Logistical research into generating ecosystem benefits from at-sea fish offal

September 2024

Natural England Commissioned Report NECR531

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Approaches to offsetting anthropogenic impacts to seabird populations remain largely novel and untested. Increasing food availability to improve reproductive success or survival in seabirds is an option that is to be explored in this project. In order to make evidence-based decisions about the technical feasibility, likely effectiveness and ecological consequences of such measures, Natural England commissioned this report to gain a better understanding of whether it is theoretically possible to provision UK seabirds with offal as a way of increasing food availability.

Executive summary

The provision of fish offal (internal organs removed whilst ‘gutting’ fish) for supplementary feeding at sea may benefit some seabirds and could be specifically targeted to improve the productivity and survival of certain species.

This report provides an overview of offal production at sea to understand current practices, quantities, and composition. It includes considerations for at-sea offal retention, including logistical, legal, health and safety, and costs, and highlights knowledge gaps.

In 2020, UK vessels landed 378.8 thousand tonnes of sea fish into the UK with a value of £601.5 million. The largest quantity of landings were pelagic fish at 143.5 thousand tonnes (38%), demersal fish landings were 122.7 thousand tonnes (32%) with shellfish comprising 112.6 thousand tonnes (30%).

The difference between the catch weight and landed weight is used as a basic estimate of at-sea offal from demersal species. The estimated quantity of at-sea offal production is almost 28 thousand tonnes per year from all UK fishing areas. The North Sea is the main source of at-sea offal (41%) with nearly 11.5 thousand tonnes produced across the three sub-areas:

- The Northern North Sea (sub area IV.a) estimated at 10,641 tonnes per year.
- The Central North Sea (sub-area IV.b) estimated at 746 tonnes per year.
- The Southern North Sea estimated at 99 tonnes per year.

Vessels over 10 metres length overall, which catch demersal finfish species using seine and trawl are the source of most at-sea offal.

A case study based on the black-legged kittiwake (*Rissa tridactyla)* breeding at the Flamborough and Filey Coast Special Protection Area (FFC SPA) in sub-area 27.IV.b (central North Sea) is used to consider whether at-sea offal is a potential source for supplementary seabird feeding.

Three scenarios have been developed to consider changing current at-sea practices. The scenarios range from minimal intervention compared to current practice through to significant additional activities.

- Scenario 1 involves macerating/mincing offal into smaller pieces and using this for seabird feeding during steaming. This is a change to onboard practices, but not fishing pattern.
- Scenario 2 assumes vessels retain offal on-board for later disposal at sea within the feeding ranges of seabird colonies. Unless vessels travel through the foraging ranges as part of their return to home port, additional costs for steaming to those feeding areas and the inconvenience of more time to return to port is expected.

- Scenario 3 is the most significant intervention as it involves the collection of offal from vessels (either at sea or in port) by a vessel specifically commissioned and outfitted for the task. However, this scenario does not require a change in fishing pattern.

Assuming 50% of estimated at-sea offal from area 27.IV.b could be collected and made available for supplementary feeding, this amounts to just over one tonne per day. It is perhaps more realistic to consider a project involving offal derived from the North Shields fishing fleet (the largest nearby fleet catching demersal fish that are gutted at sea), but the average volume offal reduces to 250 kg per day. As this supply is dependent on fishing patterns, the amounts would not be consistent during key periods for supplementary feeding, such as the breeding season.

The assumptions used in the scenarios and the case study suggest that to deliver substantial amounts of offal consistently over the breeding season and other key periods of the year for supplementary feeding, would require aggregating at-sea offal from sea areas outside area IV.b and this could only be achieved with Scenario 3.

Collecting from the much larger volume of at-sea offal produced from Area 27.IV.a would require land-based aggregation of offal. This is more feasible than at-sea collection (i.e., transshipment), which would also be a control risk for fisheries enforcement.

For fishers there must be sufficient incentive to retain the offal onboard and land it, i.e., an adequate price paid for the offal. There may also be additional costs in separating these materials on board to avoid compromising the quality of their catch. It is useful to consider the current market for bait as a comparison for how this could work.

Other factors to consider include food safety, vessel design, crew workload and unintended consequences of dispersing offal in different locations. Current regulations and policy around fishery management, animal by-products, food hygiene and marine licensing are also crucial factors to consider. The current regulatory framework allowing disposal of offal at sea without a marine license does not anticipate this use of at-sea offal. Scenario 3 is therefore likely to require licensing for landing, aggregating, and targeted ‘disposal’ of offal at sea.

With the UK withdrawal from the EU, there will continue to be phased changes in legislation and expectations for greater access to UK fishing areas and differences in share of quota in subsequent years. The rules and exemptions around the landing obligation could change. These could all provide opportunities for accessing greater quantities of at-sea offal in future, or the ability to provide a framework to remove any legislative barriers.

Contents

1. Introduction

In 2020, capture fisheries contributed 90 million tonnes of the 178 million tonnes of global production of aquatic animals (FAO, 2020). However, it is estimated that up to 35 percent of the global fisheries and aquaculture production is either lost or wasted every year (FAO, 2020).

A proportion of this global loss is realised through at-sea processing of fish and shellfish. Typically, this involves the removal of offal and other parts from marketable fish during catch sorting and cleaning. The intestines, which are seen as a waste product in many fisheries, are predominantly dumped at sea but could be further used, including as a food source for seabirds. The quantities of intestines and other parts of fish and shellfish removed at sea are broadly calculated as 1.5 to 25 million tonnes globally (Archer, 2022).

Provision of offal may benefit some seabirds, potentially helping to offset predicted losses due to impacts from human activities, without the sustainability concerns presented by other forms of supplementary feeding.

This project was commissioned to gain an understanding of whether it is possible to provision UK seabirds with fish offal from fishing vessels registered and landing in the UK.

This report aims to provide:

- A better understanding of whether it is theoretically possible to provision UK seabirds with offal. This requires information on the amount of offal available and consideration of the logistics involved in using it to provision seabirds.
- Current offal discard practices in UK waters (what is it, how much, where discarded, when discarded, vessel types, vessel origin) and key logistical considerations such as transport options (including trans-shipment of offal), legal and health and safety considerations, likely costs, and incentives).

2. Methodology

The scope of the project focused on the UK wild capture fisheries sector, prioritising catch areas within the North Sea.

- **In scope** includes UK vessels landing into the UK, including the UK demersal fleet.
- **Excluded from the scope** are whole fish discards / by-catch, species returned to sea alive, species groups landed whole (including pelagic species, molluscan shellfish, live crustacea), tails of *Nephrops norvegicus* (heads/claws which are not a target food source for seabirds), foreign vessels landing in the UK, UK vessels landing abroad.

2.1. Literature search

A literature search was undertaken between December 2022 to February 2023 to source published information on the following:

- Fishery and vessel data including UK catch and landings, vessel types, sizes, fishing gear types, fishing regions and areas.
- Fish products including by-product yields, at-sea processing, at-sea offal, composition of by-products.
- Policy and legislation relating to at-sea offal, at sea uses of offal, animal feeding.

2.2. Fishing data and statistics

Monthly and annual statistics are collected by the four fishery administrations in the UK. The Marine Management Organisation (MMO) collates the fishery data into annual data sources. These include the following data;

- Fishing vessels; number, size, fishing gear used.
- Data on fish and shellfish catch weights, landed weights, value.
- Fishing regions and areas.

Annual fishing data remains provisional until all data are verified, and any adjustments made. To ensure only finalised data was used in this report, annual data from 2016 to 2020 inclusive was obtained from the MMO. Five-year data provides a meaningful basis for calculating annual averages and identifying trends.

Other national datasets on the fishing industry were used to supplement the MMO data.

Estimations of at-sea offal were made using two approaches:

- Deducting the weight of fish landed onshore (landed weight) from the live weight of the fish catch. This assumes the difference is solely due to processing at sea i.e., removal of offal. This is a legitimate assumption for many species, however for some species, where there are exemptions under the landing obligation, a proportion of this difference will be due to discarding of unwanted catch.

- Using the live weight of fish, information gathered from industry sources on fishing practices and average gutting yields, to calculate the amount of at-sea offal. However, this approach created too many uncertainties and margins of error due to a lack of data for all fish, variability between species and variations in at-sea processing at different times of the year. As such it was not progressed.

2.3. Spatial mapping of fishing intensity

Publicly available data sets from the MMO were analysed, in addition to data acquired through specific requests from the European Maritime Safety Agency (EMSA). Fishing activity and intensity were analysed using Vessel Monitoring System (VMS) data and fishing vessel movements were analysed using Automatic Identification Systems (AIS) data. The following data were used:

- VMS data from the MMO for UK fishing vessels over 15 meters (m) in length operating between 2016 to 2020. This data records the time (in minutes) fished by specific gear types as a measure of fishing intensity and is linked to the live weight (in tonnes) landed by vessels.
- AIS data from EMSA for both UK and EU fishing vessels over 15m in length operating in 2021. AIS data provides an overview of fishing vessel route traffic. AIS data does not distinguish actively fishing vessels, but it does show vessel movement, including transiting to and from fishing grounds. This information highlights areas of high vessel transit, which could act as suitable *gathering points" for aggregation of offal from various vessels.

The data was collated using ArcMap Geographic Information System (GIS) software and presented as separate GIS layers, providing a visualisation of fishing activity and vessel transit across the study area.

2.3.1 Data Limitations

Spatial analysis of fishing activity by UK vessels, was conducted using VMS datasets only for vessels over 15m. VMS datasets produced by MMO for UK vessels over 15m are the most accurate and high-resolution datasets available for spatial analysis of fishing activity; they show within each ICES rectangle, where vessels are operating by times fished and linked with the live weight landings. This data can be disaggregated by gear type, but these datasets do not include the species landed and so it is not possible to determine what offal these landings may represent.

Datasets are available for vessels between 10 to 15m in length, but these are of a significantly lower resolution; they provide a general overview of activity by ICES rectangle and cannot show where within each ICES rectangle vessels are operating. For this reason, these datasets were not used in the spatial analysis, but these smaller vessels are expected to fish in similar areas to the larger vessels of the same gear type.

As inshore VMS (i-VMS) systems are in the process of being rolled out to UK registered vessels under 10m, no VMS datasets for UK vessels under 10 meters are available for spatial analysis of fishing activity at this time. Landings information is used to estimate offal from the under 10m fishing fleet, which shows they are predominantly targeting shellfish and account for a very small proportion of at-sea offal generated by the UK fleet (see Figure 9).

2.4. Insight from the catching sector

To obtain commercial knowledge on at-sea offal, a standard set of questions was developed (Annex I). Short telephone or online interviews were held with four stakeholders, each with detailed knowledge of the UK catching sector and at-sea practices. This included a representative of the Scottish White Fish Producers Association, a former commercial fisher / skipper and regional advisers from the Sea Fish Industry Authority.

Information was gathered on existing practices, regional variations and species processed at sea. Feedback was sought on challenges of changing current practices.

Information from the interviews was cross-referenced with catch and landings data to provide context for estimates. The information is used at various points in this report.

3. Commercial fishing in the UK

This section includes information about UK commercial fishing including areas fished, fish catch and landings data, and information about the UK fleet. Data in this section is from the MMO annual fishery statistics 2021 unless stated otherwise. This data source includes updated datasets for 2016 to 2020. This five-year dataset is used to provide an average per year, where applicable.

Terms relating to fishing vessels, fishing gear and fishing areas are provided in the glossary and Appendix II. Additional information such as time at sea and crew sizes are also included for reference. Fish scientific names are included in Appendix III.

3.1. The UK catching sector

3.1.1. Annual catch and landings

In 2020, UK vessels landed 378.8 thousand tonnes of sea fish into the UK with a value of £601.5 million.

The largest quantity of landings were pelagic fish at 143.5 thousand tonnes, 38% of landings into the UK, by UK vessels. Demersal fish landings were 122.7 thousand tonnes (32% of the UK vessels landing into the UK) with shellfish comprising 112.6 thousand tonnes (30%).

At the end of a fishing trip, a fishing vessel will return to shore to offload its catch. This offloading is undertaken at a port, harbour or landing site. Larger vessels will typically land their catch to a port or harbour, smaller vessels can land and offload at ports, harbours, or much smaller landing sites such as jetties and beaches.

Most demersal and pelagic fish (by weight and value) are landed into ports or harbours in Scotland, with the majority of shellfish (by weight) landed into England. (Table 1).

Table 1 Fish and shellfish landings by UK vessels into regions of the UK

	England	Wales	Scotland	Northern Ireland	Total
Demersal quantity (000 tonnes)	25.3	0.6	95.2	1.5	122.7
Demersal value (£ million)	71.5	1.9	169.4	1.9	244.7
Pelagic quantity	11.4	--	125.5	6.6	143.5

	England	Wales	Scotland	Northern Ireland	Total
(000 tonnes)					
Pelagic value (£ million)	4.2	--	104.2	4.2	112.7
Shellfish quantity (000 tonnes)	59.6	6.1	36.3	7.0	112.6
Shellfish value (£ million)	111.2	10	104.3	13.3	238.8

Source: MMO 2020

3.1.2. Landings information by vessel monitoring system data

Fish catches are recorded from specific areas and sub-areas of the sea. Area 27 is the Northeast Atlantic. Most fish landed into the UK, by UK vessels, are caught in the North Sea (sub-area 27.IV).

Figure 1 shows the average annual landed live weight (Tonnes) made by UK vessels between 2016 and 2020 across area 27. It provides a useful proxy for estimating fishing intensity across the sub-area during this period. Areas of lower landed live weights may indicate areas of lower fishing intensity, whilst areas with higher landings may indicate more intensely fished areas.

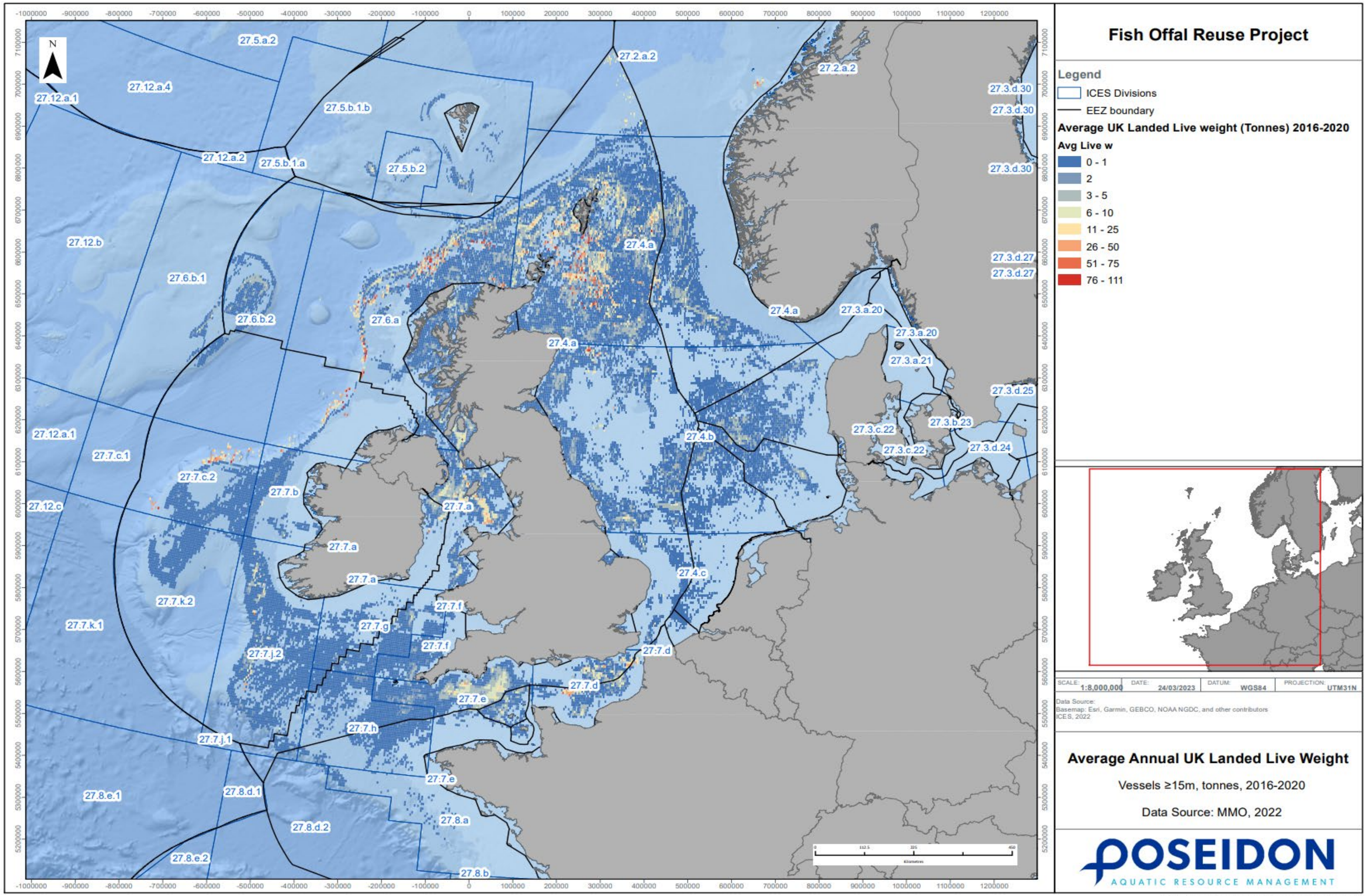

Figure 1 Average annual landed live weight (Tonnes) by UK vessels over 15 meters within area 27 (between 2016-2020) (MMO, 2022)

3.1.3. Demersal catch and landings

The UK demersal catch and landings are the primary focus of this report. Most demersal fish landed into the UK, by UK vessels, are caught in the North Sea (sub-area 27.IV), with smaller quantities caught in other sub-areas (Figure 2).

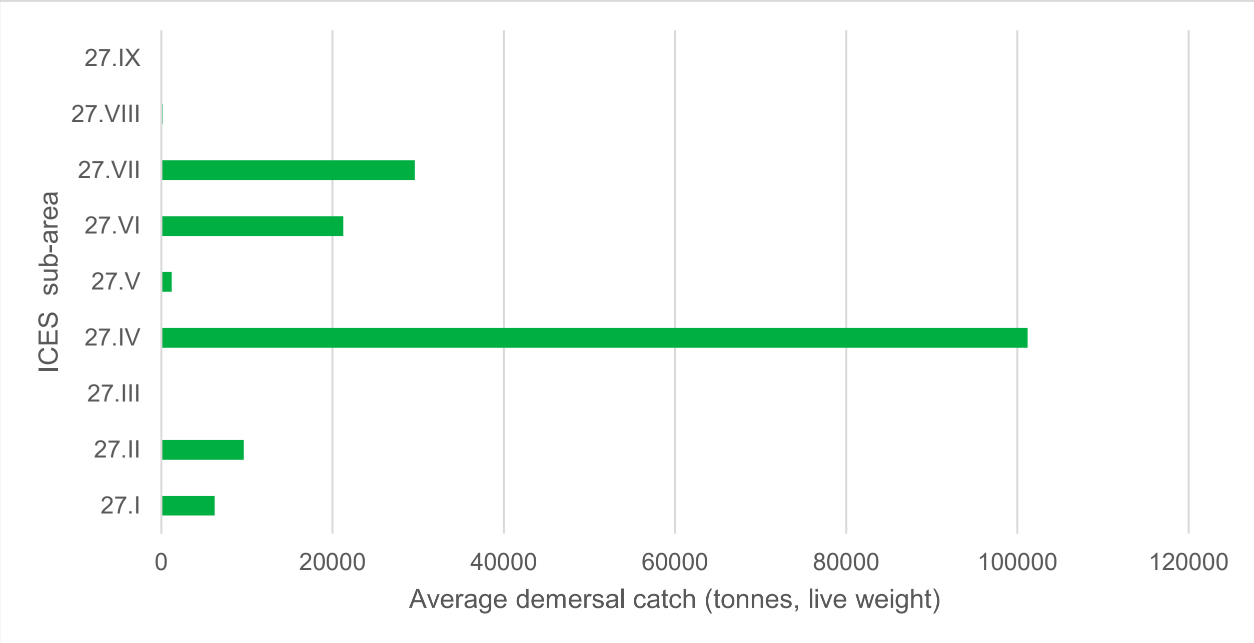

Figure 2 Average annual demersal catch by UK vessels landing into the UK, by catch sub-area (2016-2020) (MMO, 2020)

The quantity of demersal fish caught varies by species (Table 2). Typically, demersal species with a higher catch quantity are much more commercially important than other species, which are caught in smaller quantities. Commercially important species are typically subject to an annual quota, limiting the total quantity of that species that may be fished.

