North Sea Energy Island

Technical Report WP-I Fish and Fish Populations

Energinet Eltransmission A/S

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Contents

List of key terms

A list of terms (in English and Danish) and their explanations.

Table 0-1 Terminology including Danish and English terms as well as explanations.

English (abbreviation)	Danish	Explanation
Extended survey area [fisheries]	Udvidet forundersøgelsesområde	The area for which data and information from the commercial fisheries have been collected – management areas ICES rectangles 42F6 and 41F6.
Pre-investigation area [all themes apart from fisheries]	Forundersøgelsesområde	The investigation area, wherein fish surveys have been carried out and supplementary data and information have been collected.
Phase 1 area of the proposed plan for the programme North Sea Energy Island	Område fase 1 af Plan for Program Energiø Nordsøen	Extended term for the phase 1 area. This area outlines the phase 1 area of the proposed plan for the programme North Sea Energy Island where fish surveys were undertaken
Phase 1 area	Område fase 1	Abbreviated term for the "phase 1 area of the proposed plan for the programme North Sea Energy Island"
ICES	ICES	International Council for the Exploration of the Sea.
CPUE	Fangst per indsats	Catch Per Unit Effort
nm	Nautical miles	Length parameter used at sea

Summary

This technical report comprises the results of investigating the fish composition and populations within the pre-investigation area of the North Sea Energy Island. The objective of the report is to investigate and map the fish species composition and their abundance to determine if the pre-investigation area of the North Sea Energy Island serves as a possible spawning and nursery area. This information will be used to help conduct the environmental impact assessment on fish and their populations for the phase 1 area of the proposed plan for the programme North Sea Energy Island.

Data and information on the fish composition and populations in the pre-investigation area were based on a literature desk study, commercial fishery data and data from field surveys undertaken in the autumn of 2022 and in the spring and autumn of 2023.

Seabed substrate mapping in the pre-investigation area has shown that the seabed consisted primarily of soft bottoms made up of sand and sand/gravel substrates with some areas containing various amounts of smaller and larger stones. The majority of the benthic habitats in the pre-investigation area was therefore identified as soft bottom habitats and mixed bottom habitats. In the North Sea, these habitats are known to attract particularly flatfish and numerous codfish species. Data on the commercial fisheries from the ICES management areas (the extended survey area) overlapping with the pre-investigation area showed that benthic species with preference for soft-bottom or mixed substrates such as European plaice, Atlantic cod, and lemon sole comprised a large amount of the catches. The pelagic species Atlantic herring, species of sandeel and European sprat also made up substantial proportions of the catches.

Trawling surveys were conducted at a total of 14 locations (stations) in soft bottom and mixed bottom habitats within the pre-investigation area in late autumn of 2022 (October 22nd), and at a total of 15 locations (stations) again during the spring (27-31 March) and autumn (21-25 September) of 2023. In the autumn 2022 trawl survey, an ICES TV3 520/80 standard bottom trawl was used. This gear was replaced with a 4 meter wide beam trawl during surveys in 2023 to duplicate the same technical specifications of the beam trawl used in fish surveys in the Energy Island Bornholm Project. In order to investigate fish communities in the mixed and hard bottom habitats where bottom trawling was not possible, gillnet surveys were undertaken at three different locations in 2023 during the same time periods as the trawl surveys. The gonad maturity of larger individuals of codfish species (Atlantic cod, haddock and whiting) and flatfish species (European plaice, dab and lemon sole) was investigated in order to assess the likelihood of the given species spawning in the area.

A total of 34 different species were caught in the trawl and gillnet surveys combined, of which five were pelagic species and 29 were demersal or semi-pelagic species. Of the 30 benthic/semi-pelagic species, all except one species were linked to either soft or mixed bottom habitats.

In all trawl surveys, the most dominant species by abundance were European plaice (31.8%) and common dab (19.7%). Other fish species such as solenette (14.3%), haddock (8%), whiting (7.8%) and grey gurnard (7.1%) were also common species caught in various abundances at many of the sampling stations. Fish abundance in terms of both weight and individual numbers caught were highest in the southeastern and eastern areas of the pre-investigation area in both spring and autumn. Catch per unit effort (CPUE) in the spring and autumn trawl surveys of 2023 where the same gear type was used, were 6,4 kg/10.000 m^2 swept area (spring) and 6,9 kg/10.000 m^2 swept area (autumn), respectively, and thus very similar.

In the gillnet surveys, whiting (37%) and haddock (19.3%) were the most abundant species by number in both spring and autumn. Also, grey gurnard (14.1%), European plaice (4.6%), Atlantic cod (3.2%) and lesser spotted dogfish (6.8%)

were common in both the spring and autumn gillnet surveys. A higher number of species were caught in the gillnet survey during autumn (22 species represented) compared to the spring survey (12 species represented). However, the 10 additional species observed during autumn were only represented by 1-3 individuals, and the apparent difference in fish diversity between the spring and autumn did not appear to represent a major migration of any particular species to and from the pre-investigation area.

On the basis of results from the fish surveys, along with data from the fisheries and the substrate characteristics within the pre-investigation area, the key species were considered to be: Atlantic cod, European plaice, whiting, haddock, European sprat, lesser sandeel, grey gurnard, common dab, lemon sole and Atlantic herring.

A Shannon Wiener and Evenness index using the number and abundance of fish species in trawl and gillnet surveys was used to estimate seasonal and spatial differences in fish biodiversity. Seasonally, results from trawl data indicated that there was no significant difference for either of the three metrics: Species count ($p=0{,}59$), Shannon Wiener index ($p=0{,}17$) and Evenness ($p=0{,}37$). There was, however, a slight tendency towards a richer and more diverse fish community in the autumn compared to the spring. Within the pre-investigation area results showed comparable values in Shannon Wiener and Evenness indexes, and no significant differences in biodiversity. However, slight geographic grouping of biodiversity was observed, indicating slightly greater fish biodiversity in the northwest, lower in the southeast and lowest in the northeast parts of the pre-investigation area.

There was no indication that spawning was either about to take place or had just taken place in any of the individual fish of Atlantic cod or European plaice in any of the individual fish where gonad maturity was assessed. Thus, there were no indications that the pre-investigation area comprised a spawning area for the investigated Atlantic cod, European plaice or the few specimens of haddock and whiting that were analysed.

The abundances and lengths of both common dab and European plaice indicated that the soft bottom areas that characterize the majority of the pre-investigation area were used as a nursery area for these fish species. Similarly, survey results suggested that the pre-investigation area was also a nursery area for the codfish haddock, while this was less apparent for both whiting and Atlantic cod. In all three surveys there were almost no large adults represented in the catches of these three primary codfish species.

1. Introduction

With the Climate Agreement for Energy and Industry of the 22nd of June 2020, the majority of the Danish Parliament agreed to establish an energy island in the Danish part of the North Sea as an energy hub with a connection to Jutland as well as interconnectors to neighbouring countries. To establish an environmental baseline for the later environmental permitting processes for the specific projects, a series of environmental pre-investigations have been carried out. This report concerns baseline data and information on fish and fish populations.

1.1 Aim

This technical report presents baseline information on fish and fish populations obtained from three bottom trawl surveys and two gillnet surveys conducted within the pre-investigation area and a desk study compiling existing data from other sources. A trawl survey using a TV3 trawl (otter trawl) was carried out in autumn of 2022, while two beam trawl surveys were carried out in spring and autumn of 2023. To sample the fish community in the mixed and hard bottom habitats, gillnet surveys were carried out in spring and autumn 2023. The results from the field surveys are supplemented with existing data and information on the fish communities and spawning areas in the North Sea compiled from available sources such as commercial fishery data, and ICES international trawl survey data (ICES, 2022) and Institute of Marine Research data (IMR (2022), and associating the seabed fish habitats based on seabed substrate types (GEUS & WSP, 2021) with the potential presence of fish species.

The aim of the environmental pre-investigations is to collect new data and compile existing data and information to be handed over to the future concessionaires as environmental baseline information for the environmental permitting processes. The specific aim of this technical report is to present baseline information on the fish and fish populations in the pre-investigation area.

1.2 Pre-investigation and survey (phase 1) areas

In this report different areal definitions are used, as there were slight changes in the area of interest for surveys to a later different area designating the pre-investigation area. The phase 1 area of the proposed plan for the program North Sea Energy Island (Danish Energy Agency, 2022), was the area used to design and undertake the fish surveys as per the scoping report (NIRAS, 2022), whereafter the pre-investigation area was designated as the area of interest for the North Sea Energy Island pre-investigations (Figure 1.1.)

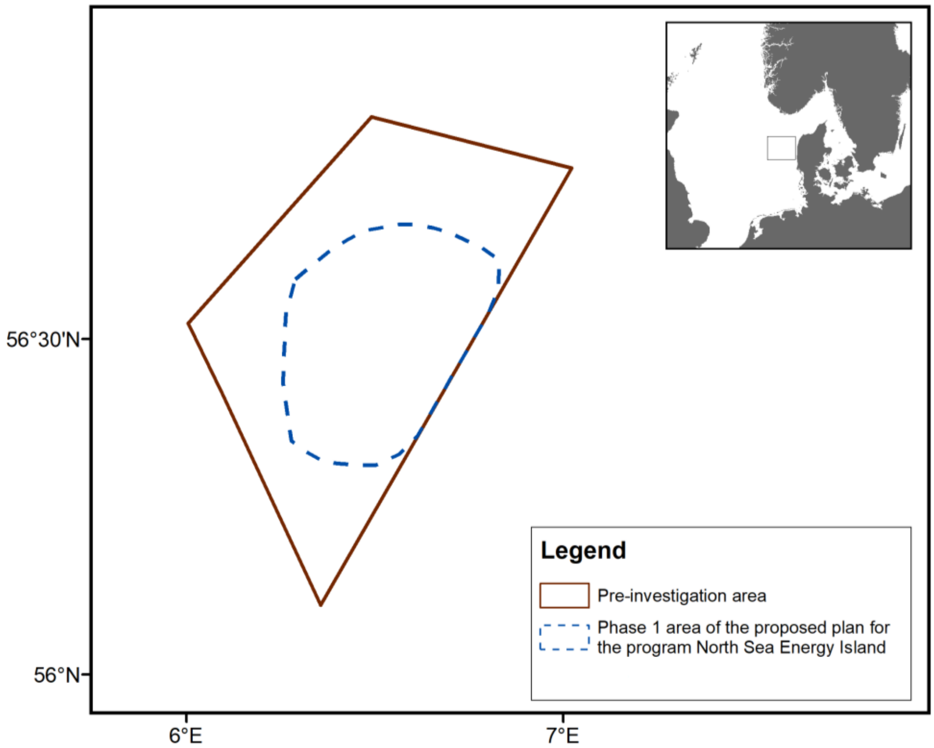


Figure 1.1. The pre-investigation area, and the phase 1 area of the proposed plan for the program North Sea Energy Island where fish surveys were undertaken, and a supplemental desktop study was performed to describe the potential occurrence of fish species and populations.

2. Existing data

In the following section existing data on fish and fish populations within the pre-investigation area is briefly described along with a description of the benthic habitat and how substrate distribution may influence species composition in the pre-investigation area. Also, data from management areas of the commercial fisheries in the region, also called the extended survey area (see Figure 2.2), have been collected and described to supplement information on which fish species may be found in the area. Furthermore, the distribution of spawning grounds for various fish species from existing North Sea surveys are also presented (IMR, 2022).

2.1 The benthic fish habitats

Up to 230 fish species have been registered in the North Sea (Walday & Kroglund, 2002) but many of these are rarely caught in fish monitoring surveys or in commercial fisheries. Most species are found in the western North Sea, in Skagerrak or along the Norwegian trench (Edelvang, et al., 2017). Fish have different life strategies and preferred habitats and in general, can be separated into fish that live in the water column (pelagic fish species) or fish species linked to habitats on the seabed (demersal or bottom living fish species). Pelagic fish species in the North Sea include common species such as Atlantic herring (*Clupea harengus*), European sprat (*Sprattus sprattus*) and seasonal guests such as mackerel (*Scomber scombrus*). The number of demersal fish species is much higher than pelagic species and can be further separated according to their preference for different benthic habitat types and water depths.

Various fish species have adapted to specific habitats and will be attracted to the specific type of substrate that characterizes the given habitat. Having knowledge on what substrate types are present, makes it possible to predict, to some extent, what species are likely to be present, and potentially how the pre-investigation area according to the distribution of habitats is used by fish (e.g. spawning areas or nursery areas). Flatfish for example, are primarily adapted to sandy or muddy areas, where they bury into the sediment to hide from predators or feed on infauna prey.

The seabed sediments in various areas of the North Sea including most of the pre-investigation area except the northern region, have been mapped in 2021 through a geophysical line transect survey (GEUS & WSP, 2021). In the northern region of the pre-investigation area seabed substrate characteristics were based on sediment types outlined by data from GEUS (GEUS, 2014). Substrate types between the survey lines mapped in 2021 were interpolated within each area to achieve coverage substrate maps for the surveyed areas and based on this, the majority of the seabed was divided into substrate types according to seven different categories (Figure 2.1). Results indicated the dominant seabed type within the pre-investigation area was sand bottoms (substrate type 1b), which was observed in more than half of the area. Other dominant substrate types were sand/gravel and pebbles with various degrees of larger stones (substrate type 2a and 2b).

