FIS012B - An economic analysis of quota allocation under a landing obligation

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An economic analysis of quota allocation under a landing obligation

Final report

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Executive Summary

This study employs a simulation model of the Scottish demersal fleet's catches and landings in order to examine the potential economic impact of the EU Landing Obligation under a range of different scenarios, including a reallocation of quota between vessel groups. In each case, the model maximises industry profits by adjusting fishing days and, where applicable, reallocating quota. The model assumes no changes in vessels' catch composition (for example through improvements in gear selectivity).

The simulation model subdivides the fleet by PO and by gear type. As a baseline, it uses 2015 data on quota allocations, landings and fishing days. Average daily fishing costs are calculated from Seafish economic data, while estimates of catch rates are based on landings together with the same scientific estimates of discard rates used by Seafish in their modelling of the Landing Obligation. Non-sector vessels and inshore (10m and under) vessels are not included in the model.

Profits in the model are defined as first-sale revenues (at 2015 average prices) less daily fishing costs, but not fixed/boat costs. Crew payments are not deducted, since in many cases crews receive a share of profits, and neither are quota lease payments, as these simply represent transfers of profit between holders of FQAs.

When the model calculates the optimal number of fishing days, it can reallocate days between Areas IV and VI where vessels have a record of activity in both areas. The model will also allocate effort optimally between gear types (whitefish trawls and *Nephrops* trawls, for example) where vessels have a record of switching between gears. All vessels are assumed to be limited to a maximum of 260 fishing days.

With a recorded total of 45,322 days fished in 2015, the model produces a baseline profit estimate of just under £120 million for the Scottish demersal sector, including £85.3m for demersal trawls and £29.4m for *Nephrops* trawls.

With the Landing Obligation imposed for all stocks, even with quota uplifts, total fleet profits are almost halved to £61.8m, with total effort cut by around two thirds, assuming the existing pattern of quota allocation remains the same. Hardest hit are the prawn trawlers, with effort reduced to just 3% of the previous total. More selective gears, such as longliners, are relatively unaffected. Removing the estimated contribution of international quota swaps to each group's quota allocation results in an even worse overall picture. Now total profits are reduced by two thirds to £40.3m, although *Nephrops* trawlers benefit a little from some increases in quota.

Allowing the model to reallocate quota between groups of vessels in order to maximise total industry profits changed the outcome significantly. Total profits increased to £98.2m, more than 80% of the baseline profit, while total fishing days were increased to over 34,000, around three quarters of the baseline figure. This is *without* the estimated contribution from international quota swaps. Unadjusted, the model did, however, very strongly favour the prawn trawlers in allocating quota, since these vessels have relatively high estimated catch rates for whitefish (due to their higher estimated discard rates). The model was therefore re-

run with whitefish revenues reduced for the *Nephrops* trawlers in order to simulate the landing of significant quantities of undersize fish by these vessels. Even then, with whitefish revenues reduced by up to 75% for the prawn trawlers, the gains from quota reallocation were still considerable, with total profits estimated at almost £90m (including £62.5m for demersal trawls and £21.4m for *Nephrops* trawls) and total fleet activity increased to nearly 33,000 days.

The results of the study provide evidence for potential gains from quota reallocation under a Landing Obligation. In policy terms this would suggest that in-year quota transfers between vessels should be greatly facilitated so that quota can more quickly and easily be allocated according to the needs of the industry.

Contents

1. Introduction and aims

This study was funded by Fisheries Innovation Scotland in order to examine the economics of quota allocation in the context of problems foreseen for the Scottish whitefish industry, in particular, under the EU Landing Obligation (LO). Here, the major problem of concern for both industry and policy makers is that of *choke species* or *stocks*: species/stocks for which UK fisheries receive quotas which are in relatively short supply compared to the usual pattern of catches and which are therefore likely to be constraining on the industry once it is no longer legal to discard over-quota fish. The extensive analyses already done by Seafish[1] have identified expected choke stocks for different fleet segments throughout the UK under a range of policy scenarios for the detailed implementation of the LO. The aim of the present study was not to duplicate the work done by Seafish, but to focus on the role that quota allocation could potentially play in alleviating choke problems.

The original intention in the study was to examine the quota allocation process all the way from the annual setting of Total Allowable Catches (TACs) by the EU Council of Ministers to the allocation of UK quotas to individual fishing vessels in Scotland. On reflection, however, and in the light of the Brexit vote which took place after the project had started, it was decided to narrow the scope of the project and to concentrate on quota allocation at the national level. There were a number of reasons for this. Firstly, the TAC setting process itself, although it undoubtedly has an economic dimension, lies largely outside the realm of an economic analysis. Secondly, any changes to the division of TACs into national quotas (according to the allocation key determined in the early 1980s) would require the agreement of all other EU Member States. What the situation will be following the UK's exit from the EU is as yet unknown, dependent upon existing international treaties and agreements (including UNCLOS) but also on the results of negotiations with the remaining EU members.[2] Thirdly, while the increasing use of international quota swaps by Member States (often reflecting quota trades between private firms, and indeed within private firms owning vessels on different national registers) means that the initial quota allocations are much more flexible than was previously the case,[3] whether this flexibility would continue to exist for the UK outside the CFP is unsure. While it may be arguable, therefore, that a number of the UK's national quota allocations are smaller than they "should" be, particularly given changes in stock distribution and fishing patterns,[4] the possibilities for change pre- or post-Brexit are uncertain.

Concentrating on quota allocation at the national level, and focusing on the Scottish demersal sector in particular, also meant that a detailed modelling framework could be developed which would have been impractical in a project with a much broader scope. Briefly, the model describes the Scottish over 10m demersal fleet's activity and landings by PO and by gear type.

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[1] *Landing Obligation Economic Impact Assessment: Final Report*, Sea Fish Industry Authority (Russell *et al.*, 2016). At the time of writing an updated assessment is close to completion.
[2] See, for example, *Fishing News*, 28 July 2016, "Brexit and the Fishing Industry" by Andrew Oliver, p8.
[3] DG Mare internal study; the volume of international swaps is evident from the Commission's FIDES/QUOTA database (for those with access).
[4] See, for example, FIS005, *Reconsideration of European Relative Stability Quota Shares and Implications for the Landings Obligation* (Needle 2016).

Quota allocations and estimated catch rates (based on discard data) are modelled by PO, gear type and sea area. Using recorded data on actual effort and landings, effort is distributed across gear types and between sea areas. Throughout, the reference year is 2015, the most recent year for which full datasets were available.

This model is distinguished in two ways. Firstly, the principal objective in the model is to maximise industry *profitability*. In order to do this, the model recalculates the optimal number of fishing days for each group of vessels depending on the quotas available to it in ICES sub-areas IV and VI. Secondly, the model is able to *reallocate* quota between groups of vessels in order to maximise profitability (at the same time ensuring that the quantity and distribution of fishing effort is optimal). In each case, the Landing Obligation can be simulated by imposing the constraint that discards are reduced to zero for all stocks with non-zero national quotas. The structure and operation of the model is described in detail in Section 5.

The modelling has two principal objectives. Firstly, to identify chokes under a LO for groups of vessels fishing with similar gear types within each PO while adjusting effort in order to maximise profitability. Secondly, and most importantly, to see whether outcomes under the LO can be improved if quota is reallocated between groups of vessels.

The report is structured as follows. Section 2 outlines the current quota allocation process from the setting of TACs to the allocation of UK quotas under the UK's sectoral quota management system, Section 3 then presents an overview of the EU's Landing Obligation for stocks subject to TACs and the associated problem of choke stocks. Section 4 looks at the economics of quota allocation for possible solutions to the problem of chokes. Section 5 describes the model used in the analysis and the modelling results are presented in Section 6. A final section discusses the results and the possible policy implications.

2. Quota allocation under the CFP

2.1. TACs and national quotas

Annual Total Allowable Catches (TACs) for most commercially important fish stocks in EU and adjacent waters (other than in the Mediterranean) are recommended by ICES (the International Council for the Exploration of the Sea) and adopted (not necessarily at the recommended levels) by the EU Council of Ministers meeting in December each year.[5] Not all TAC recommendations are based on a scientific assessment of stock levels; some are "precautionary" in the sense that, in the absence of further information, a TAC is recommended at a level designed to prevent increases in fishing mortality or simply expansions of fishing effort. Some TACs covering stocks straddling non-EU countries' waters require negotiations with those countries, Norway for example, in setting the TAC and determining the EU's share.

TACs and national quotas for EU (then EEC) fleets were first formally adopted in 1983 when the first Council regulation implementing the CFP's resource conservation and management system was introduced. The difficult process of negotiation between the EEC Member States over catch shares that took place between 1977, when EEC Member States collectively declared 200 mile Exclusive Economic Zones (EEZs), and 1982, when agreement was finally reached, is well documented (see, for example, Holden and Garrod, 1994). The guiding principles for the negotiations were historical catches (1973-1978 was the reference period finally agreed), losses of fishing opportunities in third country waters (such as Iceland) and the existence of coastal communities strongly dependent on fishing.[6]

The percentage catch shares ("keys") that were agreed in 1982 are essentially the shares which still govern the allocation of national quotas today, under the principle of "relative stability" of fishing opportunities provided for in the original 1983 and all subsequent basic regulations governing the CFP's conservation and management system.[7] Although the relative stability keys have been adapted and extended since 1983 to encompass additional stocks coming under TAC management as well as the accession of new Member States (in particular Spain and Portugal), the basic allocation keys have changed very little. As Ernesto Penas Lado, a Director in DG Mare, remarks in his recent book on the CFP, "*What makes relative stability so stable is not its legal basis but rather the political difficulty of renegotiating the allocation keys.*" (Penas Lado, 2016, p.29). Indeed, while relative stability may be enshrined in legislation, the actual keys used to allocate national quotas each year are not only absent from any regulation, they have not appeared at all in any official publication of the EU (Penas Lado, personal communication). In essence, it appears that while Member States do not want to renegotiate the keys, they do not want them "set in stone" either.

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[5] The TACs initially adopted for 2015, for example, were set out in Council Regulation 104 of 19 January 2015. TACs are frequently amended during the course of the year, usually based on advice from the EU's Scientific, Technical and Economic Committee for Fisheries (STECF).

[6] See Penas Lado (2016), Holden and Garrod (1994).

[7] For some stocks the UK and Ireland receive certain minimum quota allocations under the so-called "Hague Preferences" agreed in 1976.

Table 2.1 shows the initial quota allocations to the UK in 2015 as a percentage of the initial TACs agreed for each demersal stock in Areas IV and VI.

North Sea			**West of Scotland**		
Stock	**UK quota**	**TAC share**	**Stock**	**UK quota**	**TAC share**
Cod	12,733t	52.6%	Cod (VIa)	0t	---
Haddock	28,850t	85.0%	Cod (VIb)	45t	60.8%
Whiting	8,739t	66.9%	Haddock (VIa)	3,491t	77.0%
Saithe	5,446t	17.4%	Haddock (VIb)	2,104t	81.5%
Plaice	36,688t	30.7%	Whiting	150t	57.0%
Sole	642t	5.4%	Saithe	3,411t	53.7%
Hake	789t	24.7%	Plaice	388t	59.0%
Nephrops	16,838t	94.4%	Sole	11t	19.3%
Anglerfish	8,537t	90.9%	Hake	9,401t	18.5%
Megrim	2,225t	100.0%	Anglerfish	1,635t	30.8%
Lemon sole/Witch	3,904t	61.1%	*Nephrops*	15,522t	100.0%
Skates/rays	814t	64.8%	Megrim	1,435t	34.7%
Dabs/flounders	1,588t	8.6%	Pollack	145t	36.5%
Turbot/brill	707t	15.2%	Skates/rays	2,076t	25.8%
Ling	2,003t	82.5%	Greenland halibut	1,144t	76.2%
Tusk	107t	45.4%	Ling	3,118t	36.8%
			Tusk	293t	31.3%

Table 2.1. Initial UK quotas for 2015 in Areas IV and VI

The most significant development in quota allocation at EU level has been the increase in quota swaps between Member States. While the facility for voluntary in-year quota exchanges has existed since 1983, their frequency has increased greatly in recent years due to changes in fishing patterns (and, arguably, improvements in national quota management and enforcement) as well as the ease and speed with which exchanges can take place under computerised systems.[8] Annual quota swaps between Member States are now numbered in thousands, often involving relatively small amounts of quota. While some of these quota swaps are initiated by national governments (a number of "routine" exchanges also take place each year during the December Council), an increasing number are arranged on behalf of fishing firms and Producer Organisations (POs) and reflect private quota trades. Other changes to the quota allocation system include the "banking and borrowing" facility introduced in 1996 as well as flexibilities for Member States in the allocation of hake and anglerfish landings between the corresponding Area IV and Area VI/VII quotas.

Table 2.2 shows the final (end of year) quota allocations to the UK in 2015 together with the (estimated) contributions of international quota swaps to those final allocations, after

[8] The FIDES quota database is the portal for all EU TAC and quota changes and exchanges.

correcting for any amendments to the initial TACs during the year. A positive number indicates that the UK has swapped quota in from other Member States, a negative number indicating quota swapped out.

North Sea			West of Scotland		
Stock	**UK quota**	**+/-**	**Stock**	**UK quota**	**+/-**
Cod	14,862t	+1,127t	Cod (VIa)	0t	0t
Haddock	30,977t	+1,657t	Cod (VIb)	45t	0t
Whiting	10,154t	+1,415t	Haddock (VIa)	3,385t	-117t
Saithe	8,970t	+3,015t	Haddock (VIb)	2,104t	0t
Plaice	25,936t	-13,927t	Whiting	168t	+1t
Sole	894t	+185t	Saithe	3,392t	-474t
Hake	3,125t	+1,538t	Plaice	388t	0t
Nephrops	10,873t	-7,615t	Sole	11t	0t
Anglerfish	9,087t	-100t	Hake	8,022t	-1,755t
Megrim	2,199t	-114t	Anglerfish	2,117t	+481t
Lemon sole/Witch	3,650t	-254t	*Nephrops*	15,522t	-378t
Skates/rays	691t	-115t	Megrim	1,375t	-215t
Dabs/flounders	1,533t	-55t	Pollack	145t	0t
Turbot/brill	458t	-249t	Skates/rays	2,026t	-36t
Ling	2,113t	-34t	Greenland halibut	909t	-320t
Tusk	107t	-12t	Ling	2,948t	-486t
			Tusk	194t	-129t

Table 2.2. Estimated contributions of international quota swaps to final UK quotas in 2015

2.2. The UK quota allocation system

Since the introduction of the TAC/quota system under the CFP, UK Fisheries Administrations (FAs) have devolved a significant and increasing degree of quota management responsibility to the UK fish Producers' Organisations (POs). Until 1997 the allocations of quota to POs were based each year on the recorded landings of individual (over 10m) member vessels over the previous three years (their landings "track records"). In 1998 quota allocations were based on the same track records as the 1997 allocations, in preparation for a fixing of quota allocations in the following year. In 1999 the same allocations were converted into 100kg quota units, giving each vessel a Fixed Quota Allocation (FQA). Vessels' FQAs now remain the same each year, but the tonnage value of a quota unit depends upon the size of national quotas in relation to those set in 1999. One of the reasons underlying the move to FQAs was to remove incentives to secure larger quota allocations by "strategic" fishing activity simply in order to inflate track records.

Now initial annual quota allocations to each PO are calculated on the basis of the total FQAs of over 10m member vessels (with adjustments for any quota overshoots or quota borrowing in the previous year). The POs have always been allowed to determine their own internal quota allocation methods, provided the PO retains responsibility for total quota uptake by the membership. Some POs still operate common quota pools and set monthly landings limits which apply to all members. Others allocate individual quotas (IQs) to member vessels on the basis of each vessel's FQA. Some POs pool quotas for certain stocks and allocate IQs for others, or for some parts of the membership. Linked to an increase in quota trading (see below), in recent years more POs have implemented IQ systems while most which have traditionally operated quota pools now allow members to top up their pool allowances by leasing in extra quota (often referred to as "pool plus").

For the (over 10m) vessels which do not belong to a PO (the so-called "non-sector") a quota pool is reserved by FAs based on the sum of these vessels' FQAs. This is currently relatively small since most of these vessels target primarily shellfish stocks which are not subject to quotas. Their landings of quota stocks are regulated by means of monthly limits set by the FAs. Inshore vessels of 10m or under in length, which make up around three quarters of the UK fleet by number, do not have FQAs. The quota pool reserved for them is a very small part of the total UK quota, but for certain stocks, mainly in the English Channel, they can account for a significant proportion of total landings. Their landings are mostly regulated using monthly limits with prohibitions for exhausted allocations. Although, for the most part, these inshore vessels remain outside the sectoral quota management system, in recent years there have been facilities for under 10m vessels to lease extra quota for certain stocks.

Since they were first introduced in their present form, UK fishing *licences* have always, to a greater or lesser extent, been privately tradeable. In 1995 landings track records became formally associated with licences rather than vessels and this gave the licences a greatly increased value because of the quota rights they now carried. Under the "licence aggregation" scheme, first introduced in 1990, vessels could now increase their quota allowances by combining licences from more than one vessel. In 1997 a number of track records were also permanently traded during the last vessel decommissioning round, when owners of decommissioned vessels were permitted to sell rather than surrender their quota rights. Under the FQA system, quota units continue to be held on vessel licences or PO "dummy licences" (licences created by FAs on which to place FQAs acquired by the PO). FQAs cannot be traded as independent assets, although licences can be traded using licence transfer and aggregation rules and therefore it is possible *de facto* to trade FQAs.

