe Islands**	805.66	5.70%
China	0.00	0.00%	**China**	375.04	2.65%
Iceland	0.00	0.00%	Russian Federation	134.55	0.95%
Rest of World	0.00	0.00%	Viet Nam	23.47	0.17%
Russian Federation	0.00	0.00%	Canada	0.00	0.00%
Viet Nam	0.00	0.00%	Rest of World	0.00	0.00%
Total	**24,443.74**	**100.00%**	**Total**	**14,134.50**	**100.00%**
World	**24,443.74**	**100.00%**	**World**	**14,134.50**	**100.00%**
Countries in model as % of total trade		**99.74%**			**98.88%**
Salmon					
EU27 Members	1,161,465	43.22%	**EU27 Members**	824,751	63.06%
USA	962,807	35.83%	Faeroe Islands*	676,709	
China	268,464	9.99%	**USA**	278,381	21.29%
Other Asia, nes	39,502	1.47%	**China**	75,920	5.80%
UAE	35,791	1.33%	**Canada**	61,367	4.69%
Canada	28,874	1.07%	Norway	28,507	2.18%
China, Hong Kong SAR	28,233	1.05%	Chile	23,725	1.81%
Switzerland	26,286	0.98%	Iceland	4,157	0.32%
Viet Nam	23,867	0.89%	Switzerland	3,271	0.25%
Lebanon	20,891	0.78%	Thailand	3,175	0.24%
Total	**2,596,180**	**96.62%**	**Total**	**1,979,964**	
World	**2,687,084**	**100.00%**	**World**	**1,984,565**	
			World (excluding FI)	**1,307,855**	**100.00%**
Countries in model as % of total trade		**92.16%**			**94.84%**
* Faeroe Islands trade with the UK has been removed from the model, as it is almost exclusively shipped into a Scottish port for almost immediate re-export to the EU.					
Scallop					
EU27 Members	448,156.86	99.52%	**USA**	44,053.01	38.32%
Rest of World	445.97	0.10%	**EU27 Members**	40,921.24	35.59%
Norway	404.04	0.09%	**Canada**	13,670.84	11.89%
USA	381.38	0.08%	**Peru**	5,902.61	5.13%
Seychelles	176.61	0.04%	**Argentina**	5,099.89	4.44%
UAE	148.37	0.03%	**Japan**	4,652.57	4.05%
Iceland	126.87	0.03%	Russian Fed.	423.17	0.37%
China, Hong Kong SAR	102.12	0.02%	Norway	234.24	0.20%
Mauritius	84.61	0.02%	India	9.90	0.01%
Switzerland	80.21	0.02%	Aruba	0.00	0.00%
Total	**450,107.03**	**99.95%**	**Total**	**114,967.46**	**100.00%**
World	**450,319.51**	**100.00%**	**World**	**114,967.46**	**100.00%**
Countries in model as % of total trade		**99.52%**			**99.42%**

G Data Sources and Derivation

G.1 Production data

The partial-equilibrium modelling requires data on production of each category modelled. Much of the model preparation needed to address the difficulty of bringing together landings data (by species) with trade data (by commodity code), and estimating production of each species based on both landings and processing (which may use landed and imported material). Due to the global nature of the trade modelling, data were required for all countries and therefore United Nations (UN) Food and Agriculture Organization (FAO) datasets were used.

The approach was as follows, for each country (or country group) in the model:

- Take production of processed fish from the UN FAO commodities and trade database (in tonnes);
- Convert to live weight equivalent using European Market Observatory for Fisheries and Aquaculture Products (EUMOFA) conversion factors for the relevant trade codes;
- Take landings (or aquaculture production) from FAO production database (in tonnes);
- If landings is greater than the live weight equivalent of processed fish, the difference is allocated to the fresh/chilled category, and converted to final weight using EUMOFA conversion factors;
- Average price per tonne of each category is calculated from the UN Comtrade database (using world trade, based on export volumes and values) and applied to the final weight of each category to obtain the value of production; and
- Where production appeared to be less than exports, an adjustment to the data was made. One option would simply be to assume zero domestic consumption of domestic production, but that would appear to be an extreme assumption. Where this situation arose, we used our judgement as to the most appropriate way of adjusting the data to make it internally consistent. In some cases, we applied the average ratio of exports to production from other the countries. In one case for the EU, and in two cases for the Rest of the World (RoW) we made the adjustment on a different basis: for these we have actual data on intra-EU trade, and intra-RoW trade. That trade is part of the domestic consumption of domestic production, and therefore where the problem arose for the EU or the RoW we used the intra-regional trade flows to make the adjustment. For other cases, we estimated domestic consumption based on FAO fish consumption statistics per capita combined with population size, and an estimate of the proportion of fish consumption that might be attributable to that species.

Data on production of processed fish are only available from the FAO commodities database. The latest year available is 2013. We have therefore estimated 2015 production based on a scaling factor using 2013 and 2015 landings data as follows:

- Create scaling factor based on 2015 landings volume / 2013 landings volume;
- Apply scaling factor to 2013 live weight equivalent of production by category;
- Divide by EUMOFA conversion factor to obtain final product volume;
- Apply value per tonne per category (average worldwide export price for each category from UN Comtrade database); and
- Sum value of all categories for each country (group) to obtain total production value.

Where no landings were registered for a country, a scaling factor of 1 was applied (i.e. 2015 production was based on the same volumes as 2013 production). For salmon, the difference between live weight of production of processed fish and aquaculture production or capture landings was attributed to Atlantic or Pacific salmon according to the characteristics of each country's (or group of countries) industries.

The values of production of each species for each country (group) used in the model is shown in Table G.1.

G.1.1 Production under zonal attachment scenarios

Scenarios 1, 2 and 3 assume that UK (and EU) production adjusts based on the zonal attachment (ZA)[28] of the species in UK waters. The new level of production for each species was calculated based on the additional UK landings anticipated from a change of quota distribution to the ZA principle, by stock.