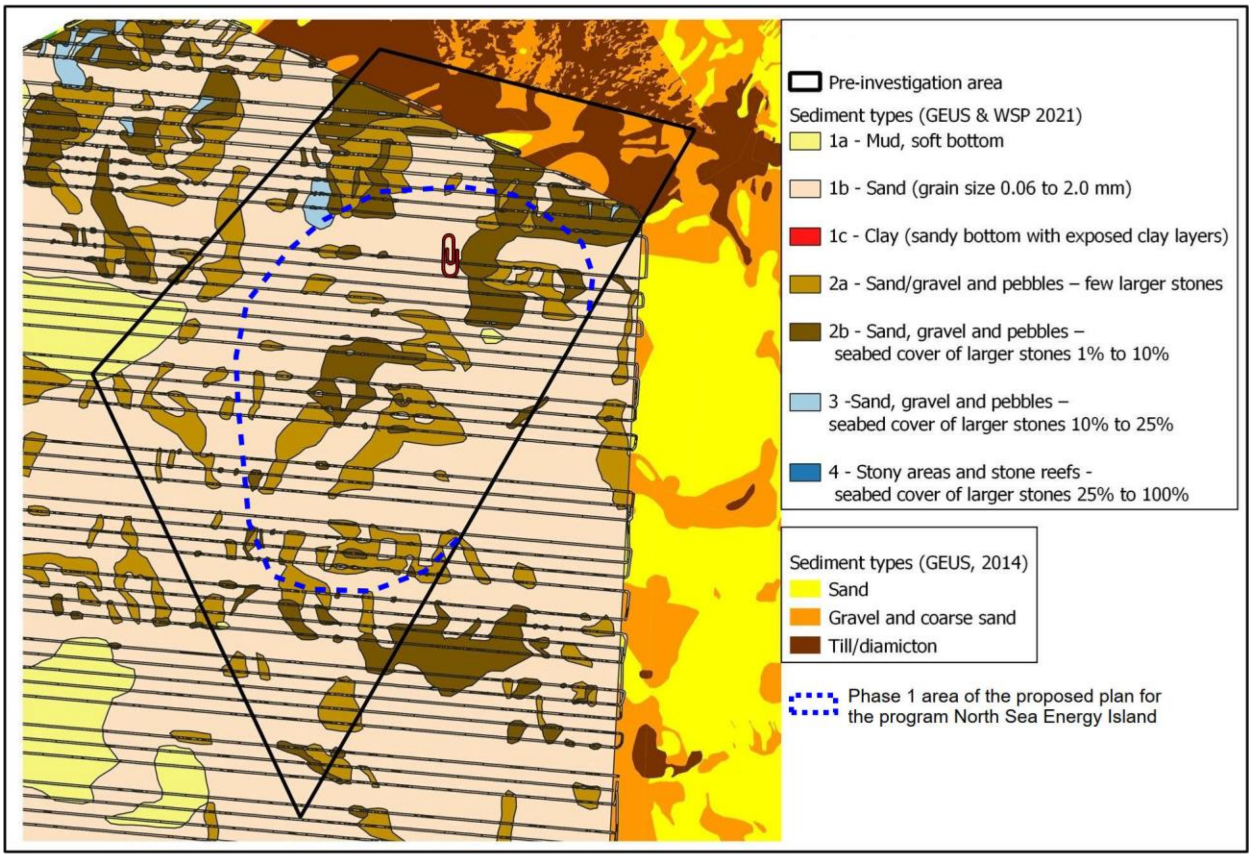


Figure 2.1 Substrate types within and around the majority of the pre-investigation area, including the phase 1 area of the proposed plan for the program North Sea Energy Island are based on two sets of data; a line transect survey and subsequent interpolation of substrates between the lines undertaken in 2021 (GEUS & WSP, 2021), and in the northern region of the pre-investigation area, sediment types were based on data from GEUS (GEUS, 2014). Sediment type sand 1b (sand) makes up the majority of the seabed in the pre-investigation area.

Based on the seabed mapping, the pre-investigation area can be divided into two primary fish habitats. These are 1) soft bottom habitats (silty, fine sand and sand) and 2) mixed bottom habitats containing a "mosaic" or mixture of sand, gravel and smaller stones (pebbles), see Figure 2.1, substrate types 1 and 2. The much less common hard bottom substrate areas (sediment types 3 and 4 in Figure 2.1) are habitats where rocks and/or large boulders supply a suitable hard substrate for epifauna (hard-bottom animals) organisms that can provide additional feeding opportunities for a number of fish species.

The large areas with soft bottom substrates, found within the survey area, is expected to be dominated by numerous benthic fish species preferring soft bottom habitats. This includes several flatfishes, primarily European plaice (*Pleuronectes platessa*), common dab (*Limanda limanda*), sole (*Solea solea*) and European flounder (*Platichthys flesus*). Also, numerous codfish species that primarily include the semi-pelagic whiting (*Merlangius merlangus*), pollack (*Pollachius pollachius*) and Atlantic cod (*Gadus morhua*), which are species that utilize a wide range of habitats and are also linked to soft bottom habitat (Muus & Nielsen, 1999).

Mixed bottoms create a variety or mosaic of habitats that often leads to a high biodiversity of both benthic flora and fauna species, and a high diversity of fish species, as these habitats contain a mix of both hard and soft bottom fish habitats preferred by different fish species. On mixed bottom habitats, flatfish species such as turbot (*Scophthalmus maximus*) and brill (*Scophthalmus rhombus*) can be found, along with European plaice and occasionally European flounder as they utilise the available soft bottom habitats. Also, adult and juvenile Atlantic cod and a variety of sculpins

(*Coittidae spp*) will also use mixed and hard bottom. The Lesser spotted dogfish (*Scyliorhinus canicula*) and Goby species such as sand goby (*Pomatoschistus minutus*), the common goby (*Pomatoschistus microps*) and black goby (*Gobius niger*) are also found in this type of habitat, most probably associated with the soft bottom areas. Other fish species found periodically on mixed bottom substrate with some showing a diurnal pattern or annual cycles of presence, such as whiting (Muus & Nielsen, 1999).

Areas with stone reefs provide a large degree of spatial heterogeneity, particularly if they are in shallow water depths where light can support vegetation growth. This varied seabed habitat gives many fish species opportunities to both search for food and to find refuge. When comparing the number of fish species on soft and hard bottom habitats it is seen that both biomass and number of individuals are often significantly higher on hard-bottom habitats (Edelvang, et al., 2017). Some species live here more or less permanently, such as species belonging to the family of wrasses (*Labridae*) which include Goldsinny-wrasse (*Ctenolabrus rupestris*), Corkwing wrasse (*Symphodus melops*), Ballan wrasse (*Labrus berggylta*) and cuckoo wrasse (*Labrus bimaculatus*)/(*Labrus mixtus*) along with rock gunnels (*Pholis gunnellus*) and lumpsuckers (*Cyclopterus lumpus*). However, almost none of the pre-investigation area is comprised of stone reefs and there is not much vegetation in these habitats due to their depths (25-46 meters) and lack of light for macroalgae growth.

2.2 Fish species observed in the commercial fisheries in the extended survey area

The commercial fishery registers data on fish species in their catch, which is recorded in all the landings from ICES management areas (ICES, 2022). Each ICES area is comprised of a rectangle, which in the North Sea is approximately 30 by 30 nm. Although commercial fishery data is biased towards targeting commercial species, the registered catches of specific species linked to the approximate location of the fishing vessel at the time of catch can give a good indication of the presence and distribution of species in a region.

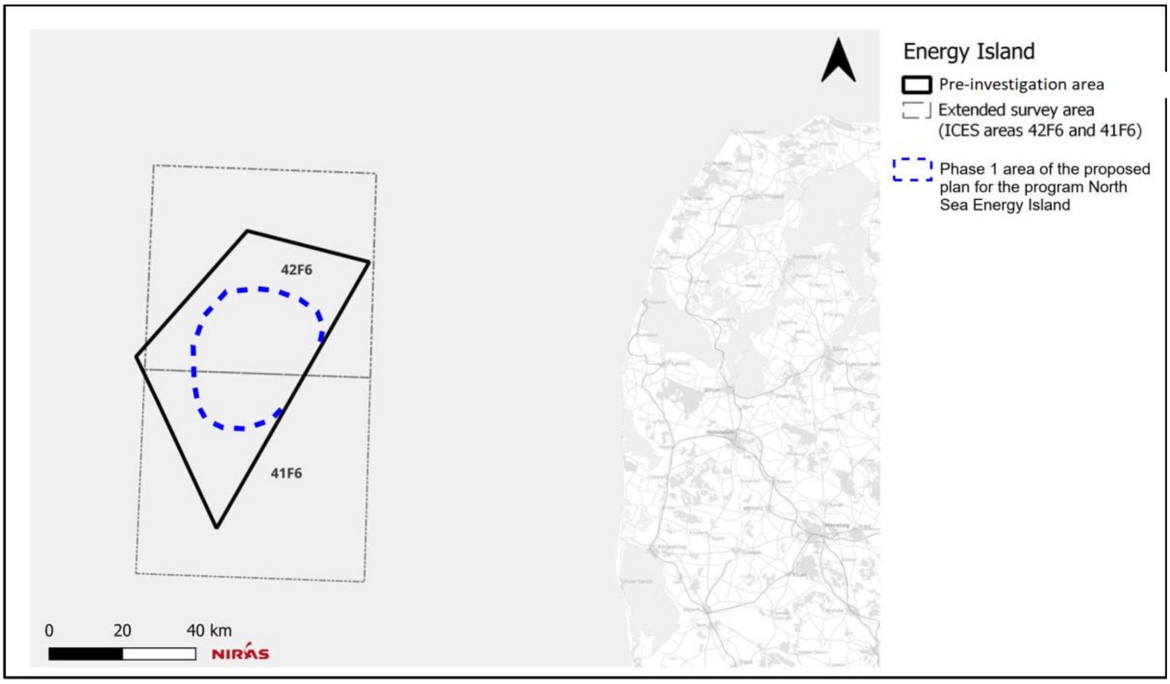


Figure 2.2. The extended survey area, which comprises the fishery management areas ICES rectangles 42F6 and 41F6 and from which fish species observed in the area was derived from fisheries catch data. The pre-investigation area and the phase 1 area of the proposed plan for the program North Sea Energy Island are also outlined within the extended survey area.

To investigate the fish species registered in the commercial landings of the region around the pre-investigation area, an extended survey area was comprised of the ICES areas 41F6 and 42F6 (Figure 2.2). Within the two ICES areas 52 different fish species have been registered in the landings over a 10-year period (2012-2021) (Table 2.1). During this period, sandeel, European sprat, European plaice, Atlantic cod, Atlantic herring, and lemon sole comprised 96% of the total landings by weight in the fisheries. Table 2.1. also includes the habitat preference and spawning behaviour of the registered species. Overall, the catch comprises species with a preference for various degrees of soft and/or mixed bottom habitats, which is in alignment with the main types of substrates found in the pre-investigation area (Figure 2.1). Hence, the species caught in the ICES rectangles comprising the extended survey area are expected to also represent species which are present in the pre-investigation area.

Table 2.1. Fish species caught in the commercial fisheries (both trawl and gillnet) in the ICES rectangles 42F6 and 41F6 (extended survey area) and their primary habitat preference and spawning behaviour. The fish species were determined in the catch by fishermen without species validation.

Fish name	Species name	Behaviour	Habitat preference	Spawning behaviour
Alaska pollock	*Gadus chalcogrammus*	Benthic/semi-pelagic	Soft and mixed bottoms	Pelagic spawner
Monkfish	*Lophius piscatorius*	Benthic	Soft and mixed bottoms	Pelagic spawner
Atlantic cod	*Gadus morhua*	Benthic/semi-pelagic	Mixed and hard bottoms	Pelagic spawner
Atlantic halibut	*Hippoglossus hippoglossus*	Benthic	Soft and mixed bottoms	Pelagic spawner
Atlantic wolffish	*Anarhichas lupus*	Benthic	Mixed/hard bottoms	Demersal spawner
Ballan wrasse	*Labrus bergylta*	Benthic	Mixed/hard bottoms	Demersal spawner
Black cardinal fish	*Epigonus telescopus*	Benthic/semi-pelagic	Soft bottoms	Pelagic spawner
Blonde ray	*Raja brachyura*	Benthic	Soft bottoms/sand	Demersal spawner

Blue shark	*Prionace glauca*	Pelagic	-	Viviparous (live bearing)
Blue whiting	*Micromesistius poutassou*	Semi-pelagic	-	Pelagic spawner
Brill	*Scophthalmus rhombus*	Benthic	Mixed bottoms	Pelagic spawner
Common ling	*Molva molva*	Benthic	Hard bottoms	Pelagic spawner
Common sole	*Solea solea*	Benthic	Soft bottoms	Pelagic spawner
Cuckoo ray	*Leucoraja naevus*	Benthic	Mixed bottoms	Demersal spawner
Cusk	*Brosme brosme*	Benthic	Mixed bottoms	Pelagic spawner
Common dab	*Limanda limanda*	Benthic	Soft bottoms	Pelagic spawner
Spiny dogfish	*Squalus acanthias*	Benthic	Mixed bottoms	Viviparous (live bearing)
European conger	*Conger conger*	Benthic	Mixed bottoms	Pelagic spawner
European flounder	*Platichthys flesus*	Benthic	Soft bottoms	Pelagic spawner
Greater forkbeard	*Phycis blennoides*	Benthic	Soft and mixed bottoms	Pelagic spawner
Greater weever	*Trachinus draco*	Benthic	Soft bottoms/sand	Pelagic spawner
Grey gurnard	*Eutrigla gurnardus*	Benthic	Soft bottoms/sand	Pelagic spawner
Haddock	*Melanogrammus aeglefinus*	Semi-pelagic	Mixed bottoms	Pelagic spawner
European hake	*Merluccius merluccius*	Benthic	Mixed bottoms	Pelagic spawner
Atlantic Herring	*Clupea harengus*	Pelagic	-	Demersal spawner
Horse mackerel	*Trachurus trachurus*	Pelagic	-	Pelagic spawner
John Dory	*Zeus faber*	Demersal/semi-pelagic	Mixed bottoms	Pelagic spawner
Lemon sole	*Microstomus kitt*	Benthic	Soft bottoms	Pelagic spawner
Lumpsucker	*Cyclopterus lumpus*	Benthic/semi-pelagic	Mixed/hard bottoms	Benthic spawner
Mackerel	*Scomber scombrus*	Pelagic	-	Pelagic spawner
Megrim sole	*Lepidorhombus whiffiagonis*	Benthic	Soft bottoms	Pelagic spawner
Norway pout	*Trispoterus esmarkii*	Benthic/semi-pelagic	Soft bottoms	Pelagic spawner
European plaice	*Pleuronectes platessa*	Benthic	Soft bottoms	Pelagic spawner
Pollock	*Pollachius pollachius*	Benthic/semi-pelagic	Mixed bottoms	Pelagic spawner
Red gurnard	*Chelidonichthys cuculus*	Benthic	Soft and mixed bottoms	Pelagic spawner
Red mullet	*Mullus surmuletus*	Benthic	Mixed bottoms	Pelagic spawner
Saithe	*Pollachius virens*	Pelagic/semi-pelagic	Mixed bottoms	Pelagic spawner
Sandeel	*Ammodytes marinus*	Benthic	Soft bottoms - sand	Demersal spawner
Lesser spotted dogfish	*Scyliorhinus canicula*	Benthic	Soft and mixed bottoms	Demersal spawner
Sardines	*Sardina pilchardus*	Pelagic	-	Pelagic spawner
School shark	*Galeorhinus galeus*	Pelagic	-	Viviparous
Sea trout	*Salmo trutta*	Pelagic	-	Freshwater spawner
Silver eel	*Anguilla anguilla*	Benthic/semi-pelagic	Soft and mixed bottoms	Pelagic spawner
Spotted ray	*Myliobatis aquila*	Benthic	Soft bottoms	Viviparous
European sprat	*Sprattus sprattus*	Pelagic	-	Pelagic spawner
Thornback ray	*Raja clavata*	Benthic	Soft and mixed bottoms	Demersal spawner
Thorny skate	*Amblyraja radiata*	Benthic	Mixed bottoms/sand	Demersal spawner
Turbot	*Scophthalmus maximus*	Benthic	Mixed bottoms	Pelagic spawner
Velvet belly shark	*Etmopterus spinax*		Soft bottoms	Benthic spawner
Whiting	*Merlangius merlangus*	Semi-pelagic	Mixed bottoms	Pelagic spawner
Witch flounder	*Glyptocephalus cynoglossus*	Benthic	Soft bottoms	Pelagic spawner
Great sandeel	*Hyperoplus lanceolatus*	Benthic	Soft bottoms	Benthic spawner

Poor cod	*Trisopterus minutus*	Benthic	Soft and mixed bottoms	Pelagic spawner

2.3 Description of Key fish species

Fish species that are abundant or are important ecologically for an area can be considered key species. Fisheries data registering the fish species in all the landings from the statistical fishing areas (ICES 41F6 and 42F6) within the extended survey area have registered 54 different fish species over a 10-year period (2012-2021). Substrate analyses describe a primarily soft or mixed bottom habitat within the survey area. Therefore, on the basis of results from the fish surveys, along with data from the fisheries in the extended survey area and the substrate characteristics within the pre-investigation area, the key species in the area are considered to be: Atlantic cod, European plaice, whiting, haddock, European sprat, lesser sandeel, grey gurnard, common dab and Atlantic herring. In the following, their general distribution, preferred habitat and biology are briefly described in relation to the surveys that have been undertaken in the pre-investigation area.