The main driving force behind the development of quota trading in the UK came from a gradual relaxation of the rules governing the swapping of quota between POs, in particular the facility from 1996 for POs to make quota "gifts" (i.e., non-reciprocated transfers of quota). This made it much easier for a vessel in one PO to lease or sell quota to a vessel in another PO. Deals were relatively complex, involving both the vessel owners and the POs, but under the track record-based allocation system a quota sale could be completed in three years. Within the POs operating IQs, quota trading had always been possible in practice.

The move to FQAs, however, meant that trading of quota could not, in principle, affect each vessel's permanent quota allocation. While this facilitated (in year) quota leasing arrangements, permanent sales of quota became effectively impossible, a quota "sale" becoming instead a long-term lease agreement. Nevertheless, in response to industry demands FAs subsequently agreed on three occasions to reconcile a number of "permanent" leases through adjustments in FQAs (see below).

Quota leasing has escalated in recent years, with a corresponding increase in the annual number of quota swaps between POs. Although there is now an active quota (lease) market in the UK, and fishing firms routinely use the money value of FQAs as security for bank loans, the legal position remains that FQAs are not private property in a legal sense. This was tested in a UK High Court judgement which found that Government ministers had the right to allocate FQAs as they saw fit, without financial compensation, and that fishing firms had no "legitimate expectation" that the rights conferred by FQAs amounted to possession in law. This was despite the fact that the Government had agreed three times (in 2001, 2005 and 2011) to adjust FQAs in order to consolidate private quota trades.[9]

PO	Member vessels in 2015	Quota management
Aberdeen FPO	9 whitefish vessels 1 *Nephrops* trawler	All quotas allocated as IQs
Fife FPO	4 whitefish vessels 17 *Nephrops* trawlers	IQs for beam trawlers and twin rig vessels; quota pools for *Nephrops* trawlers and smaller demersal vessels
Lunar FPO	2 whitefish vessels	IQs (both vessels under same ownership)
North East of Scotland FO	15 whitefish vessels 7 *Nephrops* trawlers	IQs
Northern PO	13 whitefish vessels 14 *Nephrops* trawlers	IQs
Orkney FPO	2 whitefish vessels 7 *Nephrops* trawlers	IQs
Scottish FO	30 whitefish vessels 150 *Nephrops* trawlers	Pools for all demersal vessels; *Nephrops* trawls subject to 50% of usual whitefish limits
Shetland FPO	22 whitefish vessels	Quota pools
West of Scotland FPO	25 *Nephrops* trawlers and creel boats	IQs for *Nephrops*; quota pools for whitefish bycatches

Table 2.3. Scottish demersal POs and their quota management systems in 2015

[9] "High Court Spells Out Quota Rights", *Fishing News*, 26 July 2013, p.2.

Table 2.3 lists the nine Scottish POs with member vessels targeting demersal stocks in 2015, together with the number of (over 10m) member vessels as at 1 January that year fishing primarily with whitefish and prawn (*Nephrops*) gears (although most of the smaller trawlers fish with both whitefish and prawn trawls). The table also summarises each PO's internal quota management system in that year.

3. The Landing Obligation

The Landing Obligation was introduced in 2013 by Article 15 of the new basic regulation governing the CFP.[10] Under the Landing Obligation, all catches subject to catch limits (i.e., TACs) must be "retained on board the fishing vessels, recorded, landed and counted against the quotas". Article 15 provides for a gradual phasing in of the Landing Obligation, beginning in 2015 for the pelagic fisheries, in accordance with discard plans put forward by the Member States. These plans are developed and proposed to the Commission by the appropriate Regional Advisory Councils (RACs).

For the demersal fisheries in the North Sea (Area IV) and West of Scotland (Area VI), the Landing Obligation is to be introduced from 1 January 2016 "for the species which define the fisheries" and by 1 January 2019 at the latest for all other species. Implementation of the Landing Obligation agreed for the Scottish demersal fisheries in Areas IV and VI in 2016 and 2017, as agreed by the North Sea and the North West Waters RACs, is summarised by Marine Scotland as follows.

Implementation in the North Sea and North West Waters Regions in 2016

"Member States agreed plans for which species need to be landed by vessels in the North Sea and North West Waters in 2016. These plans were accepted by the European Commission and form the basis of the delegated regulations for the North Sea and the North West Waters.[11]

In the North Sea in 2016: vessels using gear of 100 mm or more need to land haddock, plaice and northern prawn, and vessels using gear of 80-99 mm will need to land *Nephrops*, common sole and northern prawn. All long line vessels will need to land hake.

In the North West Waters in 2016: vessels where 10% or more of their total landings in 2013 and 2014 were any combination of cod, haddock, whiting and saithe have to land haddock. Vessels where 30% or more of their landings in 2013 and 2014 were *Nephrops* have to land all *Nephrops*. Vessels which meet both conditions have to land both haddock and *Nephrops*. All long line vessels need to land hake."

Implementation in the North Sea and North West Waters Regions for 2017

"Member States have drawn up plans for which species will need to be landed by vessels in the North Sea and North West Waters in 2017. These plans were accepted by the European Commission and form the basis of published delegated acts for the North Sea and North Western Waters.[12]

In the North Sea in 2017: vessels using gear of 100 mm or more will need to land all catches of saithe (if caught by a saithe-targeting vessel), plaice, haddock, whiting, cod, northern prawn, sole and *Nephrops.*

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[10] Council Regulation 1380/2013 establishing a revised Common Fisheries Policy.

[11] Commission Regulations 2015/2440 and 2015/2438.

[12] Commission Regulations 2016/2250 and 2016/2375.

Vessels using gear of 80-99 mm will need to land all catches of *Nephrops*, haddock, sole and northern prawn.

Long line vessels will need to land all catches of hake, northern prawn, *Nephrops*, sole, haddock whiting and cod.

In the North West Waters in 2017: vessels where 5% or more of their total landings in 2014 and 2015 were from a combination of cod, haddock, whiting and saithe will have to land haddock, sole, plaice and megrim.

Vessels where 20% or more of their landings in 2014 and 2015 were *Nephrops* will have to land all *nephrops* and haddock.

All long line vessels will need to land hake.

Vessels which meet both conditions will have to land both haddock, sole, plaice, megrim and *Nephrops*.

Further species will be introduced in 2018 to avoid the sudden addition of a large number of species in 2019."

Note that under the Landing Obligation, "all catches" and "bycatches" includes all fish *below* the minimum size which can legally be sold for human consumption (what used to be the Minimum Landing Size and is now the Minimum Conservation Reference Size or MCRS).

Article 15 of the CFP Regulation provides for various exemptions to the Landing Obligation, including species for which there is evidence of high survival rates after discarding, and so-called *de minimis* exemptions for species where there is evidence that increases in gear selectivity are particularly difficult to achieve or, in certain cases, where handling unwanted catches would result in "disproportionate costs".

The implementation of the Landing Obligation so far for Areas IV and VI includes a *de minimis* exemption for *Nephrops* below the MCRS caught by prawn trawlers, "up to a maximum of 6% of the total annual catches" of *Nephrops* caught by this gear (increased to 7% for catches in Area VIa during 2016-17 as a transitional measure). This exemption was made to "avoid disproportionate costs of handling unwanted catches for the gear concerned, due to the cost of disposing of *Nephrops* below MCRS". In both areas there is a survivability exemption for all *Nephrops* caught in pots (creels).

3.1. The problem of choke species/stocks

The introduction of the LO, so that catches of fish for which a vessel does not have (or have access to) quota can no longer legally be discarded, clearly makes the fishery very sensitive to quota supply. Thus fishing effort by vessels, or groups of vessels, will be constrained by the most constraining quota which applies. In economic terms this is related to the concept of "free disposal" – without free disposal (in this case, the ability to discard), unless quotas are set in the same proportions as species are caught, then the most constraining quota constrains ("chokes") the fishery. While this can be seen as a supply side (quota setting) problem, in principle a demand side solution exists if it is possible to change the species mix in the catch. This may of course be possible to some extent, through changes in fishing patterns and gear selectivity for example, but to the extent that it is not possible, the problem of choke species remains.

Industry concerns about the Landing Obligation include the economic implications of requiring vessels to retain and land catches of fish below marketable size, including the on board impacts in terms of demands on fish handling and hold space as well as the onshore consequences for ports and markets. The principal concern for both industry and policy makers, however, is the possibility of chokes and the likely impact on fleet activity and profits.

The problem of chokes can exist at different levels, however. Some quotas may be in short supply at the individual vessel level, but not at the fleet or fishery level. This would suggest that quota allocation between vessels should be adjusted. Quotas may be constraining at the PO level, but not at the national level; again, suggesting that quota allocation needs to be more efficient. In the context of the increasing separation of quota management between the devolved administrations, it is also possible that chokes may exist at the level of the English or Scottish fleets but not for the UK as a whole. Most attention has focused, however, on the species/stocks for which the UK as a whole has particularly small quotas either because the TAC is low or because the UK share is small, relative to current patterns of catches.

An international workshop on the Landing Obligation organised by Marine Scotland in 2016 identified three categories of choke species.[13] These are

Type 1. Sufficient quota at Member State level – choke is due to a distribution within the Member State such that a region or fleet segment does not have enough. This can be resolved by the Member State itself.

Type 2. Sufficient quota at EU level within a sea basin, but insufficient quota at Member State level – choke is due to distribution between Member States. This can be resolved between Member State in a regional context.

Type 3. Insufficient quota at UE level – choke is due to insufficient quota within the relevant sea basin to cover present catches, or levels to which catches can be realistically reduced to, resulting in a total cessation of fishing for a Member State or Member States.

The first comprehensive analysis by Seafish of the potential impact of the Landing Obligation[14] identified a range of possible choke stocks under various different assumptions about the implementation of the Landing Obligation by 2019.

For example, under the "best case" scenario, with *de minimis* allowances and interspecies flexibility for a range of species, together with survivability exemptions for skates and rays, the 2016 Seafish analysis identified the following choke stocks for the Scottish whitefish (demersal trawl and seine) fleet in Areas IV and VI under full implementation of the Landing Obligation in 2019.

[13] International Access to Quota (Choke Species) Workshop, 14-15 April 2016, Edinburgh
[14] Russell, *et al*., (2016)

Choke stock in 2019	2019 days as % 2013 days
Dabs IV	55%
Tusk IV	61%
Saithe IV	66%
Hake IV	67%
Ling IV	68%
Plaice VI	69%
Saithe VI	74%
Ling VI	75%
Megrim VI	92%
Anglerfish VI	99%

Table 3.1. Scottish whitefish chokes identified by Seafish's 2016 study

The Seafish model (based on 2013 data) estimated that unless measures were taken to avoid catches of North Sea dabs and flounders, the Scottish whitefish fleet could be restricted to 55% of its activity in Area IV compared to 2013. If avoidance measures were to be taken with respect to dabs, the North Sea choke stock would then be Tusk, with whitefish activity restricted to 61% of 2013 days, and so on.

For the Scottish *Nephrops* fleet, the choke stocks identified in Areas IV and VI were as set out below. In the North Sea, dabs and flounders were estimated to restrict activity to just 14% of the effort in 2013, while in Area VI the first stocks to choke the fishery were estimated to be plaice and ling (5% 0f 2013 days).

Choke stock in 2019	2019 days as % 2013 days
Dabs IV	14%
Hake IV	34%
Cod IV	37%
Tusk IV	37%
Turbot IV	39%
Plaice VI	5%
Ling VI	5%
Sole VI	7%
Hake VI	7%
Pollack VI	11%

Table 3.2. Scottish Nephrops fleet chokes identified by Seafish's 2016 study

4. Quota management solutions?

The problem of choking, due to a mismatch between quotas and catches in multispecies fisheries, has received relatively little attention in the fisheries economics literature, except in a very general sense.[15] To some extent this reflects a greater focus on the problem of bycatch and discarding in fisheries *per se* (see below) rather than the practical implications of catch/quota imbalances under a ban on discards. However, this might also be because, at the aggregate level, no simple solutions to the choke problem exist, other than to set quotas differently or for the industry to make significant advances in species selectivity.

Quota management measures which have been suggested to help solve or ameliorate problems of quota-induced discarding, and which might therefore be considered to be of some help in avoiding choke problems at the fleet level, include quota banking/borrowing and multispecies quotas. Such measures are intended to provide more flexibility for fleets operating under a quota management regime, but are not without problems. Solutions to the problem of balancing quota supply and demand at the vessel level, however, generally focus on quota tradeability (see Squires, *et al.*, 1998, Sanchirico, *et al*., 2006, Pascoe, *et al.*, 2010).

4.1. Quota trading

Tradeable quotas or ITQs (individual transferable quotas) have arguably become the fishery management tool of choice from an economic perspective. ITQ systems are now in place in a number of fishing nations, including Australia, New Zealand, Canada, Denmark, the Netherlands and Iceland. The introduction (or facilitation) of a market for quota is intended to allow vessels to choose their own quota limits in order to maximise their profits over the year, by buying and selling quota at the prevailing market price. In principle, ITQs should maximise industry profitability by ensuring that quotas are used by those vessels able to earn most from them (and hence willing to pay more in order to acquire them). The market price for quota should therefore reflect the profits that can be earned within the industry by acquiring an additional unit of quota. In a "fully-fledged" ITQ system, where the property rights of quota ownership are clear and well-defined, we would expect two quota markets to develop, one for permanent quota holdings (an asset market) and one for quota allowances for the current year (a lease or rental market). In principle, ITQs are applicable for and have been used in multispecies fisheries as well as single species fisheries (see Squires, *et al.*, 1998).

If vessels have different catch compositions, and therefore differing quota demands, quota trading, in principle, provides a mechanism for quota (re)allocation. The argument against pooled quotas is that they create competition between vessels for quotas in short supply and hence incentives to follow fishing patterns and timing which are unlikely to be those most profitable for individual vessels or the industry as a whole.

[15] In economic terms, the choke species problem is linked to production *jointness* (multiple outputs from the same inputs) together with *weak output disposability*: it is difficult (therefore costly) in the short run to change the output (species) mix. In general, efficient quota management requires that TACs are set in close proportion to the output mix. Discarding can be thought of as introducing *free disposal*, but discarding is generally seen as a "bad". See, for example, Boyce (1996), Turner (1997), Singh and Weninger (2009). The specific problem of choke species has been considered by Holland (2010) and Hatcher (2014).

In order for an ITQ system to function correctly, quota markets must be efficient, that is, they should enable all mutually beneficial trades to take place at minimal cost. As far as possible, therefore, quota trading should be frictionless and transparent, without significant transaction costs, so that all potential buyers and sellers know the market price and can trade easily and instantaneously. At the same time, mechanisms can be put in place to enable vessels to deal with short term problems in covering landings with quotas. These include various provisions for retrospective quota trading as well as mechanisms such as "deemed value" payments to remove incentives to land fish without quota (see Squires, *et al.*, 1998, Sanchirico, *et al*., 2006, Pascoe, *et al.*, 2010).

Aside from practical problems of implementation and enforcement, there are political concerns about ITQs which relate mainly to issues of equity, in particular *which* vessel owners receive wealth when quotas are initially distributed (and where that wealth subsequently goes) and which vessel owners (if any) are perceived as being disadvantaged in quota trading.[16]

A problem with ITQs, as with non-tradeable quota systems, is that they usually define rights over quantities of landings, rather than catches. Vessels therefore always have a choice whether to land fish against quota or to discard fish at sea, and there will be an incentive to discard fish whenever the expected market value of the fish is equal to or less than the cost of quota. In general, discarding is relatively costless, so that even if more selective fishing is possible, it may be more profitable to catch and discard fish of low value, or for which quota is unavailable, than it is to fish more selectively.[17] The reason why quotas are generally defined in terms of landings rather than catches is simple: with existing technology it is much easier (and therefore cheaper) to monitor landings than it is to monitor catches, particularly in a multispecies fishery.[18] A discard ban (such as the Landing Obligation) effectively represents an intended change from landings quotas to catch quotas, even if the principal point of monitoring and control remains the point of landing and first sale.

While it can be argued that quota tradeability provides the most flexible quota system possible for individual vessels, quota trading between vessels cannot solve quota supply problems which persist at the aggregate (fleet) level, i.e., which remain even when quota has been efficiently allocated. If one or more quotas are in short supply, relative to what the entire industry will normally catch while fishing against other quotas, then we have the problem of choke species. By implication, this is a problem that cannot easily be solved (in the short term at least) by more selective fishing (otherwise it would be!).

[16] Commonly reported objections to quota trading include a perceived financial disadvantage for smaller vessels, increased investment costs for new entrants to the fishery, as well as transfers of fishing income to non-fishing individuals or firms (so-called "slipper skippers") and foreign ownership of quota.

[17] Discarding and discard reduction in quota-managed fisheries has been the subject of considerable economic analysis. See for example Anderson (1994), Arnason (1994), Pascoe (1997), Pascoe, *et al.* (2010), Hatcher (2014).

[18] This could of course change if technological advances produced reliable means of quantifying catches of different species via remote on-board monitoring.

4.2. Quota management fixes

With or without quota trading, it might seem that a more flexible quota management system could help with choke species problems at the industry level. These quota management "fixes" are essentially designed to relax quota limits at the margins while retaining some overall quota control (for a discussion of various mechanisms see Sanchirico, *et al*., 2006).