The ZA estimate for each stock was taken from University of Aberdeen & SFF (2017), applied to the 2015 Total Allowable Catch (TAC), and the change in landings was calculated as the difference between the ZA quota compared to quota uptake for 2015. Zonal attachment for Nephrops was estimated based on ICES stock advice for the individual Functional Units (FU) and the proportion of each FU in UK waters. Where quota uptake was below 90% (Nephrops in North Sea and West of Scotland), it was assumed that there was no increase in landings despite a potential increase in quota under ZA. In most cases, a change in quota for the UK was assumed to result in the inverse change to the EU quota, with the exception of haddock in the North Sea, where the change in EU quota was limited to the absolute level of increase in UK quota.

The change in the value of production was calculated based on the change in landings and the average value of production per tonne of live weight landings, for each country. The average value of production takes into account the split between fresh and processed categories and the different values per tonne of those categories.

The assumed changes to production values as a result of ZA distribution of quotas are shown in Table G.2. Further details of the calculations are provided in Appendix H.

[28] Where the sharing of TACs or quotas for shared stocks is done according to an agreed percentage, based on the spatial distribution of the stock over time and over its various life stages (zonal attachment).

Table G.1. Value of production in 2015 for each country (group) for each species (group) to be modelled ($000)

Cod		Crab		Haddock		Hake		Herring	
Country	Production	Country	Production	Country	Production	Country	Production	Country	Production
China	1,152,845	China	8,289,815	Canada	36,892	Argentina	400,099	China	82,067
EU27	548,165	EU27	216,854	China	213,780	EU27	339,042	EU27	794,838
Faroe Islands	100,244	Indonesia	428,351	EU27	71,453	RoW	590,994	Nigeria	10
Iceland	588,636	RoW	944,184	Faroe Islands	17,843	South Africa	209,780	Norway	238,653
Norway	1,056,351	UK	205,936	Iceland	85,715	USA	374,014	RoW	476,774
RoW	754,980	Viet Nam	457,671	Norway	190,828	UK	33,206	UK	77,156
Russia	964,062	Thailand	223,333	RoW	2,755				
UK	79,871	China, Hong Kong SAR	6,707	Russia	192,761				
				UAE	12,692				
				UK	69,336				
				USA	17,601				
Mackerel		**Nephrops**		**Saithe**		**Salmon**		**Scallop**	
Country	Production	Country	Production	Country	Production	Country	Production	Country	Production
China	536,421	China	8,064	China	43,241	Canada	713,659	Argentina	373,116
EU27	543,825	EU27	198,821	EU27	57,678	China	534,787	Canada	482,125
Nigeria	10	India	905	Faroe Islands	52,191	EU27	2,364,840	EU27	288,714
Norway	500,987	RoW	28,351	Iceland	88,745	RoW	8,029,374	Japan	3,283,815
RoW	942,054	UK	204,683	Norway	258,432	UK	926,927	Peru	154,686
Russia	147,576	Vietnam	1,156	RoW	765,006	USA	1,948,464	RoW	19,639,925
Ukraine	665			UK	23,202			UK	189,558
UK	301,665							USA	888,155

N.B. These figures include the adjustments for situations where production appears to be less than exports.

Table G.2. Assumptions of changes to production values as a result of UK–EU quota allocation based on zonal attachment

Species	Current UK Landings (t)	Current UK Production ($000)	Change to UK Landings (t)	Change to EU Landings (t)	Price UK ($/t)	Price EU ($/t)	Change to UK Production ($000)	Change to EU Production ($000)
Cod	15,638	78,599	2,538	-2,538	2,731	2,057	6,929	-5,219
Crab		205,936	-	-			0	0
Haddock	32,321	69,315	7,039	-3,598	2,084	2,066	14,667	-7,432
Hake	10,875	33,175	21,699	-21,699	2,552	1,879	55,365	-40,769
Herring	93,595	68,075	205,634	-205,634	726	1,130	149,327	-232,320
Mackerel	247,979	273,409	132,335	-132,335	1,103	1,287	145,901	-170,348
Nephrops	25,874	204,683	1,244	- 1,244	7,899	9,337	9,831	-11,620
Saithe	12,312	23,202	24,237	-24,237	1,781	1,806	43,178	-43,776
Salmon		926,927	-	-			0	0

G.2 Trade data

The data on trade in the model are derived from the UN Comtrade database. In order to ensure compatibility with the latest available production data, the data for 2015 are used. For each species the bilateral trade flow is required, for example the level of UK imports from the EU, and exports to the EU. These bilateral flows are needed for every pair of countries that are included for any given species. Note that in the trade data there is information which is reported by the UK, as to the level of imports from the EU; and there is also information which is reported by the EU, as to the level of exports to the UK. These are the mirror flows. In principle the mirror flows should be the same, in practice this is never the case. Partly this is because the flows are reported on a different basis – this is the difference between cost, insurance and freight (c.i.f.) and free on board (f.o.b.) reporting requirements. However, in part this is also simply because of differences in the way data is collected and reported by different countries (in particular where there may be re-exports or re-imports), and differences may arise because of errors made in collecting the data. Given these inherent difficulties in the data for each bilateral flow the average of the two mirror flows was used. For the trade of the EU in each case the external trade of the EU minus the UK was used, hence excluding intra-EU trade flows, as this forms part of the EU-minus-UK domestic production. With fish there is the added complication that landings made e.g. by UK-flagged vessels into a foreign port should be treated as UK exports, but there is evidence to suggest that such landings are not always well documented. Landings of herring and mackerel to non-UK ports which are not recorded in the export data have been adjusted for.

G.3 Tariffs

The data on tariffs derives from the UN TRAINS database, which provides information on the 6-digit tariffs levied by each country on each importer. In the absence of a free trade agreement between countries the tariffs will be the MFN applied tariffs; where there is a free trade agreement then the tariffs will be the preferential tariffs. Where the data was available the tariff data is based on the 2015 tariffs. These tariffs were not always available, as countries do not always report their tariffs every year, especially where there have been no changes from the preceding year(s). Where the data for 2015 was missing data from an earlier year was therefore used.

Figure G.1 below gives the average EU MFN tariff for each species. This is an average across the underlying 6-digit HS codes which make up each of the species. In constructing such averages the user needs to decide whether to use simple average tariffs, or weighted average tariffs, where the weights are given by the share of imports of each of the relevant tariff lines. The difficulty in using weighted average tariffs is that the level of the import flow is endogenous to the level of the tariff. Suppose there were a very high tariff which drove imports to zero; that tariff would receive a zero weight (because imports are zero), although clearly the tariff is highly restrictive. For this reason we have used simple average tariffs.