2.3.1 Atlantic cod (*Gadus morhua*)

Atlantic cod is one of the most abundant fish species in Danish waters, where it is found throughout the marine waters from coastal regions to several hundred meters deep (Hoffmann, Carl, & Møller, 2021). Atlantic cod in the North Sea is comprised of three genetically distinct stocks and Atlantic cod found in the pre-investigation area belongs to a widespread stock that mixes with a northern North Sea population outside the spawning season. During the spawning season no mixing occurs (Heath, et al., 2014).

Normally, Atlantic cod is considered to be a demersal species spending most of their time on the bottom, however, depending on the area, season and whether they are juveniles or adults, Atlantic cod can also be found in the pelagic. Adult Atlantic cods can be found on various types of habitats where reefs and other structures on the seabed often comprise their preferred habitat (Reubens, et al., 2013). Yet, Atlantic cods are also regularly found on mixed bottoms and sand bottoms; the two main habitat types found in the pre-investigation area, whereas silty soft bottom habitats, are not preferred by the species (Hoffmann, Carl, & Møller, 2021; Reubens, et al., 2013).

From January to April spawning of Atlantic cods can be found in the North Sea from 10 meters depth and deeper (Worsøe et al., 2002; Knijn, Boon, Heessen, & Hislop, 1993). Atlantic cods exhibit *homing* behaviour, where individuals migrate back "home" to spawn in their natal spawning areas, thus cod spawning areas are typically located in relatively fixed areas.

Eggs of Atlantic cod are pelagic and drift with water currents over large areas as eggs hatch and larvae grow. The time frame for Atlantic cod larvae, where they change from pelagic to demersal, in the North Sea, is expected to be short (Worsøe et al., 2002) and juvenile Atlantic cods are especially found along the coast and in areas where macroalgae can provide refuge (Hoffmann, Carl, & Møller, 2021).

According to the fisheries data from the ICES rectangles squares comprising the extended survey area (ICES, 2022) landings of Atlantic cod have been decreasing over at least the last five years. Also, although Atlantic cods were caught at several stations during trawl and gillnet surveys in the pre-investigation area, they were only caught in low numbers. Most Atlantic cods were caught in the gillnets, which were placed in the mixed bottom habitats within the phase 1 area, thus supporting the preference for hard bottom habitats by Atlantic cods.

2.3.2 European plaice (*Pleuronectes platessa*)

European plaice is a demersal flatfish species. It is generally spread out over much of the Danish waters of the North Sea as well as in and around the pre-investigation area (Carl, LeBras, & Ulrich, 2019). European plaice can be found at up to 200 meters depth but are most abundant at depths between 10-50 meters (Carl, LeBras, & Ulrich, 2019). Juvenile

European plaice are often found at soft, silty sand bottoms at depths between 0-2 m where the distribution of adult European plaice varies more with different substrate compositions and coarser sediments (Carl, LeBras, & Ulrich, 2019; Lauria, Vaz, Martin, Mackinson, & Carpentier, 2011). Therefore, the soft and mixed bottom habitats within the pre-investigation area likely constitute an ideal foraging habitat for adult European plaice, and European plaice is one of main target species in the commercial fisheries conducted in and around the extended survey area (section 2.2). However, in the fish surveys in both spring and autumn, primarily juvenile European plaice of 15-20 cm were found, indicating a potential nursery ground for larger juveniles in the pre-investigation area.

In the North Sea, spawning takes place from January to April at water temperatures around 6°C and the species is a pelagic spawner.

2.3.3 Whiting (*Merlangus merlangius*)

Whiting is a common semi-pelagic and demersal species found in most of the North Sea where it is also considered to be one of the most important predatory fish (Carl & Munk, 2019). In the North Sea, the population is likely separated into two different stocks, one south of Dogger Bank and one north of Dogger Bank, with little expected mixing (Hislop & MacKenzie, 1976). Whiting found in the pre-investigation area thus belongs to the northern population. The species seemingly prefers sandy or muddy bottoms, which are prevalent in the pre-investigation area, although this species is less linked to the bottom habitats compared to other codfish.

Whiting in the North Sea are generally small. They rarely exceed 45 cm in length, and the species reach maturity after 1-5 years and at lengths above 17 cm (Carl & Munk, 2019). In the trawl surveys in autumn 2022, and in both trawl and gillnet surveys in 2023, primarily adult whiting was caught (>17 cm in length) in almost all stations. Likewise, whiting was caught at the majority of stations during both trawling and at gillnet surveys in spring 2023. However, in the spring survey around 2/3 of whiting caught in the trawl surveys, were juveniles. In the North Sea, both juveniles and adult whiting can be found in more or less equal amounts, in contrast to catches in the Skagerrak/Kattegat which are dominated by 1-year-old whiting (ICES, 2005). There is nothing in the survey data indicating that the area is a specific nursery ground for whiting. Instead, the shallow coastal waters closer to the West coast of Jutland are known to support large densities of juvenile whiting (Carl & Munk, 2019).

Pelagic spawning occurs in January through September, but according to e.g. Loots et al. (2010) the region around the pre-investigation area does not constitute a favourable spawning area for the species. This was also supported by survey data where there was no indication of spawning in the whiting investigated in the surveys.

2.3.4 Haddock (*Melanogrammus aeglefinus*)

Haddock is a common demersal species in the North Sea. It can be found on a variety of habitat types, although it primarily prefers soft and mixed bottom habitats (Hoffmann & Carl, 2019) such as those found in the pre-investigation area. Adult haddock are, however, mostly present at depths ranging from 40 to 300 m and for this reason the shallow parts of the pre-investigation area might be less likely to constitute a preferred depth for adult haddock. Furthermore, the species does not comprise large portions of the commercial fishery landings within the extended survey area. Instead, the main distribution of haddock in the North Sea extends from North-east England, along the Dogger Bank, to Skagerrak and Kattegat (ICES, 2005).

In Danish waters, including the North Sea, the majority of haddock reach maturity at approximately 30 cm in length (Hoffmann & Carl, 2019). In the pre-investigation area haddock were caught in both spring and autumn surveys and in both gillnets and trawl hauls. Many haddock were caught at almost all the survey stations, especially in the autumn trawl survey in 2022. The vast majority of haddock caught in the trawl surveys were juveniles and it appears that the pre-investigation area functions as a potential nursery ground for this species. As haddock spawn at depths ranging from 100-150 m, the pre-investigation area is not expected to constitute an important spawning ground and none of the investigated haddock showed signs of spawning.

2.3.5 Sandeel (*Ammodytes spp.*)

Sandeel in the North Sea consists of several species. Sandeel is a predominantly benthic species that, however, feeds in the pelagic (water column) during the day and bury themselves in the sand during night during the spring and early summer months of the year. Sandeel have a preference for coarse sand habitats and are absent in areas where the sediment is comprised of more than a few % silt (Holland, Greenstreet, Gibb, Fraser, & Robertson, 2005). Areas where the species is found in the North Sea are therefore relatively well defined (Figure 2.10, left). In the North Sea, the sandeel species are considered an important "wasp-waist" species, which means as a prey and predator it has large influence on both top-down and bottom-up control, as sandeel constitutes approximately 25% of the fish biomass in the North Sea (Christensen, Butenschön, Gürkan, & Allen, 2013). Sandeel also comprises more than half of the total landings of the combined commercial fisheries within the region of the pre-investigation area.

Most often, the different species of sandeel are not sufficiently verified in the fishery or during surveys and therefore data on the specific species are rarely available. A study on the commercial trawl fishery showed that the catch was divided into 30% lesser sandeel (*Ammodytes marinus*), 55% small sandeel (*Ammodytes tobianus*) and 15% great sandeel (*Hyperoplus lanceolatus*) (Møller P. R., et al., 2019). In the trawl and gill net surveys in the area, very few sandeel were caught (Lesser and Great sandeels). This is primarily because sandeel are small fish and the trawl and gillnet gear used in this survey is not particularly effective in sampling this species. This was supported by the occasional observance of a large number of sandeel in the outer section of the trawls despite only a few sandeel being registered in the trawl bags and catches. Furthermore, sandeel are primarily buried in the sand during the time of the autumn surveys making them difficult to catch in the trawl hauls. The large annual catches registered in the commercial fisheries, however, clearly show that sandeel are highly abundant in the survey plan area of the North Sea Energy Island.

2.3.6 Atlantic herring (*Clupea harengus*)

Atlantic herring is a pelagic species that swim together in large schools over large areas of the Danish marine waters including the North Sea. Similar to sandeel, Atlantic herring is an important fish for the marine ecosystem, just as it is an important commercial species for fisheries. Herring are split into many different sub-populations that separate themselves both by where and when they spawn. In the North Sea, the Atlantic herring belong to an autumn spawning stock that spawns in coastal areas along the British east coast (Worsøe et al., 2002)(Figure 2.3), thus the pre-investigation area would not constitute a spawning ground. Larvae from the British coast are transported with currents to the eastern North Sea and interannual variability in hydrodynamics and hatching date results in different transport of Atlantic herring larvae between years (Worsøe et al., 2002; Dickey-Collas, Bolle, van Beek, & Erftemeijer, 2009). Juvenile nursery areas and the general distribution of adult Atlantic herring are highly linked to environmental factors and large abundances are found in well-mixed waters along transition zones between frontal and stratified waters (Maravelias, 1997). The pre-investigation area does not constitute a specific key area for Atlantic herring but is a general part the North Sea foraging area for this species. Very few Atlantic herring were caught during the surveys, potentially because herring is pelagic, and the trawl and gillnets focus on benthic species. The occasionally large catches of herring in the commercial fisheries, however, show that Atlantic herring can be seasonally highly abundant in the region around the pre-investigation area.

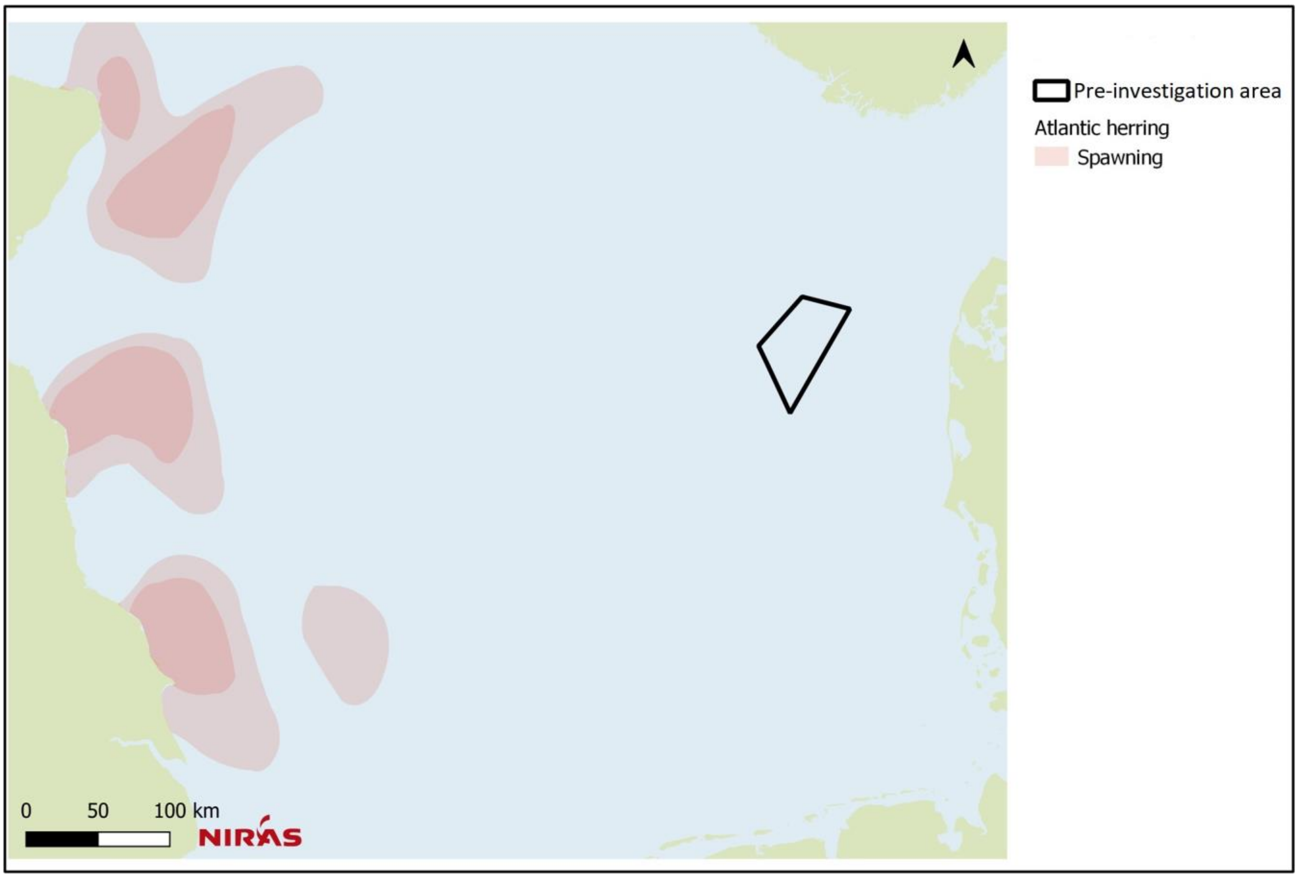


Figure 2.3 Approximate spawning (pink, darker colour is high concentration of spawning) and distribution (blue) of autumn spawning Atlantic herring in the North Sea (IMR, 2022).