Quota "risk" pools. Quota pools, rather than individually allocated (and traded) quotas, may be preferable for catches of non-target species which are highly variable and therefore uncertain. Essentially, groups of vessels can spread the risk of catching and landing these species by pooling quota, so removing the need for (and costs of) continual trading of small quantities of quota (see Abbott and Wilen, 2009, Holland, 2010, Holland and Jannot, 2012). Quota pools can operate within an ITQ system just as they do at present within the UK's FQA system. The problem with quota pools, however, is that they do not solve any fundamental supply problem: if a quota is in short supply then the quota pool will still be exhausted early compared to other quotas. The consequence is competition for pooled quota and a "race to fish". This is why quota pools are generally recommended for bycatch management, not target species management. Note that POs which pool quota ration quota uptake by means of monthly allowances.

Banking/borrowing of quota between years is already built in to the CFP and the UK's quota management system.[19] Under this arrangement, the industry is able to exceed quotas in the current year by bringing forward (borrowing) quota from the following year. At the same time, unused quota in the current year can be "banked" for use in the following year. The basic rationale for banking/borrowing is to provide some stability for the industry in the presence of year to year variability in catches and/or quotas. There are two main practical problems with this. One is that it may be undesirable from a stock conservation perspective for a particular quota to be exceeded in the current year, even if the quota for that stock in the subsequent year might be underutilised. The other problem is that over time continual borrowing of quota may result in landings (catches) significantly in excess of those set by regulators. For these reasons, limits are placed on the degree to which banking and borrowing may occur. Since, over a number of years, the intention is that landings remain within quota limits, it is not apparent that banking/borrowing can do anything to reduce a long term choke problem. A further issue is that incentives to borrow quota can arise not only from a desire to avoid chokes or discards, but simply from the current value of catches compared to their future value: given a positive discount rate, a tonne of fish is always worth more now than in a year's time, all else equal. This can create a perverse incentive from a sustainability perspective.

Multispecies quotas are intended to provide flexibility to quota limits by allowing vessels to land fish of more than one species against the same quota. Under the CFP we already have multispecies quotas for some stocks, for example North Sea lemon soles and witches, dabs and flounders, and turbot and brill. The problem for regulators is that they then lose control over landings of any single stock. If there is a significant price difference between the species

[19] EU (Council) Regulation 847/96

covered by the quota, there will be an incentive for vessels to land only the more valuable species and to discard catches of the less valuable species. Under a discard ban, setting a multispecies quota to cover two stocks, one of which would give rise to choke problem under single species quotas, would not solve the choke problem, however. If the total quota was set at a level such that the quota was exhausted when catches of the choke species reached the desired limit, then the multispecies quota would simply choke the fishery at the same level of fishing effort as before. Setting a larger total quota would then simply be equivalent to relaxing the choke species quota.

Similar arguments apply to *interspecies (or inter-stock) flexibility* between quotas. Except at the margins, regulators may lose a significant degree of control over fishing mortality if fleets can simply allocate catches to less constraining quotas. The same argument would also apply to enforcing quotas only on certain key (or “indicator”) stocks. If, when the enforced quota is exhausted, catches of the “choke” stock have exceeded the target level, then in effect the choke species quota has simply not been enforced.

The conclusion then remains that choke problems which persist at industry level, even after quota has been allocated efficiently between individual vessels, can only be solved either by adjusting the TACs or national quotas or through significant changes in catch composition.

The foregoing discussion does, of course, presuppose that TACs for choke stocks are set at levels which are necessary for conservation objectives in the first place. Otherwise, the logical implication is that the TACs (and hence national quotas) should be relaxed. This is not a trivial point: TACs and quotas with no stock conservation value or rationale cannot be efficient if they constrain an otherwise profitable fishery.

5. The quota allocation model

5.1. Model structure

The model represents activity, landings and operating profits for Scottish over 10m demersal vessels (whitefish and prawns) fishing in the North Sea and West of Scotland in 2015. Data on recorded effort and landings of all demersal stocks were provided by Marine Scotland, disaggregated by PO and by gear type. Data on quota allocations to POs were taken from Fisheries Administrations' quota management spreadsheets for 2015.

The model allocates quota between POs and between gear types within each PO. The initial "baseline" allocations for each PO were the *final* allocations recorded for 2015, including all quota from international swaps as well as domestic movements of quota between POs. Adjustments were then made for international swaps in some of the model scenarios (see Section 6).

It was not possible to obtain data on baseline quota allocations *between* gear types *within* each PO. There are various reasons for this. Firstly, some POs operate quota pools for at least some stocks and some vessel groups. This means that, in these cases, there may be no *a priori* quota allocation as such between gear types (a number of POs also hold quota on "dummy" licences). Secondly, many demersal vessels fish using more than one gear type (whitefish trawls and *Nephrops* trawls, for example). Even in the case of individual vessel quotas, this makes the allocation of quota between gear types problematic. Thirdly, while individual vessels have identifiable FQAs, quota leasing means that FQAs would not be a reliable guide to the quotas actually available to any particular vessel, even in a PO using individual vessel allocations (IQs). Because of the way in which the UK's quota management system works, the final quota allocations for individual vessels within a PO are essentially private information unavailable to the study.

Nevertheless, for modelling purposes a notional baseline quota allocation between gear types within each PO was determined for each stock according to the landings recorded for each gear type as a percentage of the total landings of that stock by the PO.

Daily catch rates for each PO and gear type were estimated by scaling up daily landings (calculated from recorded landings and effort in each sea area) by the most relevant discard rate estimates collated on the EU JRC (Joint Research Council) database. These are the same discard estimates being used by Seafish in their updating of the UK-wide impact assessment of the Landing Obligation.[20] Note that daily landings (and hence daily catch rates) may be overestimated for some Area VI stocks (such as Western hake) if significant quantities have been taken from Areas VII/VIII since activity in these areas alone is excluded from the model.

First sale prices are 2015 average annual prices per species from Marine Scotland statistics. Daily fishing costs were estimated from Seafish costs and earnings data for 2015.[21] Daily operating costs for each gear type in each ICES area were scaled according to average engine power (in kW) compared to the average kW of the vessel sample providing data for the most

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[20] I am grateful to Seafish for providing this data.

[21] www.seafish.org/research-economics/industry-economics/seafish-fleet-economic-performance-data

relevant fleet segment in the Seafish dataset. Daily fishing costs in the model *do not* include payments to crew, nor do they include quota leasing costs since these are simply transfers of profit between firms. Note that since it was not possible to separate steaming time from fishing time, average daily fishing costs may be overestimated for some vessels, particularly those using static gears such as longlines and gill nets.

Vessel profits in the model are therefore calculated as short run (operating) profits *including* crew shares or payments to crew and *all quota rents*. Boat and other fixed costs are assumed paid from operating profits.

5.2. Operation of the model

For each group of vessels, the model adjusts both effort and quota allocation optimally in order to maximise total industry profits (as defined above). The model can allocate effort optimally for a given quota allocation, or allocate both quota and effort simultaneously. Although in concept the model is relatively straightforward, given the number of PO/gear/area quota and effort combinations and the number of demersal quota stocks, the computing requirements are formidable. The model was constructed in Microsoft Excel but was solved using Premium Solver Platform (Frontline Systems Inc.) and a Gurobi large scale LP/MIP solver engine (Gurobi Optimization Inc.).[22]

The model calculates catches, landings, discards and profits for any given allocation of quota and days. It will always optimise effort and quota allocation to maximise profits, either with or without constraining discards to be zero for all or for a selection of stocks. This means that, in the context of the Landing Obligation, for example, no vessels have any loss-making days.

Within a PO, the model allocates days optimally between Areas IV and VI for each gear type. It also allocates effort optimally *between* gear types where, in each area, at least some vessels fish using more than one gear type. In these cases, the extent to which effort can be reallocated between gear types is limited by the number of vessels in the PO recorded as having used more than one gear type in that area in 2015. Overall, effort is limited by the maximum number of days a vessel can be assumed to fish in a year. By default, this limit is set globally at 260 days per vessel (roughly equivalent to five days in seven).

Note that the model assumes *compliance*, both with quotas and (where applicable) with the Landing Obligation. One result of this is that *all* over-quota fish is shown as discarded unless the Landing Obligation is in force. The exceptions are those stocks with zero TACs and quotas (Area VI cod and whiting) where all catches are assumed to be landed.[23] Another is that, because the model cannot distinguish between fish of marketable size and undersize fish (see

[22] For each group of vessels, profits are calculated as landings revenues minus fishing costs given an allocation of quota and fishing days. The model allocates days (and quota) in order to maximise total (industry) profits, with the constraint that profits are strictly non-negative for all individual groups of vessels. While the model itself contains a number of discontinuities, due to quota limits for example, the Solver software is able to transform the model into an LP (linear programming) model, which the Gurobi optimisation engine solves by the "simplex" method. Given the number of quota stocks, the model is large and complex, with the total numbers of variables and constraints running to around 600-700 where quota allocations are included.

[23] Building a percentage landings allowance for these stocks into the model was difficult and would not significantly have affected the overall results.

below), where there is unused quota, adjusting catch rates to account for estimated discard rates will increase predicted landings (and therefore revenues).

Baseline quota allocations to POs are the final allocations recorded for 2015, after all swaps. In modelling the impact of the Landing Obligation *without* international swaps, baseline quota allocations to each PO were adjusted *pro rata* according to the % change in the UK quota during 2015 attributable to international swaps (i.e., after correcting for any changes to the TAC during the year).

Quota uplifts ("discard transfers") for the Scottish demersal fleet are assumed to correspond, in percentage terms, to the TAC uplifts estimated by Seafish for each stock under a full implementation of the Landing Obligation.[24] In other words, it is assumed that all TAC uplifts are simply passed on to the Scottish fleet and to individual POs *pro rata* (ignoring any possible "top-slicing" or other adjustments at the UK or Scottish level for policy purposes). In the model the % uplifts are applied to the 2015 quotas in order to model the impact on the fleet as it operated in 2015.

5.3. Limitations of the model

There are some inherent limitations to the model which are due to data availability and technical constraints on the size and complexity of the model.

Firstly, the model can only estimate the optimal number of days for, and reallocate quota between, *groups* of vessels, not individual vessels, based upon the average catch rates and costs for each vessel group.

Secondly, because of this, and because the model does not take account of fixed (boat) costs, there is no explicit modelling of the *number* of vessels remaining active under each scenario.

Thirdly, the model does not include any upper limits on the total quantities of fish retained and landed by any group of vessels (other than those imposed by quota allocations). In other words, there are no capacity constraints in the model due to the amount of hold space available on vessels.

In addition, in order to keep the model tractable and to focus on the potential role of quota reallocation, the model contains a number of simplifications relating to both the quota management regime and the implementation of the Landing Obligation.

Banking/borrowing arrangements and *hake flexibility*. Because these adjustments are incorporated into the initial quota allocations to each PO, they are ignored in the model.

Angler flexibility. Because, for some POs, significant quantities of Area VI monkfish were counted against their Area IV monkfish quota in 2015, in the model the baseline quotas for Area IV and VI monkfish are adjusted accordingly. Thus, Area VI monk quotas are increased and Area IV monk quotas are reduced as appropriate. While this changes the baseline total quotas, the nominal allocations to those POs unaffected remain unchanged.

[24] I am grateful to Seafish for providing this data.

Zero TAC stocks (Area VI cod and whiting). Instead of the existing by-catch allowances, which are difficult to recalculate in the model as landings change, the Landing Obligation is simply not imposed for these stocks. Since quotas are zero, however, and all catches would then appear as discards in the model and not contribute to profits, all catches of these stocks are assumed to be landed.

De minimis, survivability and other derogations from the Landing Obligation. In the model partial derogations, such as discard allowances and exemptions, are difficult to handle, particularly where they apply to catches below the MCRS since the model cannot estimate the proportion of catches which are undersize (see below). The (limited) *de minimis* exemptions for *Nephrops* catches below the MCRS in both Areas IV and VI were ignored in the model.

Estimated catch rates for each vessel group are based on recorded landings, scaled up according to discard estimates for the closest available gear/area combination. Basing catch rates for a group of vessels on recorded landings may introduce a bias in the sense that declared landings will inevitably reflect quota limits. If vessels are discarding, in order to keep within quota limits, at a rate higher than the overall scientific estimate for the fleet then catch rates in the model will be underestimated accordingly. But catch rates may equally well be overestimated for some groups if discard rates are lower than fleet estimates. In the absence of any other data on which to base estimated daily catch rates for specific vessel groups, however, the estimates in the model are considered to be the best that can be made.

The methodology for stripping out *international quota swaps* from POs' baseline allocations is necessarily approximate. Clearly, baseline quotas for POs not benefiting from international swaps to any great extent will then be underestimated, whereas quotas for POs benefiting from international swaps to a greater than average extent will be overestimated. In the absence of detailed data on international quota swaps arranged on behalf of individual POs or groups of vessels within POs, however, the methodology adopted is considered a reasonable approximation. Modelling the impact of quota reallocation should not be significantly affected, however, unless the quotas available to the Scottish sector *as a whole* have been under- or overestimated.

Undersized fish. Comprehensive data on the size composition of catches and estimated discards were unavailable. The net effect on estimated catch rates in the model and the scale of predicted discards is difficult to ascertain. As stated previously, however, this does mean that in the model *all* catches not discarded will be landed against quota. In addition, by default all landings are assumed to be sold at the average first sale market price and therefore predicted revenues will tend to be overestimated wherever increased catches result in increased landings (depending on the likely proportion of undersized fish in the landings). In some of the modelling scenarios, however, an attempt is made to correct for this.

6. Analysis and results

6.1. Simulation results

Results for the simulation modelling are presented for the following scenarios.

Scenario A

- quotas as final PO allocations for 2015
- fishing days as recorded in 2015
- catches estimated from 2015 landings data *plus* estimated discard rates

This is the baseline or "business as usual" scenario for 2015. Landings will be as recorded for 2015 *except* that where there is unused quota the model will have attempted to fill any available quota with previously discarded fish.

Scenario B

- LO imposed for all stocks except those with zero quotas (area VI cod and whiting)
- quotas as final PO allocations for 2015 *plus uplifts*
- fishing days adjusted to maximise profits

Here we assume that the LO is imposed for all stocks but POs' quota allocations remain as they were at the end of 2015, including all swaps (domestic and international). All quotas are increased *pro rata* according to estimates of likely uplifts for the TACs.

Scenario C

- LO imposed for all stocks except those with zero quotas (area VI cod and whiting)
- quotas as final PO allocations for 2015 *without international swaps*, plus uplifts
- fishing days adjusted to maximise profits

This is the "worst case" scenario for full implementation of the LO. The POs' quota allocations are as they were at the end of 2015 but corrected for the estimated contribution of international swaps to final UK quotas in that year. The remaining quotas are again increased *pro rata* according to estimated uplifts for the TACs.

Scenario D1

- as Scenario C but with quotas *reallocated* between all vessel groups

Here the LO is implemented for all stocks and quotas are at 2015 levels, without international swaps, but with uplifts applied. Quota is reallocated between POs and between gear types within each PO. At the same time, effort is adjusted automatically in order to maximise profits for each vessel group.

Scenarios D2 and D3

- as Scenario D1 but with whitefish revenues reduced for the *Nephrops* trawlers

Here, quotas are again reallocated between all vessel groups but with revenues from landings of whitefish (i.e., all stocks apart from *Nephrops*) reduced by 50% (D2) and 75% (D3) for all the *Nephrops* trawlers. This reflects the possibility that under Scenario D1 a significant proportion of the additional landings by prawn trawlers might be fish below the MCRS and therefore not sold at the ex-vessel price for marketable fish. Scenario D3, for example, assumes that only 25% of the whitefish landings by prawn trawlers under the LO are fish of marketable size while the rest are undersize and generate no net revenue.

The different scenarios are summarised below:

Scenario	**A**	**B**	**C**	**D1**	**D2**	**D3**
Landing obligation for all stocks	---	✓	✓	✓	✓	✓
International swaps retained	✓	✓	---	---	---	---
Quota uplifts applied	---	✓	✓	✓	✓	✓
Days optimised	---	✓	✓	✓	✓	✓
Quota reallocated between groups	---	---	---	✓	✓	✓
Prawn trawlers' finfish revenues adjusted	---	---	---	---	50%	25%

Scenario A: baseline results

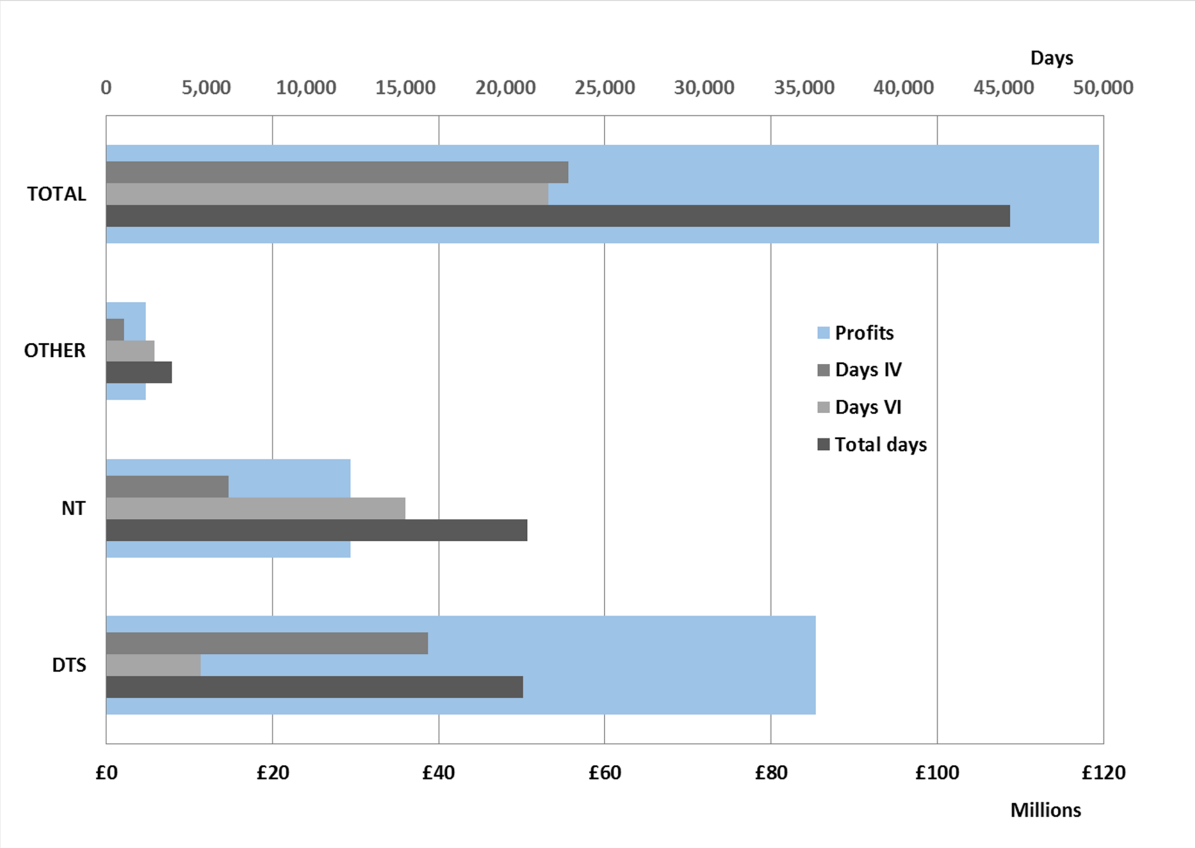

Figure 6.1. Total profits and days: Scenario A

Total operating profits for the Scottish demersal fleet are estimated at almost £120 million with a total of more than 45,000 fishing days. Table 6.1 shows the total profit for the demersal fleet together with sub-totals for demersal trawls and seines (DTS), *Nephrops* trawls (NT) and other gears (beam trawls, lines/nets and prawn creels).