Figure G.1 shows that EU MFN average tariffs on the fish species are in most cases quite high, except for salmon where it is just under 5%. For fresh/chilled, frozen and fillets of salmon, the MFN tariff is only 2%, to facilitate supply for the EU processing industry, but this rises to 13% for smoked salmon.

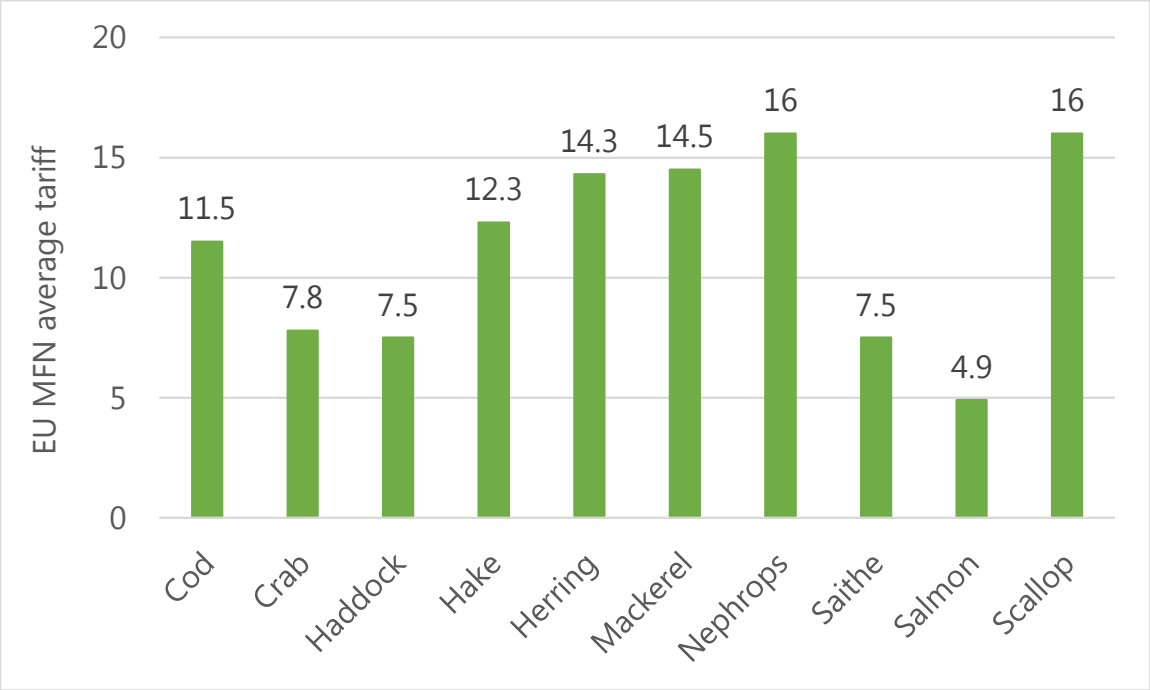

Figure G.1. EU MFN average tariffs by species

G.4 Non-tariff measures

On leaving the EU the UK faces a broad range of possible trade relationships with the EU27. As far as NTM are considered:

- In scenarios where the UK leaves the single market and does not agree mutual recognition of standards and testing and certification, traders will face SPS and TBT rules and be required to show that shipments meet EU standards. Estimates of *ad valorem* equivalents (AVE) are difficult to estimate (Fugazza, 2013) nor are product-level AVEs easy to find at the 6-digit product and country level. A recent United Nations Commission on Trade and Development (UNCTAD) paper on Fish NTMs restricted itself to coverage ratios and similar qualitative measures (Fugazza, 2017). Ghodsi *et al.* (2016) is an exception and has estimated simple average AVE for a group of 40 importers by main measures (notably SPS, TBT and Contingent Protection) for total trade). EU members are shown separately rather than as an average. The country range of AVE for SPS is –2.9% to 14.7% (a negative meaning that complying with the SPS standard leads to an increase in trade not a reduction), although this is not specific to fish. Estimates specific to fish, for all countries worldwide, are –3.7% to –1.3%. For TBT the equivalent range is 0.6% to 16% for EU countries (all trade), and 0.7% to 2.1% for fish trade worldwide. The differences across Member States likely arises from trade composition differences and perhaps from different customs procedures across the Member States.
- In scenarios where the UK agrees a Free Trade Agreement with the EU27 (e.g. Scenario 2), UK traders will be required to produce Certificates of Origin (CoO) crossing into EU territory. As the Marine Scotland (2017) study shows the cost of certificates *per se* is low[29] but for processed products there may be costs in tracing origin of purchased inputs and possible costs of delay in crossing borders as customs check origin. The stylised fact on the tariff equivalent costs of Rules of Origin are in the range of 4–8% (Cadot & Gourdon, 2015).

[29] £30 to £60 per shipment.

- If the UK leaves the single market and/or the Common Commercial Policy it will face the full rigours of EU Contingent Protection (anti-dumping measures). Turning to Ghodsi *et al.* (2016) once more, their simple average AVE for contingent protection varies across EU Member States from 5.4% to 65.7%.
- When the UK leaves the EU, catch certificates will be required for fish exports to the EU. UK catch certificates are currently required for UK catches that are exported to third countries for processing and subsequently re-exported back to the EU. Catch certificates are also required for exports to some other countries (including Iceland, Norway, Thailand and Ukraine)[30]. There is currently no charge for issuing a UK catch certificate, with the costs to the exporter being only the administrative time in obtaining the documentation. For importers, there are charges for checking the validity of catch certificates from third countries[31], which range from £21–45 per country (with mixed consignments potentially requiring catch certificates from multiple countries).