2.3.7 European sprat (*Sprattus sprattus*)

European sprat is a pelagic species similar to herring and is likewise an important prey item for a number of important predatory fish in the ecosystem (e.g. Atlantic cod). European sprat is found throughout the North Sea with particular high abundancies in the Southeastern North Sea (ICES, 2023); (IMR, 2022) and is generally found in most of the Danish waters from shallow fjords to deep offshore waters (Hoffmann & Carl, 2019). Although European sprat does not prefer any particular habitat, they will seek areas near the bottom during daylight hours as a refuge from predators, whereafter they will move up and spread out in the water column during the night to feed. During winter months the species often seek deeper areas (Hoffmann & Carl, 2019). In the North Sea, European sprat spawn from March through August throughout their distribution (Figure 2.4), albeit often in general areas where large schools of European sprat gather or are present (Hoffmann & Carl, 2019). Spawned eggs drift with ocean currents, whereafter juveniles start to school with adults as soon as they can swim and thus there are no specific habitats or areas that can be considered specifically as nursery areas (Hoffmann & Carl, 2019; Worsøe et al., 2002). Like Herring, very few European sprats were caught during the surveys, most probably due to the pelagic lifestyle of European sprat and the survey gear that primarily targeted fish on or near the seabed. The large catches in the commercial fisheries, however, show that sprat can be highly abundant in the pre-investigation area.

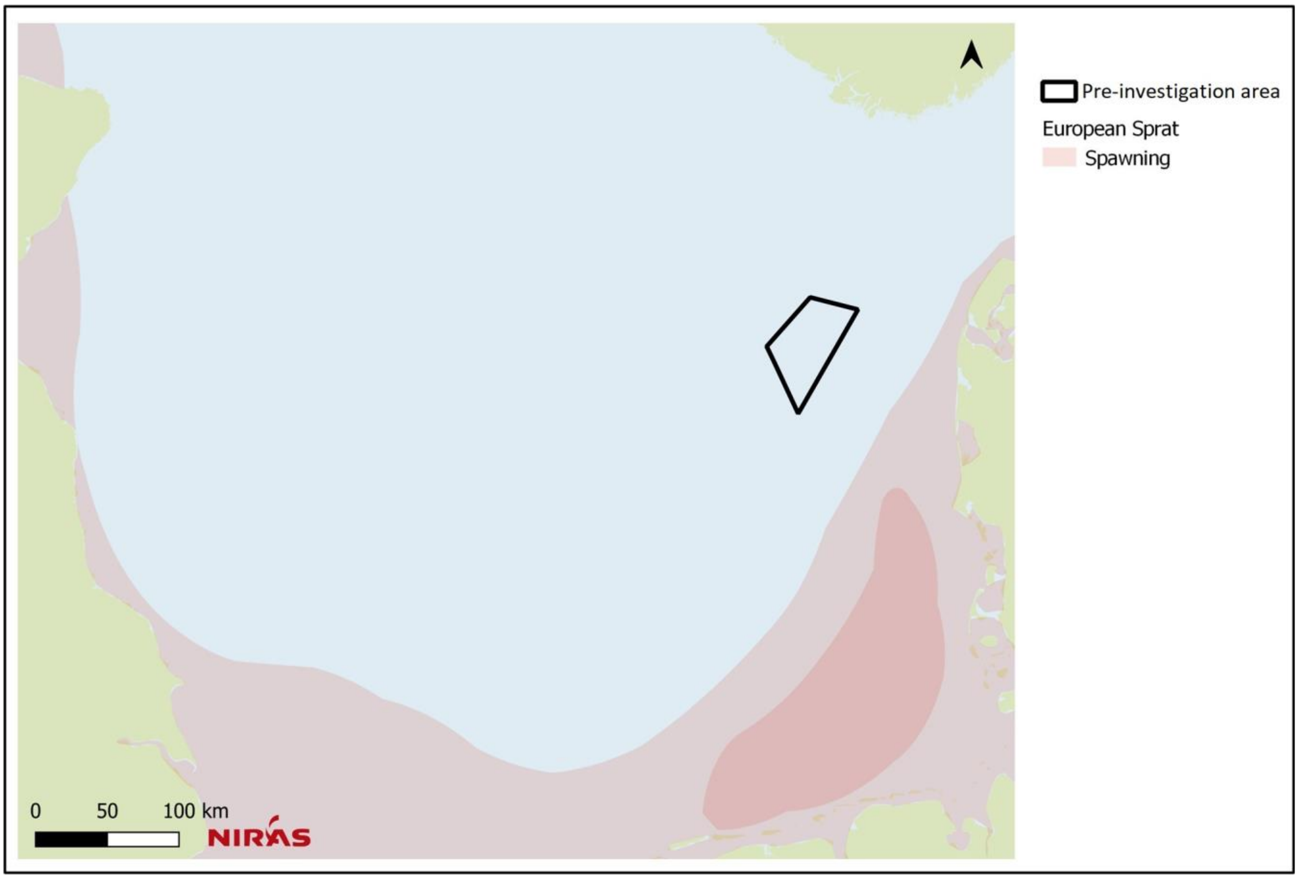


Figure 2.4 European sprat spawning areas in the North Sea. Darker red areas depict high concentration spawning areas, and general distribution of European sprat is blue (IMR, 2022).

2.3.8 Grey gurnard (*Eutrigla gurnardus*)

The grey gurnard is a demersal species and the most common gurnard species in the North Sea where it is very abundant (Carl H. , 2018). Because of their high abundance, grey gurnard play an important role in the marine ecosystem as both prey and predator. Grey gurnards are also caught in high numbers as bycatch in the commercial fisheries (ICES, 2022; ICES, 2005). Their preferred habitat is sandy bottoms although they can be found on both muddy and hard bottoms (Carl H. , 2018). This species is therefore probably found throughout the pre-investigation area where the preferred habitats of grey gurnard are predominant.

The grey gurnard undertakes seasonal migrations. During winter, the species occurs in dense aggregations northwest of Dogger Bank in the southern part of the North Sea and will therefore be found in lower abundance off the Danish west coast (ICES, 2005) during this time. However, during summer the species is found more widespread. In the fish surveys within the pre-investigation area, grey gurnards were caught in high abundance in both spring and autumn surveys at almost all stations, and thus were common in the area.

Sexual maturity is reached around a length of 18 cm for males and 24 cm for females when grey gurnard are three and four years of age, respectively (Carl H. , 2018). No obvious nursery grounds are known for gurnards in the North Sea and there is an absence of small fish in the commercial fisheries either because the juveniles remain in the pelagic or reside on hard bottoms which are difficult to trawl (ICES, 2005). In the gillnet surveys in both spring and autumn and the trawl survey in 2022 the majority of grey gurnards caught were most likely adults (>18 cm), whereas in both beam trawl surveys in 2023 the majority of gurnards were juveniles, which might be a result of the difference in trawl types between 2022 and 2023.

2.3.9 Common dab (*Limanda limanda*)

Common dab is the most common species of flatfish in Danish waters and is widespread throughout the marine waters of Denmark (Carl & Munk, 2019). Common dab was also one of the most abundant fish species observed in the trawl surveys. Common dabs prefer soft bottom habitats similar to European plaice, though often on bottoms of finer material such as fine sand/silt substrates and at depths from 20-150 meters (Muus & Nielsen, 2006). This corresponds to the type of soft bottom habitats identified in large parts of the pre-investigation area.

The Common dab in the North Sea spawn their eggs throughout their distribution from April-June where no specific spawning grounds exist (Carl & Munk, 2019). Fish larvae of common dab are also common during this time and can be found in all deeper Danish waters. In the North Sea, common dab reach maturity when approximately 15-20 cm for males and 20-25 cm for females (Muus & Nielsen, 1998). Juvenile common dab prefers habitats at depths around 10-20 meters, in contrast to other common juvenile flatfish species (European plaice and flounder) that often have their nursery areas in very shallow water (<2 meters). In the fish surveys, both adult and juvenile common dab were observed, with the majority being juveniles. None of the investigated common dab showed signs of spawning but it is still possible that parts of the pre-investigation area may function as a nursery ground for common dab as they spawn, and juveniles settle throughout their area of distribution.

2.3.10 Lemon sole (*Microstomus kitt*)

Lemon sole is a demersal and common flatfish species in the North Sea. Compared to other flatfish, such as European plaice, lemon sole requires high salinity and colder water and is typically found in deeper waters of the North Sea from 10-200 meters (Carl H. , 2019).

Lemon sole can be found on various types of substrates, however, the preferred habitat seems to be hard- and mixed bottoms or coarse sand, while mud and silty habitats are avoided by this species (Hinz, Bergmann, Shucksmith, Kaiser, & Rogers, 2006). While hard bottoms (stone reefs) are very seldom in the pre-investigation area, large areas of the benthic habitat consist of mixed bottom habitats, which offer preferred habitats and may support the presence of lemon sole. Very few lemon soles were caught in both the gillnet and trawl surveys in 2022 and 2023. The species is, however, caught in large numbers in the commercial fisheries in the extended survey area (ICES, 2022) and fishery data indicate that lemon sole is one of the most common fish species in the northern part of the extended survey area which is north of the pre-investigation area.

Spawning takes place from April to August, although it may continue until November and drifting larvae of lemon sole are found during this time and into the winter (Geffen, Albretsen, Huwer, & Nash, 2020). According to the literature, the approximate spawning area overlaps with the pre-investigation area (Figure 2.5). Here, lemon sole spawn their pelagic eggs in the deeper parts of the North Sea down to 125 meters in some areas (Geffen, Albretsen, Huwer, & Nash, 2020; Carl H. , 2019). The pelagic larvae are later found in high concentrations in the western and southern parts of the North Sea (Figure 2.5). The majority of the seabed in the pre-investigation area does not constitute a suitable habitat for juvenile lemon sole, as juveniles are most often found in shallower waters with hard bottom substrates that can provide refuge (Carl H. , 2019).

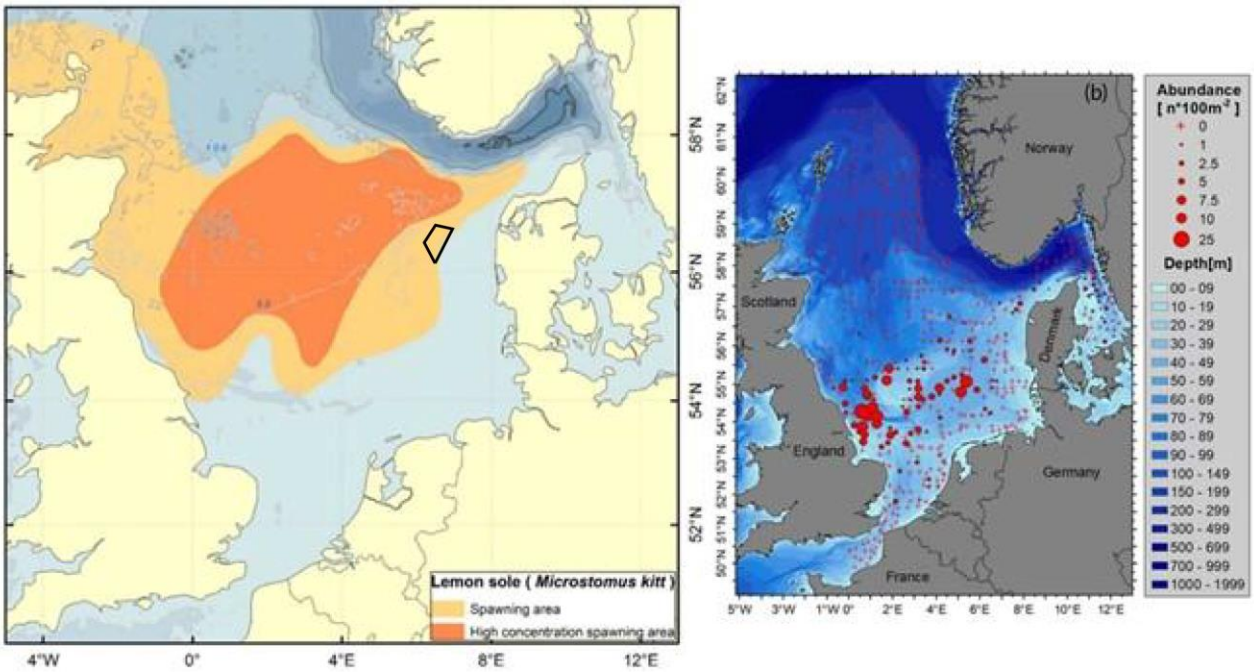


Figure 2.5. Left: Approximate spawning area of lemon sole (Microstomus kitt) in the North Sea (Sundby, Kristiansen, Nash, & Johannessen, 2017). Right: Abundance of lemon sole larvae sampled across the North Sea from January to March (Geffen, Albretsen, Huwer, & Nash, 2020).

2.4 Spawning areas in the North Sea

The Central North Sea contains several spawning grounds for various fish species. During spawning periods, fish typically congregate in species-specific spawning grounds. The spawning time and duration of the spawning period are also species-specific, but spawning is typically completed within 3-4 months, and for most species is primarily undertaken during the first half of the year (Table 2.2). Species that spawn in the open water (pelagic spawners, such as most flatfish species, Atlantic cod, and European sprat etc.) often spawn a very large number of eggs freely, where the eggs drift with currents until they hatch, and the larvae develop further. These spawning areas are often large and can move from year to year depending on the changing hydrographic conditions such as water currents, salinity, and temperature (Warnar, et al., 2012; Munk, et al., 2009). Large, dynamic pelagic spawning areas are considered to be less vulnerable to disturbance compared to demersal spawning, where eggs of bottom-dwelling species, such as sandeel, adhere to the bottom substrates (Carl, H. & Møller, P. R., 2019a; Møller P. , Warnar, Hintze, Fietz, & Munk, 2019).

Table 2.2 Overview of spawning periods (grey-shaded areas) for a selection of the most common fish registered in the pre-investigation area.