Table 2 Top twenty-five species (by weight) of demersal fish caught by UK vessels landing into the UK (average tonnes per year, 2016-2020)

	Is the species subject to a quota?	Average annual weight of fish catch (Live weight, tonnes)	Average annual weight of fish landed (Actual weight, tonnes)
Cod	Yes	32169.5	21998.4

	Is the species subject to a quota?	Average annual weight of fish catch (Live weight, tonnes)	Average annual weight of fish landed (Actual weight, tonnes)
Monks or Anglers	Yes	18962.8	13436.4
Haddock	Yes	33307.5	29192.9
Saithe	Yes	13549.2	11208.7
Hake	Yes	12214.3	10909.9
Skates and rays (comprising Thornback ray, Blonde ray, Cuckoo ray, spotted ray, long-nosed skate)	Yes	2810.3	1962.2
Ling (comprising Ling, blue ling)	Yes	6171.5	5374.9
Plaice	Yes	13665.4	13010.6
Whiting	Yes	11793.2	11181.4
Pollack	Yes	1817.5	1555.1
Megrim	Yes	4791.1	4535.1
Redfishes	No	489.3	308.6
Catfish	No	600.2	471.6
Lemon Sole	Yes	2005.1	1907.3
Dogfish (Lesser Spotted Dog, Smoothhound)	Part	2092.6	2014.4
Sole	Yes	1895.1	1824.0
Witch	Yes	1238.0	1167.5
Turbot	Yes	822.4	756.1

	Is the species subject to a quota?	Average annual weight of fish catch (Live weight, tonnes)	Average annual weight of fish landed (Actual weight, tonnes)
Halibut (comprising Halibut, Halibut - Greenland)	Yes	460.9	411.6
Dabs	Yes	465.3	429.6
Brill	Yes	441.6	406.2
Conger Eels	No	214.3	193.0
John Dory	No	252.9	232.5
Torsk (Tusk)	No	130.8	114.5
Greater Forked Beard	No	110.7	99.7

Source: MMO 2020, Cefas, 2021.

Demersal fish landings follow the same pattern as the overall UK in that the majority, by weight and value, are landed into Scotland (Table 3). Small quantities of demersal fish are landed across the UK into smaller ports or landing areas. For data collection purposes these are allocated to the nearest 'designated' fishing port or harbour.

Table 3 Top thirty ports (by weight) for landings of demersal fish caught by UK vessels landing into the UK (average tonnes per year, based on 2016-2020)

Port / landing site	Weight of demersal fish landed (Tonnes, live weight equivalent)	Percentage of demersal landings from UK vessels landing into the UK
Peterhead	47.7	35.7%
Scrabster	13.2	9.8%
Lerwick	11.0	8.2%
Fraserburgh	8.0	6.0%

Port / landing site	Weight of demersal fish landed (Tonnes, live weight equivalent)	Percentage of demersal landings from UK vessels landing into the UK
Kinlochbervie	7.4	5.5%
Ullapool	7.3	5.4%
Others	7.0	5.3%
Scalloway And Isles	6.4	4.8%
Newlyn	6.3	4.7%
Brixham	5.0	3.8%
Hull	3.4	2.5%
Cullivoe	2.7	2.0%
Kilkeel	1.4	1.1%
Plymouth	1.3	1.0%
Grimsby	1.0	0.7%
Milford Haven	0.6	0.4%
Mevagissey	0.6	0.4%
Mallaig	0.5	0.3%
North Shields	0.5	0.3%
Shoreham	0.4	0.3%
Portavogie	0.4	0.3%
Ardglass	0.3	0.2%
Hartlepool	0.2	0.1%
Blyth	0.2	0.1%
Buckie	0.2	0.1%
Scarborough	0.2	0.1%

Port / landing site	Weight of demersal fish landed (Tonnes, live weight equivalent)	Percentage of demersal landings from UK vessels landing into the UK
Eastbourne	0.1	0.1%
Weymouth	0.1	0.1%
Portsmouth	0.1	0.1%
Whitehaven	0.1	0.1%

Source: MMO 2020

Fishing vessels are registered to a 'home' port as dictated by their port letter number. This relates to the fishery administration under which they are licensed / registered. However, they may not land their catch at their home port. They are permitted to land at other ports subject to local rules. The quantity of fish caught and landed will be recorded for the vessel but assigned to the port to which it is landed. After landing, catches of fish may be sold locally, or be loaded for transport to other locations. This includes to another UK port for auction, directly to a buyer for them to process or trade, or even exported.

3.1.4. Fleet and vessel size

Vessel size can be described by gross tonnage, engine power (kW) or length overall (LOA). For the purposes of this report LOA is used.

Standard length classes exist to understand vessel size, with under 10 metres and over 10 metres most used. The UK commercial catching sector is typified by many small vessels, however larger vessels catch most of the fish and shellfish by both quantity and value. (Tables 4 and 5).

Table 4 Number of registered fishing vessels, by LOA and country of administration (2020)

	England	Wales	Scotland	Northern Ireland	Total
10 metres and under	2,300	375	1,589	199	4,463
Over 10 metres	499	28	550	126	1,203

Source: MMO 2020

Table 5 Quantity and value of landings, by vessel size group (2020)

Vessel length	Quantity (‘000 tonnes)	Value (£ million)
10 metres and under	35.1	99.6
Over 10 metres	580.6	731.3

Source: MMO 2020

3.1.5. Fishing methods

Fishing fleet segments are categorised according to the method used to catch fish i.e., the fishing gear (FAO, 2016. European Commission, 2016, repealed). The following are main European categories for the purpose of data collection, but there are many more subcategories, variations of fishing gear (see Appendix II) plus variations in the UK.

- Beam Trawl*
- Demersal Trawl/Seine *
- Dredge
- Pelagic
- Polyvalent - Mobile gears only
- Drift & Fixed Net
- Gears using hooks.
- Pots & Traps
- Polyvalent - Passive gears only
- Polyvalent - Mobile and Passive gears
- Purse Seine*
- Scottish seine*

For the purposes of this report, the fishing fleet segments marked with an asterisk are of most relevance.

3.1.6. Processing at sea

After capture, some species of fish and shellfish may undergo some form of processing (product transformation) at sea. However, this varies depending on the main species group (pelagic, demersal, molluscan shellfish, crustacea), species type (some demersal fish are more processed more than others), fish length (whether small or large), geographic location (variations in practices in different part of the UK fleets), and market preferences. Other factors include fishing season (for example fish roes vary in size at different times of the year), and availability of markets.

Processes that may be undertaken at sea are detailed in Table 6.

Table 6 Processes that may be undertaken at sea.

Type of processing	Parts of fish removed
Evisceration (gutting)	Viscera comprising the intestines, liver, roe, reproductive organs, blood.
De-heading	Head
Skinning	Skin

Gill removal	Gills
Filleting	Everything other than the fillet or portion destined for human consumption. Depending on the type of product can also include trimmings, bones,

In the UK, the most common process undertaken at sea is gutting, typically only on demersal species.

Common variations in types of processing of demersal fish include;

- Monkfish caught and landed in south-west England, usually gutted and headed at sea.
- A proportion of the respective catches of haddock and whiting, landed predominantly in Scotland, which may be too small to gut at sea.
- Skates and rays, some of which are landed only as 'wings' with the tails retained for bait.
- The roe of some species may be retained at certain times of year.

Vessels that further process at sea typically also freeze at sea, producing frozen at sea fillets. These are limited to only one registered in the UK. Most common are demersal vessels landing gutted fish, which have been stored on-board in chilled conditions (i.e., 0 to 4^{o}C).

Some fish groups are predominantly landed whole and therefore excluded from the scope of this report. These are:

- Pelagic species which are typically landed whole.
- Shellfish (molluscs, cephalopods, crustacea) which are typically landed whole (live or dead). *Nephrops norvegicus* (langoustine) are also excluded even though they may be 'tailed' (heads and claws removed) at sea.

3.1.7. Defining 'at-sea offal'

To estimate quantities of at-sea offal, it is important to have a clear definition and scope of what that includes.

There are many terms used in the seafood industry to describe the parts of fish and shellfish not used directly in human consumption. Terms depend on the region (national and global), the species and the point in the supply chain. Examples of terms are by-products, processing waste, rest raw material, co-products, offal, and trimmings.

For the purposes of this report, the term 'at-sea offal' is used to define parts of fish removed from the whole fish whilst at sea.

For this report, at-sea offal excludes by-catch, i.e., unwanted or unintended catch, or fish/shellfish that may be returned to sea alive after capture.

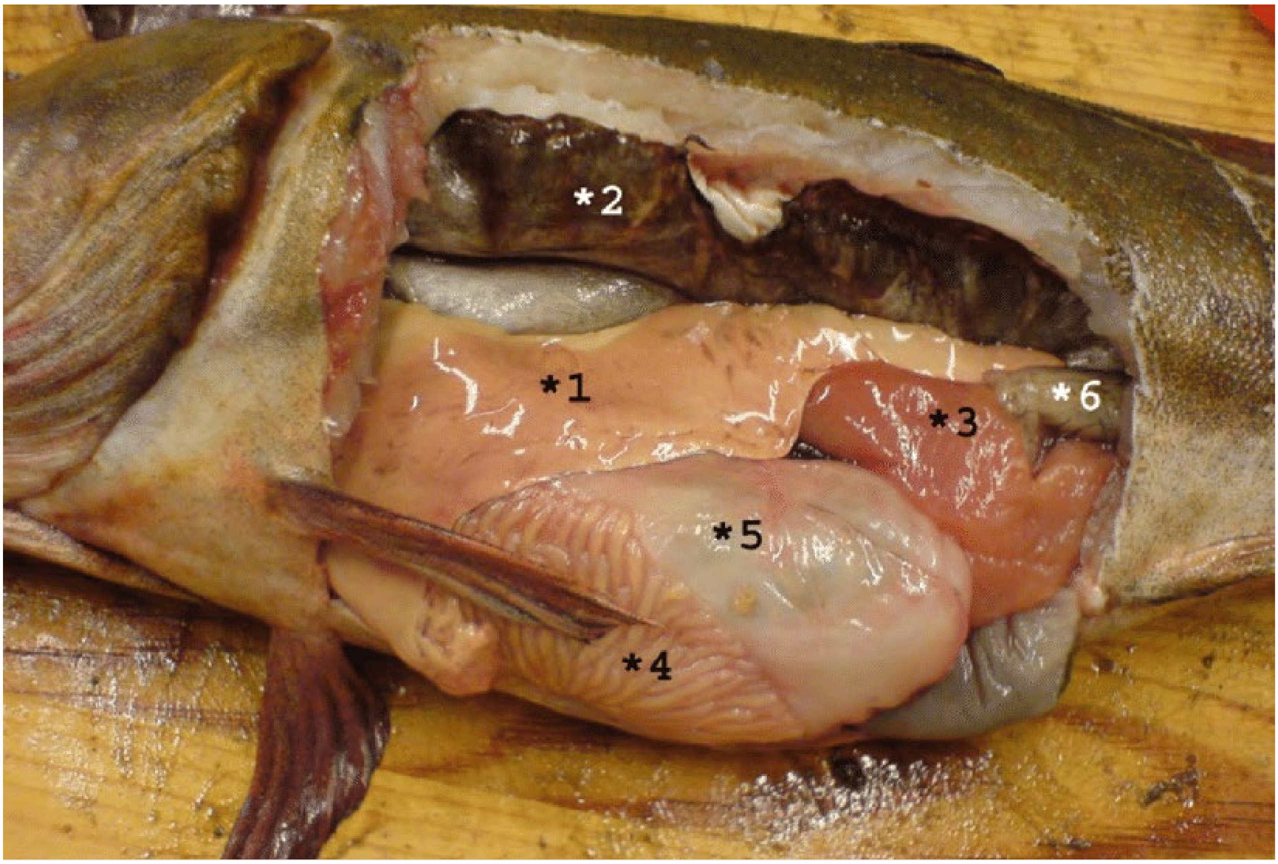

Figure 3 Internal anatomy of cod. 1) liver, 2) swim bladder, 3) ovaries/roe, 4) duodenum, 5) stomach, 6) intestine.

Source: H. Dahlmo/Wikimedia Commons (CC BY-SA 3.0).

3.1.8. Offal handling and spoilage

To maximise access to at-sea offal, it is important to ensure the offal is preserved as quickly as possible. It is of the utmost importance to ensure fish for human consumption are handled and stored in hygienic conditions and avoid any sources of contamination i.e., from fish offal.

Fishery products start to deteriorate in quality during capture and as soon as they die. Live seafood flesh is sterile and in the first couple of days after death, changes in seafood are mainly due to chemical processes. However, after a few days, bacteria from the gills, skin and guts enter the flesh of the fish where they start to degrade different components. In time this produces odours and flavours associated with decomposition or spoilage.

The removal of sources of bacteria such as offal, are important to maximise the amount of time that seafood remains palatable i.e., fish shelf-life or storage life. Temperature control is also important; ensuring fishery products are held at a temperature approaching melting ice (0 to 2^{o}C) slows down the rate of bacterial growth. It is good practice to remove fish guts at sea, wash the gutted fish and store them in clean containers with ice, in refrigerated rooms (hold) in the vessel.

Fish offal contains high levels of natural bacteria and deteriorate more quickly than fish flesh. Retaining fish offal on a fishing vessel for any length of time will require the offal to be stored separately from the products for human consumption, and to be preserved, to slow down the rate of deterioration. This is particularly relevant when considering any further use, for example whether advanced spoilage affects palatability as a food source for sea birds.

Considerations / data gaps

- The UK catch of fish and shellfish varies significantly across regions of the UK, with species of primary interest to this report in the Northern North Sea, landed into Scotland.
- Commercial fishing has many variations in vessel types, sizes, where vessels land to, how well crewed they are.
- Most of the at-sea offal is from demersal fish and is currently discarded overboard after removal. This is mainly to preserve freshness quality and maximise the storage / shelf life of the fish.

4. Policy and legal requirements

There are several areas of policy and regulation for the handling of fish at sea, the production and handling of at-sea offal and the use or disposal of offal in the marine environment. This section provides an overview of the key policy and licensing considerations.

4.1. Food hygiene requirements

Food hygiene legislation requires food to be handled, processed, and stored safely to protect consumers. Specific hygiene rules for food of animal origin apply to fishery products from point of capture, (European Parliament, 2004).

Fishery products are defined as all “seawater or freshwater animals (except for live bivalve molluscs, live echinoderms, live tunicates and live marine gastropods, and all mammals, reptiles and frogs) whether wild or farmed and including all edible forms, parts and products of such animals”.

In relation to fishery products:

(a) primary production covers the farming, fishing and collection of live fishery products with a view to their being placed on the market; and
(b) associated operations cover any of the following operations, if carried out on board fishing vessels: slaughter, bleeding, heading, gutting, removing fins, refrigeration and wrapping.

There are numerous requirements for fishing vessels and fishery products from point of capture. Of relevance are:

- The design, layout and equipment used on fishing vessels must not cause contamination of the catch, must be easy to clean, and made of corrosion-resistant materials. Water used in contact with fishery products must be maintained safe to avoid catch contamination.
- Temperatures for any fishery products held over 24 hours must be achieved. For fish, this is deemed to be a temperature approaching that of melting ice (i.e., close to 0^{o} C).
- Operations such as heading and gutting must be carried out hygienically. Where gutting is possible from a technical and commercial viewpoint, it must be carried out as quickly as possible after the products have been caught or landed. The products must be washed thoroughly immediately after these operations.
- Holds and containers used for the storage of fishery products must ensure their preservation under satisfactory conditions of hygiene.

Factory vessels that carry out heading and/or gutting on board are required to follow specific requirements. “Such operations must be carried out hygienically as soon as possible after capture, and the products must be washed immediately and thoroughly. In that event, the viscera and parts that may constitute a danger to public health must be removed as soon as possible and kept apart from products intended for human consumption. Livers and roes intended for human consumption must be preserved under ice, at a temperature approaching that of melting ice, or be frozen".

4.2. Animal by-product regulations

Animal by-products are animal carcasses, parts of animals, or other materials which come from animals but are not meant for humans to eat. Fish and shellfish are covered by animal by-product regulations (UK Statutory Instruments, 2013).

Animal by-products are categorised according to level of risk. Categories 1 and 2 are high risk, with Category 3 classed as low risk. Aquatic animals including shellfish from wild capture are typically Category 3.

Approval is required from the regulatory authority for the handling, transport, storage, processing, and ultimate use of animal by-products. In terms of animal feed, this is highly regulated and animal by-products must be processed according to an approved treatment method.

The use of raw or untreated animal by-products is permitted for animal feed in specific circumstances, for example including (but not limited to) feeding zoo or circus animals, or other wild animals. However, any site using these types of by-products must register with the relevant authority. Currently there is no specific provision for returning fish offal from fishing vessels to sea, for feeding seabirds.

The animal by-product regulations do not apply to at-sea offal where it is removed and thrown overboard at sea. However as soon as the fish by-products (at-sea offal) are brought ashore i.e., removed from the vessel and landed, the requirements of the regulations will apply. It is permitted to use raw or untreated fish by-products in fishing as bait, providing it is used in traps or on hooks. This still requires controls on handling and storage.

4.3. Definition of waste and by-products

The definition of waste or by-product is important as it can affect potential uses.

'Waste' is defined in Article 3 of the EU Waste Framework Directive (2008/98/EC) as 'any substance or object which the holder discards or intends or is required to discard' (European Parliament, 2008).

Article 5 of the same Directive states that to be a by-product the following conditions must be met:

a) further use of the substance or object is certain;
b) the substance or object can be used directly without any further processing other than normal industrial practice;
c) the substance or object is produced as an integral part of a production process; and
d) further use is lawful, i.e., the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.

At-sea offal is covered by legislation relating to at sea licensing. However, if it is landed, different rules apply i.e., animal by-product regulations.

4.4. Licensing at sea

4.4.1. The Landing Obligation

The Landing Obligation (LO) applies to all fishing vessels, including those under 10 metres in length. It does not apply to recreational fisheries. Quota species must be landed and counted against quota unless exemptions apply. The LO applies to all sizes of fish so it is important to minimise catches of undersized fish which will use up quota (MMO, 2021).

Since its introduction, there have been numerous exemptions to the LO. The latest are defined in the most recent technical measures guidance (MMO, 2022). Each exemption has specific requirements, and each is defined applicable to a catch area, type of fishing gear, and target species.

Examples of exemptions in the North Sea, which permit discarding at sea of associated unwanted catch, are:

- Skates and rays – all fishing gears, no conditions.
- Plaice:
    - caught by Danish seine, no restriction;
    - caught by otter trawlers or pair trawlers with nets with a minimum cod end mesh size of 80mm;
- Whiting below minimum size of 27cm, for nets with a cod end mesh size 80 to 99mm.
- Cod below minimum size of 35cm, from vessels with nets with cod end mesh size 80 to 99mm. Subject to percentage restrictions.

Other exemptions are in place for other areas and associated fishing gears within the UK. Exemptions also change and become repealed and/or replaced. Exemptions i.e., discarding of unwanted catch, impact on any estimates of at-sea offal for the respective species.

4.4.2. OSPAR Convention

OSPAR is the mechanism by which 15 Governments & the EU cooperate to protect the marine environment of the North-East Atlantic. Their vision is a clean, healthy and biologically diverse North-East Atlantic Ocean, used sustainably.

The various strategies and objectives are outlined in the North-East Atlantic Environment Strategy (The OSPAR Strategy) cover:

- Biological Diversity and Ecosystems
- Eutrophication
- Hazardous substances
- Offshore Oil and Gas Industry
- Radioactive Substances

Included within this includes deposits in the sea (waste).

OSPAR has no role in fisheries management, which falls to the states with fishing within their respective exclusive economic zones (EEZ) or the North-East Atlantic Fisheries Commission (NEAFC) in areas beyond national jurisdiction.

4.4.3. Deposit of any substance or object in the marine environment

A marine licence is required to deposit any substance or object within UK waters, either in the sea or on or under the seabed if the deposit is made from a: vehicle, vessel, aircraft, marine structure, floating container, or structure for the purpose of depositing solids in the sea (MMO, 2023).

Disposing of most wastes or other matter at sea is prohibited by the OSPAR Convention. Only specific types of waste may be disposed of at sea, and only after a marine license based on a detailed assessment of risks is granted from the Marine Management Organisation (MMO) (or devolved agency in the other regions of the UK). Permitted types of waste to be disposed at sea include dredged material; inert materials of natural origin; and fish waste – including shellfish and any part of a fish.

The Marine Licensing (Exempted Activities) Order 2011 Article 4 provides a list of activities for which fishermen do not need a marine licence to carry out, providing it is during a fishing operation:

- deposit fishing gear;
- remove fish or take fish;
- remove fishing gear;
- deposit, by way of return to the sea, any fish or other object removed.

Article 4 also applies to the deposit by way of return to the sea of any fish during the course of fish processing at sea.

The exemption does not apply to deposits made for the purpose of disposal.