Table G.3. Estimates of NTM in fisheries

NTM Type	Tariff Equivalent Estimate	Source
SPS, health/ hygiene certification	General trade (EU countries): -2.9% to 14.7% Fish (worldwide): –3.7% to –1.3% £5–30/tonne, depending on shipment size (tariff equivalent will depend on shipment size and value per tonne).	Ghodsi *et al.* (2016) Marine Scotland (2017)
Other TBT	General trade (EU countries): 0.6% to 16% Fish (worldwide): 0.7% to 2.1%	Ghodsi *et al.* (2016)
Rules of Origin	4 to 8%	Cadot & Gourdon (2017)
Anti-dumping measures (trade defence)	General trade (EU countries): 5% to 65% Fish (worldwide): 1.7% to 1.9%	Ghodsi *et al.* (2016)
Catch certificates	Currently no charge for issue Check of validity for importers: £21–45 per country	See footnotes
Freshness /border delays	2 nights delay = 5% price reduction 3 nights delay = 10% price reduction 4 nights delay = 20% price reduction	Marine Scotland (2017)

The wide range of these estimated AVEs, taken together with the lack of fish-specific estimates for the EU, suggests caution in modelling changes in NTMs and in interpretation of the results. The modelling therefore uses estimates based on these AVEs to explore possible impact of different levels of NTMs. A common level of NTMs in the base equilibrium is assumed across all species, equivalent to a 15% *ad valorem* tariff equivalent (AVE) for non-EU countries. This AVE is applied for all species across all bilateral trade flows for trade with non-EU countries. The exception to this is that in order to capture the EU's Single Market we assume that the NTMs within the EU are equal to a 5% AVE equivalent. While the Single Market has achieved a very substantial amount of non-tariff measure reductions, nevertheless these have not been reduced to zero.

In modelling the scenarios, the AVE is assumed to be 10% for scenarios with a moderate level of NTMs (non-EU countries in Scenario 1, the EU in Scenario 2), and 15% for scenarios with a higher level of NTMs (non-EU countries in Scenario 2, EU and non-EU countries in Scenarios 3 and 4).

30 https://www.gov.uk/guidance/catch-certificates-for-non-eu-imports-and-exports-of-fish

31 E.g. https://www.cityoflondon.gov.uk/services/port-health/Pages/charges.aspx and http://www.porthealth.eu/fees.htm

G.5 References

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H Zonal Attachment Calculations

Changes to production in the scenarios were based on a redistribution of quotas between the EU and the UK, moving from quota allocation based on Relative Stability and to one based on the zonal attachment (ZA) principle.

Zonal attachment estimates for individual species, from the University of Aberdeen & SFF (2017) report, were used to calculate the potential additional catch for UK vessels, above their current (baseline) level of reported landings. The availability of zonal attachment information for the ten species is shown in Table H.1.

For each species (comprising several stocks), the new landings level (N), was calculated as:

$N = L + M$

Where:

L	=	current level of landings for a species (2011-2015 annual average, tonnes, from FAO production database)
M	=	extra landings as a result of zonal attachment redistribution of quotas for the species

M was calculated as:

$$M = \sum_{k=1}^{n} Z_{UK} - Y_{UK}$$

Where:

k	=	stock
ZUK	=	UK quota allocation based on zonal attachment
YUK	=	(current) UK landings

And Z_{UK} was calculated as:

$$Z_{UK} = A * Q_{EU28}$$

Where:

A	=	zonal attachment percentage for UK waters
QEU28	=	Quota for EU-28 (i.e. UK quota + rest of EU quota)

So, the full equation would be:

$$N = L + \sum_{k=1}^{n}((A * Q_{EU28}) - Y_{UK})$$

Table H.1. Availability of zonal attachment information for key species

Species	Zonal Attachment Information Available?	
Cod	✓	
Crab	N/a	(non-quota species)
Haddock	✓	
Hake	✓	
Herring	✓	
Mackerel	✓	
Nephrops	No	Zonal attachment was calculated based on the stock advice for each Functional Unit, together with an estimate of the proportion of the Functional Unit within UK waters
Saithe	✓	
Salmon	N/a	(aquaculture production)
Scallops	N/a	(non-quota species)

The change in production value as a result of the distribution of quotas according to the zonal attachment principle was calculated as follows:

- UK landings under ZA were calculated by applying the ZA average percentage from University of Aberdeen & SFF (2017) for North Sea and West of Scotland stocks to the TAC for each stock (taken from the TACs and Quotas Regulation) for 2015. Exceptions to this were:
  - For mackerel, the ZA percentage was applied to the overall TAC from the management plan agreed by the EU, Norway and the Faroes (1,054,000 t).
  - For herring in the North Sea, ZA percentages were provided separately for the adult and juvenile portions of the stock. Based on herring reaching maturity at age 3, and most herring in the North Sea being under 7 years old, the adult ZA percentage was pro-rated 4/7 (reach maturity @ age 3, most under 7 yr old); and the juvenile ZA pro-rated 3/7 (year classes 0, 1, 2).
  - For hake, the lower 95% quantile estimate was used instead of the average, because the Aberdeen University & SFF (2017) study probably overestimates the zonal attachment of this species because it is based on survey data from Area VI (which predominantly lies in UK waters) but the stock distribution covers a much wider area.
  - For Nephrops, ZA was based on the ICES stock advice for each Functional Unit (FU), together with an estimate of the proportion of each FU in UK waters.
- Distribution of quota from Area VII was assumed not to change, as no ZA estimates were available for Area VII stocks (i.e. cod, haddock, saithe, herring), with the following exceptions:
  - Hake, for which the stock management unit incorporates Areas VI, VII, Union and international waters of Vb, international waters of XII and XIV[32], and the ZA percentage was applied to the whole stock management area;
  - Nephrops, for which the calculation was based on Functional Units (see above).
- The potential additional landings for the UK under ZA were calculated from the ZA estimate compared to the actual level of 2015 UK landings (taken from quota uptake spreadsheets from Marine Scotland/MMO).
- It was assumed that there was no change in landings of Nephrops from North Sea and West of Scotland, because uptake of quota in these areas in 2015 was low (45% and 85% of initial quota allocation, respectively). The increase in Nephrops landings modelled was based on an increase in quota for Area VII grounds (an additional 1,244 tonnes). This is comparable with

[32] Note that the Zonal Attachment estimate was based on survey data from Area VIa to 300 m depth only. It may therefore under- or overestimate the Zonal Attachment across the whole stock area.

the potential increase in UK quota from the Zonal Attachment principle, compared to the UK's initial quota allocation (an additional 1,471 tonnes).[33]

- The change in UK landings was assumed to result in an inverse change in EU landings, except for haddock, where the decrease in EU landings was limited to the absolute level of increase of UK quota.
- The change in the value of production was calculated based on the change in landings and the average value of production per tonne of live weight landings. Average value of production per tonne of live weight landings was calculated for the UK and EU, and applied to the change in landings expected from ZA. Using these average values of production incorporates the existing pattern of processing of each species in each country (group).