Species	Spawning period												Pelagic spawning	Demersal spawning
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
European plaice (*Pleuronectes platessa*)	■	■	■	■									X	
Sandeel (*Hyperoplus lanceolatus*)	■	■												X
Common dab (*Limanda limanda*)	■	■	■	■	■	■	■						X	
Atlantic cod (*Gadus morhua*)	■	■	■									■	X	
European sprat (*Sprattus sprattus*)	■	■	■	■	■	■							X	
Haddock (Melanogrammus aeglefinus)		■	■	■	■	■							X	
Whiting (*Merlangius merlangus*)	■	■	■	■	■	■	■	■	■				X	
Atlantic herring (*Clupea harengus*)								■	■	■				X
Lemon sole (*Microstomus kitt*)				■	■	■	■	■	■	■			X	

2.4.1 Potential spawning in or near the pre-investigation area

The following section describes the potential utilisation of the pre-investigation area as a spawning area as suggested by existing literature mapping spawning areas in the North Sea.

Atlantic cod

From January to April aggregations of spawning Atlantic cods can be found throughout the North Sea from 10 meters depth and deeper (Worsøe et al., 2002; Knijn, Boon, Heessen, & Hislop, 1993). Atlantic cods typically exhibit *homing* behaviour, where individuals migrate back "home" to spawn in their natal spawning areas despite having drifted for several hundred kilometres during the egg and larval stage. The accuracy of this mechanism has been shown to be down to a few hundred meters for some individuals, while other individuals may be less accurate or even stray to other Atlantic cod spawning areas (Robichaud & Rose, 2001); (Kristensen, et al., 2021). Atlantic cod spawning areas are therefore typically located in relatively fixed locations, compared to pelagic or benthopelagic species that may aggregate with less site fidelity.

Some literature indicate the approximate location of spawning (and nursery) grounds of Atlantic cod are generally located in the western and southern parts of the North Sea, however some spawning grounds have been indicated to be in the middle of the North Sea slightly to the west and south of the pre-investigation area (Warnar, et al., 2012) Figure 2.6 These suggest that some spawning by cod could potentially occur near the pre-investigation area. In contrast, spawning grounds based on data of spawning adult cod registered in the catches of the standardized ICES North Sea, Kattegat and inner Danish waters surveys from 2000-2022 indicate that there were no spawning cod observed in survey data from the Danish parts of the North Sea and thus not near the pre-investigation area Figure 2.6

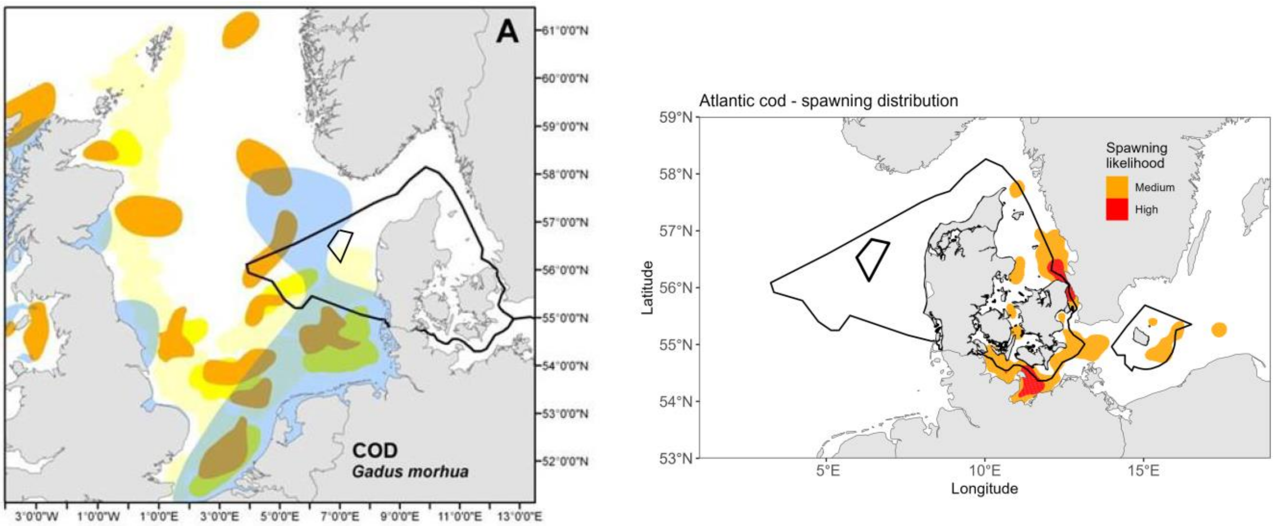


Figure 2.6. Left: Known spawning areas and nursery grounds for Atlantic cod (Gadus morhua) in the North Sea and Kattegat. Left: Light yellow and orange: general spawning areas (based on different publications), yellow: important spawning areas and blue: nursery grounds. (Warnar, et al., 2012). Right: Distribution of Atlantic cod spawning grounds in Danish waters based on data of spawning adults registered in the catches of the standardized ICES North Sea, Kattegat and inner Danish water fish surveys from 2000-2022 (ICES, Database on Trawl Surveys (DATRAS), 2022).

European plaice

In the North Sea, spawning by European plaice has been known to take place from January to April at water temperatures around 6°C. European plaice is a pelagic spawner, and the approximate location of spawning areas in parts of the North Sea was mapped by the Institute of Marine Research (IMR) according drifting eggs and larvae and hydrographic data (Figure 2.7). The location of these spawning areas was also supported by a peak in the abundance of plaice eggs and larvae by Munk et al. (2009) who found the highest egg abundance in the region area around the Danish parts of the North Sea and near the pre-investigation area (Figure 2.7).

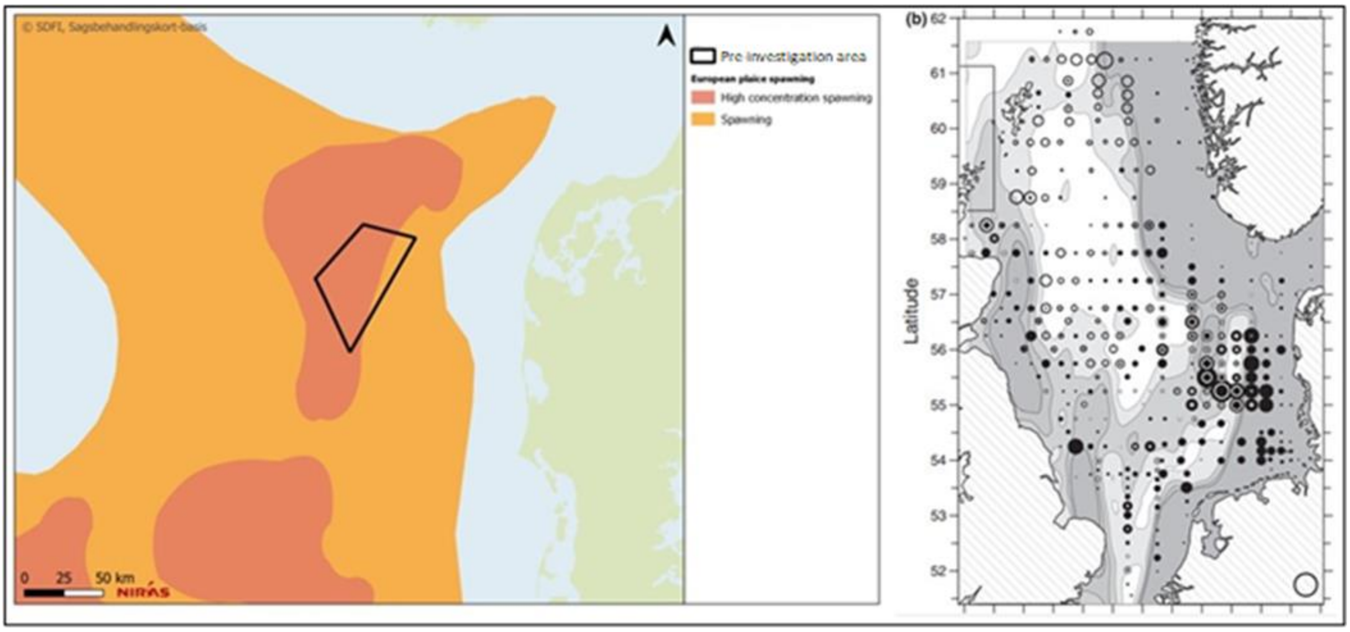


Figure 2.7. Left: Approximate spawning areas (pink) of European plaice in the North Sea, with darker colours indicating high concentration areas (IMR, 2022). Right: Circles indicate where most eggs and larvae of European plaice were observed (Munk, et al. 2009)

Similarly, data of the distribution of spawning adult European plaice according to ICES North Sea fish surveys from 2000-2022, indicate that spawning grounds of European plaice were in the region, but predominantly south of the pre-investigation area (Figure 2.8).

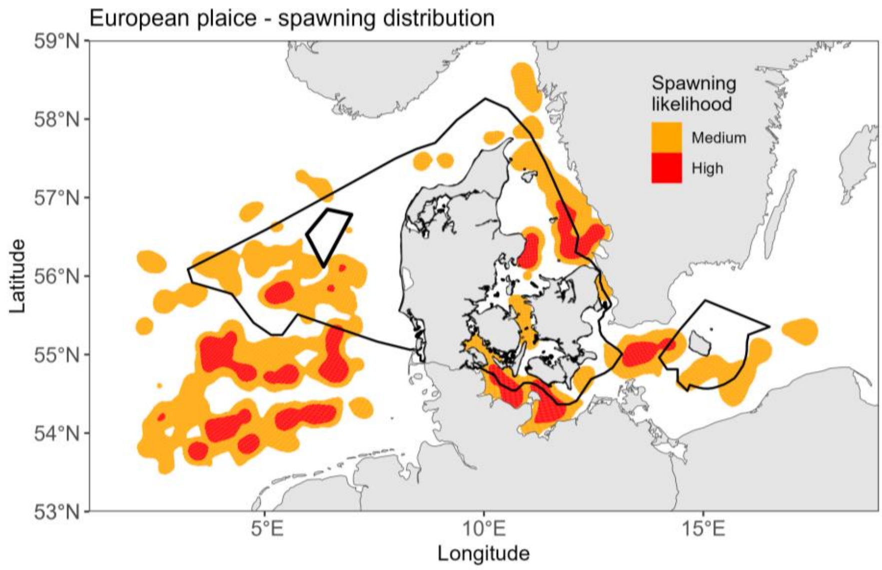


Figure 2.8. Distribution of European plaice spawning grounds based on data of spawning adult registered in the catches of the standardized ICES North Sea fish surveys from 2000-2022 (ICES, Database on Trawl Surveys (DATRAS), 2022)

Haddock

In Danish waters, including the North Sea, the majority of haddock will have attained maturity when they reach approximately 30 cm in length (Hoffmann & Carl, 2019). A map of the potential spawning areas based on the observance of spawning adult Haddock registered in the catches of the standardized ICES North Sea fish surveys from 2000-2022 indicates that there is some potential for Haddock spawning near the pre-investigation area (Figure 2.9).

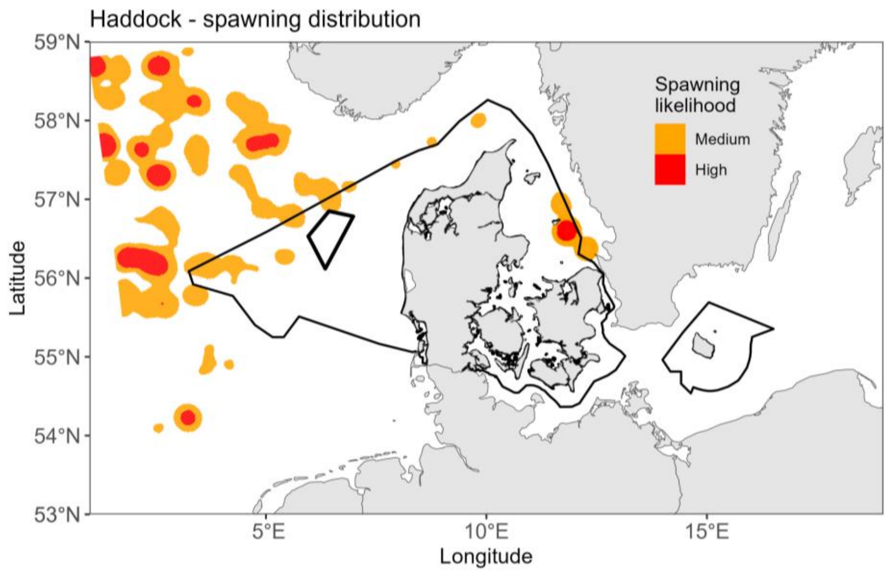


Figure 2.9. spawning grounds of Haddock based on data of spawning adults registered in the catches of the standardized ICES North Sea fish surveys from 2000-2022 (ICES, Database on Trawl Surveys (DATRAS), 2022).

Sandeel

Sandeel in the North Sea consists of several species all of which spawn demersal eggs during winter (Bergstad, Høines, & Krüger-Johnsen, 2001). Sandeel spawn eggs on the seabed near their specific habitats in several areas along the Danish West coast, east of Scotland and also on Dogger Bank and Fisher Banks in the southern parts of the North Sea (Worsøe et al., 2002). Although, there is no specific nursery area for sandeel in the North Sea, the Institute for Marine Research in Norway have mapped the distribution of sandeel spawning areas according to the distribution of sandeel eggs and larvae, and this distribution is also supported by the high abundances of sandeel larvae (Munk, et al., 2009), which in both cases strongly indicate spawning grounds in the pre-investigation area (Figure 2.10). During larvae dispersal they depend on good accessibility to optimal benthic habitats for later settlement (Worsøe et al., 2002), as they depend highly on settling on suitable sandy sediment habitats.