Feeding sea birds with at-sea offal should be considered within marine licensing requirements as to what may or may not apply. If it is an exempt activity, it may still require registration with the MMO.

Marine licenses are required for any fixtures at sea including pontoons, which could be an option for feeding seabirds from fixed platforms.

Considerations / data gaps

- The definition of at-sea offal as 'waste' applies if the offal is landed, as it is currently unwanted or discarded by the owner (vessel owner/skipper). As such there will be registration and approval requirements for returning to sea, any at-sea offal that has first been landed / unloaded from the fishing vessel for the purpose of feeding seabirds.
- Fish offal originating from fishing vessels at sea is exempt from marine licensing. This should be further investigated to cover different scenarios including if the at-sea offal is further processed (including modified by adding other ingredients) or if it is transshipped at sea.
- The use of any quota species under MCRS is not permitted for sea bird feeding at sea, as these cannot be 'discarded' by the vessel. However, if they are landed by the vessel to enter the animal by-product market, they may then be used at sea, subject to animal by-product controls and marine licensing.
- The use of undersized or unwanted non-quota species could offer an additional source for sea bird feeding as they can be 'discarded' at sea. However, if they are landed, they would also be subject to animal by-product controls and marine licensing.

5. Characterising at-sea fish offal

This section of the report provides estimates of the quantities of at-sea offal produced overall, and by different criteria.

5.1. Quantities of at-sea offal

The estimated quantity of at-sea offal is almost 28 thousand tonnes per year (Table 7). This assumes that the difference between live weight and landed weight is only due to the difference from processing fish at sea i.e., removal of guts and heads where applicable. However, as some species have specific exemptions under the landing obligation, this total quantity is an overestimate of offal. For certain species a proportion of the difference will include whole fish i.e., permitted discards under an exemption to the landing obligation or discards of non-quota species.

Table 7 Average live weight landed weight and calculated weight of at-sea offal (2016-2020).

Average live weight* (tonnes)	Average landed weight* (tonnes)	Average weight of at-sea offal* (tonnes)
169,714	141,824	27,890

*Includes demersal fish caught in ICES area 27 by UK vessels landing into the UK

Source: MMO 2020 and author calculations

Annual variations are evident in the period 2016 to 2020, due to fluctuations in catch and latterly the impact of COVID-19, which significantly affected commercial fishing (Figure 4). Between 2016 to 2020, the estimated quantity of at-sea offal varied between 25 thousand to 30 thousand tonnes each year.

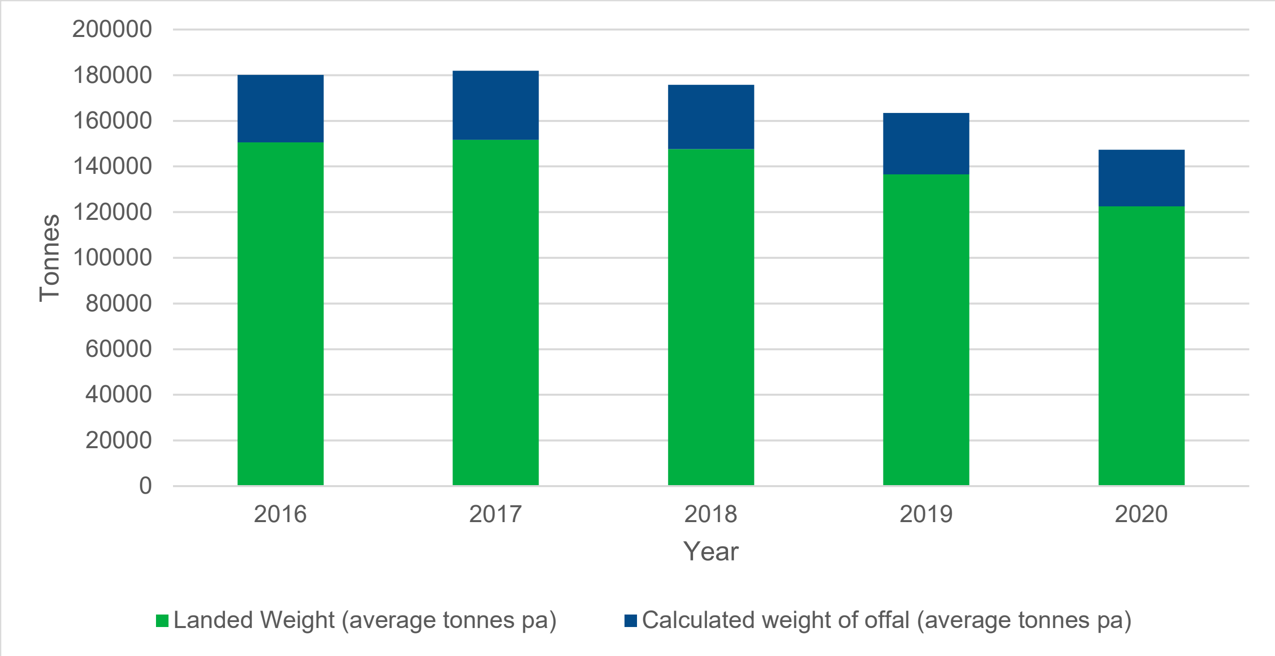

Figure 4 Total catch weight of demersal fish from UK vessels landing into the UK, showing landed weight and calculated at-sea offal (2016-2020).

Source: MMO 2020 and author calculations.

Fluctuations in estimates of at-sea offal are also seen during different months of the year (Figure 5), aligning with variations in fishing, for example peaking in months with good weather for fishing, or avoiding fish in poor condition (post spawning).

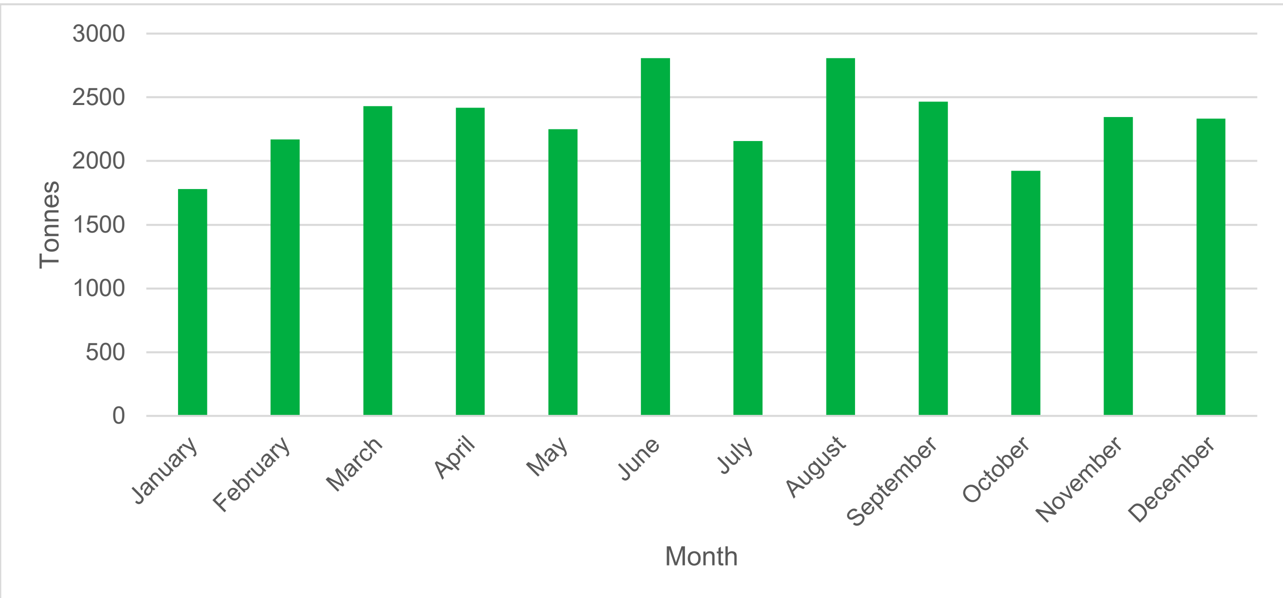

Figure 5 Calculated monthly weight of at-sea offal from demersal fish, from UK vessels landing into the UK, (2016-2020).

Source: MMO 2020 and author calculations.

Certain species of demersal fish are the source of most at-sea offal, because of the extent of the initial catch. Three species, cod, monkfish or anglerfish, and haddock are the source of just over 70% of at-sea offal. Ten species are responsible for 95% of at-sea offal (Table 8).

Table 8 Estimated quantity of at-sea offal for the top 10 species of demersal fish (2016-2020).

Fish species*	Estimated weight of at-sea offal (Average tonnes per year)	Landing obligation exemption
Cod	10,171	Yes
Monks or Anglers	5,526	Yes
Haddock	4,115	Yes
Saithe	2,340	No
Hake	1,304	No
Skates and rays (Comprising Thornback ray, Blonde ray, Cuckoo ray, spotted ray, long-nosed skate)	848	Yes
Ling (comprising Ling, blue ling)	797	No
Plaice	655	Yes
Whiting	612	Yes
Pollack	262	No
Total top 10 demersal species	**26,630**	[Blank cell]
Other demersal species	1,260	[Blank cell]

*Categorised as demersal according to MMO annual dataset

Source: MMO 2020 and author calculations

For the species which have had or continue to have exemptions under the landing obligation (Table 9) it is assumed that a proportion of the estimated weight of offal is unwanted whole fish returned to sea. To cross-check the data on species, it useful to consider the estimated at-sea offal as a percentage of catch weight.

According to industry feedback in the interviews, an ideal target is approximately 10% i.e., the percentage difference between catch weight and landed weight. On this basis it is reasonable to assign a range of 8 to 12% for expected levels. However, there are variations to this:

- The gutting yield of demersal fish can be 16% for 'round fish' such as cod, haddock etc. (Archer, 2022).
- A yield of 37% can be used for species which may be headed at sea, such as monks or anglers. This practice varies between catch areas so would not be reasonable to use as an indicator for all the catch. As such 21.5% is applied as the midway point between the two ranges.

Several species exceed these range, some by a significant extent (Table 9).

Table 9 Demersal species where the difference between the catch weight and landed weight exceeds expected levels.

Above the expected range for demersal gutted fish (>16%)		**Above the expected range for fish that are gutted / headed / winged at sea (>21.5%)**	
Cod	32%	Monks or Anglers	29%
Saithe	17%	Skates and rays (comprising Thornback ray, Blonde ray, Cuckoo ray, spotted ray, long-nosed skate)	30%
Catfish	21%		
Redfishes	37%		

Source: MMO 2020 and author calculations

It is important to note that cod, monks or anglers, and skates and rays have had, or continue to have, exemptions under the landing obligation. This will account for a proportion of the difference.

For monks and anglers, the variation is also be explained by the quantity of heading and gutting being more significant than estimated. Information from surveys show that monks and anglers are subject to significant regional variations in processing at sea i.e., removal of heads at sea in some areas.

With skates and rays, the extent of variations in regional practice are likely to account for some of the difference, in addition to the discards of unwanted / undersized / over quota species. Again, feedback from the industry surveys show that skates and rays have several variations across different parts of the UK i.e., removal of heads and backbones at sea for some species, some of which may be landed for use in bait.

Redfish are typically landed whole, so the difference is likely to be due to discarding, which is permitted as it is a non-quota species.

Cross referencing the estimates at species level with industry insight from the interviews suggests that a proportion of the difference between catch weight and landed weight is not at-sea offal. With the exemptions under the landing obligation, considerable variations in regional practice and seasonal activities it is challenging to determine what proportion of the estimated at-sea offal is whole fish.

5.1.1 Estimates of whole fish quantities discarded under exemptions from the landing obligation

To estimate the proportion of at-sea offal that may be whole fish, the use of discard data has been considered (Cefas, 2021). However, data are limited, incomplete for different species, and presented as estimates only. From the work by Cefas, it is evident that rates of catches of unwanted fish are applied using available data, with assumptions applied to parts of the fleet and thus the quantities of ‘discards’ produced. Table 10 includes the data from Cefas on unwanted whole fish that was discarded from UK vessels fishing using demersal fishing gear of interest to this report. This is based on the North Sea and North-West Waters.

Table 10 Estimated average at-sea offal production and unwanted catch key quota species (annual tonnes)

	Estimated average at-sea offal (tonnes pa)	Aggregated discard quantities (tonnes pa)	Difference between at-sea offal and quantities of unwanted catch (tonnes pa)
Cod	10,171	11,109	-937
Monks or Anglers	5,526	212	5,314
Haddock	4,115	2,016	2,098
Plaice	655	10,702	-10,047
Whiting	612	3,661	-3049
Sole	71	1	71

Source: Cefas, 2021, authors.

For cod, plaice and whiting, the estimate of at-sea offal is lower than the estimates of whole fish discards. For haddock, sole, and monks and anglers, the reverse is true. This provides a confusing picture of the data for some species. For example, a proportion of the estimated at-sea offal for cod, plaice and whiting, is ‘offal’ and cannot all be whole fish. This could imply the discard data is overestimated for some species compared with others. The application of the landing obligation and different exemptions applied during the timescale from which the estimates of at-sea offal are derived could also be confusing the calculations.

Given the gaps in data it is impossible to determine with any confidence what proportion of the estimated at-sea offal would be whole fish. It can be concluded that the estimated at-sea offal will include offal and whole fish. On that basis, it is advisable to consider any estimates as indicative.

With the variations and uncertainties around discard data, there is a medium level of confidence in the estimates of at-sea offal.

5.2. At-sea offal by catch area

ICES sub-area 27.IV is the origin of 42% of the overall estimated quantity of at-sea offal from demersal fish (Figure 6).

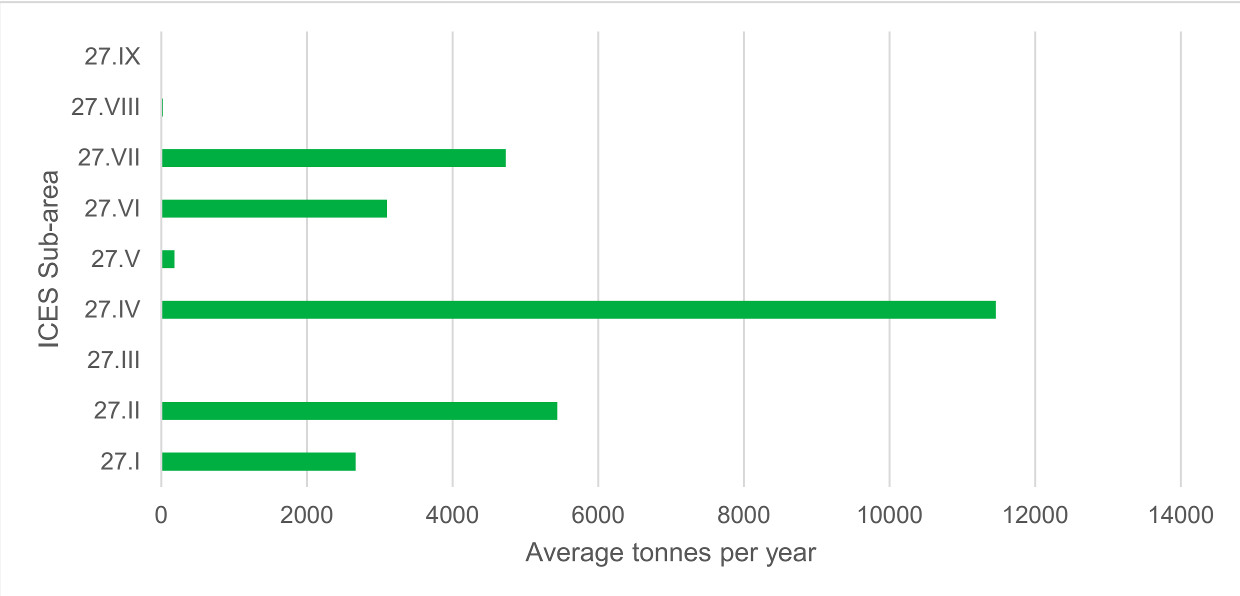

Figure 6 Estimated annual quantity of at-sea offal, by ICES sub-area (2016-2020)

Source: authors calculations

Sub-area 27. IV comprises three sub-divisions a, b. c. Across the three sub-divisions there are significant differences in quantities of at-sea offal (Figure 7), relating to the main demersal catch area (Northern North Sea, area 27.IV.a).

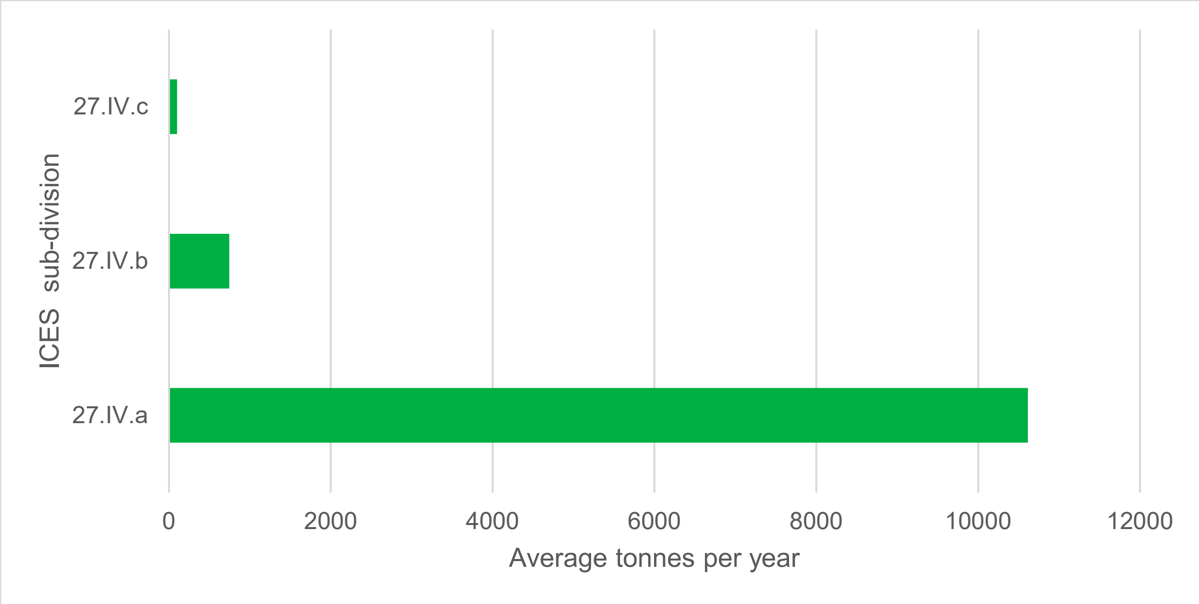

Figure 7 Estimated annual quantity of at-sea offal, within ICES sub-area 27.IV (2016-2020).

Source: author calculations

5.3. At-sea offal by fleet segments

The quantity of at-sea offal produced by segments of the fleet relate directly to the main types of fishing vessel which target demersal fish (Figure 8). Nearly 80% of demersal at-sea offal produced each year is from otter trawls.

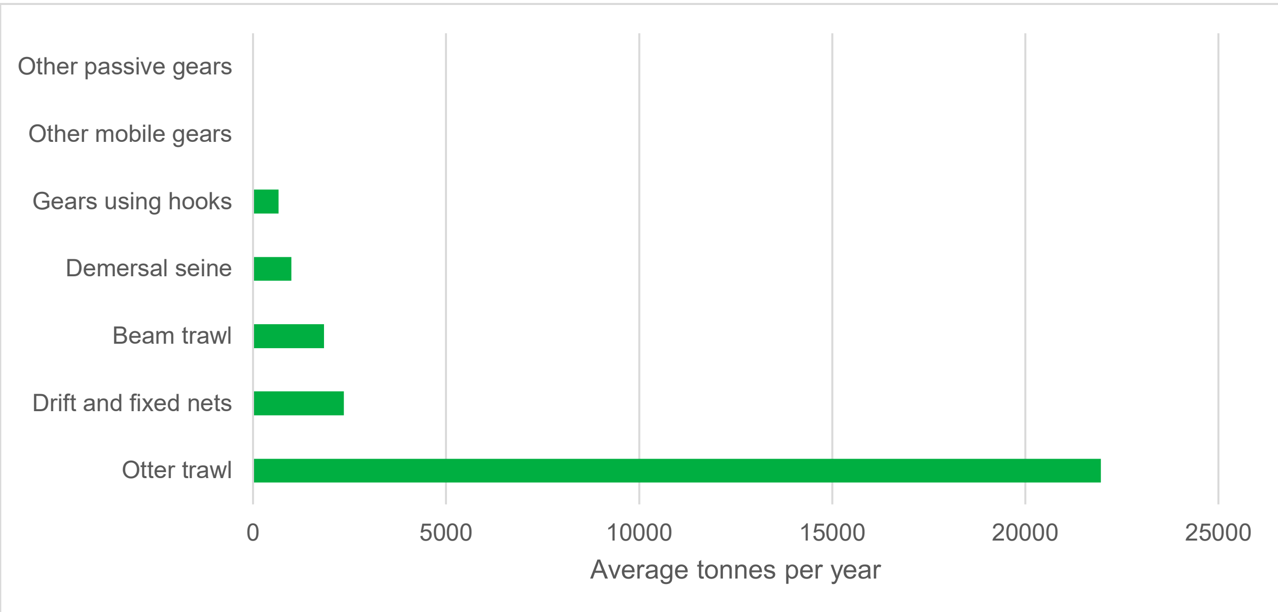

Figure 8 Estimated annual quantity of at-sea offal, by fleet segment (2016-2020)

Source: author calculations

The quantity of at-sea offal produced by size class of vessel shows the majority (98%) is caught by large, over 10m sized vessels, (Figure 9).