Detail of the change in landings as a result of using zonal attachment to determine the distribution of quotas is provided in Table H.2.

[33] In contrast, if the UK's landings were assumed to increase from current (2015) levels to the full quota allocation under the Zonal Attachment principle (as for the other species), this would have resulted in an increase of 12,052 tonnes. However, landings of this level would have been possible in 2015 under the existing quota allocations, therefore applying this level of production to the scenarios would have over-represented the potential contribution of quota allocation under the Zonal Attachment principle.

Table H.2. Calculations for change in landings based on zonal attachment distribution of quotas

Stock	EU28 TAC/ Quota (t) (2015)	Overall TAC (t) (2015)	UK Uptake*	UK ZA%**	ZA Allocation (UK) (t)	UK Landings (t) (2015)	Change to UK Landings (t)	Change to EU Landings (t)	Comments
NS Cod	24,227	29,189	130%	0.60	17,513	14,818	2,696	-2,696	Spare catching capacity in demersal sector - UK likely to be able to catch extra quota
WS Cod	74	74	416%	0.93	69	187	- 118	118	
Other Cod stocks	6,955	6,955	107%	0.09	593	633	- 40	40	No ZA estimate - based on current allocations
Cod total					***18,175***	***15,638***	***2,538***	***- 2,538***	
NS Haddock	34,197	40,711	90%	0.80	32,569	25,824	6,745	-3,784	Quota uptake was low in 2015 due to mismatch between the science and what is actually happening on the grounds - increasing quota but low availability of haddock on fishing grounds. Assumed UK catches increase to ZA allocation; EU reduction in landings limited to absolute increase in UK quota.
WS Haddock	4,536	4,536	86%	0.87	3,946	3,052	895	- 414	
Rockall Haddock	2,580	2,580	99%	0.56	1,445	2,052	- 607	607	
Other Haddock stocks	9,523	9,523	99%	0.15	1,400	1,393	7	-7	No ZA estimate - based on current allocations
Haddock total					***39,360***	***32,321***	***7,039***	***- 3,598***	
NS Hake	3,190	3,190	519%	0.31	989	2,978	- 1,989	1,989	Lower 95% quantile used for ZA percentage (ZA estimate based on survey from VIa to 300 m depth, but stock area covers VI, VII, Vb, XII, XIV), although this may still overestimate UK allocation.
WS Hake	50,944	50,944	84%	0.62	31,585	7,723	23,862	- 23,862	
Other Hake stocks	47,803	47,803		0.00	-	174	- 174	174	
Hake total					***32,574***	***10,875***	***21,699***	***- 21,699***	
NS Herring	369,115	504,677	109%	0.55	275,409	73,087	202,323	- 202,323	ZA estimate based on adult ZA pro-rated 4/7 (ages 3-6), and juvenile ZA pro-rated 3/7 (ages 0-2)
WS Herring	22,690	22,690	111%	0.87	19,740	15,260	4,481	-4,481	
Other Herring stocks	24,982	24,982	129%	0.16	4,079	5,249	- 1,170	1,170	No ZA estimate - based on current allocations
Herring total					***299,229***	***93,595***	***205,634***	***-205,634***	
Mackerel	521,689	1,056,427	0%	0.36	***380,314***	***247,979***	***132,335***	***-132,335***	ZA percentage applied to management plan TAC
NS Nephrops	18,843	18,843	45%	0.81	15,321	6,959	-	-	Assume no increase in landings from ZA, as uptake is only 45% currently. ZA would potentially reduce UK quota by 188 t (1%).
WS Nephrops	14,190	14,190	85%	1.00	14,190	11,744	-	-	Assume no increase in landings from ZA, as uptake is only 85% currently. ZA would potentially increase quota by 336 t (2.4%), but current landings are >2000 t below UK quota allocation.
Nephrops VII	21,619	21,619	101%	0.39	8,415	7,171	1,244	-1,244	ZA based on ICES advice for landings for Functional Units

Stock	EU28 TAC/ Quota (t) (2015)	Overall TAC (t) (2015)	UK Uptake*	UK ZA%**	ZA Allocation (UK) (t)	UK Landings (t) (2015)	Change to UK Landings (t)	Change to EU Landings (t)	Comments
Nephrops total					***37,926***	***25,874***	***1,244***	***- 1,244***	
NS Saithe	31,383	66,006	170%	0.46	30,363	8,923	21,439	- 21,439	
WS Saithe	6,348	6,848	109%	0.84	5,752	3,286	2,466	-2,466	
Other Saithe stocks	3,176	3,176	24%	0.14	434	103	331	- 331	No ZA estimate - based on current allocations
Saithe total					***36,549***	***12,312***	***24,237***	***- 24,237***	

I Wider Economic Impacts Method

I.1 Applying the model outputs to the primary and processing sectors

The trade model combines production of unprocessed and minimally processed fresh/chilled product, as well as processed products such as fillets, smoked, canned and prepared/preserved products. The input-output (IO) tables include sectors that relate to the two primary industries of fishing and aquaculture production, as well as the secondary industry of fish processing. The outputs of the model were therefore disaggregated, or apportioned, between the relevant primary industry and the processing industry, to be run through the IO tables.

The apportionment of output was based on the output of the fishing sector (value of landings by UK vessels to UK and non-UK ports), the output of the aquaculture sector (value of production), and a calculation of the output of the processing sector for each species. The latter is based on the turnover of the fish processing industry (from Seafish data), apportioned based on the processing output attributed to each species. This in turn was calculated from the FTEs in processing demersal, pelagic and shellfish species (from Seafish data), apportioned by the volume of landings to the UK (by UK and non-UK vessels) of the species as a percentage of landings of the species group. The employment per species, as a percentage of processing sector employment, was then applied to the turnover of the processing sector to derive the output of the processing sector for each species. For example, the value of landings of cod to the UK as a percentage of the value of demersal landings to the UK was applied to the FTEs in the demersal processing sector. This figure, as a percentage of processing sector employment, was applied to the processing sector output.