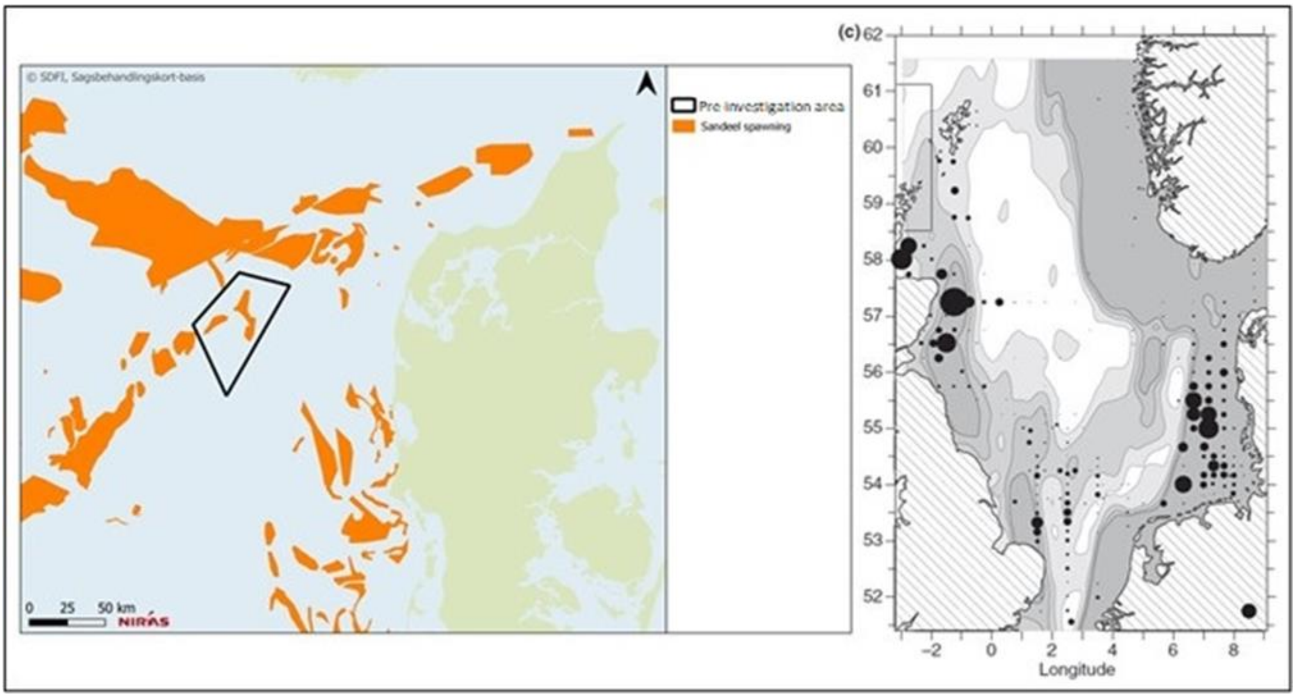


Figure 2.10. Left: Approximate distribution of habitat and spawning areas (orange) of sandeel in the North Sea (IMR, 2022) and Right: Abundance of sandeel larvae in the North Sea found in a study by Munk (2009).

2.5 Protected and red listed fish species

The Habitat Directive ensures conservation of rare, threatened, or endemic flora and fauna along with conservation of specific habitat types and the EU member states are obliged to protect them accordingly. The specific species are listed in the Habitat Directive Annex II, Annex IV and Annex V. Species listed in Annex II are species that must be protected within areas (Natura 2000-areas) that have been assigned to protect them and their habitat. Species listed on Annex IV are strictly protected both within and outside the Natura 2000 areas assigned to protect them and species listed on Annex V must be managed in a way so that exploitation does not prevent the species from maintaining a favourable conservation status.

Houting (*Coregonus maraena*) is a fish species listed in Annex IV list, while fish species listed in the Annex II list, and that are appointed in some Natura 2000 sites and can potentially occur in the pre-investigation area, are the European sturgeon (*Acipenser sturio*), sea lamprey (*Petromyzon marinus*), European river lamprey (*Lampetra fluviatilis)*, Atlantic salmon (*Salmo salar)*, twaite shad (*Alosa fallax)* and allis shad (*Alosa alosa)*.

The Annex IV species, houting is only found in the Wadden Sea and in the southern parts of the west coast of Denmark, and the large watercourses that run into these areas (Carl, H.; Berg, S.;Møller, P.R., 2019), and is thus not considered to be found or relevant for the pre-investigation area.

The critically endangered European sturgeon is primarily a coastal species and within the last couple of decades, there have been several registrations along the Danish West coast (Carl & Møller, 2019). The registered specimens likely originate from the German river Elben, where a release campaign was started in 2007, and the increase of registration in the North Sea is expected to be a result of this. The preferred habitat of European sturgeon, while at sea, is soft bottom areas in less than 50 meters depth, where they feed on benthic organisms (Carl & Møller, 2019). This type of substrate is widespread within the pre-investigation area and individual European sturgeons have been registered in the regional area (Figure 2.11). However, the species has not been registered as by-catch in the commercial fishery within the extended survey area and thus not in the pre-investigation area since 2012 (Table 2.1). It is unknown if European sturgeons have been registered in the commercial fisheries prior to this.

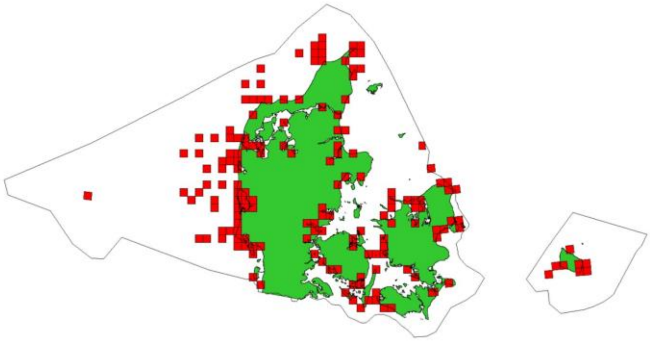


Figure 2.11 Registered distribution of European sturgeons in Danish waters based on catch registrations (Møller & Carl, 2019).

Knowledge of the distribution of the Annex II sea lamprey (*Petromyzon marinus*) and European river lamprey in Danish marine waters is sparse, as there have never been fish studies targeting these species, and the sea and river lamprey tend to be rare and only seldom registered in fish studies and the fisheries. According to information of their distribution in the North Sea from the Danish Fish Atlas, both of these species have only been observed in the coastal areas of the North Sea far from the pre-investigation area (Carl & Møller, 2019). Both lamprey species are anadromous and spawn in freshwater.

The Annex II species Twaite shad is considered to be widely distributed in the Danish marine waters, including the North Sea, but in low abundances (Carl & Møller, 2019). Thus, Twaite shad could potentially be in the observed in pre-investigation area. In contrast, the Annex II species Allis shad (*Alosa alosa*) is considered a seldom guest in Danish marine waters with only very few conclusive registrations from coastal regions in the North Sea, Skagerrak, and inner Danish waters (Carl & Møller, 2019). Both Twaite shad and Allis shad er found in the pelagic either individually or in small schools and will concentrate in the coastal regions during the springtime where they enter fjords and the outer reaches of watercourses to spawn, and thus not near the pre-investigation area. Spawning by Twaite shad has been observed in Denmark, whereas it is highly unsure that Allis shad have spawned in Danish waters (Carl & Møller, 2019).

The Danish Red List contains several species of Chondrichthyes, that may be found in the pre-investigation area (Figure 2.12). The endangered spiny dogfish (*Squalus acanthias*) and the near threatened thornback ray (*Raja clavate*) have both been caught as by-catch in the commercial fisheries in the area (Moeslund, et al., 2019)(Table 2.1). Both species prefer soft, silty bottoms, and for the thornback ray, also mixed habitats with gravel and small pebbles (Carl & Møller, 2019). Soft silty bottoms comprise a very small part of the general benthic habitat in the pre-investigation area (GEUS & WSP, 2021), however the mixed bottom habitat in the area may support the presence of thornback rays.

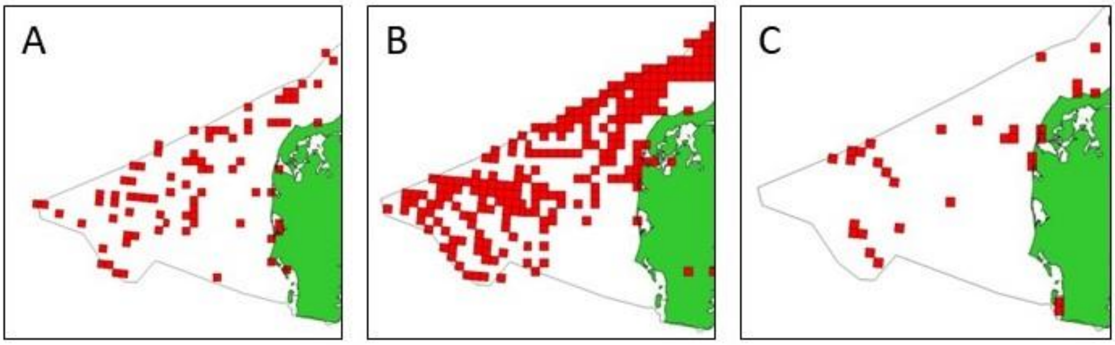


Figure 2.12 Registrations of A) Thornback ray, B) Spiny dogfish and C) Porbeagle in the Danish waters of the North Sea (Carl & Møller, 2019).

The distribution area of the vulnerable porbeagle (*Lamna nasus*) also overlaps with the pre-investigation area although, the species has not been registered as bycatch in the commercial fishery. Blue sharks (*Prionace glauca*), on the other hand, have been registered on several occasions in the fishery within the area. Yet, as blue sharks are rare in Danish waters and as porbeagles are known to be mistaken for blue sharks, it is highly likely that the registered blue sharks are porbeagles (Carl & Møller, 2019c).

The pre-investigation area is not known to be a common area for any of the three species but is likely part of a larger foraging area. Thornback rays lay their eggs on vegetation in coastal areas, typically within hard bottom habitats with substrates that allow growth of macroalgae (Carl & Møller, 2019). In the Northwest Atlantic porbeagle is known to migrate to deep waters offshore during parturition however it is unknown where parturition takes place in the North Sea (Carl & Møller, 2019c). Spiny dogfish can reside in both deep and shallow water during parturition (Carl & Møller, 2019).

Overall, the pre-investigation area for the North Sea Energy Island is therefore very unlikely to represent an area of importance for fish species listed on Annexes II and IV or the Danish Red List.

3. Methods and surveys

The phase 1 area of the pre-investigation area was initially the area where fish surveys were to be undertaken (NIRAS, 2022) and thus the placement of all sampling stations are within this area. The objectives of the fish surveys undertaken in the phase 1 area of the pre-investigation area were to obtain site-specific information on the presence, density, and distribution of the fish species in the pre-investigation area for the North Sea Energy Island, and to gain insight to the area's potential use as spawning and nursery area.

In general, large spatial and temporal variability and species- and size-specific variation in catchability with different types of fishing gear, complicates the process of reliably sampling all fish species in the open sea. Spatial variability is particularly large in many pelagic fish species whose distribution is often highly aggregated because they swim in schools and are often less stationary (seasonal/migratory). Furthermore, the presence/absence of pelagic fish is not necessarily associated with seabed habitats, but more often with changing hydrographic conditions (water currents, water temperature, salinity etc.) and the immediate presence of their prey. Thus, an "active" bottom gear, like a bottom trawl, was chosen as the survey gear of choice because sampling of fish is less dependent on fish activity level, and because bottom dwelling fish species in general are more associated with the seabed habitats that may be impacted by project activities like the Energy Island and its associated wind farm installations and cables. Pelagic sampling would also require a much greater number of samples to obtain reliable results, which would also be more difficult to interpret and associate with the immediate environment in the pre-investigation area.

Surveys to be undertaken in the spring and autumn
To gather information on the temporal variation of the fish communities and potential spawning periods in the pre-investigation area, fish surveys were undertaken in both the early spring to coincide with the spawning period of several important species and in the autumn to expose potential temporal/seasonal differences in the fish communities (species and abundance) and to indicate the potential use of the pre-investigation area as a potential nursery area.

Seabed characteristics and choice of sampling gear and distribution of sampling stations
Prior to planning fish surveys a preliminary scoping of seabed characteristics and surface habitat maps indicated the phase 1 area is primarily a mixture of soft bottom habitats (sand) with some mixed bottoms (coarse sand and gravel) with some hard bottom habitats (sand, sand and gravel and stones – 1b and 2a)(Figure 2.1). Because bottom trawling on mixed and hard bottom habitats with potential boulders involves a risk of damage to the trawl and safety risks to the crew, and the need to gather specific knowledge of fish associated with hard bottom habitats, gillnets were used in the hard bottom habitats. Thus, fish surveys were carried out by using two types of methods, a bottom trawl to sample fish in the predominantly soft bottom habitats, while gillnets were used to sample fish in the predominantly mixed and hard bottom habitats where trawling is not applicable. Thus, information of the primary substrate types (sand, sand/gravel and pebbles (1b and 2a), and sand/gravel and pebbles and larger stones (see section 2.1) indicating which fish habitats were predominantly present in the pre-investigation area was used to design where to place trawl stations on soft bottom habitats and where to set gillnets on mixed and hard bottom habitats.

Distribution of trawl and gillnets stations to ensure sampling of different habitats
The sampling layout was designed to ensure sampling in all the different primary sediment types (i.e. habitats). Because different sediment types are not evenly distributed within the pre-investigation area, the location of sampling stations were also unevenly placed, but spread out to cover different parts of the pre-investigation area as best as possible.

According to the amount of soft bottom habitats in the pre-investigation area that would allow trawling, it is estimated that approximately 15 trawl hauls in the predominantly soft bottom habitats, allocated as mentioned above, and supplemented with gillnet surveys in mixed and hard bottom habitats (see gillnet section), will give sufficient baseline data indicating which fish species are present, their relative abundances and their distribution in these habitats.

The placement of the 15 bottom trawl stations were based on a slightly smaller area (phase 1 area) originally outlined for the baseline surveys than the trapezoid pre-investigation area shown in Figure 3.1, and the distribution of seabed substrate characteristics and thus the distribution of the major habitat types (soft bottom and mixed bottom habitats) that would allow the use of a bottom trawl, without risking gear damage.