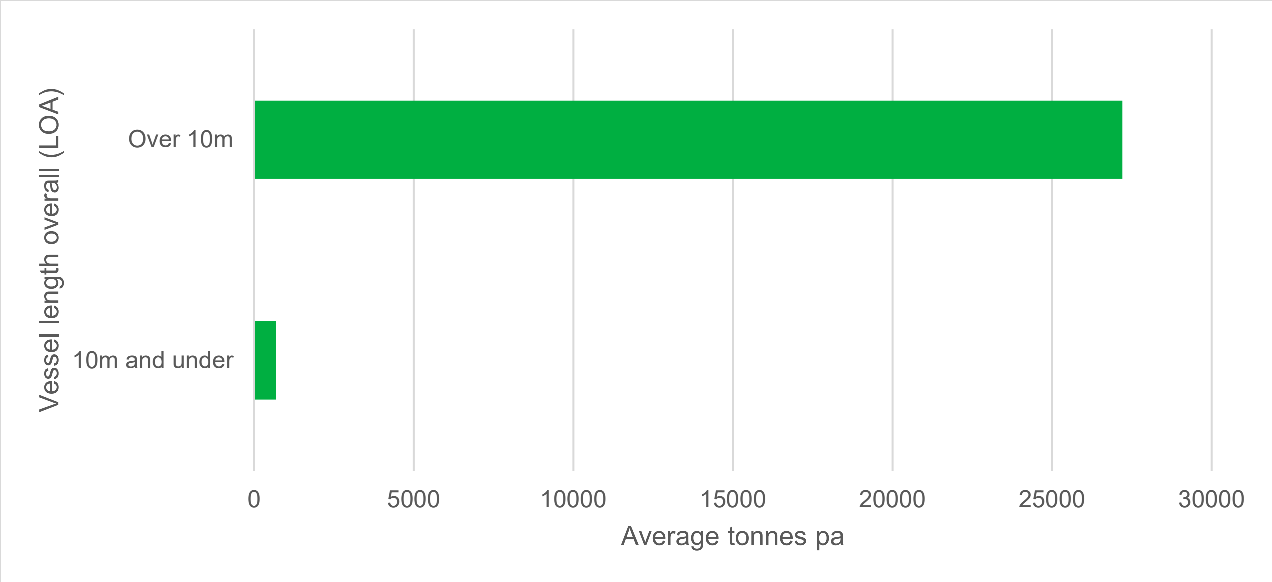

Figure 9 Estimated annual quantity of at-sea offal, by vessel size (based on average 2016-2020)

Source: author calculations

5.4. Potential landing areas for at-sea offal

Applying the percentage of total catch landed at UK ports, to the estimated quantity of at-sea offal, provides a basic estimate of the landing sites where at-sea offal could or would most likely be landed, (Figure 10). Approximately 76% of the total estimate of demersal at-sea offal would be landed into ports in Scotland.

Small quantities of at-sea offal could be landed in different ports or landing sites across the UK; however, it is not possible to provide estimates of these.

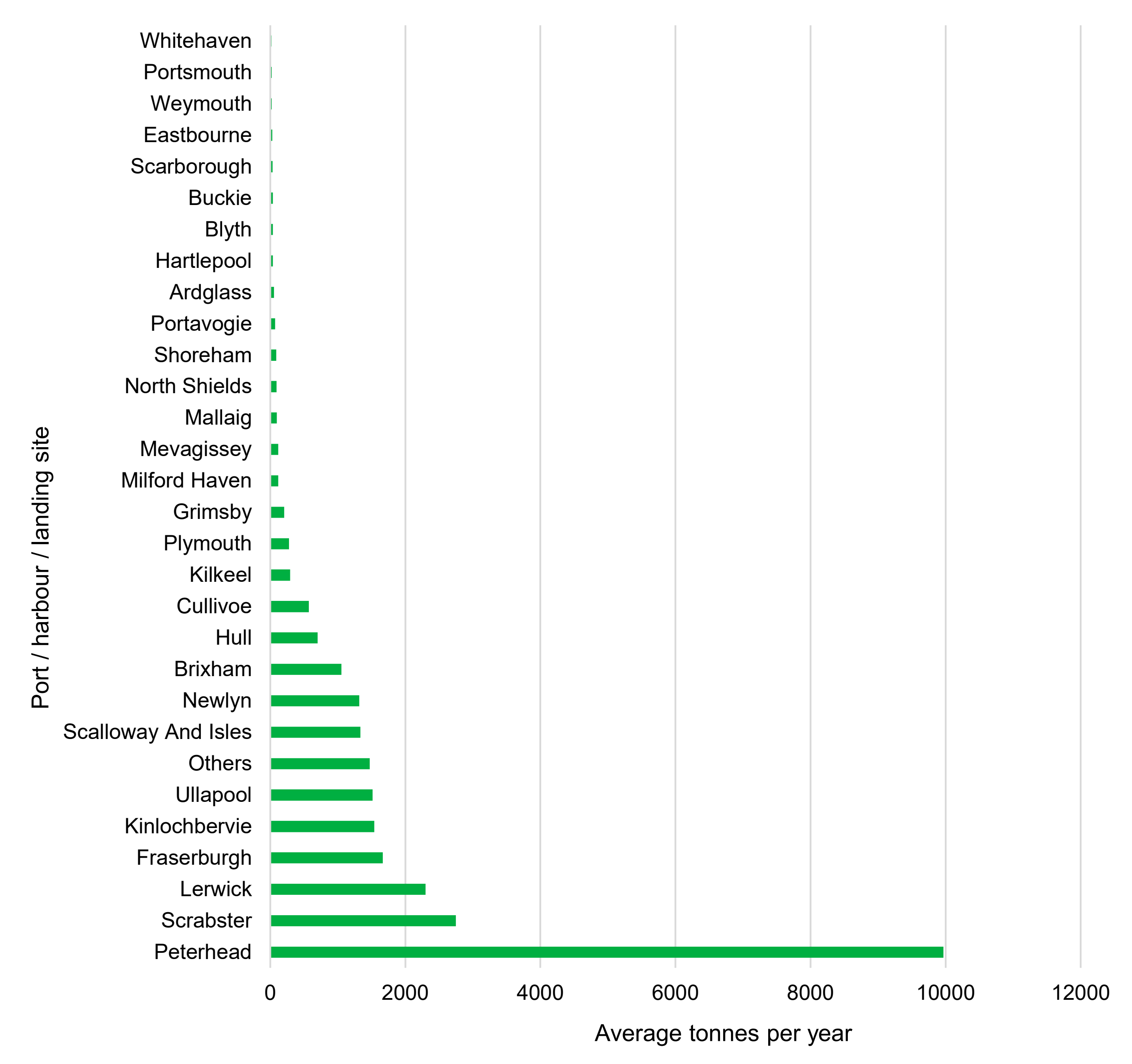

Figure 10 Estimated annual quantity of demersal at-sea offal that potentially could be landed at ports (2016-2020)

Source: author calculations

5.5. Other sources of offal or by-products

Other sources of offal or by-products are potentially available including:

- Fish that must be landed under the requirements of the landing obligation and cannot be used for human consumption.
- Fish currently used for bait, including low value species, non-quota species or processing by-products for the onshore fish processing sector.
- By-products from the fish processing sector.

The seafood processing sector is a large producer of by-products. During processing the edible portion of fish is removed, leaving behind parts of fish that are not typically directly eaten (albeit there are variations in species and various cultures). Typical by-products from onshore sources include fish heads and frames.

In the main processing areas of the UK (the region around the Humber estuary and North-East Lincolnshire, and North-East Scotland), the majority of processing by-products are collected for the production of marine ingredients i.e., fishmeal and fish oil. In these areas, fish processors receive payment for the by-products which varies depending on where it is supplied to and in what format, the species and composition such as oil content and quality etc. The current rate is around £200 per tonne, lower for regions such as South-West England.

Accessing sources on-land would require paying for by-products at the current market rate. A useful indicator is the price at or marginally above the going rate paid by the fishmeal company. However other considerations such as handling, storage and logistics also need to be factored in.

Fish processors need a continuous and consistent outlet for their by-products, as by-products quickly deteriorate. Any company taking by-products also needs to be registered under animal health requirements and handle them according to the required end use.

There are markets for onshore by-products with some fish processors utilizing more of the raw material, e.g., fish heads for drying and export, processed trimmings for pet food. There is more value in homogeneous material that has been properly handled and processed. Typically, the higher the extent of processing the more expensive the raw material is. There are fewer markets for mixed offal.

Considerations / data gaps
• Demersal at-sea offal is mainly produced in the Northern North Sea, by larger vessels, catching fish using otter trawls. However there are variations, with smaller quantities produced across the different catch areas. • The estimated quantities of at-sea offal from demersal species should be seen as indicative only. For species where the calculated amount of offal is significantly higher than expected, the level of confidence in the estimate is low. • The variability in fishing means that annual patterns do change, and the estimates provided will also vary. For example, potential landing sites will change depending on where vessels choose to land their catch. • Variability in practices in certain species will ensure the composition of offal varies. For example, more monkfish heads and skate backbones in SW England. Roe is retained at certain times of year for some species, which will affect the quantities available.

6. Characteristics of at-sea offal

6.1. Composition of offal

Fish offal provides vitamins, minerals, and proteins. This section of the report provides summary data on composition.

Data on the composition of raw/untreated offal is limited to some commercially important species. It often also includes other parts of fish, not just the offal, hence the use of the wider term ‘by-products’.

By-products and offal have been studied to different degrees, ranging from analysis of single by-products (e.g., eyes, bones, skin) to combinations of by-products (e.g., head, viscera). Several valuable components have been identified (Table 11)

Table 11 Summary of valuable components of marine by-products

Lipids	Proteins	Other components
• Oils • Omega-3: EPA, DHA, fatty acids • Phospholipids • Squalene • Vitamins • Cholesterols	• Enzymes • Hydrolysates (proteins chemically or enzymatically broken down to peptides) • Surimi • Thermostable dispersions • Peptides, amino acids • Gelatine, collagen • Protamine • Hyaluronic acid	• Nucleic acid • Calcium • Phosphorous • Bioactive compounds • Colours • Chitin / chitosan / glucosamine / chondroitin

Source: Shahidi, 2006

6.1.1. Proximate composition

The proximate composition (moisture, protein, fat) of seafood varies according to the type of species, sex, age, nutritional status, time of year (e.g., spawning) and overall health. This can result in significant variations in levels of moisture, protein and fat. Comparing different species and body parts shows on a wet weight basis, levels of protein can range from 7 to 25%, fat from 4 to 16% and ash from 3.6 to 4.1% (Alaska Sea Grant, 2002). A different assessment of non-specified fish by-products which comprised multiple species and body parts, indicated a composition of approximately 58% protein, 19% fat, 22% ash and 1.3% crude fibre (dry weight basis). (Ghaly, 2013).

The nutritional value of by-products is affected by the quality of the raw material. By-products rapidly spoil and would need to be preserved to avoid loss of valuable nutritional components.

6.1.2. Micronutrients and amino acids

Depending on the dietary requirements of seabirds, the valuable components in offal could provide a range of valuable nutrients.

Fish by-products and offal provide levels of micronutrients quantified in varying levels, depending on the species and by-product components. Micronutrients identified in by-products include:

- *Vitamins* A, D, B, particularly B-12
- *Minerals:* calcium, copper, iodine, iron, magnesium, manganese, potassium, phosphorous, selenium, sodium, zinc.

Amino acids have also been found in by-products, also in varying levels, depending on the species and by-product components. The amino acids identified in by-products include alanine, arginine, aspartic acid, cysteine, glutamic acid, glycine, hydroxyproline, isoleucine, leucine, lysine, methionine, phenylamine, proline, serine, valine, histidine, theanine, and tyrosine.

6.1.3. Contaminants

There can be issues in some seafood, from specific species caught in specific areas. This may be particularly true for offal, notably viscera and livers, where contaminants are more likely to accumulate. Other by-products, such as heads and cheeks, are less likely to accumulate contaminants.

Sea birds already consume seafood in whole form and in part, through offal thrown overboard at sea. The extent of a change in diet to increase offal may need to be considered in context of bioaccumulation of contaminants. This also needs to be considered for certain nutrients, where the increased intake of offal may cause accumulation of certain vitamins, which can be toxic in high doses.

6.2. Physical properties of offal

The size of offal will vary according to the physical size of the fish. Whether it remains intact during processing is dependent on the skill of the crew undertaking gutting, and the size of the fish etc. During gutting the aim is to remove offal in its entirety, although small pieces may remain and need to be removed separately.

Fish offal is typically soft, difficult to handle and susceptible to damage during handling.

6.2.1. Fate of at-sea offal in the marine environment

The fate of at-sea offal in the water column will be influenced by a combination of factors including vessel practices and method of disposal, waste characteristics (buoyancy, size, shape etc), hydrodynamics of the system, and weather.

Anecdotal information from commercial fishers in the survey, suggests smaller parts float and remain on the surface of the sea where they are rapidly eaten by seabirds. Larger or intact offal can quickly sink.

Lighter, more buoyant fractions of the waste will float on the sea surface and, together with oil-based liquid waste, will form a surface slick. Discarded offal can remain on the surface for up to six hours. During this time smaller fractions will be dispersed over the sea surface, whereas the larger/denser fractions will begin to sink (Mazik et al, 2005).

In general, any liquid waste that remains on the sea surface will be dispersed as a direct result of the local hydrodynamic and weather conditions at the chosen site although oily material will remain for a longer period than non-oily material.

6.2.2. Seabirds feeding on at-sea offal

Most of the offal on the surface is taken by scavenging seabirds. It was reported that in the North Sea between 1.4 and 3.4 million scavenging birds were known to feed on fishery waste during the winter (Camphuysen *et al.*, 1995 in Bluhm & Bechtel, 2003). Since birds tend to be size-selective in their feeding behaviour, this emphasises the importance of the size and weight of the discharges (Hill & Wassenberg, 1990 in Bluhm & Bechtel, 2003).

The amount of at-sea offal taken by sea birds may also be dependent on the time of day, weather and/or season (Bluhm & Bechtel, 2003) as these factors relate to the availability of other food sources and also the presence of migratory birds in the region.

Information on seabirds feeding on fish discards is covered in numerous papers. However, 'discards' are typically whole fish. Larger scavenging seabirds tended to consume larger discards than smaller seabirds. The median length of roundfish consumed ranged from 14 cm in common gulls (*Larus canus*) to 25 cm in gannets (*Morus bassanus*) and great skuas (*Stercorarius skua*). The median width of flatfish consumed by seabirds ranged from 3.5 cm in fulmars (*Fulmarus glacialis)* and kittiwakes (*Rissa tridactyla*) to 6.5 cm in gannets (*Morus bassanus*) and great black-backed gulls (*Larus marinus*). (Camphuysen et al., 1995).

Many discards were stolen from smaller birds by larger species, resulting in the success rates of the former tending to be lower than those of the latter. Gannet (Morus bassanus), great black-backed gull (*Larus marinus*) and great skua (*Stercorarius skua*) were consistently the species highest in rank in the dominance hierarchy, whereas fulmar (*Fulmarus glacialis)* and kittiwakes (*Rissa tridactyla*) were most vulnerable to robbery. Smaller species such as kittiwakes (*Rissa tridactyla*) and common gulls (*Larus canus*) usually avoided fights for discards. Great black-backed gulls (*Larus marinus*) and great skuas (*Stercorarius skua*) obtained most discards through kleptoparasitism. (Camphuysen and others., 1995).

Camphuysen and others., 1995, also found that in the North Sea, the consumption rates of offal and discards by seabirds were higher in February and November than in May and August. Overall consumption rates by seabirds showed that, of the fish and offal discarded at sea, seabirds consumed an estimated 95% of offal, 80% of roundfish, 20% of flatfish and 6% of benthic invertebrates. The competition for fishery waste increased between summer and winter and from south to north.

In comparison to proportions of each species present, fulmars and kittiwakes obtained more offal than expected. For experimentally discarded gadids, feeding success of fulmars and kittiwakes was comparatively low and gannets had very high success rates. Lesser black-backed gulls and herring gulls were the most important consumers of gadids in the south-eastern North Sea. Of experimentally discarded clupeids (oily fish), Fulmars obtained considerably less than their numerical abundance might predict. Gannets obtained significantly more clupeids than gulls in most seasons and subregions, but particularly in the northern and western parts of the North Sea. Kittiwakes, lesser black-backed gulls and herring gulls were the most important consumers of clupeids in the south-eastern North Sea.

Considerations / data gaps

- The data available on the composition of offal and by-products is variable in content, scope and analytical method, with limited information for different fish species.
- The loss of nutritional value will be influenced by spoilage of by-products.
- By-products and offal could provide a valuable source of nutrients for seabirds. However, changing the food intake for a greater reliance on fish offal may need to be considered for any dietary risks to seabirds, from the concentrations and accumulation of contaminants and nutrients.
- The physical composition of at-sea offal will vary by species and time of year. At certain times it will have a greater quantity of oil present, in certain seasons roe may be retained by the vessel. The physical composition of offal will affect how it behaves in the water column and its potential availability for seabirds.
- Information on fish discards is useful to some extent but as discards are typically whole fish they behave very differently in the marine environment and their attraction as a food source will be different to that of offal.

7. Changing current practices

This section provides an overview of the costs and implications of changing current practices. This is based on retaining at-sea offal produced by UK fishing vessels.

7.1. Scenarios

Table 14 presents three scenarios that are developed for further consideration of approaches to changing current practices in terms of cost and other criteria. The scenarios range from what may be considered as minimal intervention compared to current practice through to significant additional activities.

Scenario 1 involves increasing the availability of fish offal to smaller bird species, which is assumed to be achieved simply through maceration/mincing of offal into smaller pieces. By providing more numerous, smaller components, the feeding success of those smaller bird species should increase as they can access items at the same time as larger species.

No change in current practice is envisaged beyond the maceration of offal, which is a change to current onboard handling practices. It is disposed of while steaming during the usual gutting and catch-handling procedures.

Scenario 2 involves more active intervention as it assumes vessels retain offal on-board for later disposal at sea within the feeding ranges of bird colonies. The offal is minced / macerated on board. Unless vessels travel through the foraging ranges as part of their return to home port, some additional cost would be expected for the steaming to those areas. There is additional inconvenience for crew from it taking longer to return to port by diverting to feeding areas.

Scenario 3 is the most significant intervention as it involves the collection of offal from vessels (either at sea or in port) by a vessel commissioned for the task. For the purposes of this exercise, it is assumed that a fishing vessel may be hired for collection from port and disposal of this material at selected sea bird colonies. Other considerations include the additional regulatory concerns (and potential costs) associated with the practice of collection at sea (transshipment) as authorities may view this as creating a control risk that catch may also be transshipped. If in port, there may be regulatory barriers as offal becomes food by-product ‘waste’.

Table 12 Scenarios for ecosystem benefits from at-sea fish offal

Business as usual	1. Increased availability	2. Feeding visits by vessels	3. Dedicated 'Feeder' vessel
Description			
• Current practice: • Offal is thrown overboard as the vessel is steaming. • No additional distance travelled. • No additional equipment – rapid disposal of offal from fish room.	• Additional processing of offal required at sea (grinding/mincing) • Offal is thrown overboard as vessel is steaming. • Additional boxes / chilled or iced storage / handling • No additional costs for travel	• Offal retained on-board. • Additional processing of offal required at sea (grinding/mincing) • Additional preservation (boxes / chilled or iced storage / handling) required. • Vessel travels to nearby feeding grounds to dispose of offal at sea.	• Offal retained on-board. • Additional preservation (boxes / storage / handling) required. • Vessel lands offal for further storage / processing / aggregation or • Vessel must transship. • Feeder vessel goes to sea.
Assumptions			
Due to no changes, limited or no additional benefit to seabirds in the breeding season.	Increased benefit to small species such as kittiwake through additional processing to reduce average size of offal items (see Camphuysen et al, 1995 re. availability and competition)	Increased benefit to small species such as kittiwake when offal is available near their colonies. Additional cost incurred for steaming to and disposal at seabird colonies.	Increased benefit to small species such as kittiwake when offal is available near their colonies. Additional cost for collection, storage and hiring vessels to disperse offal.