Fishing method	**Effort in days**	**Operating profit (millions)**
Demersal trawls/seines	20,903	£85.3
Nephrops trawls	21,113	£29.4
Other gears	3,306	£4.8
Total	45,322	£119.5

Table 6.1. Fishing effort and operating profits under Scenario A

The results are illustrated in Figures 6.1-6.3 and Figure 6.19. Figure 6.1 shows the breakdown of total effort between Areas IV and VI, while Figures 6.2 and 6.3 show the profits and effort by PO and gear type. Figure 6.19 at the end of the section shows the uptake of each quota stock, with unused quota indicated in a lighter shade of blue and estimated discards by the black columns. Note that the quantities in Figure 6.19 are plotted as *log transformed* values in order to show small and large quotas on the same chart. All catches of Area VI cod and whiting are assumed landed.

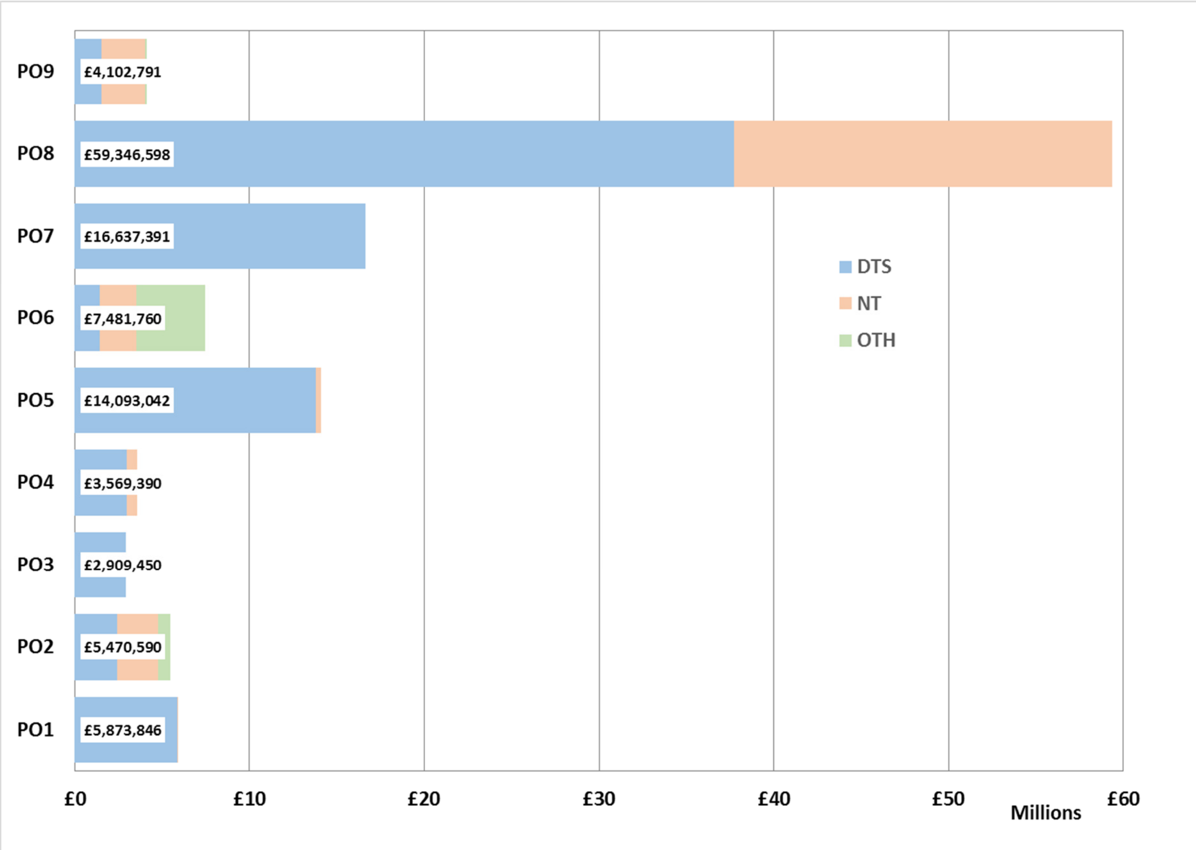

Figure 6.2. Scenario A: profits for each PO and gear type

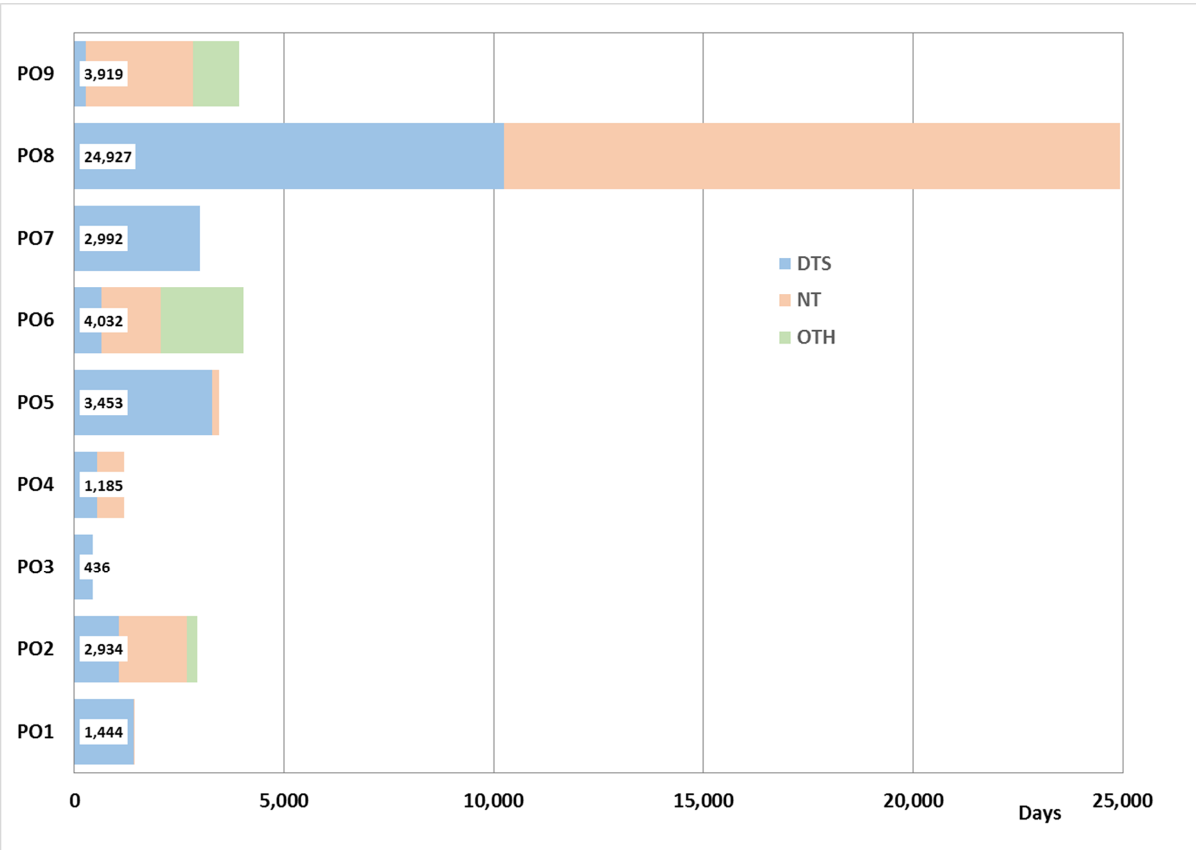

Figure 6.3. Scenario A: fishing days for each PO and gear type

Scenario B: LO with existing international swaps

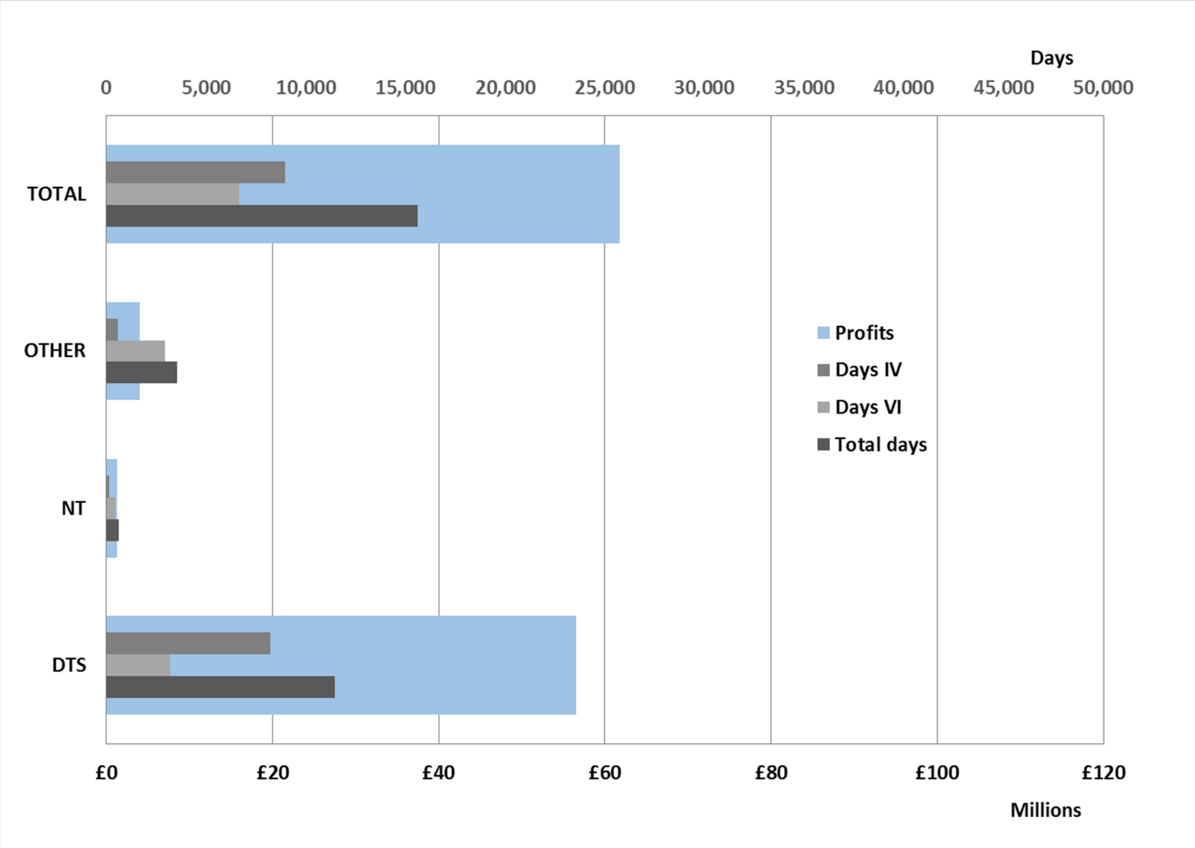

Figure 6.4. Total profits and days: Scenario B

Under Scenario B total operating profits for the Scottish demersal fleet are reduced to just under £62 million and total effort to under 16,000 days. These totals represent just over half the profits and a third of the effort under Scenario A. In Table 6.2 the figures in parentheses indicate the percentages of Scenario A results.

Fishing method	Effort in days	Operating profit (millions)
Demersal trawls/seines	11,440 (55%)	£56.6 (66%)
Nephrops trawls	622 (3%)	£1.2 (4%)
Other gears	3,528 (107%)	£4.0 (84%)
Total	15,591 (34%)	£61.8 (52%)

Table 6.2. Fishing effort and operating profits under Scenario B (% Scenario A)

The biggest impact is felt by the *Nephrops* trawlers, with effort reduced to 3% and profits to 4% of the corresponding figures for Scenario A. Note that total effort by other gears has actually *increased* under the LO. This is because actual effort in 2015 was not optimal in the model and here additional days have been used by gears with low or zero discard rates (longliners and netters in PO6 and prawn creel boats in PO9). Notice from Figure 6.20 that North Sea hake is the only quota that is completely taken up.