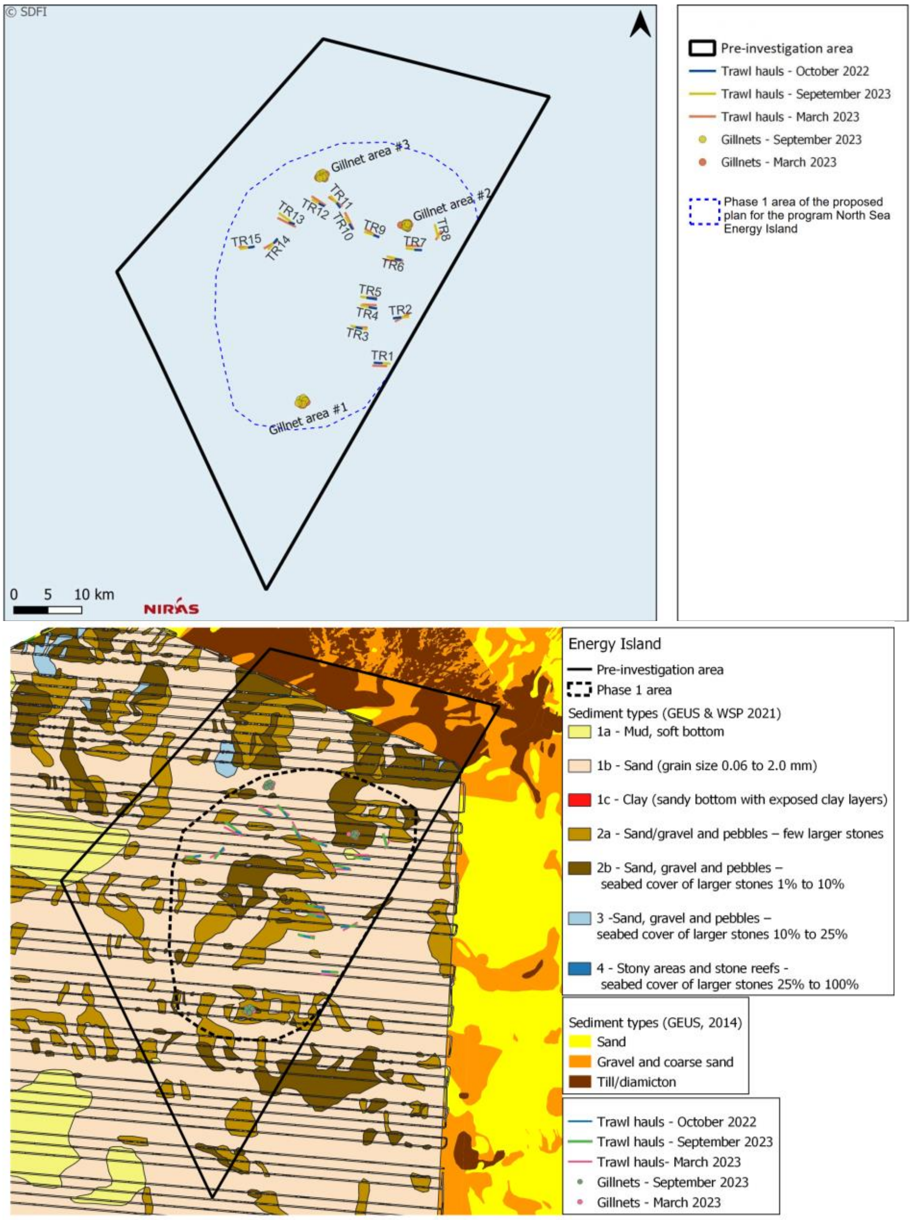


Figure 3.1. Upper map: Position of the trawl hauls (TR stations 1-15) undertaken in autumn 2022 and spring and autumn 2023, along with gillnet positions (Gillnet area 1, 2 and 3) in spring and autumn 2023. Lower map depicts the position of the trawl stations and gillnet survey areas in relation to sediment types according to GEUS and WSP (GEUS & WSP, 2021) and GEUS (GEUS, 2014).

The seabed sediment map indicated that there are several hard bottom areas with a mixture of sand, gravel and pebbles and some large stones located in different areas of the phase 1 area. To ensure a good spatial coverage of surveying hard bottom habitats in different areas as best as possible, three hard bottom areas, one area in the southern part of the phase 1 area (Gillnet area #1), one in the northeastern part of the phase 1 area (Gillnet area #2) and one hardbottom area in the northwestern part of the phase 1 area (Gillnet area #3), see Figure 3.1.

3.1 Trawl surveys

To describe the fish community, trawl surveys were conducted in the autumn (October 22nd) of 2022, and again during the spring (27-31 March) and autumn (21-25 September) of 2023. For the survey in the autumn 2022, a standard ICES TV3 520/80 survey bottom trawl was used. This type of trawl is designed to sample both benthic and semi-pelagic species because of the gear's relatively high trawl opening and is generally used for fish monitoring and investigations in Danish waters and the Baltic Sea ICES (2017). The overall detail of the TV3 bottom trawl is found in Figure 3.2. and more details are found in ICES (2017).

For the trawl surveys in spring and autumn of 2023, the project decided to use a 4-meter beam trawl designed to duplicate the same technical specifications of the beam trawl used in fish surveys in the Energy Island Bornholm Project. Beam trawls are designed to primarily sample benthic fish species. The technical specifications of the beam trawl used in the phase 1 area of the pre-investigation area are given in Figure 3.3.

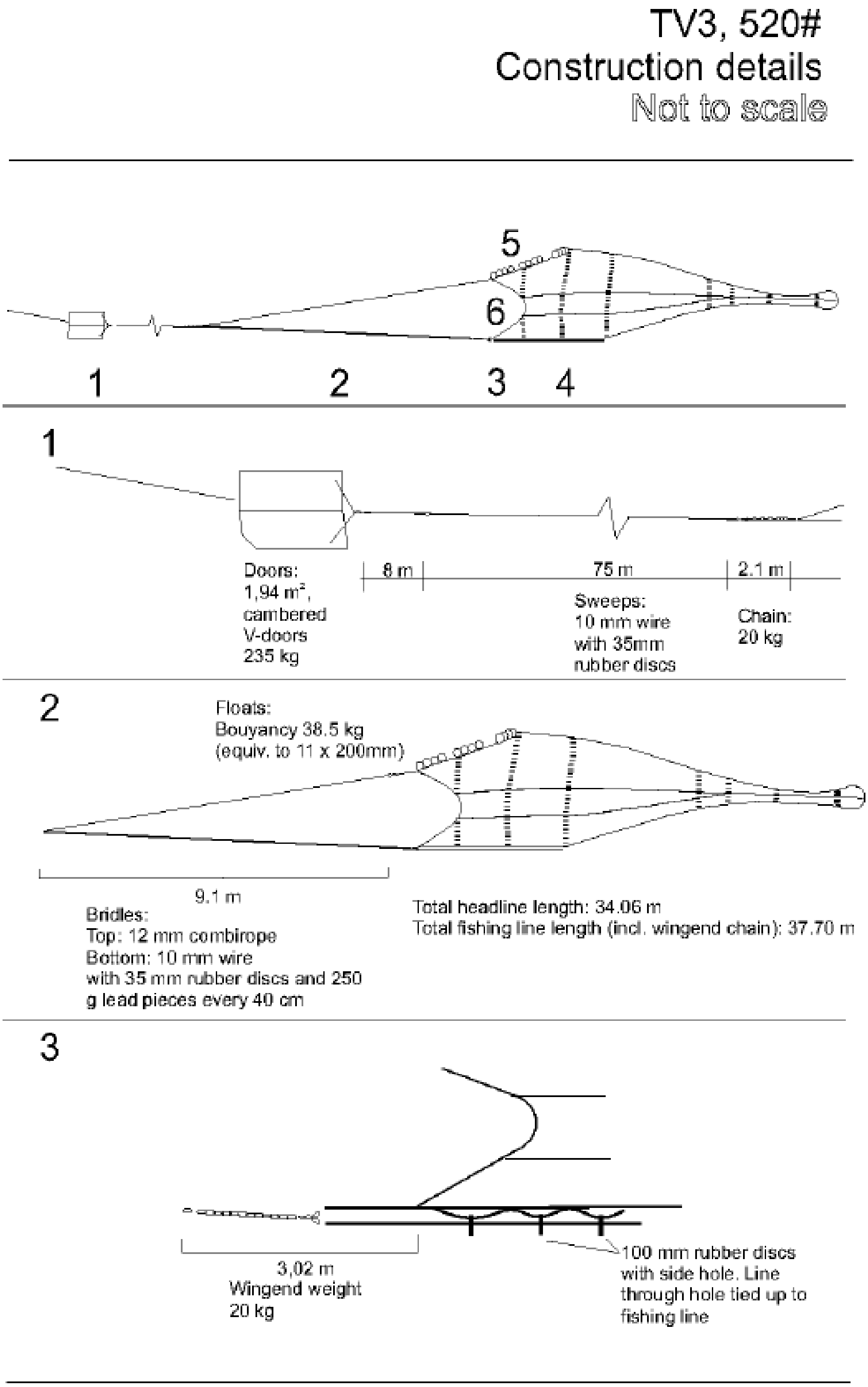


Figure 3.2. Overall layout of the TV3 trawl used in the 2022 autumn trawl survey in the phase 1 area of the pre-investigation area.

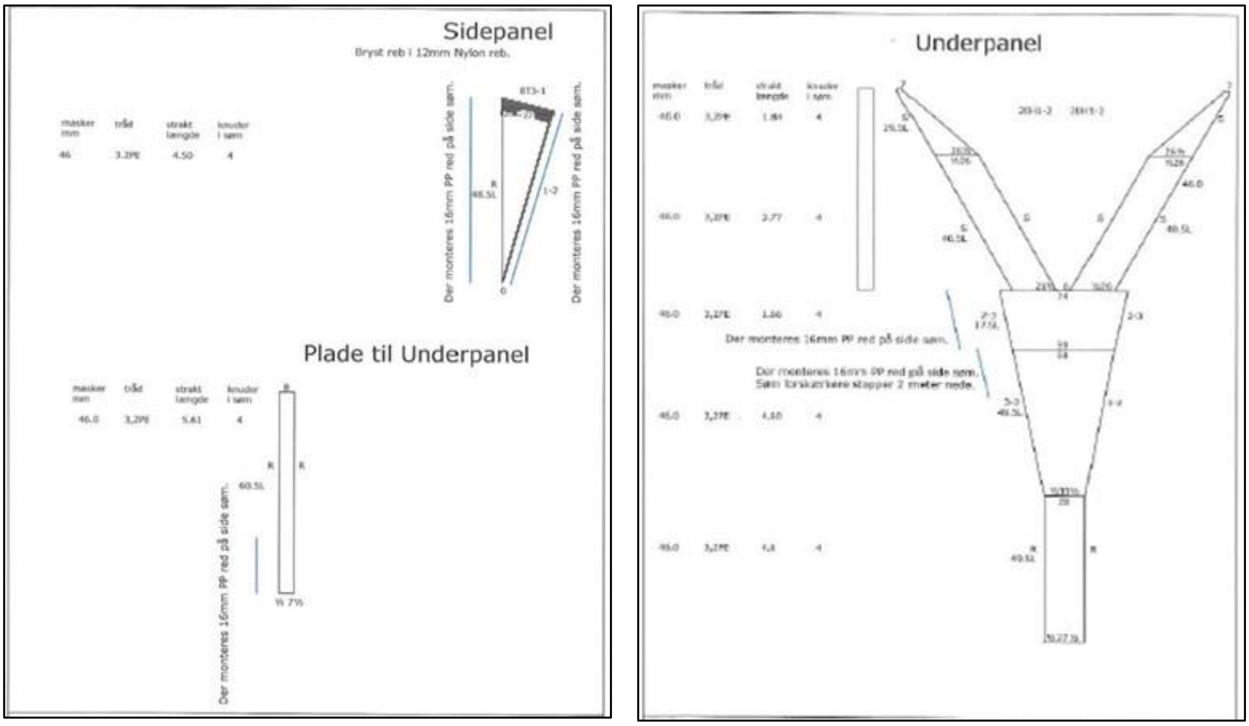


Figure 3.3. Overall layout of the 4 meters wide beam trawl used in the 2023 spring and autumn trawl surveys in the phase 1 area of the pre-investigation area.

Trawling was only undertaken during the day, which is determined as the period 15 minutes after sunrise until 15 minutes before sunset. Most of the trawl hauls were made from west towards east due to prevailing wind directions and to ensure trawling with or against the wind. Standard haul times were 30 minutes with a standard speed of 2-3 knots (speed over the bottom). This led to hauls of approximately 1.5-2.5 km in length (Appendix 1).

However, during the autumn survey in 2022, the time used for hauls was shortened to approximately 10-12 minutes and consequently to haul lengths of approximately 0.5-1.3 km for each station due to bad weather circumstances. This abbreviation in haul time was chosen to allow the completion of all trawl stations within the suitable weather window. Data analysis of the summed number of registered fish species and indications of fish abundance during sequential hauls showed that the shortened sampling time of hauls in the autumn trawl survey of 2022 was still sufficient for obtaining representative samples of the existing fish community (Appendix 2).

3.2 Gillnets surveys

During the spring and autumn surveys in 2023, gillnets were used as a supplement to the trawl surveys to investigate the mixed and hard bottom habitats where bottom trawling was not possible (Appendix 1). Three areas with mixed and hard bottom habitats were investigated. In each area, 1 Ny Nordisk Norm bottom gillnet, made up of 12 separate sections with mesh sizes ranging from 5-55 mm (, was combined with either a gillnet of a larger mesh size of 70 mm (commonly called plaice gillnets), 110 mm (commonly called turbot gillnets) or a "herring" gillnet (28 mm mesh size). The variation in mesh size was used to increase effort targeting large fish and juvenile codfish. Nets were set pairwise at 6 to 7 adjacent positions/stations in each area (20 gillnet stations in all – see Appendix 1 for details). This amounted to a total of 14 gillnets set in 2 areas and 12 gillnets set in 1 area (40 gillnets in all). Nets were typically deployed in a southwest direction with prevailing winds and with soak times between 14–26 hours during the spring and autumn surveys in 2023, respectively.

Tabel 3.1. Mesh sizes of NOVANA - Ny Nordisk Norm gillnets used in the gillnet survey

Section no.	1	2	3	4	5	6	7	8	9	10	11	12
Mesh size (mm)	43	19,5	6,25	10	55	8	12.5	24	15,5	5	35	29
Line diameter (mm)	0.2	0.15	0.1	0.13	0.23	0.1	0.13	0.16	0.15	0.1	0.2	0.16

For each station in all three areas surveyed with gillnets, information of the catch included species determination, fish lengths (± 0,5 cm), total number of fish, individual and total weight of each species. Furthermore, biological information to investigate gonad maturity in adult individuals were analysed to determine potential spawning and/or nursery areas.

After net retrieval, all fish were kept on ice in containers and taken back to the laboratory to be removed from the nets, sorted according to species, measured and weighed in accordance with the methods described in section 3.3.

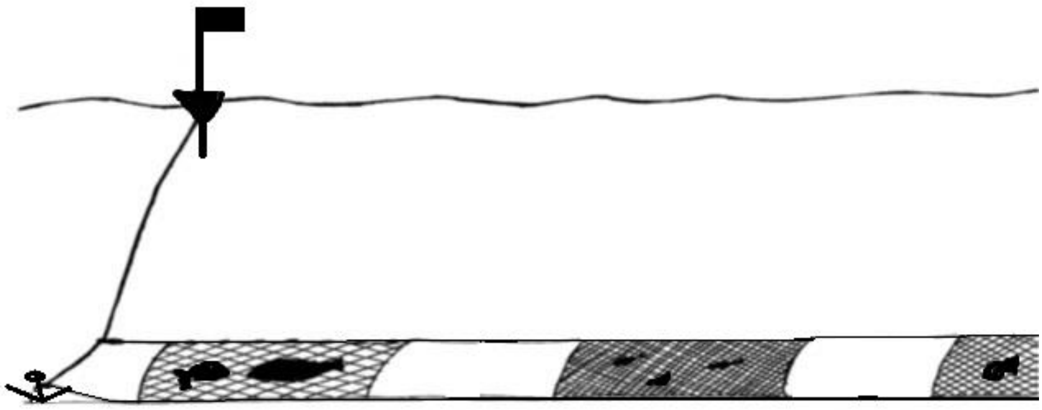


Figure 3.4. Schematic drawing of the survey gillnets with different mesh sizes used in the gillnet fish survey.