For salmon, the turnover of the aquaculture production industry was based on the value of salmon production. The turnover of the salmon processing industry was based on the value of output of the salmon and sea trout processing industry (derived from Seafish data on the overall value of the fish processing sector, less the value of the sea fish processing sector), with 98% attributed to salmon and 2% to sea trout, based on the volume and value of aquaculture production of these two species.

The apportionment percentages for output are provided in Table I.1.

Table I.1. Apportionment of output to primary and processing industries

Species	Fishing	Aquaculture	Processing
Cod	37%	0%	63%
Crab	16%	0%	84%
Haddock	22%	0%	78%
Hake	27%	0%	73%
Herring	18%	0%	82%
Mackerel	31%	0%	69%
Nephrops	29%	0%	71%
Saithe	11%	0%	89%
Salmon	0%	34%	66%
Scallop	17%	0%	83%

These apportionment percentages were applied to the model results for 'change in output'. More detail of the calculations is provided in Table I.5. The percentage change in output for each species from the trade modelling was applied to the calculated value of output from fishing, aquaculture and processing sectors for each species at the UK level. This assumes that the percentage changes from the trade modelling (which captures a proportion of output of each species) will apply to the rest of the sector.

I.2 Identifying impacts on the Scottish economy

The outputs of the trade modelling are for the UK as a whole. In order to determine the proportion of these impacts that might occur in Scotland, the UK-level impacts were apportioned to Scotland for each species, based on the importance of the production (catching or aquaculture) sector and of the processing sector in each case.

The fishing sector impacts were apportioned based on the value of landings by Scottish vessels as a proportion of the total value of landings by UK vessels (to the UK and overseas); the aquaculture sector impacts were apportioned 99% to Scotland, to take account for the small amount of salmon aquaculture that takes place in Northern Ireland (actual volumes and values are not published for confidentiality reasons). Seafish provided data on the output, GVA and employment of the processing industry in Scotland and for the UK as a whole, broken down by demersal, pelagic, shellfish and salmon. The percentages for apportionment of output between Scotland and UK are shown in Table I.2. Further details of the calculations are provided in Table I.6.

Table I.2. Apportionment percentages for output of fishing, aquaculture and processing industries between Scotland and Rest of UK

Species	Fishing		Aquaculture		Processing	
	Scotland	Rest of UK	Scotland	Rest of UK	Scotland	Rest of UK
Cod	46%	54%	-	Cod	47%	53%
Crab	37%	63%	-	Crab	29%	71%
Haddock	83%	17%	-	Haddock	47%	53%
Hake	54%	46%	-	Hake	47%	53%
Herring	65%	35%	-	Herring	59%	41%
Mackerel	82%	18%	-	Mackerel	59%	41%
Nephrops	74%	26%	-	Nephrops	29%	71%
Saithe	62%	38%	-	Saithe	47%	53%
Salmon	100%	0%	99%	Salmon	77%	23%
Scallop	59%	41%	-	Scallop	29%	71%

I.3 Determining direct, indirect and induced output, GVA and employment impacts

The outputs of the trade modelling are provided for each of ten (shell)fish species as percentage change from the baseline in terms of:

- Prices
- Output
- Imports
- Exports

Based on the apportionment calculations outlined above, the direct impacts on output were determined for fishing, aquaculture and processing in Scotland. The relevant multipliers (Type I and Type II, for fishing, aquaculture and processing) from the IO tables were applied to the change in output (split between the fishing or aquaculture primary industries, and the secondary processing industry and apportioned to Scotland) to give, for Scotland:

- Direct impact
- Indirect impact
- Induced impact

The change in output (quantity) and change in price from the model outputs were combined to give the percentage change in GVA. GVA will change pro rata with quantity. It will also change linearly (but more than pro rata) with price, the ratio being (1 / GVA share of value of output). The indirect and induced GVA impacts were calculated using the relevant multipliers from the IO tables.

Because the change in GVA was calculated from the model results (rather than being based on the change in output and a GVA percentage), the change in GVA was apportioned across fishing, aquaculture and processing sectors, and between the UK and Scotland according to percentages that were calculated specifically for GVA (Table I.3).

Table I.3. Apportionment percentages for GVA

Species	Change in GVA by Sector			Processing GVA Apportioned to Scotland*
	Fishing	Aquaculture	Processing	
Cod	52%	0%	48%	46%
Crab	26%	0%	74%	28%
Haddock	34%	0%	66%	46%
Hake	41%	0%	59%	46%
Herring	29%	0%	71%	37%
Mackerel	45%	0%	55%	37%
Nephrops	43%	0%	57%	28%
Saithe	19%	0%	81%	46%
Salmon	0%	47%	53%	69%
Scallop	27%	0%	73%	28%

* Fishing and aquaculture GVAs are apportioned to Scotland using the percentages in Table I.2. Further detail on the processing GVA apportionment calculation is provided in Table I.7.

In relation to employment, employment is assumed to change linearly with volume of output. Change in volume of output specific to Scotland is derived by weighting UK changes by the percentage landings attributed to Scotland relative to total UK landings. MMO employment figures on part- and full-time equivalents (FTEs) by administration port were used, assuming that part-time is 0.5 FTE. The Seafish Processing Industry Report (Seafish, 2016) includes FTEs for the fish processing industry. The employment impacts were calculated for Scotland based on employment in fishing, aquaculture and processing sectors in Scotland, and then apportioned between the sectors, according to percentages that were calculated specifically for employment (Table I.4). Based on this, the indirect and induced employment impacts were calculated, using the multipliers from the IO tables.

Table I.4 Apportionment percentages for employment impacts in Scotland

Species	Change in Employment by Sector		
	Fishing	Aquaculture	Processing
Cod	75%	0	25%
Crab	37%	0	63%
Haddock	58%	0	42%
Hake	65%	0	35%
Herring	25%	0	75%
Mackerel	40%	0	60%
Nephrops	55%	0	45%
Saithe	39%	0	61%
Salmon	0%	37%	63%
Scallop	37%	0	63%

I.3.1 Identifying the main sectors affected

The changes in output and GVA (apportioned between the fishing, aquaculture and processing sectors, and apportioned to the Scottish economy), were run through the IO tables as a 'shock' to identify the impacts on other upstream and downstream sectors of the economy. This was used to identify those other sectors that are likely to be subject to the greatest impacts.