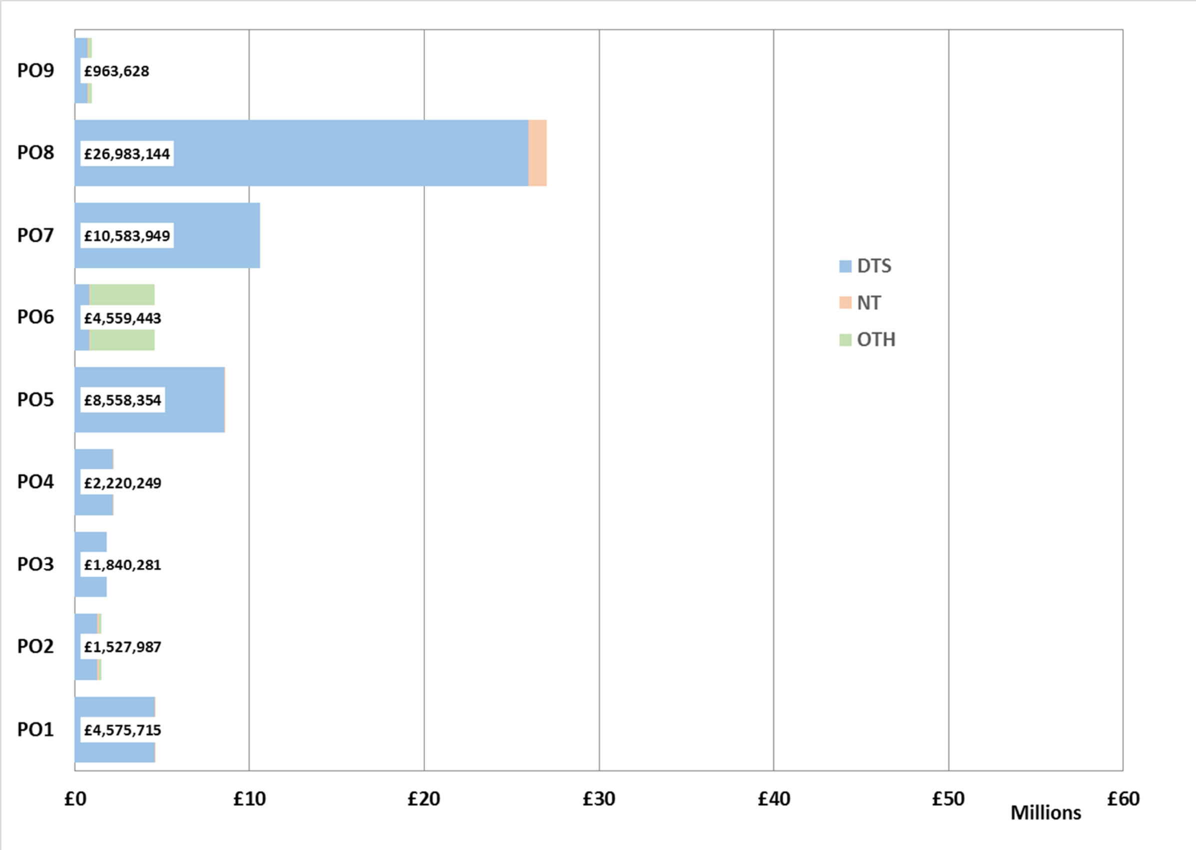

Figure 6.5. Scenario B: profits for each PO and gear type

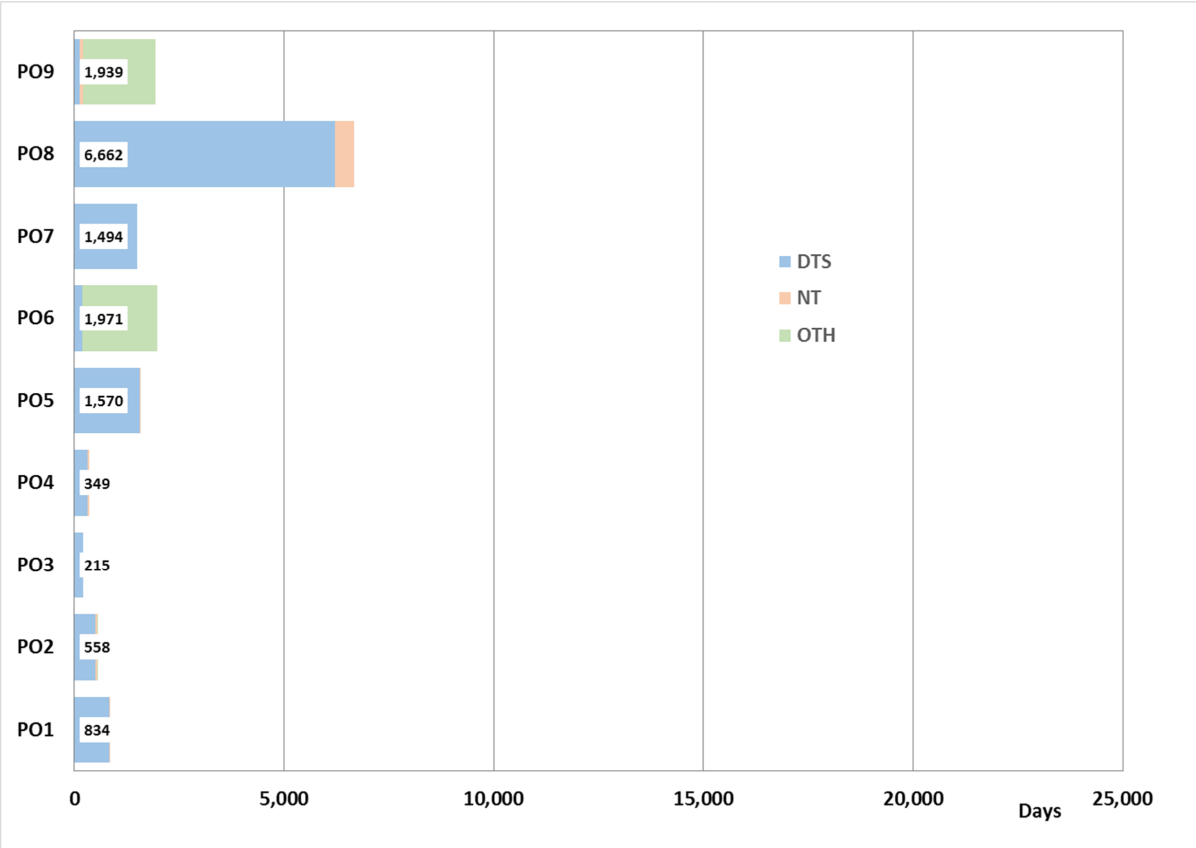

Figure 6.6. Scenario B: fishing days for each PO and gear type

Scenario C: LO without existing international swaps

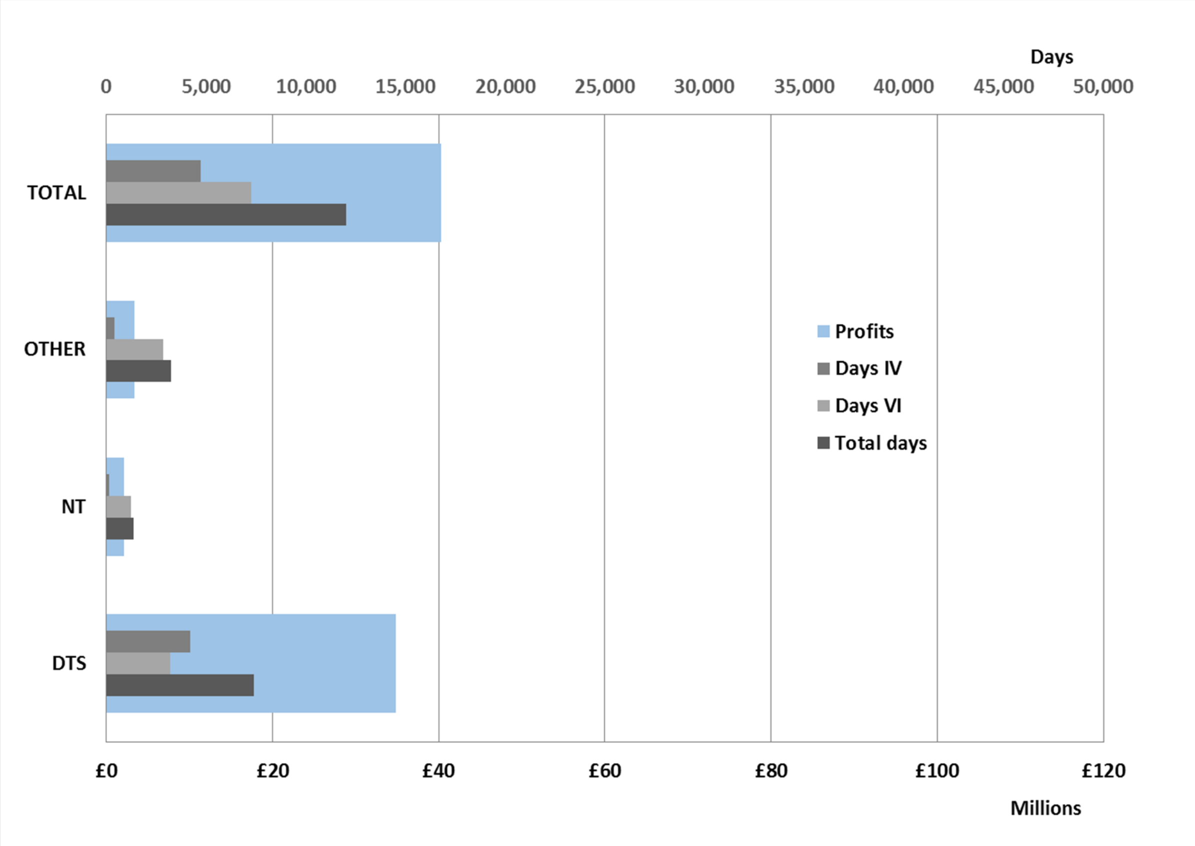

Figure 6.7. Total profits and days: Scenario C

Under Scenario C total operating profits for the Scottish demersal fleet are reduced to just over £40 million and total effort to a little over 12,000 days. These totals represent a third of the profits and not much more than a quarter of the effort under Scenario A.

Fishing method	**Effort in days**	**Operating profit (millions)**
Demersal trawls/seines	7,402 (35%)	£34.9 (41%)
Nephrops trawls	1,383 (7%)	£2.1 (7%)
Other gears	3,235 (98%)	£3.4 (70%)
Total	12,020 (27%)	£40.3 (34%)

Table 6.3. Fishing effort and operating profits under Scenario C (% Scenario A)

These results emphasise the importance of international quota swaps to the Scottish industry. Again, the biggest impact is felt by the *Nephrops* trawlers, although they do a bit better than under Scenario B since effort in the model is used to take up some of the *Nephrops* quota previously swapped to other Member States. Least affected are the netters/longliners and prawn creel boats. Again, Figure 6.21 shows that North Sea hake is the only quota that is exhausted.

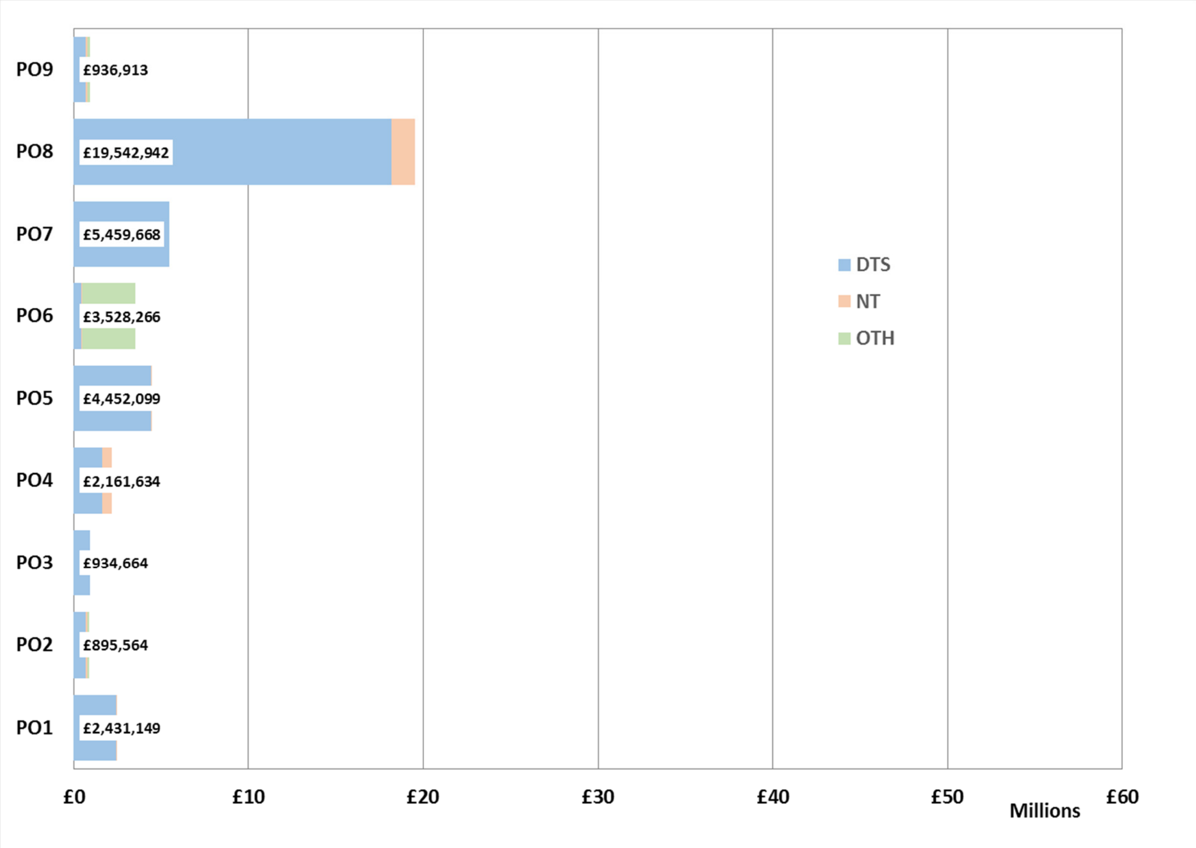

Figure 6.8. Scenario C: profits for each PO and gear type

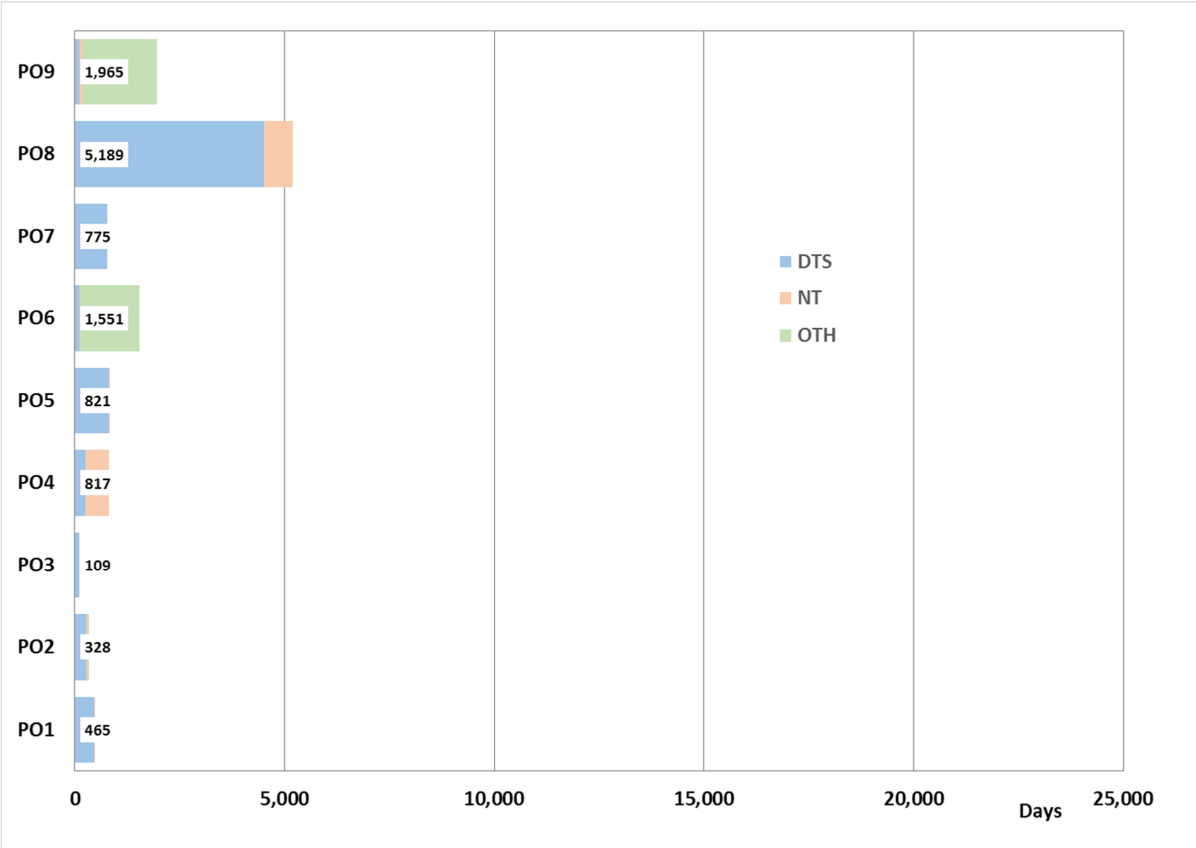

Figure 6.9. Scenario C: fishing days for each PO and gear type

Scenario D1: LO without international swaps but with quota reallocated within Scotland

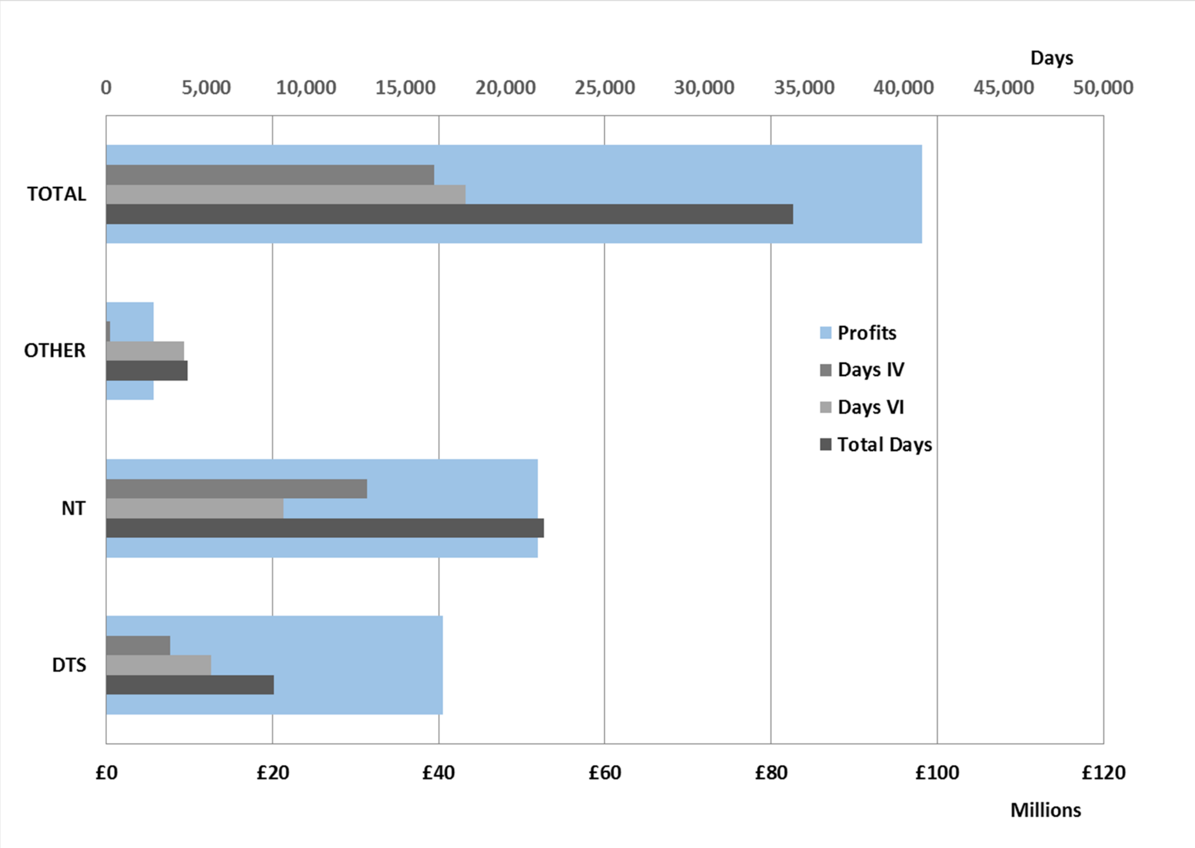

Figure 6.10. Total profits and days: Scenario D1

Under Scenario D1 total operating profits for the Scottish demersal fleet are over £98 million and total effort is over 34,000 days. These figures represent more than 80% of the profits and around three quarters of the total effort under Scenario A.