7.2. Costs

The three scenarios result in some additional costs to vessels compared to business as usual.

For **scenario 1**, which involves increasing availability of offal to smaller species such as kittiwakes, additional costs relate to:

- Capital investment in equipment for macerating offal (estimated at £5,000[1] for small vessels and £15,000[2] for larger vessels);
- Changes to existing onboard systems such as conveyor belts to accommodate new equipment (estimated at £10,000 per large vessel);
- Additional maintenance of new equipment (5% of capital costs per annum, £1,250 for large vessels); and
- Additional costs of separate storage of offal (if onboard systems do not allow for immediate processing and disposal overboard) estimated at £5,000 for partitioning and hygienic storage in small vessels and £10,000 in larger vessels.

All the above costs would be incurred by the fishing vessel operator.

For **scenario 2**, involving the dispersal of macerated offal at specific feeding grounds, the above costs are assumed, plus:

- Additional costs of separate storage of offal (as above);
- Additional costs of steaming to feeding grounds (if not en route to home port).

For the additional fuel costs for steaming to feeding grounds, the North Shields fishing fleet is used as an example as it is a significant nearby fleet that generates at-sea offal (Bridlington is mainly a crab & lobster fleet). We assume that vessel diverting course to disperse offal within the mean feeding range of kittiwake in the Flamborough and Filey Coast SPA (FFC SPA), the subject of the case study in section 8, results in an additional two hours steaming.

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[1] Based on commercial meat grinder with 650 kg/hr capacity: https://www.nisbets.co.uk/sirman-nevada-meat-mincer-tc32/fp528

[2] Based on a macerator of material from conveyor belt/pipe systems: https://www.durapump.co.uk/product/seepex-m-macerator/

Vessel fuel use data is derived from recent research on fuel use by the UK fishing fleet (Metz et al, 2022 and Cappell et al, 2022), which found that Nephrops and whitefish vessels use between 600 and 1,500 litres of diesel per day depending on the type and size of the vessel. An average of 1,000 litres per trip day is used, equating to around 50 litres per hour. To divert to the FFC SPA for dispersal of offal, an average of an additional 80 litres of fuel is assumed. Marine diesel prices have dropped down recently from highs of over £1.20/litre, but £1/litre means around £100. Factoring in compensation for time and inconvenience, a payment of £200 per small vessel per trip and £400 per large vessel trip is assumed.

For **scenario 3**, involving use of a dedicated vessel, we assume that a fishing vessel is commissioned to visit the feeding grounds to disperse the offal. Fishing vessels are commissioned for guard duty work with daily rates ranging from £2,000 to £3,000 depending on the size and specifications of the vessels. An alternative approach would be to pay fishing vessels exiting port to take processed offal back to sea for dispersal at agreed feeding areas.

Two sub-options include the transfer of offal at sea to a collection vessel or the landing of offal to port and the subsequent transfer of offal to a collection and handling system. In the case of at sea transfer, the costs relate to the vessel itself and the cost to vessels of separate handling and storage of offal, as proposed under scenario 2. For the handling, transport and storage of the offal on land there are expected to be additional costs. The extent of these may be highly variable depending on the arrangements. We assume a total handling, processing and storage cost of £100 per tonne.

For the purposes of scenario 3 we make a conservative assumption that 50% of the Area 27.IV.b offal calculated (746 tonnes) is made available for collection, i.e., 373 tonnes. This amounts to just over 1 tonne per day on average.

The outline costs associated with supplementary feeding scenarios for these scenarios are presented in Table 15. For the purposes of comparative costings, these costs relate to the case study area and assume that the North Shields fishing fleet is engaged in any these scenarios as these are relatively close to the FFC SPA that are mostly landing Nephrops and whitefish bycatch. The North Shields fleet consists of nine 10-15m vessels and fifteen over 15m vessels.

The costs for supplementary feeding scenarios are presented in terms of a 1-year programme and a 5-year programme. These highlight that a key difference between scenarios is that scenarios 1 & 2 rely on significant capital costs from year 1, while scenario 3 is based on operational costs (purchase of raw material and hire costs).

It is also worth noting the differing levels of inconvenience/changes in behaviour required for each scenario: scenario 1 requires more on-board processing and maintenance of associated equipment; scenario 2 goes further, additionally requiring the vessels to divert to seabird feeding grounds to disperse material; and scenario 3 requires vessels to retain offal onboard and return it to port (and so kept separate from other landings). All scenarios require funding and sufficient financial incentive to make those changes in behaviour.

The maximum contribution to the seabird feed requirement case study is estimated to enable consideration in terms of value for money and impact. These estimates suggest that the volumes of materials indicate that only scenario 3 has the potential to make a significant contribution to feed requirements if sufficient material can be sourced. This is discussed further in the following case study section.

Table 13 Estimated costs of three supplementary feeding programme scenarios

Scenario 1 Improving availability Assumes all vessels in the North Shields fleet are part of the programmes				
		small vessels	**large vessels**	**total**
Capital costs	maceration	£45,000	£225,000	£270,000
	conveyors	0	£150,000	£150,000
Operating costs	maintenance of equipment over 5 years	£11,250	£93,750	£105,000
Scenario 1: Total costs for a 1-year programme				£420,000
Scenario 1: Total costs for 5-year programme		£56,250	£468,750	£525,000
Scenario 2 Diversion to feeding grounds Assumes all vessels in the North Shields fleet each paid for weekly visit to FFC SPA feeding range during May-August breeding season				
		small vessels	**large vessels**	**total**
Capital costs	maceration	£45,000	£225,000	£270,000
	conveyors	0	£150,000	£150,000
Operating costs	maintenance of equipment over 5 years	£11,250	£93,750	£105,000

	payment for vessel visits to feeding grounds (5 years)	£108,000	£360,000	£468,000
Scenario 2: Total costs for a 1-year programme				£534,600
Scenario 2: Total costs for 5-year programme		£164,250	£828,750	£993,000
Scenario 3 Landing offal for dedicated feeding vessel Assumes hiring storage and handling services, commissioning a vessel that can carry and disperse 4 tonnes per day over breeding season.				
Capital costs				£0
Operating costs	purchase of offal (£200/tonne)			£400,000
	transport, handling and storage costs (£100/tonne)			£200,000
	vessel commissioning (£2000 per day)			£1,000,000
Scenario 3: Total costs for a 1-year programme				£320,000
Scenario 3: Total costs for 5-year programme				£1,600,000

Source: Author estimates

7.3. Other considerations for retaining at-sea fish offal

Changing current practice may create unintended consequences for the environment, the crew or the vessel; or there may be other factors that have to be considered before by-products could or should be retained, for example legal requirements. Table 16 provides a summary of some of the considerations identified during the production of this report.

A number of these additional considerations were mentioned in the interviews with industry stakeholders. Their primary concerns were around changes to vessel configuration and on-board handling, the revenue that may be generated, and most importantly, avoiding any risk of catch contamination.

Table 14 Other considerations for retaining at-sea fish offal on fishing vessels

Element	Considerations
Ecosystem	• Ensuring the feeding patterns for seabirds and fishing patterns align to avoid peaks / troughs in supply and demand. • Impact on loss of food source to other seabirds, predatory species, bottom feeders, general nutrient cycle. • Heavy metals and contaminants in offal and how changing the dietary intake to a greater quantity of this in the diet may affect seabirds. • The risk of spreading nematodes (parasitic worms that may be found in fish offal) to new areas of the marine environment could create new or greater nematode infestations. Seabirds are hosts for nematodes. • The use of feeding areas will potentially create seabird aggregation points, more so that at present. This could present a greater risk of spreading Highly Pathogenic Avian Influenza.
On-vessel	• Fish by-products, especially when containing viscera, deteriorate very rapidly. Requires on-board available preservation techniques. • Vessels are optimised to handle and process the catch and offal is quickly removed from the processing area. There may be requirements for modifications to the vessel processing deck, which includes conveyors, chutes etc. • There will be increased work for the crew to sort and separate the catch and retain the offal. This is particularly challenging where crew sizes are limited for the size of vessel. • Vessel sizes are limited in terms of storage and handling capabilities, particularly as separate/sealed storage is required for offal. • Suitability for small-scale fishers (artisanal) would be different compared to larger vessels. For example, smaller vessels have limited space, crew and facilities, they fish closer to shore. • The method of distribution of offal at sea must be safe for the crew and vessel.
Food safety	• On-board facilities not geared to handle/store by-products. • Prevention of cross-contamination if viscera (offal) are retained on board. • Need for rapid handling and effective preservation; some by-products will spoil much more rapidly than products for human consumption

Element	Considerations
Economic	• Potential for reduced income for fishers if valuable space is taken up by at sea storage of offal. • Additional costs of shipping offal to different areas. • Additional costs for offal storage containers, any additional handling or preservation.
Transshipping	• The legality of transshipping of offal would need to be clarified if the ownership of the offal is transferred from one vessel to another. The at-sea offal is no longer being discharged as part of a normal fishing operation. • Transshipping can be hazardous and should be undertaken only by vessels that are suited for that purpose. • Transshipping is a major concern for ensuring catch legality and traceability. This would extend to oversight of any fish under MCRS, or avoiding of any discarding practices that are not permitted. • The policy for use or disposal at sea would have to be considered for transshipping, to ensure it is a managed activity that is properly licensed or registered as exempt from licensing. • The vessel used for transshipping would need to be funded.

Considerations / data gaps
• The scenarios presented show the retention of at-sea offal will incur costs for the fishing vessel. The major cost would be the need to divert (steam) to different feeding grounds if no other vessels are involved. • The use of transshipment offers the most cost-effective option, based on the estimates and assumptions. However, the policy and licensing requirements need to be considered from a fishery management perspective and from an environmental perspective. • The impact of change on the crew, the vessel and at-sea handling should not be underestimated given that vessels suffer crew shortage, and that vessels are currently designed to ensure at-sea offal is quickly diverted away from the fish for human consumption.

8. Flamborough and Filey Coast SPA case study

This section provides an example based on the Flamborough and Filey Coast Special Protection Area (FFC SPA). For the purposes of this case study, the black-legged kittiwake (*Rissa tridactyla*) is the species of interest.

8.1. The Flamborough and Filey Coast site

The site was designated an SPA in 1993 (Natural England, 2014). It covers 7,858 hectares, 97% of which is marine. (Figure 12).

The SPA data form (Natural England, 2018) shows the site regularly supports more than 1% of the biogeographical population of four regularly occurring migratory species; black-legged kittiwake (*Rissa tridactyla*) (89,040 breeding adults, 2008-2011, 2% North Atlantic), northern gannet (*Morus bassanus*) (16,938 breeding adults, 2008-2012, 2.6% North Atlantic), common guillemot (Uria aalge albionis) (83,214 breeding adults 2008-2011, 15.6%) and razorbill (*Alca torda islandica*) (21,140 breeding adults, 2008-2011, 2.3%). The site also regularly supports an assemblage of more than 20,000 individual breeding seabirds (average number of individuals: 216,730, 2008-2012), including over 2,000 individual northern fulmars (*Fulmarus glacialis*).

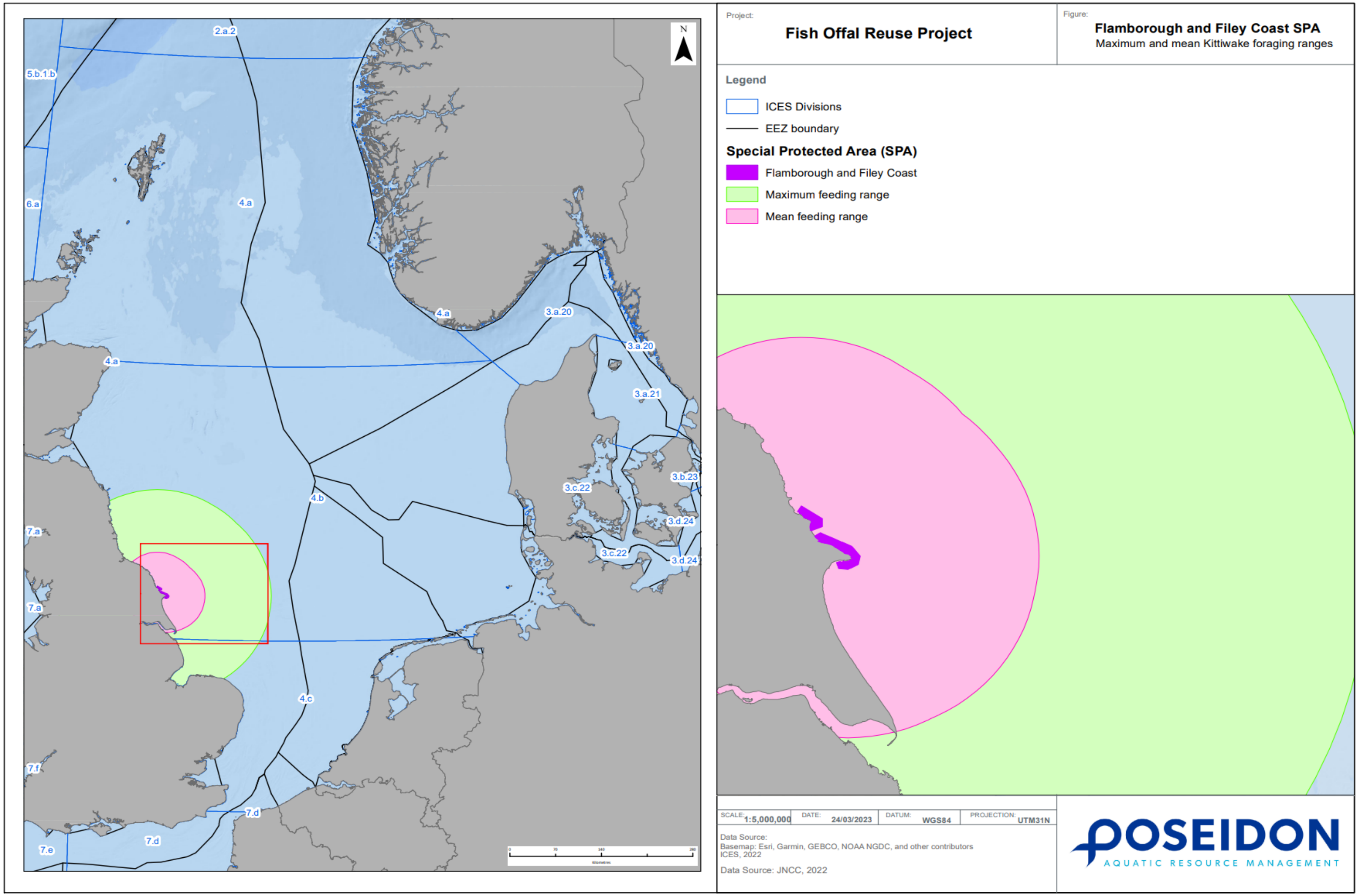

Figure 12 The Flamborough and Filey Coast SPA and kittiwake mean and maximum foraging areas: Source JNCC 2023, Woodward and others, 2019.

8.2. Kittiwakes

The latest colony counts found that in 2022 the FFC SPA supported a total of 44,574 apparently occupied nests, representing 89,148 breeding adult individual kittiwakes. This represents a 13% decline in the colony size since 2017, coinciding with a decade of low productivity (Clarkson and others, 2022).

Generally, kittiwakes have a mean foraging range of 54.7km (+/- 50.4km), with a mean maximum foraging range of 156.1km (+/- 144.5km). (Woodward and others, 2019).

Kittiwakes tend to feed gregariously on marine fish, typically small sized sandeels and clupeids, taken from the surface waters while sitting, or making shallow dives while in flight. They are also known to take discards and fish offal from fishing vessels (Sherley, et al, 2019).

Breeding kittiwakes are present at FFC SPA between March and August, during which time they operate as central place foragers, commuting between cliff face nests and prey patches within their known foraging range. Outside these months they will be widely dispersed across the Atlantic and North Sea, regularly as far south as 40°N, congregating at productive areas with high prey availability (Coulson, 2011).

8.3. Fishing in areas within kittiwake foraging ranges

Fishing activity within kittiwake feeding ranges are show in time fished (minutes) by gear type and live weight (tonnes) landed by vessels over 15m in length. This highlights fishing intensity and areas where significant quantities of offal may be sourced from.

Fishing activity for vessels under 10m is not shown within this spatial analysis. However, most <10m vessels operate as potters targeting shellfish, and produce very little at-sea offal. It was estimated (Section 5.3, Figure 9) that the under 10m fleet is responsible for 2% of the at-sea offal. Therefore, their exclusion from the spatial analysis has very little impact on the results.

For vessels between 10-15m, which are not shown in the spatial analysis, these are likely operate in the same fishing grounds as the over 15m vessels. The spatial analysis therefore shows the areas which are most intensely fished by vessels producing at-sea offal.

8.3.1. Weight of fish landings

Figure 13 indicates the average landed live weight (Tonnes) of all species made by UK vessels >15m within the North Sea-sub areas between 2016 and 2020.

Within the mean and maximum kittiwake foraging ranges, average landings were between 0-1 tonnes, with areas of moderately high landings between 0-10 tonnes, present in ICES rectangles 39E8, 36F0, 36F1 and 37F2. Other areas of moderate landings are scattered across the average and maximum kittiwake feeding ranges. As these are live weights, and not yet gutted, there is the potential for quantities of at-sea offal to be collected and disposed of within range of feeding kittiwakes.

Within the wider North Sea, the areas of highest landed live weights can be found in sub-area 27.IV.a, where areas of landed live weights ranging between 25 and 1,045 tonnes are present. Sub area 27.IV.c had on average the lowest average landings between 2016 and 2020.

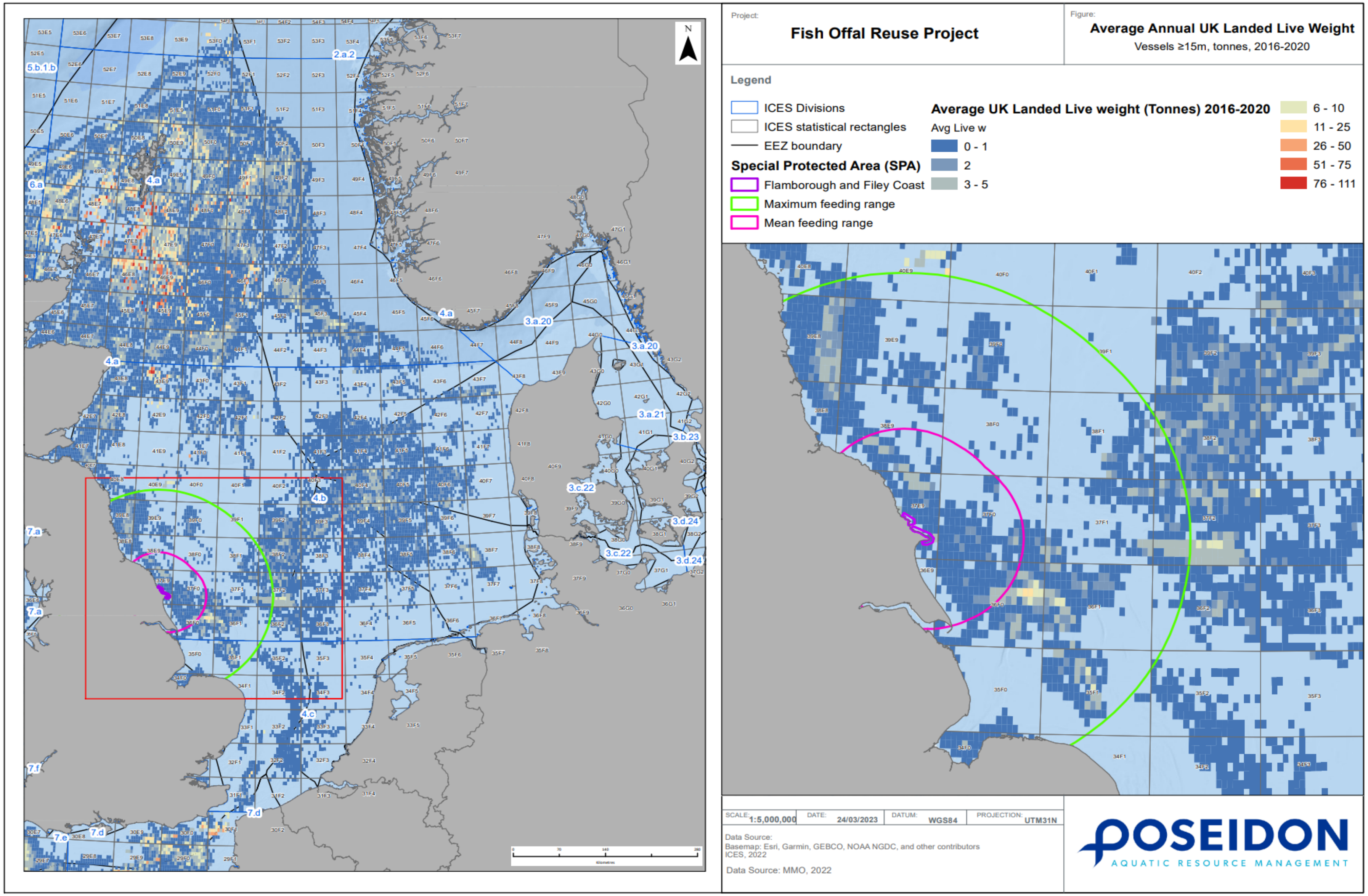

Figure 13 Average annual UK landed live weight (Tonnes) of all species, landed by UK vessels between 2016-2020: Source MMO 2023

8.3.2. Fishing intensity (based on VMS data)

VMS data sourced from the MMO displays the time fished (minutes) by UK registered vessels by different gear types, landed live weights (Tonnes), and covers vessels 15m and over in length.