I.4 Reference

Seafish (2016) Seafood Processing Industry Report. Prepared by Struan Noble, Marta Moran Quintana and Hazel Curtis. Seafish Report No SR700. Edinburgh: Seafish Economics.

Table I.5. Detail of calculations of fishing/aquaculture and processing output apportionment percentages

Species	Quantity Landed to UK (tonnes) (from UK and Non-UK Vessels)	Percentage of Total Quantity of Landings	Value of Landing of UK Vessels, to UK and Overseas (£1,000)	Percentage of Species Group Total	Percentage of Set Total Landings Value	Estimate of FTE Processing Jobs by Species (UK Total)	Percentage of Total Processing Employment	Estimate output of Processing Per Species Through Share of Employment	Total Output Per Species (£1,000)	Percentage of Species Output in Processing	Percentage of Species Output in Fishing/ Aquaculture
Cod	16,737	11%	48,881	36%	8%	355	3%	81,869	130,750	63%	37%
Haddock	33,487	22%	45,119	33%	7%	711	5%	163,801	208,920	78%	22%
Hake	15,892	11%	29,335	22%	5%	337	2%	77,735	107,070	73%	27%
Saithe	18,846	13%	11,737	9%	2%	400	3%	92,186	103,923	89%	11%
Total Demersal	*150,008*	-	*135,073*	-	*22%*	*1,804*	*0.13*	*415,590,299*	-	-	-
Herring	42,043	25%	32,948	17%	5%	633	5%	145,731	178,679	82%	18%
Mackerel	103,935	61%	159,804	83%	26%	1,564	12%	360,267	520,071	69%	31%
Total Pelagic	*169,332*	-	*192,753*	-	*31%*	*2,196*	*0.16*	*505,998,038*	-	-	-
Crabs	29,317	21%	43,993	23%	7%	991	7%	228,220	272,213	84%	16%
Nephrops	25,860	18%	82,680	43%	13%	874	6%	201,308	283,988	71%	29%
Scallops	41,424	29%	64,335	34%	10%	1,400	10%	322,465	386,800	83%	17%
Total Shellfish	*142,421*	-	*191,008*	-	*31%*	*3,264*	*0.24*	*751,992,385*	-	-	-
Total seafish	**461,761**		**617,577**			**13,554**					
Salmon	171,722	100%	637,089			1,273	98%	1,247,175	1,884,264	66%	34%

NB. For salmon, the figure in 'Estimate of FTE processing jobs by species' is the salmon and sea trout processing sector turnover (£million). The 98% is salmon aquaculture production as a proportion of salmon and sea trout production. These figures are used to estimate the output of processing for salmon.

Table I.6. Detail of calculations of Scotland/UK apportionment percentages for output of fishing and aquaculture sectors

Species	Fishing			Aquaculture		
	Value of Landings of Scottish Vessels (£000) 2015	Value of Landings of UK Vessels (£000) 2015	Scotland as % of UK	Value of Scottish Aquaculture Production (£000) 2015	Value of UK Aquaculture Production (£000) 2015	Scotland as % of UK
Cod	22,664	48,881	46%	-	-	-
Crab	16,225	43,993	37%	-	-	-
Haddock	37,375	45,119	83%	-	-	-
Hake	15,894	29,335	54%	-	-	-
Herring	21,307	32,948	65%	-	-	-
Mackerel	130,512	159,804	82%	-	-	-
Nephrops	60,924	82,680	74%	-	-	-
Saithe	7,220	11,737	62%	-	-	-
Salmon*	-	2	0%	637,089	N/A	99%
Scallop	37,930	64,335	59%	-	-	-
Data sources	MMO			Scottish Government		

* N/A. Value not disclosed due to confidentiality. Assumed 1%.

Table I.7. Detail of calculations of apportionment percentages for processing sector

Species Category	Turnover (£000)		Turnover with Mixed Category Reallocated (£000)			GVA (£000)		GVA with Mixed Category Reallocated (£000)		
	Scotland	UK	Scotland	UK	Scotland %	Scotland	UK	Scotland	UK	Scotland %
Demersal	76,783	156,933	188,233	400,886	47%	15,981	31,960	33,530	73,268	46%
Pelagic	177,798	288,473	435,871	736,904	59%	25,463	62,460	53,423	143,190	37%
Shellfish	240,196	790,292	588,839	2,018,800	29%	43,009	138,116	90,236	316,635	28%
Salmon and other freshwater	312,018	441,695	764,911	1,128,310	68%	75,438	100,293	158,273	229,925	69%
Mixed	1,171,059	2,607,507	-	-		175,572	430,190	-	-	
Total	**1,977,855**	**4,284,900**	**1,977,855**	**4,284,900**		**335,463**	**763,019**	**335,463**	**763,019**	

J Sensitivity Analysis

Sensitivity analysis has been carried out for Scenarios 1 and 4 by changing the degree to which species from different sources are substitutable, and the degree to which supply can expand to meet increased demand. In the model simulations the elasticity of substitution was assumed to be 5 for fish species and 2.5 for shellfish species.

The results for the original model simulations are replicated in Table J.1 and Table J.5, respectively. These include tariff and NTM changes and, for Scenario 1, quota allocation changes.

The model simulations are replicated with the supply elasticity increased from 1 to 3 (Table J.2 and Table J.6), and decreased to 0.5 (Table J.3 and Table J.7). They are also replicated with the substitution elasticity halved to 2.5 or 1.25 (Table J.4 and Table J.8). The reduction in the substitution elasticity means that imports from different sources are less substitutable, hence as EU tariffs rise on UK exports, consumers are less able to switch to other suppliers, and so we see a smaller impact on all the quantities.