Fishing method	**Effort in days**	**Operating profit (millions)**
Demersal trawls/seines	8,421 (40%)	£40.5 (48%)
Nephrops trawls	21,946 (104%)	£52.0 (177%)
Other gears	4,064 (123%)	£5.7 (119%)
Total	34,430 (76%)	£98.2 (82%)

Table 6.4. Fishing effort and operating profits under Scenario D1 (% Scenario A)

With quota reallocation, the *Nephrops* trawlers as well as the longliners and creel boats have actually *increased* their activity and earnings significantly compared to Scenario A. This partly reflects a choking of effort for the demersal trawlers and partly a relative cost advantage for the prawn trawlers. To the extent that the prawn trawlers may be catching relatively high percentages of fish below the MCRS, however, results will be biased in their favour since the model assumes all landings are sold at the same ex-vessel price. Nevertheless, the demersal trawlers do somewhat better overall in terms of profits under quota reallocation compared to Scenario C. From Figure 6.22 it is evident that while a number of stocks are fully utilised (see below) and overall quota uptake is improved significantly (see below), many quotas remain underutilised.

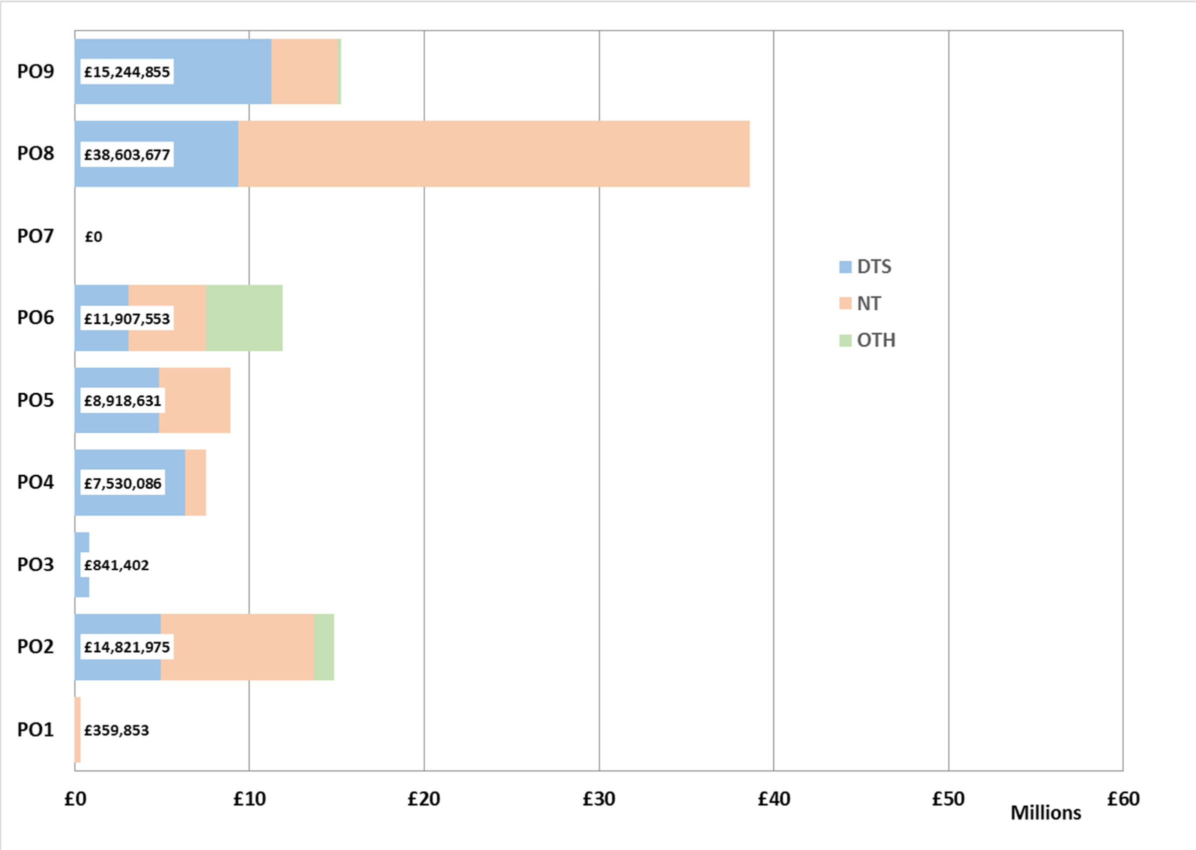

Figure 6.11. Scenario D1: profits for each PO and gear type

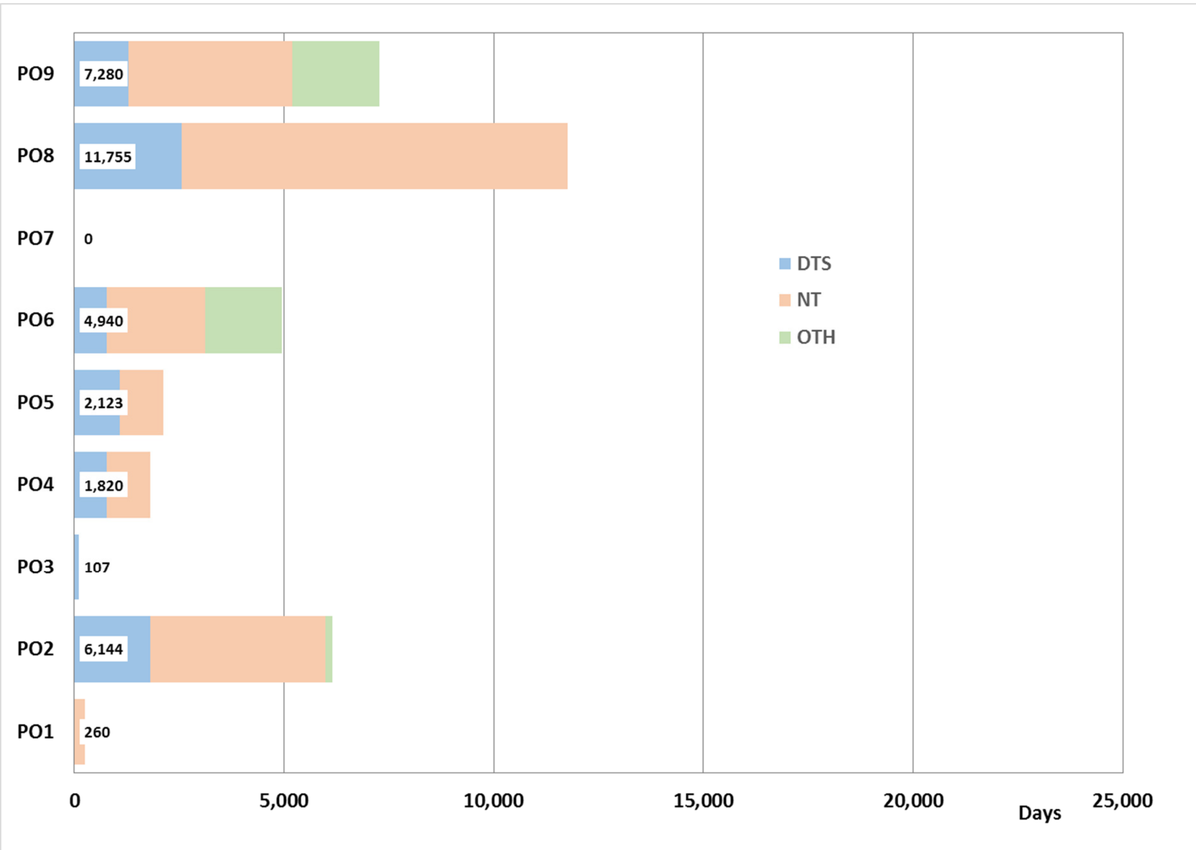

Figure 6.12. Scenario D1: fishing days for each PO and gear type

Scenario D2: As Scenario D1 but with whitefish revenues reduced by 50% for prawn trawlers

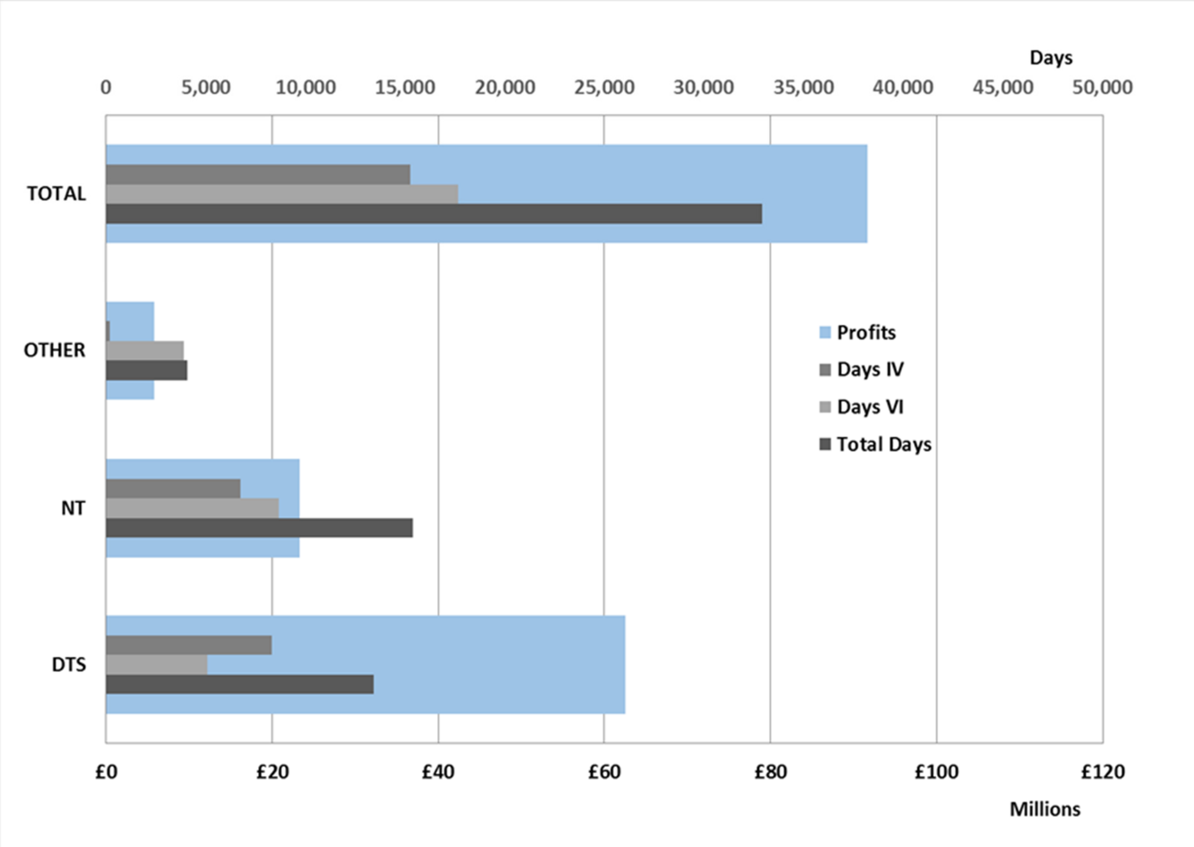

Figure 6.13. Total profits and days: Scenario D2

Under Scenario D2 total operating profits for the Scottish demersal fleet are just under £92 million and total effort is nearly 33,000 days. These represent some 77% of the profits and 73% of the total effort under Scenario A.

Fishing method	**Effort in days**	**Operating profit (millions)**
Demersal trawls/seines	13,409 (64%)	£62.5 (73%)
Nephrops trawls	15,412 (73%)	£23.3 (79%)
Other gears	4,080 (123%)	£5.8 (122%)
Total	32,901 (73%)	£91.6 (77%)

Table 6.5. Fishing effort and operating profits under Scenario D2 (% Scenario A)

With the assumption that a significant proportion of the whitefish landings by prawn trawlers under a LO may be undersize and therefore not generating revenue, a reallocation of quota between groups results in more quota and activity for the whitefish trawlers (compared to Scenario D1) and less for the prawn trawlers. The overall improvement compared to Scenario C is still marked, however. Allowing for the prawn trawlers landing a significant quantity of undersize finfish does not greatly reduce the total operating profit or the total activity in days.

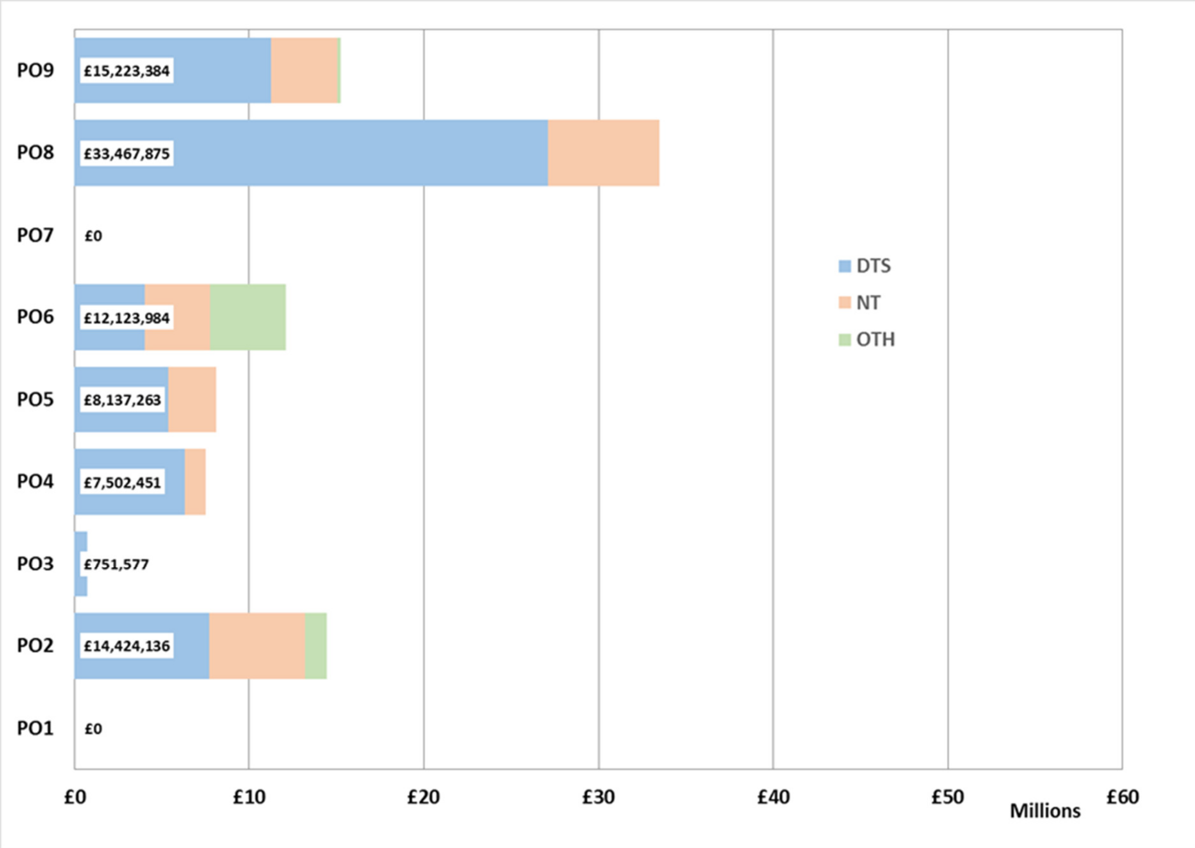

Figure 6.14. Scenario D2: profits for each PO and gear type

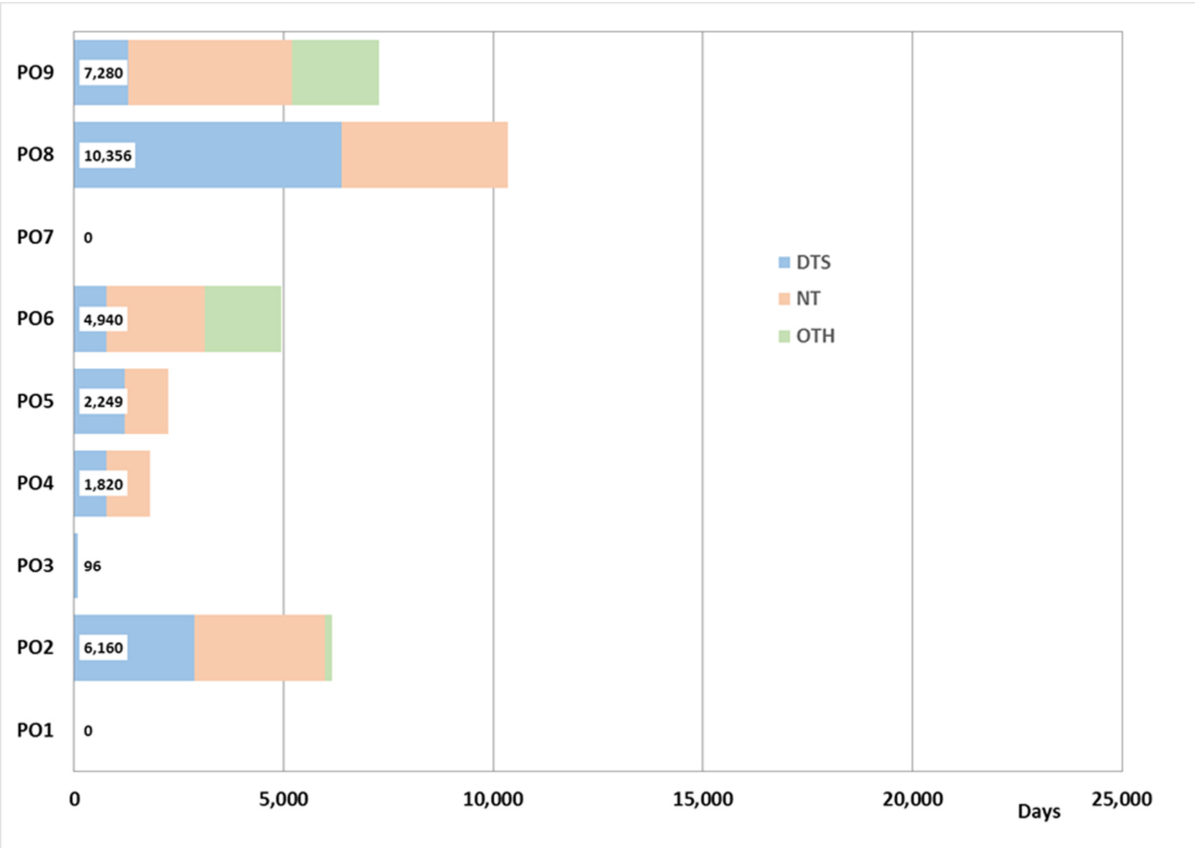

Figure 6.15. Scenario D2: fishing days for each PO and gear type

Scenario D3: As Scenario D1 but with whitefish revenues reduced by 75% for prawn trawlers