The fishing gears shown are those used to target mainly demersal species, which will be the source of most of the useable at-sea offal.

8.3.2.1. Otter Trawls

Otter trawls target predominantly demersal species including cod, haddock, monkfish and anglers, which account for the greatest contribution to at-sea offal (Figure 8 and Table 8).

As shown by Figure 14, UK otter trawls operate across much of the North Sea study area. Data indicates that sub area 27.IV.a was on average the most intensely fished sub area between 2016 and 2020, in terms of time fished, with large areas subject to annual average fishing times greater than 11000 minutes, indicating significant fishing intensity.

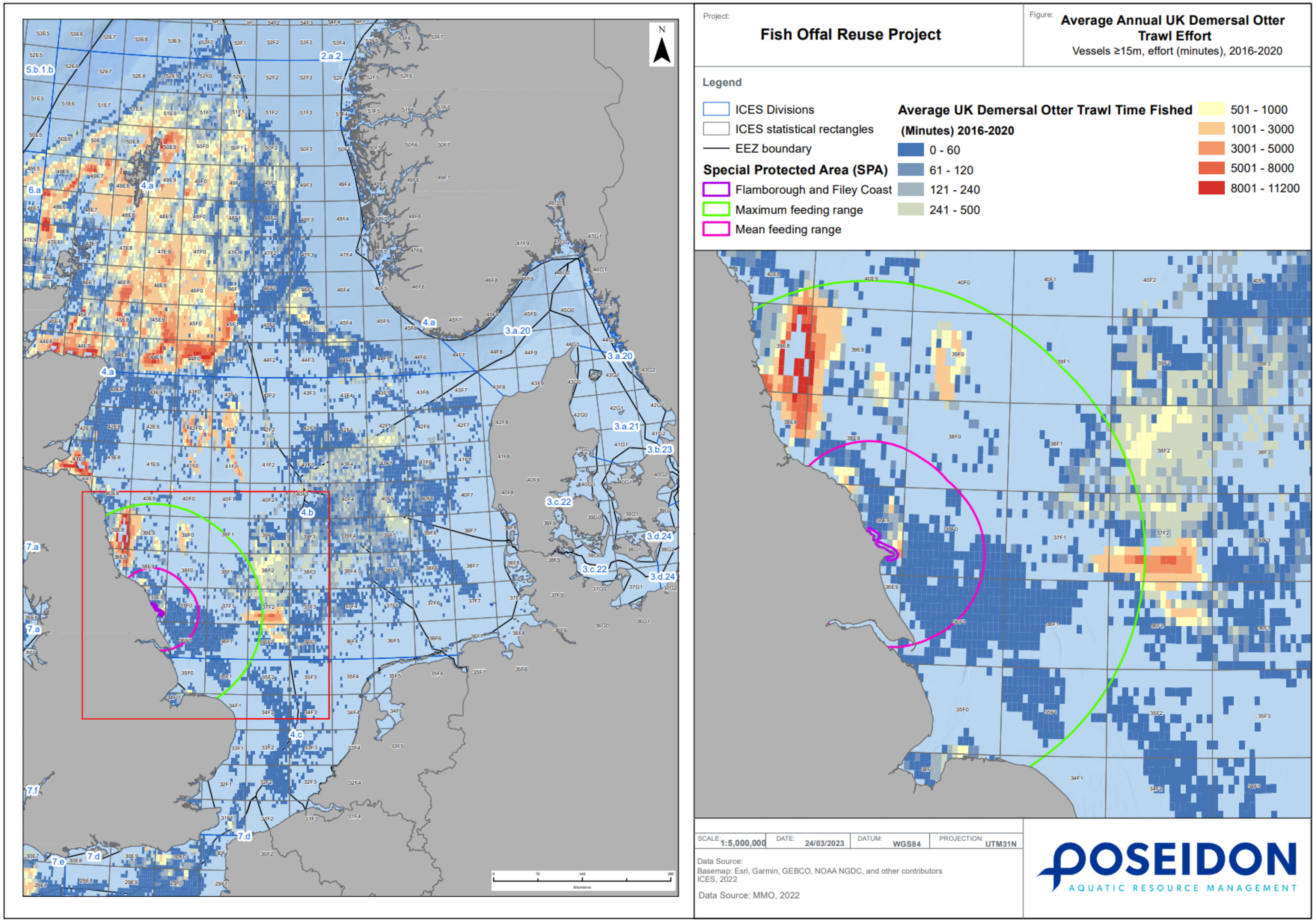

Figure 14 Fishing intensity; Annual average UK demersal otter trawl effort, (time fished in minutes), for vessels >15m, 2016-2020: Source MMO 2023

Within the mean and maximum feeding ranges of kittiwakes, time fished varies. Within the mean feeding range, large areas of low intensity are present, with areas of higher intensity found within ICES rectangles 39E8, 39E9 and 38E8. Smaller areas of moderate intensity are also present within rectangles 39E9 and 39F0. Within the maximum feeding range, sporadic areas of higher intensity are present in rectangles 42F0, 42F1, 41F1 and 37F2, with areas of moderate intensity concentrated within rectangle 38F2.

These areas of high intensity otter trawling could act as a potential source of significant quantities of at-sea offal, particularly as otter trawls contribute to the majority of at-sea offal into the North Sea sub-region (Figures 5 and 6), and consist of useable offal from demersal species such as cod, haddock and monks or anglers etc. As they are within range of feeding kittiwakes, it may reduce the distance required to deliver offal to feeding kittiwakes.

However, it must be considered that the majority of at sea offal available within the North Sea, contributed by otter trawls, likely comes from landings from 27. IV. a, thus there may be significantly less offal available in the area of 27.IV.b, where the SPA and kittiwake foraging ranges are located.

8.3.2.2. Beam Trawls

Average beam trawling intensity for UK vessels operating between 2016 and 2020 is shown in Figure 16. Across much of the North Sea, beam trawls operate at relatively low intensities of between 0-60 minutes. Areas of highest intensity are located within the eastern portion of sub region 27. IV. b and central portion of sub-region 27.IV.c.

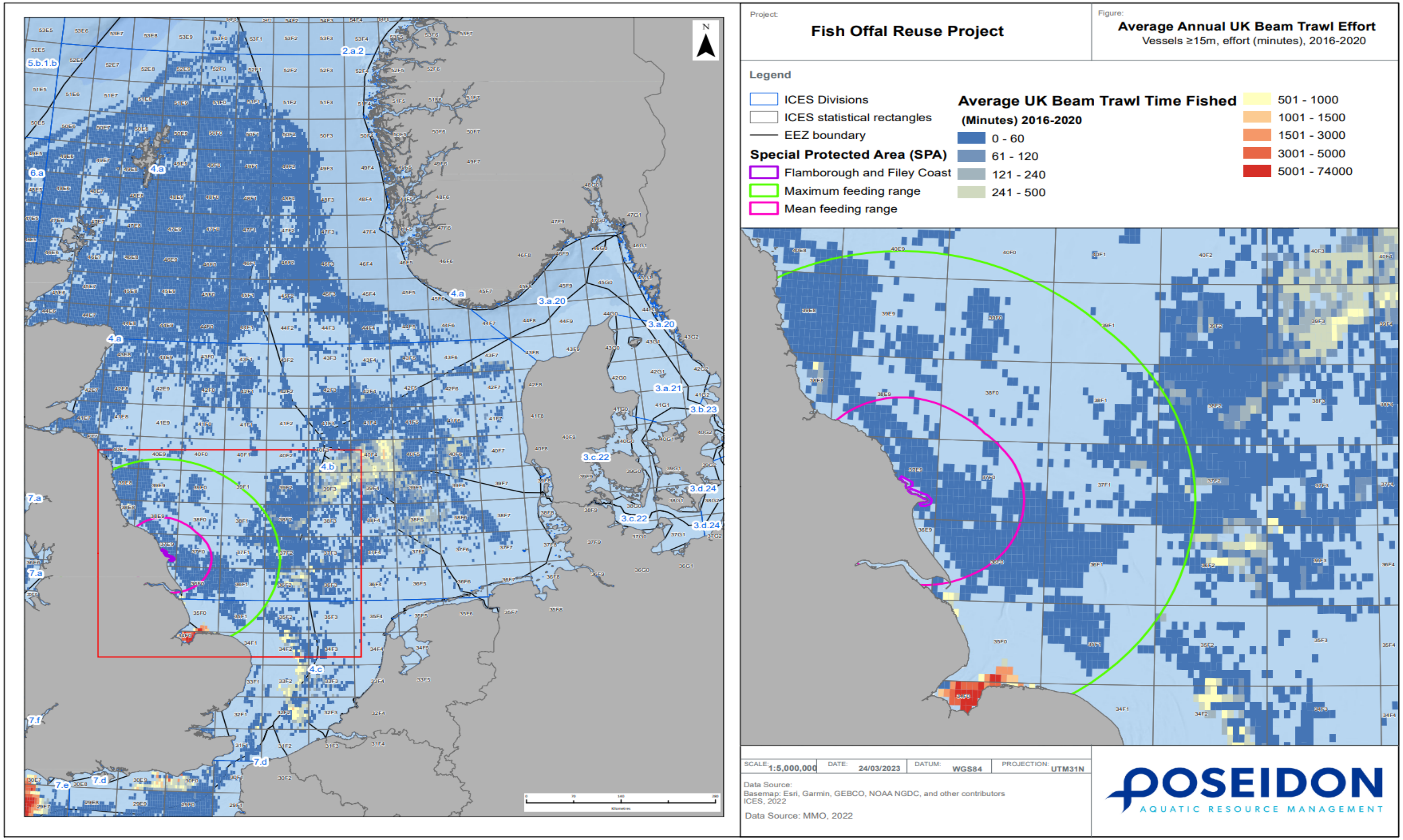

Figure 15 Fishing intensity; Annual average UK beam trawl effort, (time fished in minutes), for UK vessels >15m, 2016-2020: Source MMO 2023

Within the mean and maximum kittiwake feeding ranges, beam trawling intensity is low, with small sporadic areas of moderate intensity activity present. Areas of higher intensity beam trawling can be found outside of the mean-maximum kittiwake foraging ranges, in rectangles 39F3 and 34F2. Data appears to suggest that beam trawls would likely offer lower quantities of at sea offal to kittiwakes within the study area, which is supported by the fact that beam trawls contributed to less than 5,000 tonnes of at sea offal to the entire North Sea (Figure 8).

Due to the lack of higher intensity beam trawling activity within kittiwake foraging ranges (Figure 17), it would be necessary to aggregate offal from trawls operating in higher intensity areas outside of the kittiwake feeding ranges, such as the central portion of 27.IV.c and eastern portion of 27.IV.b and deliver these to the kittiwakes to make a meaningful supplementary food source. However, it should be recognised that these areas may already be used by seabirds foraging from other colonies.

8.3.2.3. Demersal seine

Average time fished for UK demersal seines operating between 2016 and 2020 is shown in Figure 18. On average UK demersal seines operated at low intensity across much of the North Sea, with areas of higher intensity concentrated within sub region 27.IV.a, particularly around the Shetland Isles. A small area of higher intensity seine is present within sub region 27.IV.c, in ICES rectangle 31F1.

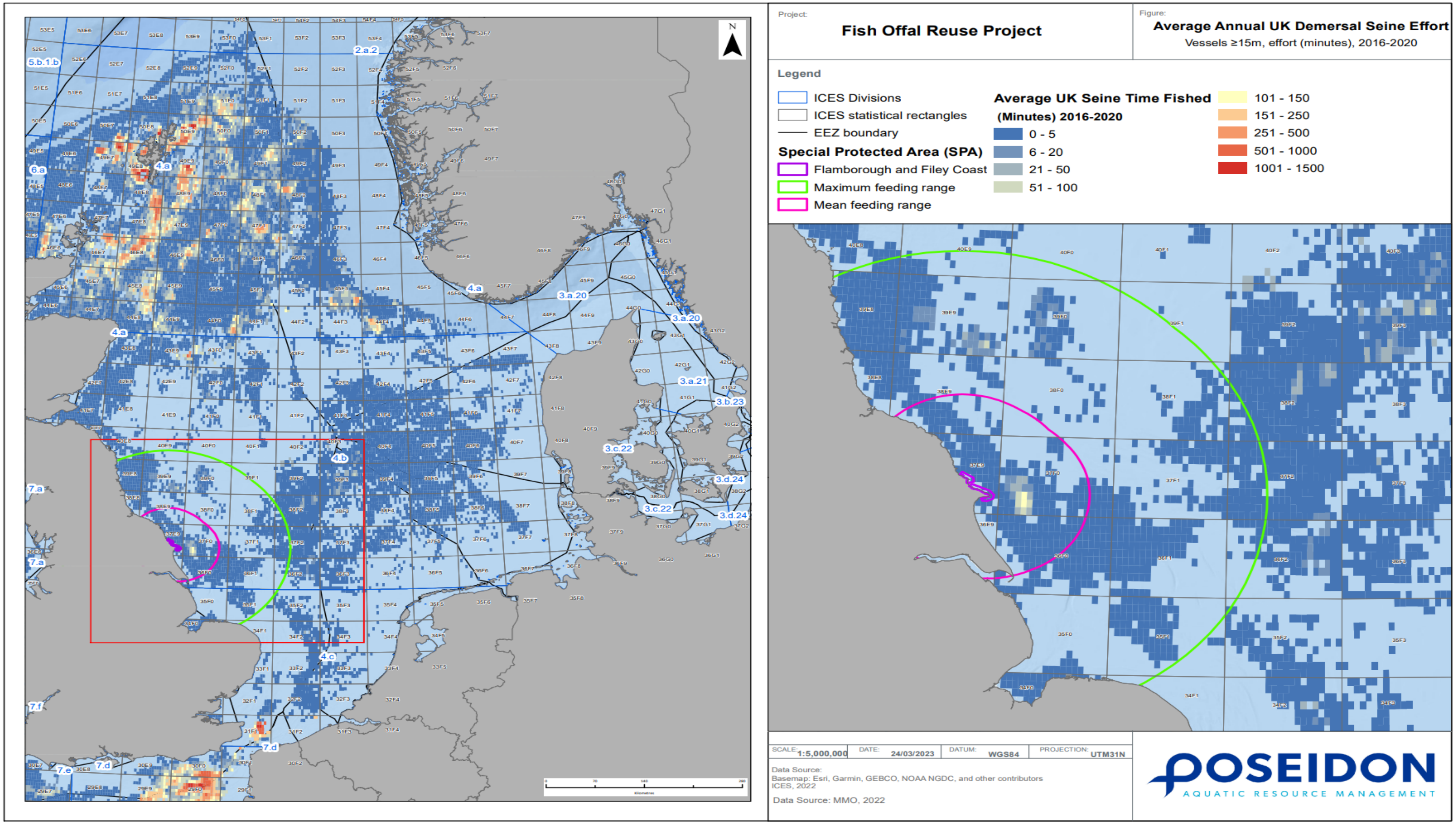

Figure 16 Fishing intensity; Annual average UK demersal seine effort, (time fished in minutes), for vessels >15m, 2016-2020: Source MMO 2023

Low intensity seine activity is present across much of the mean kittiwake foraging ranges, particularly the nearshore areas, with only a small area of higher intensity present within the southwestern portion of ICES rectangle 37F0. Across the mean-maximum kittiwake foraging range, intensity remains low.

For vessels operating demersal seines, offal would need to be aggregated from other seine vessels to make a significant impact upon kittiwake feeding, particularly those operating in 27.IV.a and brought to kittiwake foraging areas.

8.3.3. Fishing vessel route density

Fishing vessel route density based on vessel Automatic Information System (AIS) positional data is shown in Figure 19, AIS is required to be fitted on fishing vessels ≥15 m length. This data indicates the route density per square km per year and is specific to fishing vessels, however it does not distinguish between transiting and active fishing vessels. Despite this it can be used as a useful proxy to corroborate fishing grounds.

Figure 19 indicates sustained vessel traffic across the North Sea study area, particularly within sub region 27.IV.a and the Shetland Isles, the nearshore and eastern portion of sub region 27.IV.b and the eastern and central areas of 27.IV.c. These high intensity vessel routes overlap with many of high intensity fishing areas highlighted in Figures 14 to 18.

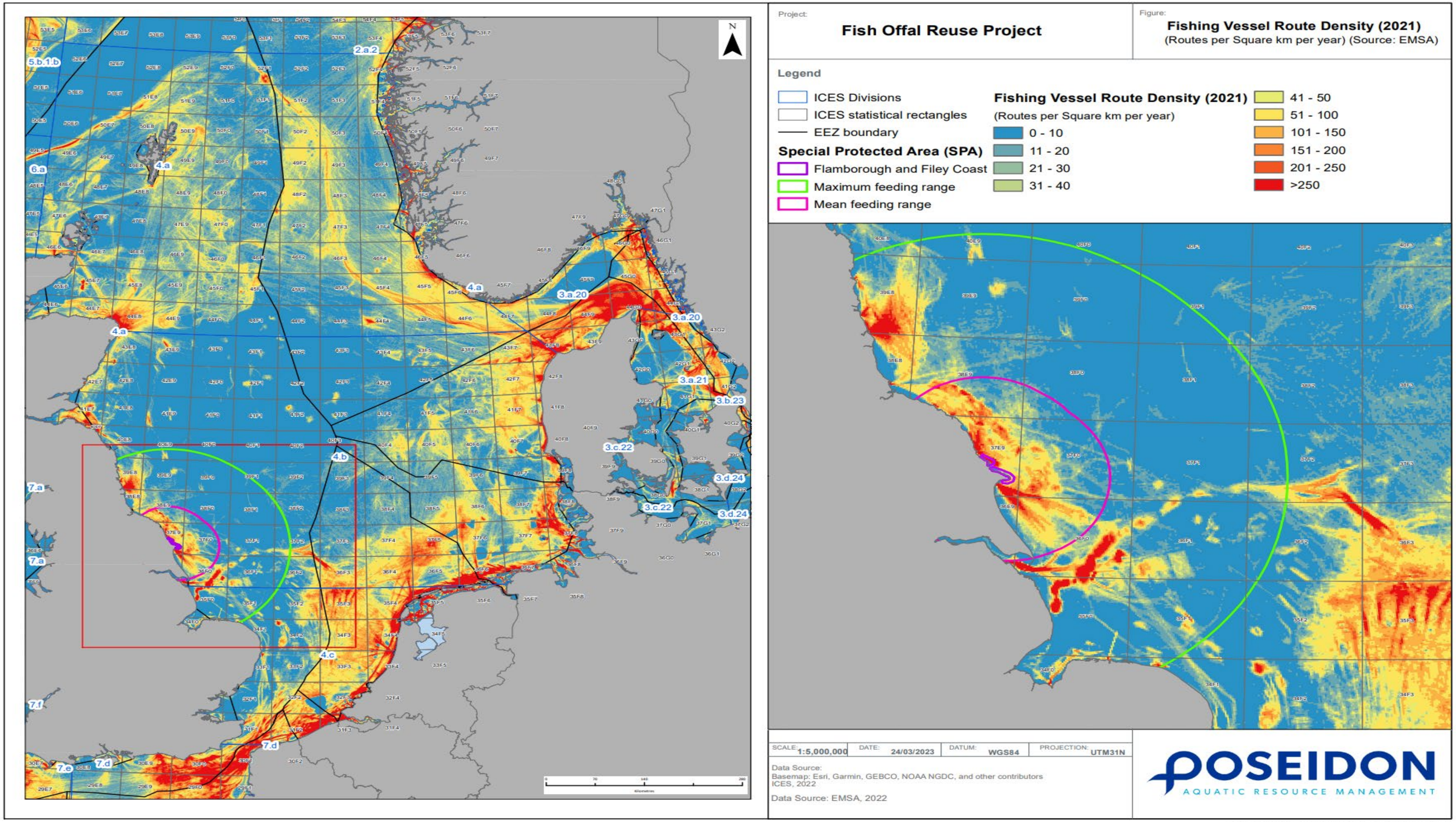

Figure 17 Fishing vessel route density in 2021, based on vessel Automatic Information System: Source EMSA 2022.