Table J.1. Scenario 1: Original model outputs (supply elasticity 1, substitution elasticity 5 or 2.5)

Species	Price index	Output (Q)	Output (V)	Exports	Imports
Cod	-1.12	8.78	6.99	7.37	5.09
Crab	-0.23	0.45	0.36	0.60	3.18
Haddock	-4.50	21.17	12.38	26.80	-7.59
Hake	-6.60	65.94	61.31	62.59	-5.25
Herring	8.31	118.97	88.92	88.96	-18.10
Mackerel	5.41	53.39	37.68	37.43	-20.84
Nephrops	-1.48	4.80	2.99	3.53	-2.53
Saithe	-47.21	85.91	37.70	108.64	-67.90
Salmon	-0.63	2.03	1.53	3.58	0.60
Scallop	-2.43	-0.30	-0.64	0.03	1.49

Table J.2. Scenario 1 sensitivity – supply elasticity =3

Species	Price index	Output (Q)	Output (V)	Exports	Imports
Cod	-2.51	8.78	6.99	7.66	12.29
Crab	-0.50	1.03	0.81	1.15	6.30
Haddock	-5.08	21.20	11.71	32.72	-7.63
Hake	-7.55	65.94	60.73	63.11	-2.53
Herring	7.66	118.98	88.82	88.91	-16.94
Mackerel	4.74	53.40	38.09	37.90	-19.78
Nephrops	-1.47	4.80	2.86	3.53	-1.31
Saithe	-27.93	86.04	50.16	118.13	-56.75
Salmon	-0.91	5.44	4.50	10.17	1.90
Scallop	-3.38	-0.81	-1.12	0.06	3.17

Table J.3. Scenario 1 sensitivity – supply elasticity = 0.5

Species	Price index	Output (Q)	Output (V)	Exports	Imports
Cod	-0.63	8.77	6.98	7.24	2.65
Crab	-0.13	0.24	0.20	0.35	1.83
Haddock	-4.06	21.17	12.91	25.32	-7.50
Hake	-6.09	65.94	61.65	62.60	-6.11
Herring	8.45	118.97	88.96	88.97	-18.41
Mackerel	5.41	53.39	37.50	37.23	-20.87
Nephrops	-1.56	4.80	3.07	3.55	-3.12
Saithe					
Salmon	-0.44	1.08	0.76	1.81	0.27
Scallop	-1.72	-0.12	-0.40	0.02	0.79
N.B. Model does not solve for saithe.					

Table J.4. Scenario 1 sensitivity – substitution elasticity halved (2.5 and 1.25)

Species	Price index	Output (Q)	Output (V)	Exports	Imports
Cod	-1.12	8.78	5.66	5.32	5.05
Crab	-0.23	0.48	0.42	0.15	1.34
Haddock	-4.36	21.20	8.70	20.12	-6.23
Hake	-6.71	65.94	55.98	57.10	-4.78
Herring	9.58	118.98	59.47	59.57	-18.48
Mackerel	7.00	53.39	28.68	28.85	-18.44
Nephrops	-1.74	4.80	1.08	1.36	-1.39
Saithe	-48.37	86.04	24.22	83.21	-60.02
Salmon	-0.63	1.91	1.31	3.10	0.50
Scallop	-2.39	-0.12	-0.30	0.01	-0.12

Table J.5. Scenario 4: Original model outputs (supply elasticity 1, substitution elasticity 5 or 2.5)

Species	Price index	Output (Q)	Output (V)	Exports	Imports
Cod	1.20	-9.27	-7.57	-11.20	-5.41
Crab	0.16	-3.75	-2.48	-6.33	-2.20
Haddock	3.47	1.95	4.58	-7.19	0.66
Hake	1.96	-15.91	-14.61	-15.83	-0.84
Herring	5.26	-10.48	-8.43	-8.59	-9.53
Mackerel	4.84	-5.00	-3.69	-4.22	-8.79
Nephrops	3.76	-9.01	-1.88	-3.25	-3.27
Saithe	1.46	-4.71	-2.89	-9.44	-3.07
Salmon	3.28	-2.19	-0.61	-5.69	-3.20
Scallop	2.37	-9.85	-4.38	-6.86	-1.48

Table J.6. Scenario 4 sensitivity – supply elasticity =3

Species	Price index	Output (Q)	Output (V)	Exports	Imports
Cod	2.65	-18.80	-15.64	-23.04	-11.55
Crab	0.33	-6.94	-4.69	-11.81	-4.12
Haddock	4.23	5.83	8.42	-15.16	-0.47
Hake	2.76	-36.09	-33.83	-36.71	-1.79
Herring	10.37	-20.80	-17.11	-17.48	-17.79
Mackerel	8.75	-9.50	-7.28	-8.56	-16.68
Nephrops	4.90	-14.61	-4.59	-7.23	-6.75
Saithe	1.74	-9.23	-6.54	-20.06	-7.52
Salmon	4.23	-3.69	-1.56	-13.81	-9.53
Scallop	3.15	-16.65	-8.41	-12.96	-3.04

Table J.7. Scenario 4 sensitivity – supply elasticity = 0.5

Species	Price index	Output (Q)	Output (V)	Exports	Imports
Cod	**0.66**	**-5.26**	**-4.26**	**-6.32**	**-3.01**
Crab	0.09	-2.22	-1.45	-3.74	-1.30
Haddock	2.70	0.74	2.92	-4.00	0.81
Hake	1.32	-8.66	-7.87	-8.53	-0.48
Herring	3.02	-6.00	-4.78	-4.87	-5.62
Mackerel	2.88	-2.92	-2.13	-2.41	-5.18
Nephrops	2.75	-5.87	-0.83	-1.62	-1.75
Saithe	1.15	-2.76	-1.48	-5.22	-1.49
Salmon	2.37	-1.39	-0.27	-3.02	-1.47
Scallop	1.71	-6.18	-2.51	-3.98	-0.79

Table J.8. Scenario 4 sensitivity – substitution elasticity halved (2.5 and 1.25)

Species	Price index	Output (Q)	Output (V)	Exports	Imports
Cod	1.21	-8.33	-5.64	-7.42	-5.35
Crab	0.16	-3.18	-1.30	-2.76	-0.96
Haddock	3.50	1.46	3.59	-4.63	1.13
Hake	1.97	-15.03	-12.87	-13.94	-0.77
Herring	5.27	-9.14	-5.69	-5.75	-9.33
Mackerel	4.88	-4.53	-2.73	-2.95	-7.69
Nephrops	3.86	-7.73	0.92	0.66	0.14
Saithe	1.47	-4.10	-1.66	-6.02	-1.66
Salmon	3.29	-2.13	-0.49	-4.99	-2.67
Scallop	2.44	-8.09	-0.60	-1.24	0.12

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