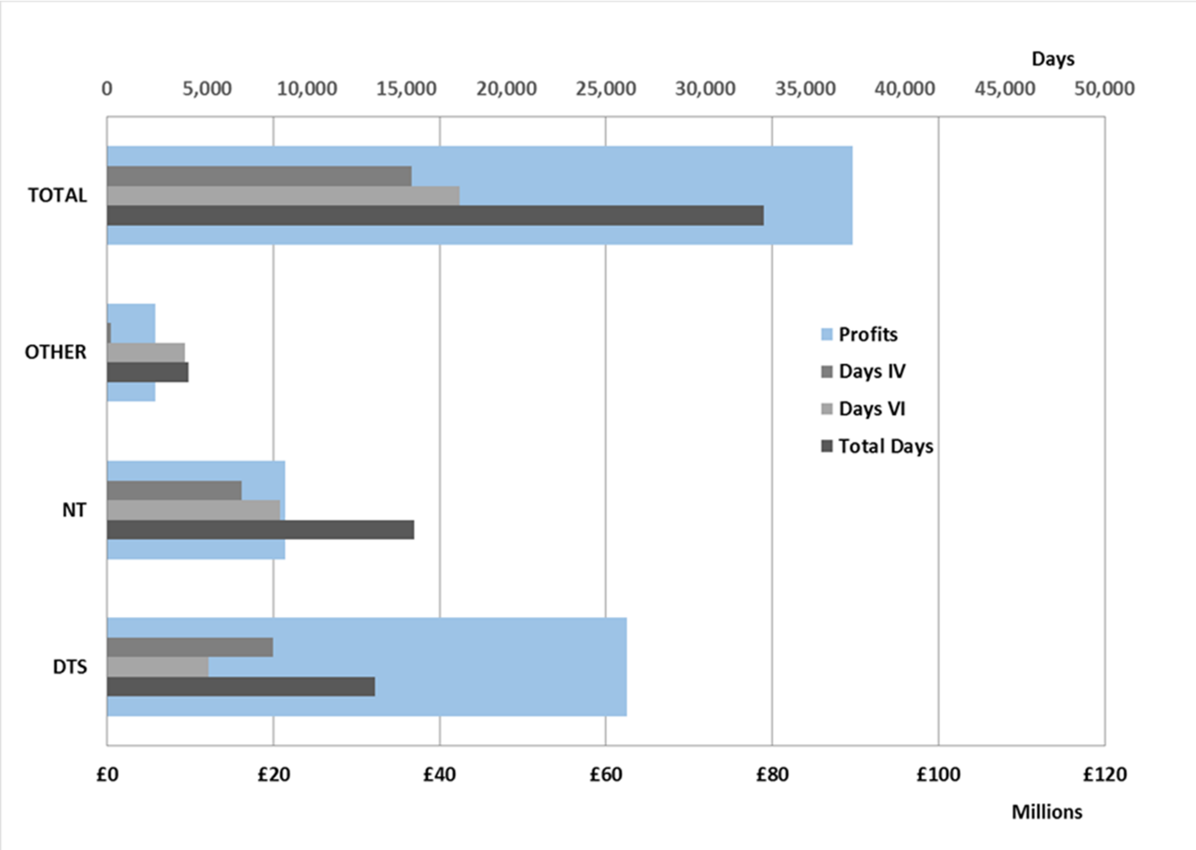

Figure 6.16. Total profits and days: Scenario D3

Under Scenario D3 total operating profits for the Scottish demersal fleet are just under £90 million and total effort (unchanged from D2) is nearly 33,000 days. These represent 75% of the profits and 73% of the total effort under Scenario A.

Fishing method	Effort in days	Operating profit (millions)
Demersal trawls/seines	13,409 (64%)	£62.5 (73%)
Nephrops trawls	15,412 (73%)	£21.4 (73%)
Other gears	4,080 (123%)	£5.8 (122%)
Total	32,901 (73%)	£89.7 (75%)

Table 6.6. Fishing effort and operating profits under Scenario D3 (% Scenario A)

With the assumption that only 25% of the whitefish landings by prawn trawlers are sold at the ex-vessel price for marketable fish, the optimal allocation of days and quotas across groups remains unchanged. This reflects the more profitable whitefish trawlers and selective gears fishing up to their maximum days in D2. Although the profits for the prawn trawlers are smaller compared to Scenario D2, the difference is relatively modest since the majority of these vessels' earnings come from *Nephrops*.

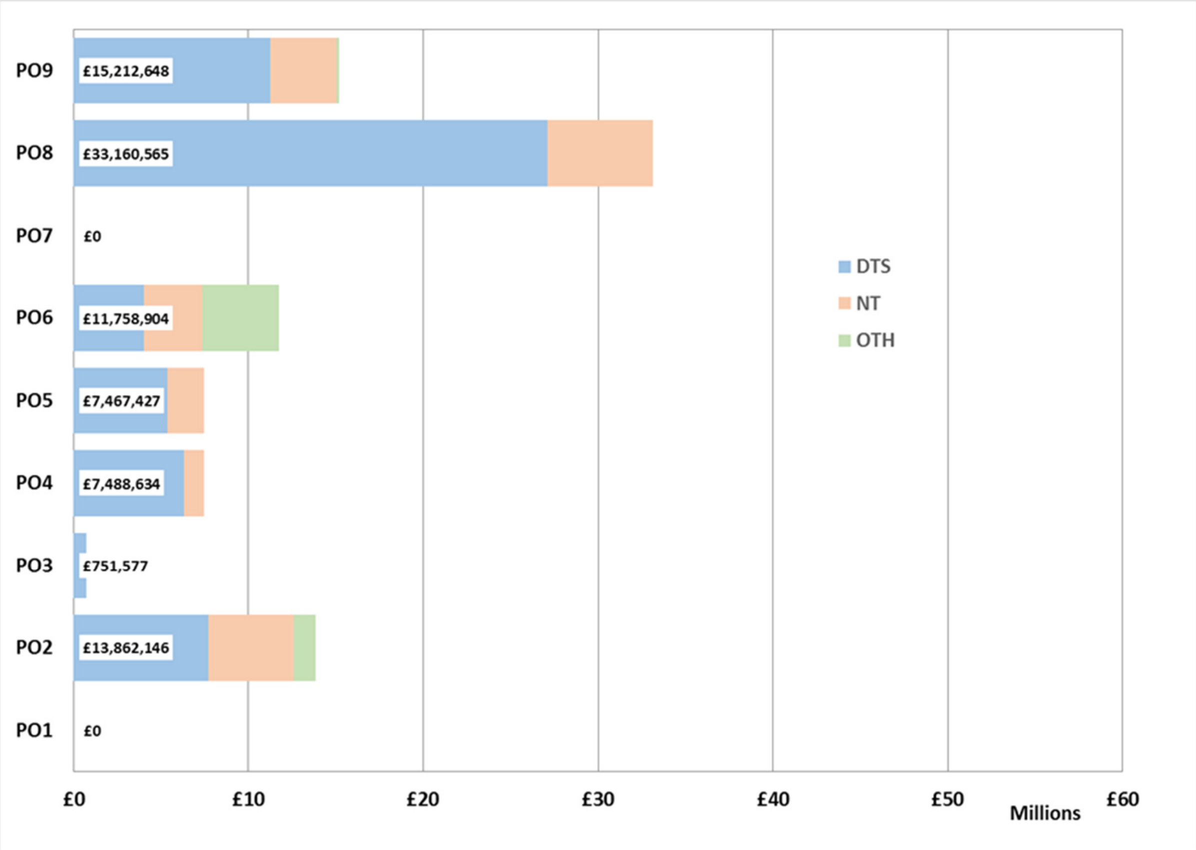

Figure 6.17. Scenario D3: profits for each PO and gear type

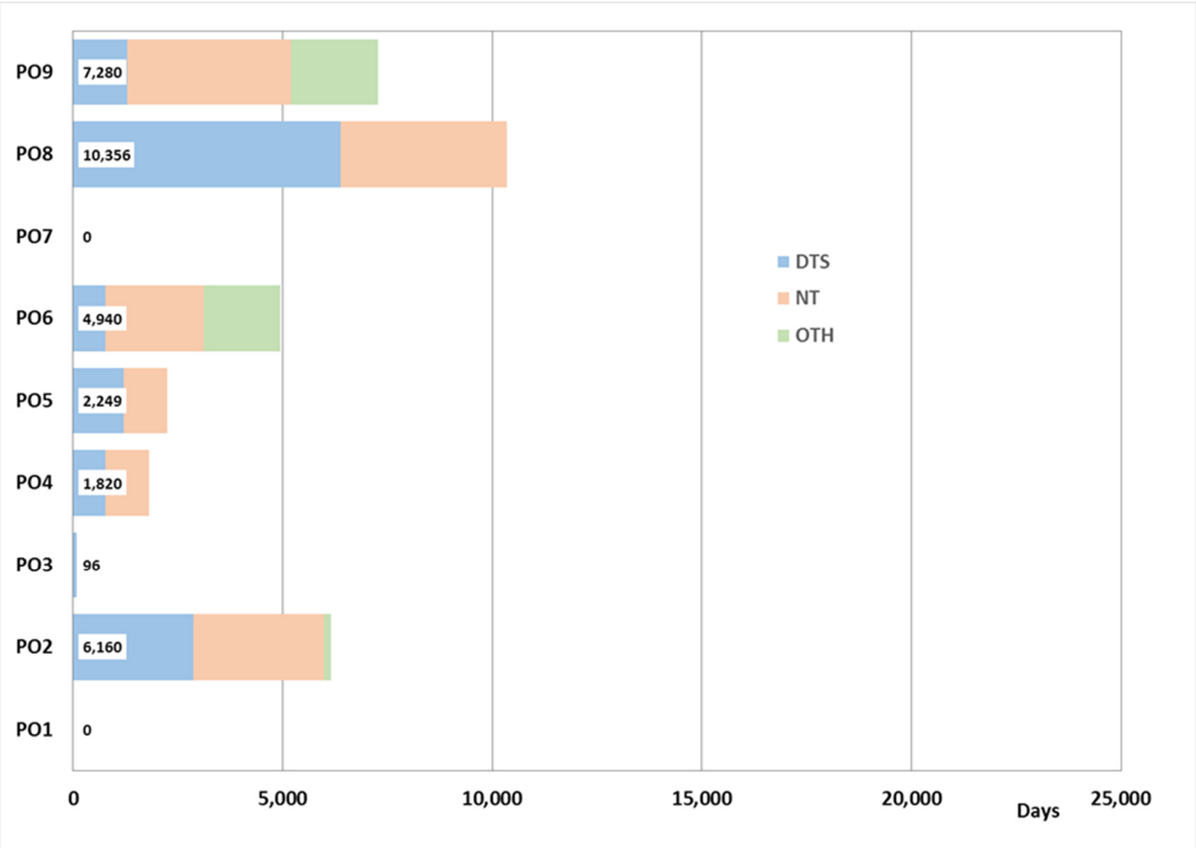

Figure 6.18. Scenario D3: fishing days for each PO and gear type

6.2 Choke stocks

Table 6.7 lists the choke stocks identified in the model under Scenario C for each PO and gear category, together with the number of fishing days compared to those recorded under Scenario A. The chokes identified vary by PO, although hake is the choke stock for all demersal trawls/seines fishing in the North Sea. Demersal trawls are mostly choked by haddock in Area VI, as are prawn trawls. In the North Sea *Nephrops* trawls are choked by cod in most cases. For the longliners and netters in PO6 the choke stocks are hake in the North Sea and monkfish in Area VI.

PO	Demersal trawls/seines		*Nephrops* trawls		Other gears	
	Area IV	Area VI	Area IV	Area VI	Area IV	Area VI
1	hake	haddock VIa	hake	haddock VIa	---	---
	383 (1,288)	81 (135)	0 (15)	0 (6)	---	---
2	hake	skates/rays	cod	haddock VIa	whiting	---
	232 (926)	43 (146)	31 (1,547)	3 (65)	19 (250)	---
3	hake	haddock VIa	---	---	---	---
	109 (414)	0 (22)	---	---	---	---
4	hake	haddock VIb	cod	skates/rays	---	---
	116 (299)	132 (250)	2 (78)	568 (558)	---	---
5	hake	haddock VIa	cod	haddock VIa	---	---
	774 (3,056)	44 (233)	3 (143)	0 (21)	---	---
6	hake	haddock VIa	cod	haddock VIa	hake	monkfish
	82 (330)	22 (313)	11 (549)	3 (875)	352 (626)	1,081 (1,339)
7	hake	haddock VIb	---	---	---	---
	742 (2,937)	32 (55)	---	---	---	---
8	hake	monk	cod	haddock VIa	---	---
	1,734 (6,796)	2,774 (3,438)	75 (3,716)	606 (10,977)	---	---
9	hake	haddock VIa	haddock	haddock VIa	---	---
	28 (109)	74 (156)	26 (89)	55 (2,474)	---	---

Table 6.7. Choke stocks under Scenario C with maximum days compared to 2015 days

With quota reallocation (Scenario D2), we can see from Figure 6.23 that the North Sea stocks fully utilised, and therefore constraining effort overall, were sole and hake. In Area VI the fully utilised stocks were haddock (VIa), saithe, sole and monk, with hake very close to full uptake.

Table 6.8 shows the optimal number of days calculated for each PO and gear category when quota is reallocated in order to maximise total industry profits under the Landing Obligation (Scenario D2). Quota is allocated by the model not just in order to avoid chokes where possible, but to where the quota is used most profitably, depending on both estimated catch rates and daily fishing costs. While, overall, effort has shifted from whitefish trawls towards *Nephrops* trawls, in some cases the whitefish trawlers have increased their effort. In general, however, there appears to have been a reallocation away from larger whitefish trawlers towards smaller vessels and *Nephrops* trawlers, and, in Area VI, longliners/netters and creels (for *Nephrops*).

PO	Demersal trawls/seines		*Nephrops* trawls		Other gears	
	Area IV	Area VI	Area IV	Area VI	Area IV	Area VI
1	0 (1,288)	0 (135)	0 (15)	0 (6)	---	---
2	2,860 (926)	0 (146)	3,120 (1,547)	0 (65)	180 (250)	---
3	0 (414)	96 (22)	---	---	---	---
4	780 (299)	0 (250)	780 (78)	260 (558)	---	---
5	0 (3,056)	1,209 (233)	1,040 (143)	0 (21)	---	---
6	780 (330)	0 (313)	1,300 (549)	1,040 (875)	0 (626)	1,820 (1,339)
7	0 (2,937)	0 (55)	---	---	---	---
8	3,895 (6,796)	2,489 (3,438)	0 (3,716)	3,972 (10,977)	---	---
9	0 (109)	1,300 (156)	520 (89)	3,380 (2,474)	0 (3)	2,080 (1,088)

Table 6.8. Optimal days under Scenario D2 compared to 2015 days

From the detailed modelling results we find that quota reallocation markedly improves overall quota utilisation: total landings across all species increases from 32,790 tonnes under Scenario C to 68,861 tonnes under Scenarios D2/D3.

Figures 6.19-6.24 on the following pages show quota uptake (and discards, where permitted) for each quota stock in the model under the different modelling scenarios. Where quota uptake is less than 100% of the total quota (for the Scottish sector) this will show as a lighter area at the top of the respective column. Estimated discards are shown as thin black columns (Figure 6.19). The stock codes used are as follows:

Stock code	Stock	Stock code	Stock
NSCOD	North Sea cod	COD6A	West of Scotland cod (area 5B/6A)*
NSHAD	North Sea haddock	COD6B	West of Scotland cod (area 6B)*
NSWHG	North Sea whiting	HAD6A	West of Scotland haddock (area 5B/6A)
NSPOK	North Sea saithe	HAD6B	West of Scotland haddock (area 6B)
NSPLE	North Sea plaice	WSWHG	West of Scotland whiting*
NSSOL	North Sea sole	WSPOK	West of Scotland saithe
NSHKE	North Sea hake	WSPLE	West of Scotland plaice
NSNEP	North Sea *Nephrops*	WSSOL	West of Scotland sole
NSANF	North Sea anglerfish (monk)	WSHKE	Western hake
NSLEZ	North Sea megrim	WSANF	West of Scotland anglerfish (monk)
NSLEM	North Sea lemon soles and witches	WSNEP	West of Scotland *Nephrops*
NSSRX	North Sea skates and rays	WSLEZ	West of Scotland megrim
NSDAB	North Sea dabs and flounders	WSPOL	West of Scotland pollack
NSTUR	North Sea turbot and brill	WSSRX	West of Scotland skates and rays
NSLIN	North Sea ling	WSGHL	Greenland halibut
NSTUS	North Sea tusk	WSLIN	West of Scotland ling
		WSTUS	West of Scotland tusk
			*zero TAC stock

Important: In order to depict the results for relatively large and small quotas on the same charts, a log scale is used for the quantities in tonnes (thus the vertical scale goes from 1-10, 10-100, 100-1,000 and 1,000-10,000). As a result, some care should be taken in interpreting the charts. For example, a relatively modest level of discards may look considerable against the total quota, while a quite significant change in uptake of a large quota stock may appear as a rather small difference on the chart.