The vessel transit routes provide a proxy for highlighting potential high activity areas which could be used a potential aggregation point for vessels to offload at-sea offal for transhipments; for example, within ICES rectangle 37F2 there is high vessel activity present, as this location lies within the maximum kittiwake foraging range and overlaps areas where beam, otter and seine vessels operate in moderate to high intensity. This area could be a potential aggregation point for vessels to offload at sea offal for transhipments.

8.4. At-sea offal for kittiwake supplementary feeding

The estimated quantities of at-sea offal in the North Sea vary by sub-area.

- The Northern North Sea (sub area IV.a) estimated at 10,641 tonnes per year.
- The Central North Sea (sub-area IV.b) estimated at 746 tonnes per year.
- The Southern North Sea estimated at 99 tonnes per year.

Sub-area IV.b is closest to the Flamborough and Filey coast SPA. The annual at-sea offal production covers the whole sub-area. The quantity of at-sea offal fluctuates throughout the year with June and August being peak months.

Assuming 50% of this at-sea offal could be collected and made available for supplementary feeding, this amounts to just over 1 tonne per day, or around 4% of the Flamborough and Filey Coast SPA kittiwake colony feed requirement.

There is the potential to freeze offal on landing and stockpile it (incurring additional cost for cold storage) for use in the months that supplementary feeding would be most beneficial. For example, kittiwakes breed between approximately May and August, during which time they will commute between cliff nests and areas of food within their known foraging range. Targeted supplementary feeding could be limited to the breeding months, which amounts to approximately 100 days per year, with the aim to increase breeding success. This could facilitate aggregated frozen offal to provide a little under 4 tonnes per day of the breeding season and so equating to 16% of the Flamborough and Filey Coast SPA kittiwake colony feed requirement.

The above is based on 50% of the total UK fleet's offal production in Area 27.IV.b in relation to one species in one colony, which would be difficult to achieve. There are options to increase the volume of material available to a supplementary feeding programme in English SPAs by accessing the much larger volume of offal from Area 27.IV.a. However, it would be necessary to understand current consumption of offal in those areas by seabirds foraging from other colonies.

While most of the UK fleet fishing in IV.a are Scottish vessels landing into NE Scotland and Shetland, some English vessels do fish into the Northern North Sea (sub-area IV.a) and land back to English home ports. These are likely to be larger English vessels with a potentially greater capacity to handle and store at-sea offal.

8.5. Potential landing sites in the case study area

The ports in the mean foraging range, particularly those on the Yorkshire and Northumberland coasts, are primarily ports where most landings are shellfish species.

The kittiwake mean foraging range covers a small number of ports where demersal fish are landed including Hull, Grimsby, North Shields, Hartlepool, Blyth, and Scarborough. Between these six ports, an estimated 1,113 tonnes of at-sea offal could theoretically be landed. That assumes the at-sea offal is sourced only from vessels normally landing into those ports.

Additionally, there are other ports in the area, but these would only generate very small quantities.

The maximum foraging range extends into the southern waters around Scotland and the Thames Estuary in South-East England. However, this area does not include ports listed in the data.

Considerations / data gaps
• The case study provides an indication that at-sea offal could be sourced from fishing vessels, however, there are challenges such as accessibility to nearest fishing grounds. • The Central North Sea (sub-area IV.b) which is the nearest catch area to the FFC SPA produced an estimated 746 tonnes of at-sea offal per year. However, the fishing vessels associated with most of the offal are catching and discharging this offal throughout this sub area. The catch areas nearest to the kittiwake foraging grounds are associated with under 10m vessels, which produce limited quantities of at-sea offal. • In this example Scenario 3, aggregation of offal onshore and/or through transhipping would be needed to source sufficient quantities of at-sea offal whilst remaining cost-effective.

9. Conclusions and recommendations

It is estimated that the UK fleet produces almost 28 thousand tonnes of at-sea offal, albeit a proportion of this will be whole fish, permitted for disposal at sea as a non-quota species or under an exemption from the landing obligation. The ratio of whole fish is impossible to determine with any accuracy, but it is evident that seabirds already use this as a source of feeding and therefore the total amount of this estimated quantity could theoretically be available, if permitted under fishery management rules.

The estimates for at-sea offal indicate that significant quantities are potentially available, however it is produced in areas with high fishing intensity. The North Sea is the main source of most of the at-sea offal with nearly 11.5 thousand tonnes produced across the three sub-areas:

- The Northern North Sea (sub area IV.a) estimated at 10,641 tonnes per year.
- The Central North Sea (sub-area IV.b) estimated at 746 tonnes per year.
- The Southern North Sea estimated at 99 tonnes per year.

However, each of these sub-areas are substantial in size with the at-sea offal widely dispersed across areas of higher fishing intensity. Most of these fishing areas are a considerable distance from shore. In the case-study area, fishing intensity within the mean-maximum foraging range of kittiwakes was low indicating it would be useful to aggregate at-sea offal from a wider area.

To ensure at-sea offal is available for supplementary feeding of seabirds on a substantial level, changes to current practice would be required. Based on the findings in this report, this would include aggregation of offal, either on land or transshipped at sea. The most appropriate approach is dependent on the source of the offal (fishing areas) and the designated seabird feeding areas. The case-study presented in this report shows that land-based aggregation of offal may be advantageous as it would provide access to a larger quantity of material compared with the quantities that may be available from just the local fleet.

Current practice at sea is not aimed at offal retention and it is likely to take a significant shift to change. This includes vessel design, infrastructure for handling and storage, and ensuring food safety. However, these on-board considerations could be dealt with through changing equipment, which would require investment. For fishers there must be sufficient incentive to retain offal onboard and land it, i.e., an adequate price paid for the offal. There may also be additional costs in separating these materials on board to avoid compromising their catch.

The regulatory framework for aggregating offal should be considered. If at-sea offal is landed to shore, it becomes an animal by-product. Returning it to sea for seabird feeding would need to be an approved use and follow any prescribed requirements that may require. Aggregating offal at sea may change marine licensing rules given that the offal is no longer being dispersed at sea within the normal operation of the fishing vessel from which it originated.

On-board retention of offal should also be considered in the context of balancing supply and demand through seasonal peaks on troughs of fishing and seabird feeding requirements. The data available shows there are synergies, but this would need to be managed on an ongoing basis. This is highly likely to require on-land storage / preservation.

With the UK withdrawal from the EU, there have already been some changes in fishing access and fishery management in the UK. There will continue to be phased changes with expectations for greater access to UK fishing areas and differences in share of quota in subsequent years. The rules and exemptions around the landing obligation could change. These changes could provide opportunities for accessing greater quantities of at-sea offal in future, or the ability to provide a framework to remove any legislative barriers.

Recommendations

1. The estimate of at-sea offal is mostly offal, with a proportion of whole fish. Future seabird feeding should consider the inclusion of non-quota whole fish. The option to access unwanted quota species currently discarded at sea under a landing obligation exemption could be a future option if fishery management rules change.
2. Review policy requirements for animal by-products and returning fish offal to sea after it has been landed with Defra and the Marine Management Organisation. This is in context of use for seabird feeding which is not currently covered regarding offal aggregation at sea and on land.
3. Undertake a pilot project to investigate at sea considerations. This should take account of different sizes of vessel, different catch areas, consider on-board changes required. It should consider aggregation at sea and onshore for comparison.
4. Gain a better understanding of the composition of offal for seabird supplementary feeding and whether it is acceptable to seabirds, and any risks of dietary changes resulting from increased offal ingestion. Consider different formats for offal; whole, minced, chilled, frozen, further processed e.g., pellets. This is particularly important if any onshore storage/preservation is required.
5. Using the information gathered in this project consider whether this option is more suited to SPAs in areas closer to those with higher catches of fish.

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Glossary

By-catch	The unintended capture or entanglement of non-target species in fishing gear
Demersal	Species living on or near the sea bottom and feeding on benthic organisms. (Fishbase)
Estimated EEZ of capture	The Exclusive Economic Zone (EEZ) is the nation's EEZ of capture; unportioned landings are those which cannot be attributed to an EEZ or region. MMO report refers to 0-200nm (or median line) rather than 12-200nm. 'United Kingdom' waters includes all devolved administration and crown dependency waters. (MMO, 2021)
Estimated region of capture	The Region of capture aggregates the EEZ of capture into four categories, plus unportioned; international waters are those outside any nation's EEZ. (MMO, 2021)
Gear Category	Grouped into several gear categories - more information on the exact nature of fishing gears can be found at: http://www.fao.org/fishery/topic/1617/en (MMO, 2021)
ICES division	The International Council for the Exploration of the Sea (ICES) divides the sea into ICES divisions (MMO, 2021)
Landed weight	Quantity of fish at point of landing - this may be less than the live weight caught if fish have been processed (e.g., gutted or shelled) on board a vessel (MMO, 2021)
Live weight	Quantity of fish caught adjusted for any processing before landing - the MMO uses the live weight caught for most of the analysis as it shows the total weight of fish extracted from the sea; unless there is a specific reason to use landed weight, the MMO recommends the use of live weight. (MMO, 2021)
Landing type	Landings are grouped into quota or non-quota landings; quota landings are catches of fish stocks that are managed by quota limits (whether a landing is a quota stock is dependent on the species, zone and area of landing); non-quota stocks are any that aren't managed by quota limits. (MMO, 2021)

Length group (vessel)	Grouped into vessels 10 metres and under in length and those over 10metres. (MMO, 2021)
Minimum Conservation Reference Size (MCRS)	Previously 'minimum sizes', MCRS are applied to certain species of fish and shellfish. The MCRS is the set size that fish or shellfish can be removed from a fishery.
Month / month of landing	refers to date when fish was landed into port rather than when fish was caught at sea. (MMO, 2021)
Offal / at-sea offal	The internal organs removed from whole fish.
Pelagic	Living and feeding in the open sea; associated with the surface or middle depths of a body of water; free swimming in the seas, oceans or open waters; not in association with the sea bottom. (MMO, 2021)
Quota	Maximum limits that can be caught for some stocks are known as quota limits. Quota is divided between England, Wales, Scotland and Northern Ireland. All UK vessels are subject to detailed quota management rules, which are updated each year. https://www.gov.uk/guidance/manage-and-lease-fishing-quota
Rectangle	ICES Rectangles which are a sub-division of the sea surface area each approximately 30 nautical miles by 30 nautical miles in size; ICES Rectangle is the highest resolution of spatial landings data available for all UK fishing vessels. (MMO, 2021)
Shellfish	Any aquatic invertebrate animal having a shell and belonging to the phylum Mollusca, the class Crustacea (phylum Arthropoda), or the phylum Echinodermata. • Mollusca includes gastropods (including abalones, limpets, land and marine snails, whelks), bivalves (including oysters, mussels, scallops) and cephalopods (including squids, octopuses). • Crustaceans are aquatic animals that have jointed legs, a hard shell and no backbone, and include Crabs, lobsters, shrimps etc. • Echinoderms are covered by a hard, spiny covering or skin and include species such as starfish, sea cucumbers.

Species code	The 3-letter Food and Agriculture Organisation (FAO) United Nations short code: http://www.fao.org/fishery/collection/asfis/en
Species group	Grouped into demersal, pelagic or shellfish species. (MMO, 2021)
Species name	The common name associated with the FAO 3-alpha species code. (MMO, 2021)
Transshipment (trans-shipment or transhipment)	Unloading of goods from one vessel and its loading into another to either complete a journey to a further destination, or further processing at sea.
Vessel nationality	The devolved UK administration or crown dependency where the vessel was registered when landing was made. (MMO, 2021)
Year / year of landing	Date when fish was landed into port rather than when fish was caught at sea. (MMO, 2021)
Total allowable catch (TAC)	The total tonnage of each fish stock that may be removed from the sea each year by fishing fleets that fish it. https://www.gov.scot/policies/sea-fisheries/negotiations-and-total-allowable-catch/
TAC code	Where the landing type is quota, the TAC code is specified - a TAC code is the consistent identifier used to identify stocks; for quota species, TAC codes are mostly presented at stock level except for mackerel that is presented at species level which is more robust due to a number of special conditions used for the management of mackerel quotas. The TAC code here is based on the landings data. Some stocks have conditions associated which allow landings to be moved between stock codes for accounting purposes. For this reason, the tonnages reported here may not match end-year quota figures used in e.g., the quota allocations process: https://www.gov.uk/government/publications/fishing-quota-allocations-for-2021-for-england-and-the-uk (MMO, 2021)

Appendix I Questions for industry stakeholders

This set of questions formed the basis for telephone or online conversations with representatives from the fishing industry. Additional information was gathered during the discussions.

Part 1 – About the fish catch and extent of gutting at sea.

1	Our assumption is that most demersal fish are gutted at sea. Is this correct?	Yes / No
2	We understand small haddock are not gutted at sea. Is this correct?	Yes / No
2 b	Would you have an estimate, for example %, of how much haddock is not gutted at sea? We are only looking for an approximation, so any estimate is useful.	% of catch Quantity? Seasons / peak months?
3a	Are any other fish species not gutted at sea?	Yes / no
3b	If yes, what species?	Other demersal (list) Dogfish Size related? Season related? (If so which times of year)
4a	Are any other fish species processed in any other way, for example head-off?	Yes / no
4b	If yes which species?	Other demersal Size related?
4c	How commonplace is it?	

Part 2 Now thinking about what happens with the guts when they are removed.

6	Our assumption is that the guts will be thrown over the side. Is this correct?	Yes / no
7a	For the UK demersal fleet (ignoring the Kirkella freezer trawler), are you aware of vessels that do anything else with the guts they remove?	Yes / no
7b	If yes, what are they doing with them?	Retain on-board for Bait Fishmeal Human consumption; livers, roe Other (list)
7c	Is this widespread practice in the fleet?	Yes / no

Part 3 – Barriers to retaining guts on-board.

8	If vessels were asked to retain fish guts on board, what issues would you think there would be with this?	
	Lack of space for storage (would limit space for the catch)	Yes / no
	Smell / rapid spoilage	Yes / no
	How to store them safely to avoid contamination	Yes / no
	Would need extra equipment e.g., boxes, ice	Yes / no
	Extra work involved	Yes / no
	Design of the gutting area would make it difficult to keep them	Yes / no
	Removing food from the sea (for other fish, shellfish etc)	Yes / no
	Other (specify)	
8b	What would be the most important / your top 3?	

Part 4 – any other comments / observations

Appendix II Classification of fishing areas, vessels and fishing gear

Fishing areas

For ease of data collection and analysis, the world's oceans are divided into major fishing areas and provided a specific number, for example FAO area 27 is the division given to the Atlantic northeast (Figure 1). FAO areas are then further divided and numbered into sub-areas, for example subdivision 27.4 refers to the entire North Sea (Figure 2).

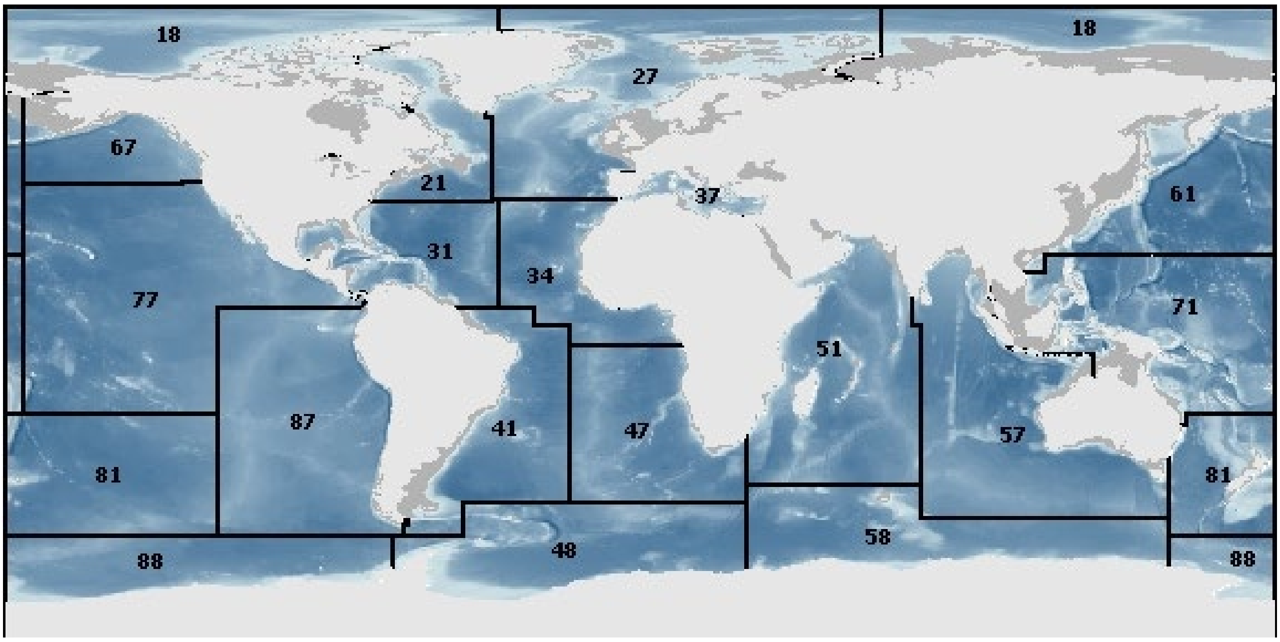


Figure 1: FAO major fishing areas of the world's oceans (FAO)

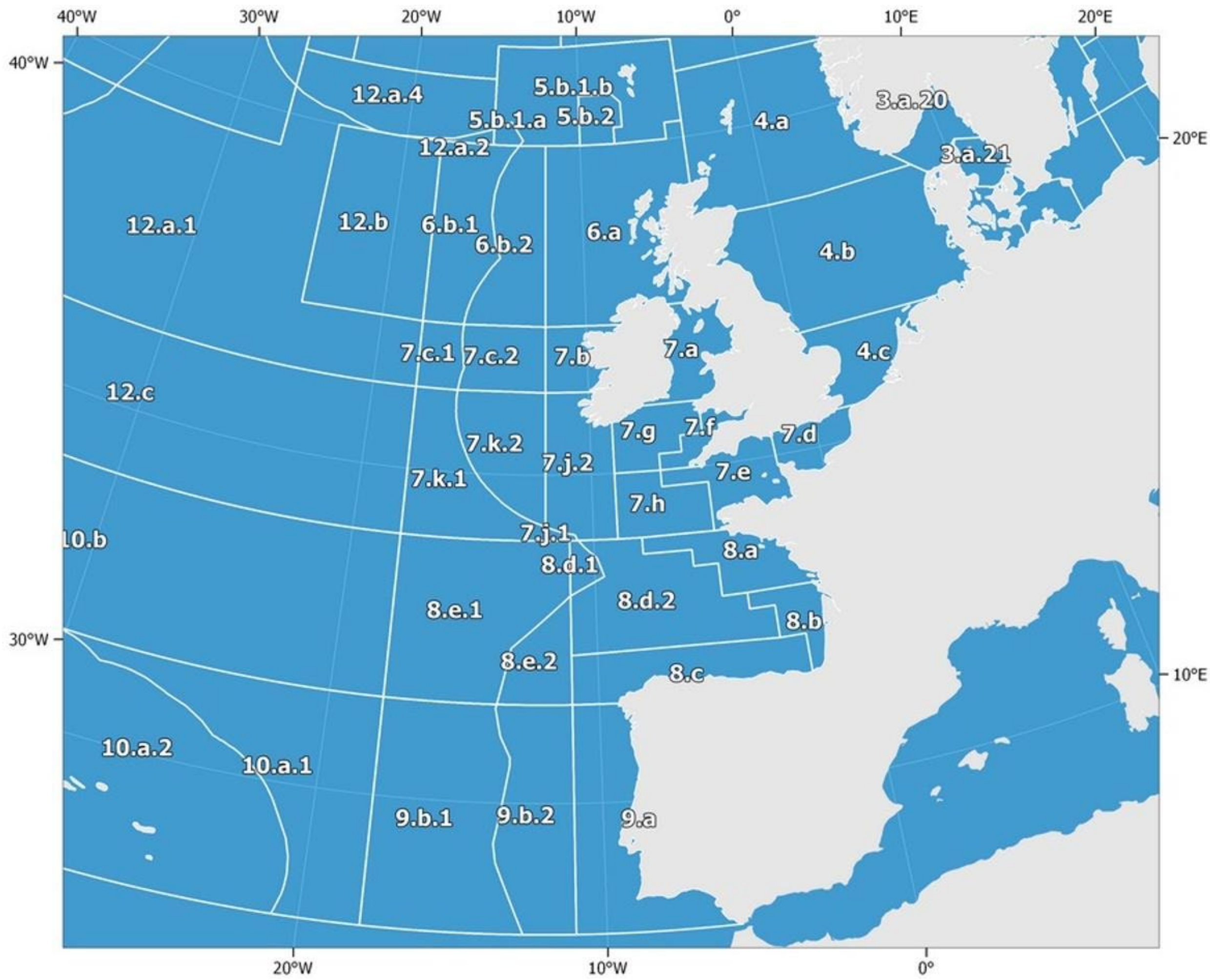


Figure 2: Detailed boundaries of the ICES subareas 27.4, 27.5, 27.6, 27.7, 27.8, 27.9 (FAO, 2023)

Sub-areas are then subdivided into smaller areas known as sub-divisions, for example the North Sea contains 3 subdivisions, Northern North Sea (27.4a), Central North Sea (27.4b) and Southern North Sea (27.4c), as shown in Figure 3. Finally, each subdivision is further divided into ICES Statistical Rectangles, a gridded, latitude-longitude based area notation system. Each ICES statistical rectangle is '30 min latitude by 1 degree longitude' in size which is approximately 30 nautical miles by 30 nautical miles and are used for the gridding of data to make simplified analysis and visualisation (Figure 4).

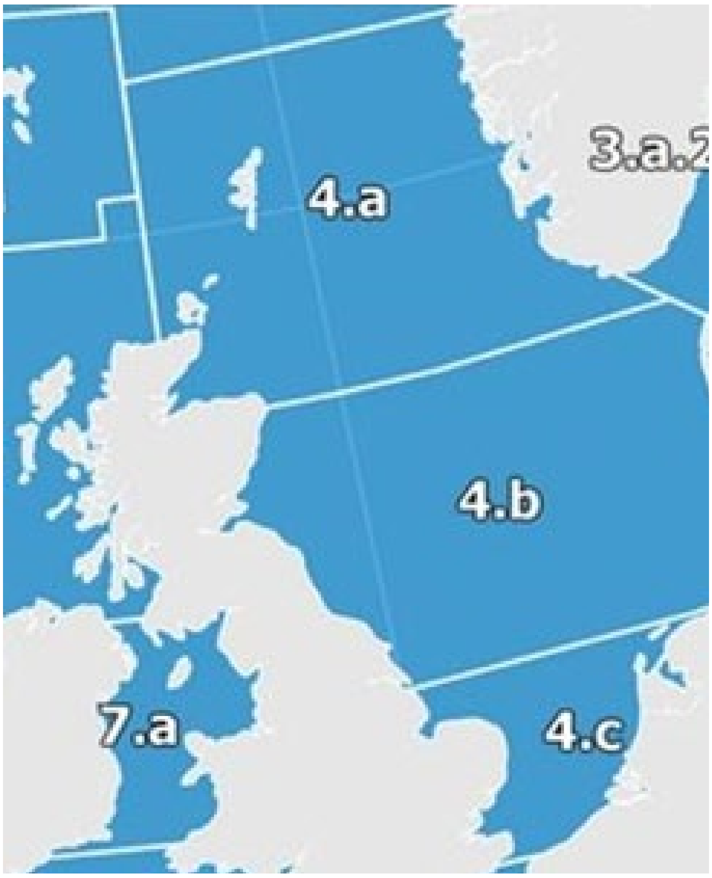


Figure 3: Subdivisions within the North Sea (Subarea 27.4) (FAO, 2023)

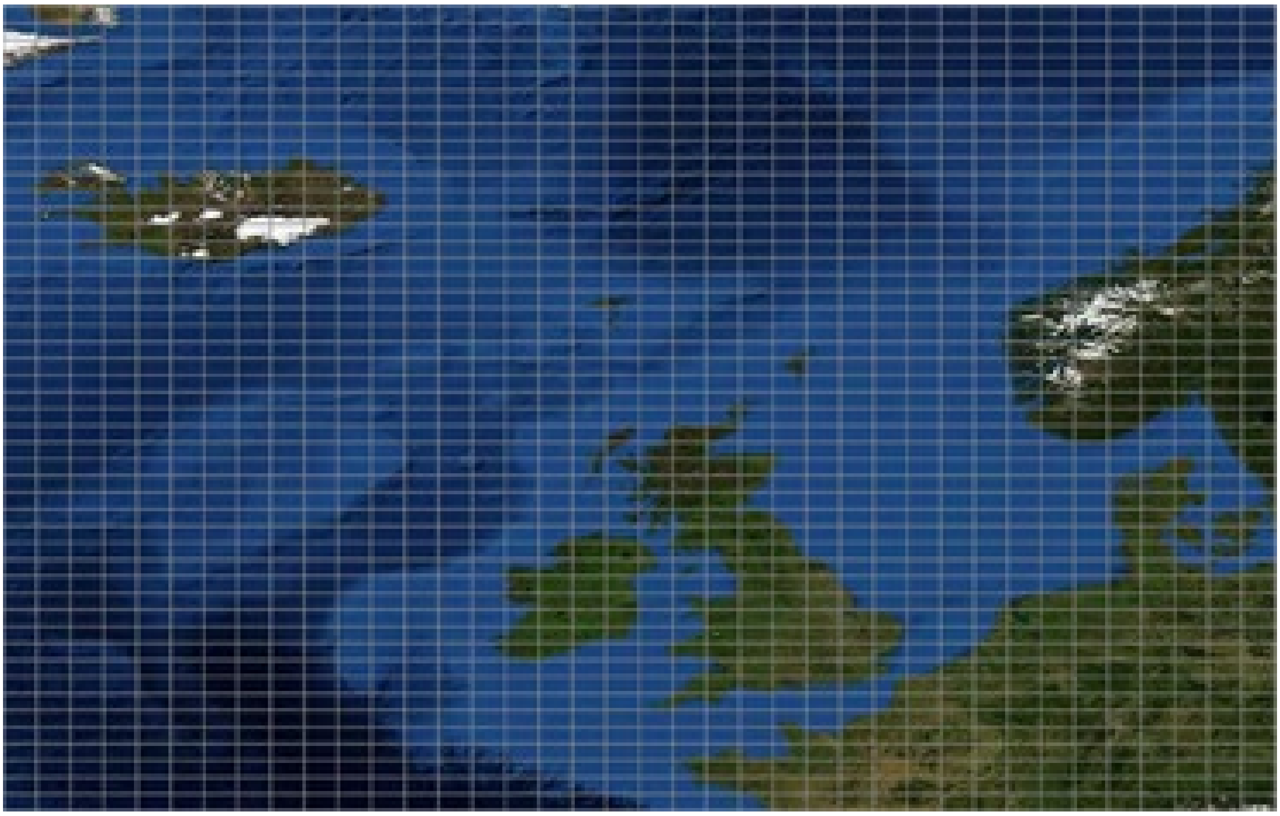


Figure 4: ICES statistical rectangles (ICES 2023)

Sub-areas and divisions of FAO fishing areas 27 and 37 – North-East Atlantic

Sub-area and sub-division	Name
Subarea I	**Barents Sea**
Subarea II	**Norwegian Sea, Spitzbergen, and Bear Island**
Division II a	Norwegian Sea
Division II b	Spitzbergen and Bear Island
Subarea III	**Skagerrak, Kattegat, Sound, Belt Sea, and Baltic Sea; the Sound and Belt together known also as the Transition Area**
Division III a	Skagerrak and Kattegat
Division III b, c	Sound and Belt Sea or Transition Area
Division III b (23)	Sound
Division III c (22)	Belt Sea
Division III d (24-32)	Baltic Sea
Subarea IV	**North Sea**
Division IV a	Northern North Sea
Division IV b	Central North Sea
Division IV c	Southern North Sea
Subarea V	**Iceland and Faroes Grounds**
Division V a	Iceland Grounds
Division V b	Faroes Grounds
Subarea VI	**Rockall, Northwest Coast of Scotland and North Ireland, the Northwest Coast of Scotland and North Ireland also known as the West of Scotland**
Division VI a	Northwest Coast of Scotland and North Ireland or West of Scotland
Division VI b	Rockall
Subarea VII	**Irish Sea, West of Ireland, Porcupine Bank, Eastern and Western English Channel, Bristol Channel, Celtic Sea North and South, and Southwest of Ireland - East and West**
Division VII a	Irish Sea
Division VII b	West of Ireland
Division VII c	Porcupine Bank
Division VII d	Eastern English Channel
Division VII e	Western English Channel
Division VII f	Bristol Channel
Division VII g	Celtic Sea North
Division VII h	Celtic Sea South
Division VII j	South-West of Ireland - East
Division VII k	South-West of Ireland - West
Subarea VIII	**Bay of Biscay**
Division VIII a	Bay of Biscay - North
Division VIII b	Bay of Biscay - Central
Division VIII c	Bay of Biscay - South
Division VIII d	Bay of Biscay - Offshore
Division VIII e	West of Bay of Biscay

Sub-area and sub-division	Name
Subarea IX	**Portuguese Waters**
Division IX a	Portuguese Waters - East
Division IX b	Portuguese Waters - West
Subarea X	**Azores Grounds**
Subarea XII	**North of Azores**
Subarea XIV	**East Greenland**
Division XIV a	North-East Greenland
Division XIV b	South-East Greenland

Classification of fishing vessels

Fishery vessels are classified in accordance with international standards (FAO, 2021) which includes vessels engaged only in catching operations (i.e., fishing vessels) and other vessels supporting fishing related activities (i.e., non-fishing vessels such as motherships, fish carriers and reefers).

The main categories of fishing vessels are in the list below however many more subcategories exist (FAO, 2021).

- Trawlers
- Purse seiners
- Other seiners
- Gill netters
- Trap setters
- Long liners
- Other liners
- Multipurpose vessels
- Dredgers
- Other fishing vessels

The most frequently used and preferred measure of the length of a fishing vessel is length overall (LOA) which refers to the maximum length of a vessel from the two points on the hull most distant from each other, measured perpendicular to the waterline. The table below shows the size ranges by main type of vessel.

Lower limit (metres)	Upper limit (metres)
Decked fishing vessels	**Decked fishing vessels**
0	11.9
12	17.9
18	23.9
24	29.9
30	35.9
36	44.9
45	59.9
60	74.9

Lower limit (metres)	Upper limit (metres)
75	
Non-decked vessels	**Non-decked fishing vessels**
0	5.9
6	11.9
12	17.9
18	23.9
24	29.9
30	

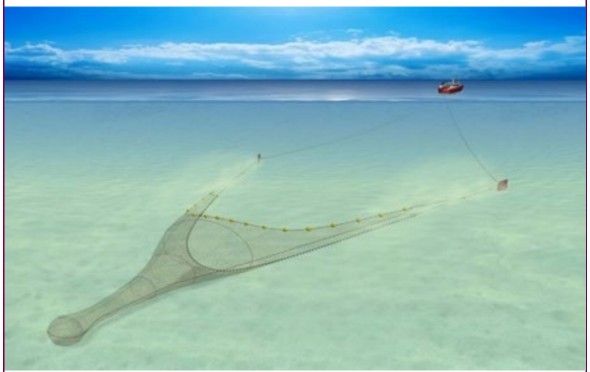
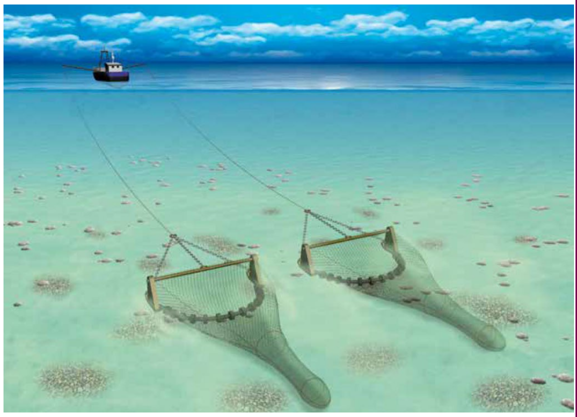
In the UK, data on the weight of fish caught and landed relates to vessel licensing, which uses main categories of under 10m or over 10m LOA.

Main categories of fishing gear

The following is a simplified list of the international classification of fishing gear types (FAO, 2016).

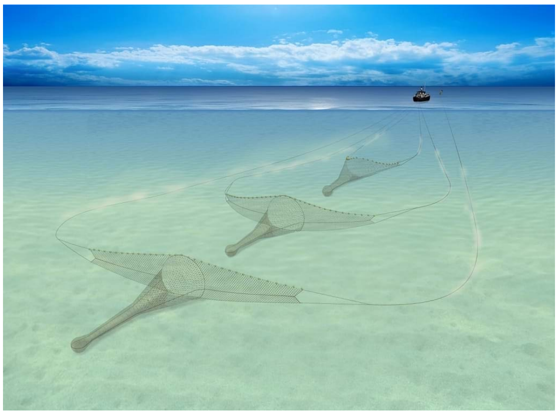
- Surrounding nets: A surrounding net is a long piece of net constructed mostly from rectangular sections of netting framed by ropes and catches fish by surrounding a school of fish.
- Seine nets: Seine nets can be cone-shaped nets with long wings and a codend, or a long piece of net without a codend, catching fish by encircling and herding.
- Trawls: The trawl is a cone-shaped body of netting, usually with one codend, towed behind one or two boats to catch fish through herding and sieving.
- Dredges: A dredge is a cage-like structure often equipped with a scraper blade or teeth on its lower part, either pulled or towed to dig animals out of substrate and lift them into the cage or bag.
- Lift nets: A lift net is a piece of netting mounted onto a frame that is lowered into the water to allow fish to enter the area above the net and is then lifted or hauled upward to collect the fish accumulated there.
- Falling gear: Falling gear is a net or a basket-like structure which is cast, pushed down, or allowed to fall from above to catch fish underneath it.
- Gillnets and entangling nets: Gillnets and entangling nets are long rectangular walls of netting that catch fish by gilling, wedging, snagging, entangling or entrapping them in pockets.
- Traps: Stationary structures of many shapes and sizes into which fish are guided, or pushed by the current, or drawn into the gear by bait or other attractants.
- Hooks and lines: Gears that use hooks (including jigs) and lines to catch fish.
- Miscellaneous gear: Include all other gears not included in other categories. There are a variety of other gears in world fisheries, especially in small-scale and artisanal fisheries. They include harpoons, rakes etc.

The following tables provide a description and image for the main gear types of relevance in this report. (Seafish, 2023).

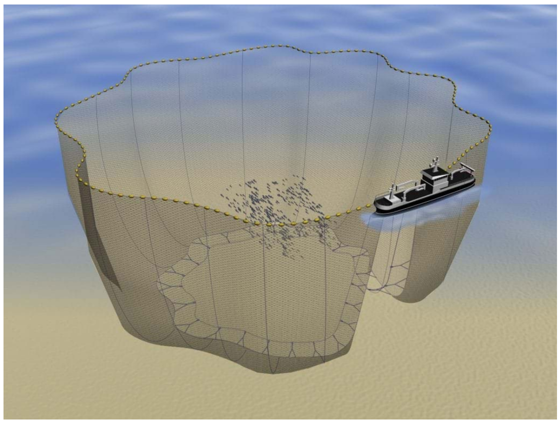
Gear type	Image (Courtesy of Seafish Gear Database 2023)
Otter trawl A cone shaped net towed on/near the seabed to target demersal fish species (or mid-water to target pelagic fish species) The mouth of the trawl is held open by a pair of trawl doors (otter boards) The prawn net used by *Nephrops* trawlers is a long winged low net with lightweight ground gear for towing over the soft, muddy areas where *Nephrops* are found.	
Beam trawl There are various forms of trawling in which one or two vessels (pair trawling) may be used to tow a net along to catch fish. Demersal trawls are designed to catch species above the seabed, whilst beam trawls target species that are found on and within the seabed. Beam trawl nets are held open by a heavy steel beam which is towed along the seabed on a line approximately three times the depth of the water	

Demersal Seine

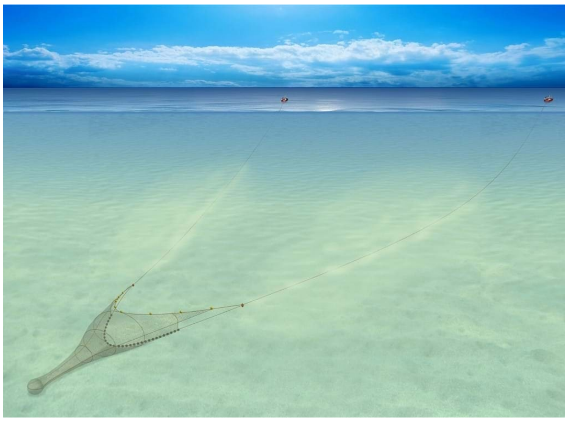
Seine fishing involves using an enclosing net called a seine. The net hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats. The nets work by enclosing around the fish as they are hauled in. several types of seine operate within UK waters.



In the Scottish seine the gear is shot on the seabed in a rounded triangle shape with very long weighted ropes attached to each end of the net. The net is gradually hauled in with the vessel maintaining station using its engine power rather than an anchor as in anchor seining.



A purse seine is a large net used to surround a shoal of pelagic fish. Once shot, the bottom of the net is drawn together by hauling in a long wire called the ‘purse line’ to form a huge cup shape of netting just below the surface of the water with the targeting fish inside. The net is gradually hauled onboard the vessel and the catch taken onboard the vessel.



Pair seine uses a net similar to a demersal trawl is towed by two boats simultaneously, one towing each side of the trawl and held open by the distance apart of the vessels. The gear and way of operating a pair seine differs very little from a pair trawl except that the pair seine has a much greater length of rope and wire on the seabed, sweeping a much greater area of seabed.

Images courtesy of Seafish Gear Database 2023.

Time at sea / days at sea

Understanding fishing is important in the context of this report and the potential availability of at-sea offal as a year-round source for seabird feeding.

Time spent fishing varies and is not a consistent daily operation throughout the year.

Days at sea are a means of managing fishing effort and describes the time a fishing vessel is engaged in fishing. Fishing vessels over 10m are required to have 'days at sea' allocation within their fishing licence. This influences when and where they fish.

The need to balance annual quota is also relevant, vessels may opt to maximise fishing opportunities at certain times, or they can face quota shortage and no longer able to fish without purchasing additional quota.

Nature plays an important part in dictating fishing patterns during the year. Fishing patterns will vary by target species, for example fish condition (seasonality, pre and post spawning). The weather is also important and will affect catches at different times of the year. Smaller vessels are particularly influenced by weather and tides.

Fishing employment and crew sizes

The number of employed fishers has reduced over time to current levels (table below). The total number of employed fishers equates to 6,559 full-time equivalent employees (Seafish, 2023).

Number of fishers in the UK

Part time	Full time	Total
9,023	2,275	11,296

Source: MMO 2020

Individual vessels have crew sizes relative to the type and size of vessel. Small vessels will have anything from one crew member (single handed) two; larger vessels could have between five and 10 crew members.

Crew shortages are an issue in the UK fleet, ensuring crew on vessels are fully engaged in their normal work whilst at sea. Any additional work or additional time spent handling and processing the catch is limited by the number of crew available. It is also a safety consideration as the more time spent working, the less rest time there will be.

Appendix III Fish names including scientific name.

Fish name	*Scientific name*
Cod	*Gadus morhua*
Monkfish, Monks or Anglers	*Lophius piscatorius*
Haddock	*Melanogrammus aeglefinus*
Saithe	*Pollachius virens*
Hake	*Merluccius merluccius*
Skates and rays (including Thornback ray, Blonde ray, Cuckoo ray, spotted ray, long-nosed skate)	*family Rajidae*
Ling (including Ling, blue ling)	*Molva molva, Molva dypterygia*
Plaice	*Pleuronectes platessa*
Whiting	*Merlangius merlangius*
Pollack	*Pollachius pollachius*
Megrim	*Lepidorhombus whiffiagonis*
Redfishes	*All species of Sebastes, All species of Helicolenus*
Catfish	*Anarhichas spp.*
Lemon Sole	*Microstomus kitt*
Dogfish (including Lesser Spotted Dog, Smoothhound)	*Squalus acanthias, Scyliorhinus canicula, Mustelus mustelus*
Sole	*Solea solea*
Witch	*Glyptocephalus cynoglossus*
Turbot	*Psetta maxima*
Halibut (comprising Halibut, Halibut - Greenland)	*Hippoglossus hippoglossus, Reinhardtius hippoglossoides*
Dabs	*Limanda limanda*
Brill	*Scophthalmus rhombus*
Conger Eels	*Anguilla spp.*
John Dory	*Zeus faber*
Torsk (Tusk)	*Brosme brosme*
Greater Forked Beard	*Phycis blennoides*

References for Appendices

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