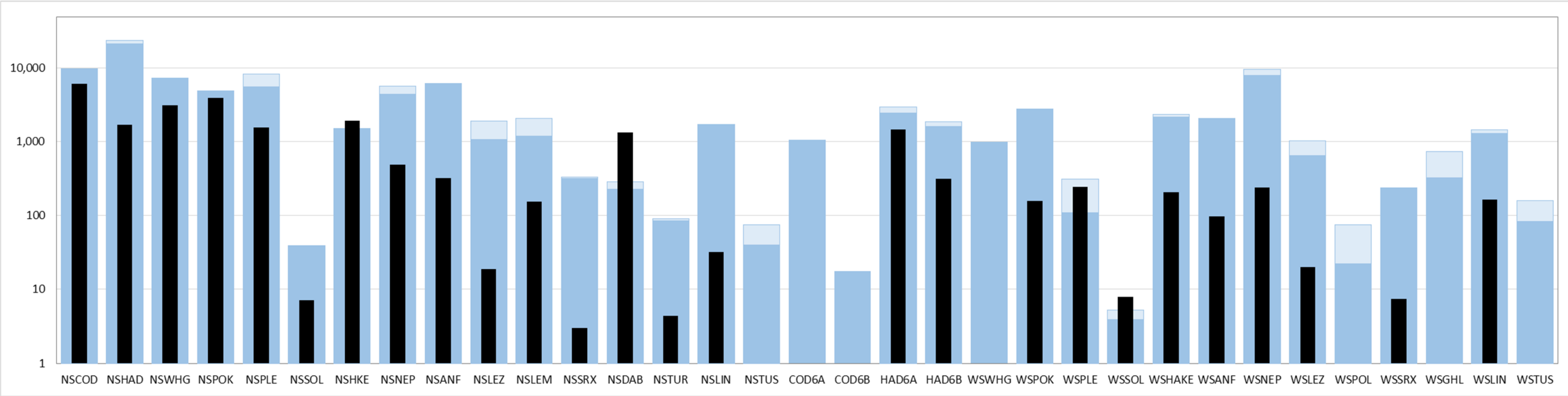

Figure 6.19. Quota uptake and estimated discards (in tonnes) under Scenario A

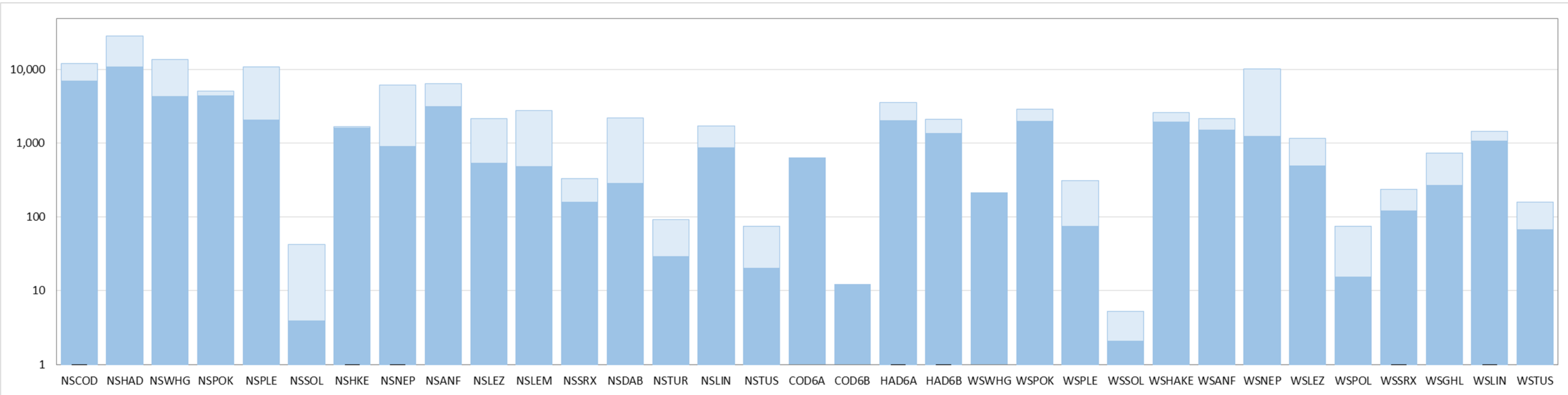

Figure 6.20. Quota uptake (tonnes) under Scenario B

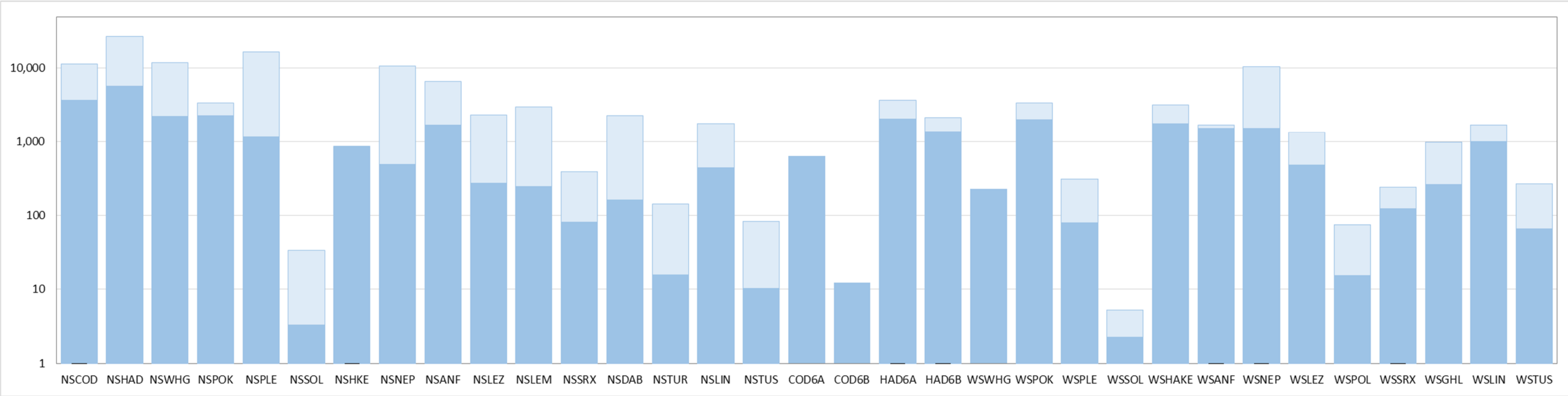

Figure 6.21. Quota uptake (tonnes) under Scenario C

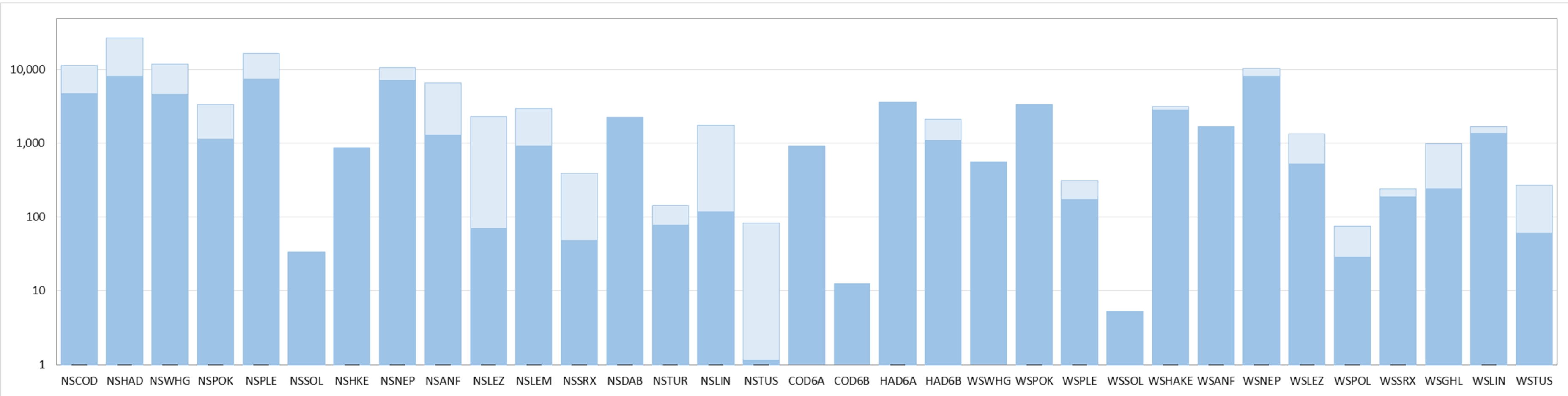

Figure 6.22. Quota uptake (tonnes) under Scenario D1

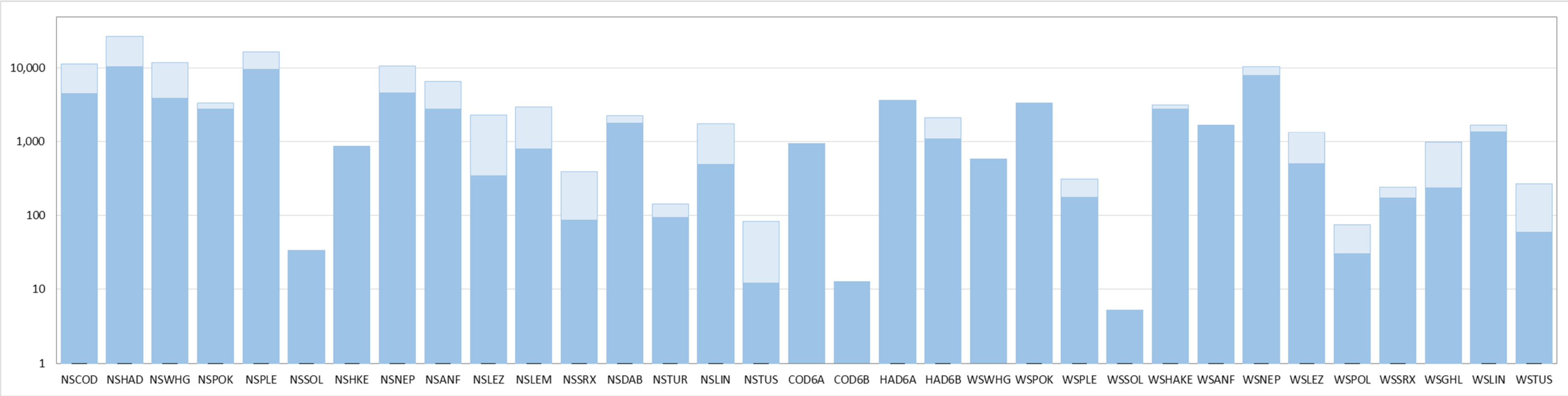

Figure 6.23. Quota uptake (tonnes) under Scenario D2

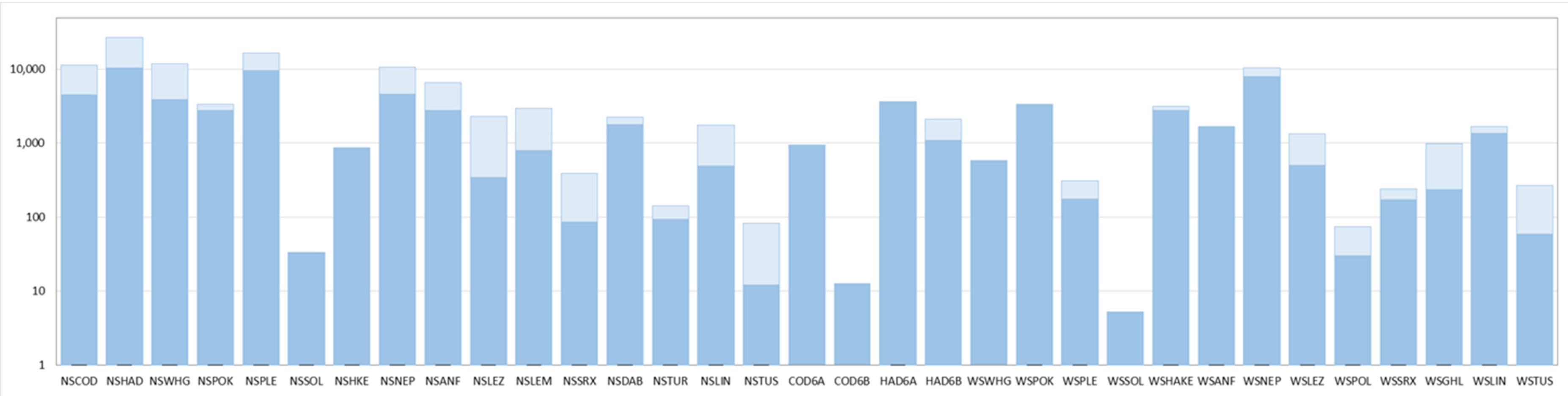

Figure 6.24. Quota uptake (tonnes) under Scenario D3

7. Conclusions

It is clear that choke problems which *persist* at the aggregate level (whether EU, national or sectoral), assuming that they cannot be solved through quota reallocation, or changes in gear selectivity or fishing behaviour, will only be avoided if the TAC or the national quota share is increased or removed.

The question this study attempted to answer was the extent to which, given the current distribution of national quotas, a more efficient allocation of quota at the (Scottish) industry level could help alleviate or reduce the currently anticipated choke problems arising from the Landing Obligation. The modelling results suggest that this is possible, although the results should be seen as illustrative rather than predictive of the gains that could be made by making quota allocation more efficient.

The results from the model, particularly for the reallocation of quota, should be interpreted with care for a number of reasons.

Firstly, the model can only reallocate quota between *groups* of vessels (by PO and gear type), not individual vessels, based on the average catch rates and fishing costs for each group. Related to this, the model only estimates activity for each group of vessels in terms of fishing days, not numbers of active vessels.

Secondly, the results are based on 2015 patterns of effort and landings. Quotas are also at 2015 levels and adjustments for international swaps are estimated rather than recorded. Quota uplifts are estimates based on the estimated uplifts used by Seafish in their current work on the Landing Obligation and are simply applied *pro rata* to all groups.

In addition, the model is sensitive to estimated daily fishing costs as well as to catch rates. If fishing costs are over- or under-estimated for any groups of vessels then this will affect the profitability calculations and hence the optimal distribution of quota and days. Also, only average ex-vessel prices are used to estimate revenues: it was not possible to model higher or lower market prices for the landings of particular vessels or groups of vessels. Thus it was only possible to model *average* revenues, costs and catch rates for each gear type within each PO. In reality some vessels will be more or less profitable than the average within all groups. It is very unlikely in practice that quota would be reallocated away from entire groups of vessels or POs as is the case in the results for Scenarios D1-D3.

Estimated discard rates are based on aggregate data (from ICES/JRC) although the estimates used are specific for each sea area and gear category and, wherever possible, are based on data for UK vessels. While these are the best estimates that are available (the same estimates as used by Seafish) they may under- or over-estimate discard rates for some specific groups of vessels represented in the model.

There were no data available to the study on which to estimate the proportion of juvenile and undersized fish (below MCRS) in the estimated catches for different gears. By default, all fish previously discarded is assumed to be landed and sold at the same price as fish of marketable size. Clearly this will overestimate revenues and profits overall, but will do so to a greater or lesser extent for particular groups of vessels.

To the extent that some groups have *higher* rates of discards of undersize fish (and correspondingly higher estimated catch rates) the model results for quota reallocation might therefore be biased in favour of these vessels. This partly explains why the efficient quota allocation favours *Nephrops* trawls to the extent that it does in Scenario D1. However, the results for Scenarios D2 and D3, where the model is run again with finfish revenues reduced by 50% and 75% for prawn trawlers (reflecting the possibility of significant landings of undersize fish) suggest that the gains from quota reallocation remain considerable

Finally, fishing behaviour patterns and selectivity are assumed to remain as they were in 2015. No allowance could be made in the model for changes in relative catch rates in response to the Landing Obligation.

Nevertheless, the model results do suggest that economic outcomes, including overall quota utilisation, under the Landing Obligation could be significantly improved with quota reallocation. The implication is that the industry should be able to move quota between vessels much more easily than is the case at present. Since in practice quota *is* transferable between vessels under the UK's sectoral quota management system, it is arguable that *in-year* quota transfers at least (through leasing, for example) should be much easier to effect. The details of the necessary policy changes and institutional arrangements lie well beyond the scope of this study, but some sort of centralised platform for real-time quota transfers and exchanges would seem to be necessary to enable quick and efficient quota reallocation. This could be an area for further consideration by Government and industry.

The significance of *international* quota swaps for the Scottish industry is also highlighted by the study. Given the uncertainties created by Brexit, it is difficult to expand much on this point, but clearly the question of flexibility in international quota allocation is important for the industry and is likely to remain so whatever the UK's future relationship with the EU.

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