3.3 Data analysis

During the trawl surveys, information on the start and stop positions and length of time of each haul was recorded to determine swept area and water volume sampled for each haul. For hauls with large catches (>20 kg) of a specific species, random sub-samples of these species were taken to obtain length frequency analysis. All excess fish were weighed and included in the catch data. All fish caught at sea were stored on ice for later analyses when back on land and in the laboratory.

3.3.1 Analysis of fish samples

For all three fish surveys (spring and autumn trawl surveys and autumn gillnet survey) the following procedures and information of the fish samples was registered for each trawl haul and for each gillnet station:

- Number and total weight (gram) of each species
- All individual fish were measured (total length down to the nearest half cm).

- The individual length (total length 0.5 cm) and corresponding weight (0.1 g) of 5 specimens in each centimetre group (when possible) was measured.

All data was registered and secured digital in the program FishBase which runs with a SQL server saving data continuously.

3.3.2 Analysis of gonad maturity

To determine the potential importance of the pre-investigation area as a spawning site for the most important species, the maturity stages of gonads was examined in all adult cod and for a selection of the dominant flatfish (dab, plaice) in both the spring and autumn surveys. Gonad maturity was determined according to a maturity index key based on the development stage of gonads in mature (adult) fish according to modified guidelines for cod by Tomkiewicz (Tomkiewicz, 2005) and other fish species in the ICES sexual maturity sampling report (ICES, 2007).

3.3.3 Post-processing of catch data

Data from analysis of the fish samples will be used to determine the following parameters:

- Total number and species-specific biomass (weight) of all species to determine species diversity and key species (dominant species).
- Calculating CPUE (catch-per-unit-effort) to determine the mean catches of fish pr. swept area - 1000m^2 in the trawl surveys.
- The gonad development of the largest fish and potential adults of codfish (Atlantic cod, haddock and whiting) and the most abundant flatfish (plaice, dab and flounder) in the area were examined to determine the extent of a potential spawning population and the importance of the pre-investigation area as a spawning ground.
- Length frequency histograms to identify cohorts (age-groups) and help determine the importance of the pre-investigation area to different life-stages of the individual species. This included the use of the pre-investigation area as a nursery ground according to the number of juvenile fish, and the use of the pre-investigation area as a spawning ground according to the number of mature fish (adults) combined with the degree of gonad maturity.

3.4 Biodiversity and evenness analysis

Species diversity and community Evenness for the fish population within the phase 1 area of the pre-investigation area was explored through Shannon Wiener and Evenness index analysis of catches from the spring and autumn fish surveys. These two metrics were estimated for both the bottom/beam trawl and gillnet data.

The Shannon Wiener index is a diversity metric often used to explore the biodiversity of a fish community composition. This index provides a single numerical value of diversity within a fish community, which accounts for both the species richness (number of species present) and evenness, by comparing individual species abundance. The lowest possible Shannon Wiener value is 0, and represents a habitat inhabited by a single species. The value grows with an increase in species richness. The Shannon Wiener value is maximized at any species richness if the species are present at equal quantity, and conversely, will be reduced if one or few species dominate, represented by a low value. Theoretically there is no upper limit to the Shannon Wiener index, but realistically the value range is between 1 and 4 in ecological studies. Worth noting is that the Shannon Wiener index is a relative and unitless metric, meaning that comparing index values of habitats is abstract. For instance, if an index value of a habitat is double the value of another habitat, it does not mean it is twice as diverse. Instead, a higher value only suggests that the biodiversity is higher compared to areas of lower index values.

The Evenness index is a measure of how well the total amount of individuals is distributed across all species present. This index value ranges between 0 and 1, where low values represent the presence of dominating species, while 1 is found in communities with perfect distribution of individuals across species. The Evenness index is calculated by dividing the Shannon Wiener value with the total species richness.

Species count, Shannon Wiener and Evenness index were compared across surveys and within the sampling of phase 1 area of the pre-investigation area, using a two-way ANOVA that investigated the impact of survey, phase 1 area and their interaction.

4. Results of surveys

Trawling surveys were conducted at a total of 14 locations (stations) in soft bottom and mixed bottom habitats within the pre-investigation area in late autumn of 2022 (October 22nd), and at a total of 15 locations (stations) again during the spring (27-31 March) and autumn (21-25 September) of 2023. In the autumn 2022 trawl survey, an ICES TV3 bottom trawl was used. While trawl surveys in spring and autumn of 2023 were undertaken by a beam trawl.

In all, a total of 6,681 fish were caught, 5900 individuals in the trawls: 2783 in the autumn survey of 2022, and 1,428 and 1,689, individuals in the spring and autumn surveys of 2023, respectively. In the gillnet surveys alone, a total of 342 fish were caught in the spring and 439 fish caught in the autumn. By weight, a total of 374 kg of fish were caught in the trawls and 199 kg of fish in the gillnet surveys.

These fish represented total of 34 different species caught in the trawl and gillnet surveys combined, of which five were pelagic species and 29 were demersal or semi-pelagic species (Table 4.1). Of the 29 benthic/semi-pelagic species, all except one species were linked to either soft or mixed bottom habitats.

Table 4.1. Species caught during bottom trawl and gillnet surveys in 2022 and 2023 along with their habitat preference and spawning behaviour. X marks the surveys where the species were caught).

Species	Scientific name	Pelagic or Benthic	Habitat preference	Spawning behaviour	Autumn 2022	Spring 2023	Autumn 2023
		Pelagic fish species					
Atlantic herring	*Clupea harengus*	Pelagic	-	Demersal	X		X
European sprat	*Sprattus sprattus*	Pelagic	-	Pelagic	X		X
Mackerel	*Scomber scombrus*	Pelagic	-	Pelagic	X		X
Saithe	*Pollachius virens*	Pelagic	-	Pelagic			X
Horse mackerel	*Trachurus trachurus*	Pelagic	-	Pelagic			X
		Benthic fish species					
European plaice	*Pleuronectes platessa*	Demersal	Soft	Pelagic	X	X	X
Common dab	*Limanda limanda*	Demersal	Soft	Pelagic	X	X	X
Common sole	*Solea solea*	Demersal	Soft	Pelagic	X		
Lemon sole	*Microstomus kitt*	Demersal	Soft	Pelagic	X	X	X
Turbot	*Scophthalmus maximus*	Demersal	Mixed	Pelagic	X		X
Brill	*Scophthalmus rhombus*	Demersal	Mixed	Pelagic			X

Great sandeel	*Hyperoplus lanceolatus*	Demersal	Soft	Demersal	X	X	X
Lesser sandeel	*Ammodytes marinus*	Demersal	Soft	Demersal	X	X	X
Atlantic cod	*Gadus morhua*	Demersal	Mixed	Pelagic	X	X	X
Whiting	*Merlangius merlangus*	Demersal	Soft/mixed	Pelagic	X	X	X
Haddock	*Melanogrammus aeglefinus*	Semi-pelagic	Soft/mixed	Pelagic	X	X	X
Grey gurnard	*Eutrigla gurnardus*	Demersal	Soft	Pelagic	X	X	X
Greater weever	*Trachinus draco*	Demersal	Soft	Pelagic	X	X	
Lesser weever	*Echiichthys vipera*	Demersal	Soft	Pelagic	X	X	
Common dragonet	*Callionymus lyra*	Demersal	Soft/mixed	Pelagic	X	X	X
Reticulated dragonet	*Callionymus reticulatus*	Demersal	Soft/mixed	Pelagic			X
Long rough dab	*Hippoglossoides platessoides*	Demersal	Soft	Pelagic		X	
Norway pout	*Trisopterus esmarki*	Semi-pelagic	Soft	Pelagic			X
Mediterranean scaldfish	*Arnoglossus laterna*	Demersal	Soft	Pelagic	X	X	X
Solenette	*Buglossidium luteum*	Demersal	Soft	Pelagic		X	X
Lesser spotted dogfish	*Scyliorhinus canicula*	Demersal	Soft/mixed	Demersal	X	X	X
Hooknose	*Agonus cataphractus*	Demersal	Soft	Demersal		X	X
Common stingray	*Dasyatis pastinaca*	Demersal	Soft	Demersal			X
Angler	*Lophius piscatorius*	Demersal	Soft/mixed	Pelagic			X
Thorny skate	*Raja radiata*	Demersal	Soft	Demersal		X	
Pouting	*Trisopterus luscus*	Demersal	Hard	Pelagic		X	X
European hake	*Merluccius merluccius*	Semi-pelagic	-	Pelagic			X
Surmullet	*mullus surmuletus*	Demersal	Soft/mixed	Pelagic			X
Pollack	*Pollachius pollachius*	Semi-pelagic	Hard	Pelagic			X

In all trawl surveys, the most dominant species by abundance were European plaice (31.8%) and common dab (19.7%). Other fish species such as solenette (14.3%), haddock (8%), whiting (7.8%) and grey gurnard (7.1%) were also common species caught in various abundances at many of the sampling stations. Fish abundance in terms of both weight and individual numbers caught were highest in the southeastern and eastern areas of the pre-investigation area in both spring and autumn. Catch per unit effort (CPUE) in the spring and autumn trawl surveys of 2023 where the same gear type was used, were 6,4 kg/10.000 m^2 swept area (spring) and 6,9 kg/10.000 m^2 swept area (autumn), respectively, and thus very similar.

In all, 80 gillnets were used to sample fish at 3 different mixed bottom habitats in the pre-investigation area. The soak time of gillnets was approximately 16-24 hours and nets were set during the day and retrieved the following day, which amounted to soak times between 16-24 hours. Total catches by gillnets amounted to 184,2 kg, with the largest amount of fish (119,6 kg) caught during the autumn gillnet survey.

In the gillnet surveys, whiting (37%) and haddock (19.3%) were the most abundant species in both spring and autumn. Also, grey gurnard (14.1%), European plaice (4.6%), Atlantic cod (3.2%) and lesser spotted dogfish (6.8%) were common in both the spring and autumn gillnet surveys. A higher number of species were caught in the gillnet survey during autumn (22 species represented) compared to the spring survey (12 species represented). However, the 10 additional species observed during autumn were only represented by 1-3 individuals, and the apparent difference in fish diversity between the spring and autumn did not appear to represent a major migration of any particular species to and from the pre-investigation area.

On the basis of results from the fish surveys, along with data from the fisheries and the substrate characteristics within the pre-investigation area, the key species were considered to be: European plaice, whiting, haddock, European sprat, lesser sandeel, grey gurnard, common dab, lemon sole and Atlantic herring.

4.1 Seasonal variation in the catches

Because there was a change in trawl type (TV3 520/80 bottom trawl) from the trawl survey undertaken in 2022 to a 4 meters beam trawl in the surveys in March and September 2023, general comparisons, including changes in the seasonal variation was only analysed between results of the 2023 beam trawl surveys, as these were directly comparable.

Trawl surveys

The distribution (location) of the 15 spring and autumn beam trawl stations, as well as the amount of swept area during the spring (126,668 m²) and autumn (122,548 m²) surveys were almost identical. Trawling was undertaken on soft-bottom habitats throughout the pre-investigation area as this was the dominant substrate type.

The abundance (number) of fish was slightly greater in the autumn survey (1,689 individuals) and slightly more diverse (19 species) compared to the spring survey (1.428 individuals and 17 species). Standardized weight of fish according to swept area in the trawling was used to account for differences in trawling distance. Results indicated only a slightly greater biomass of fish in the autumn survey (avg. of 6.9 kg per 10,000m²) compared to the spring survey (6.4 kg per 10,000m²). The difference appears to be driven by the slightly greater abundance and biomass of the flatfishes; Mediterranean scaldfish, solenette and common dab in the autumn survey. Hence, the biomass in the spring and autumn surveys is more or less comparable. In contrast, in the spring survey the species haddock, whiting and European plaice were caught in greater abundance. For haddock and whiting, these species were observed in a broader area within the phase 1 area of the pre-investigation area during the spring, as they were caught in a greater number of trawl stations than the autumn survey ().

Comparisons of the densities (number of individuals per 10,000 m²) of the bottom living fish species in both the spring and autumn trawl surveys, strongly indicate that the abundance of common dab, European plaice, whiting, solenette, grey gurnard as well as numerous other species caught on the seabed, were represented by approximately the same abundance during the spring and autumn seasons (Appendix 3). Thus, other than the presence of a few species caught only in the spring survey (greater weever, Atlantic cod, thorny skate and rough dab) and one to a few individuals of 6 species caught only during the autumn survey (Atlantic herring, common stingray, monkfish, turbot, brill and reticulated dragonet), results of the beam trawl survey indicated only small seasonal changes in the abundance and diversity of the benthic fish community in the pre-investigation area.

In all, 23 species were recorded in the gillnet survey, with the biodiversity of fish in the catches considerably greater in the autumn survey with 22 species represented, compared to 12 species represented in the catches in the spring survey. The abundance of all the new fish species observed in the autumn survey was, however, low and they were typically only represented by one to a few individuals.

The abundance and distribution of the most common fish species (whiting, haddock, European plaice, lesser spotted dogfish, common dab and grey gurnard) in the spring and autumn gillnet surveys undertaken over mixed and hard bottom habitats, these species were both abundant and had similar seasonal distributions in both surveys. The overall fish biodiversity was, however, considerably greater in the autumn survey with 22 species represented, compared to 12 species represented in the catches in the spring survey. However, because the 10 new species in the autumn gillnet survey were represented by 1-3 individuals typically caught in 1 gillnet at one station, the apparent difference in fish diversity between the spring and autumn did not appear to represent a major migration to and from the area, as none of the new species that were caught were excessively abundant.

4.2 Trawl surveys

The spring and autumn trawl surveys were undertaken by bottom trawling at 14-15 stations located exclusively in soft bottom habitats (sand). Trawl stations were spread out on where possible soft bottom habitats to sample as broad an area of the pre-investigation as possible (Figure 2.1).

4.2.1 Autumn survey 2022

A standard TV3- 520/80 bottom survey trawl was used to sample fish during the autumn survey of 2022. The survey was undertaken on the 22nd of October 2022, and due to poor weather conditions was limited to one full day. Because of time limitations the trawl station 8 (TR8 in) was not taken, thus a total of 14 trawl hauls of approx. 10-12 minutes per haul were undertaken. In all, 2,782 fish were caught representing 19 different species with a total weight of 217 kg (Table 4.2). The total trawl swept area amounted to 149,018 m². Standardized to a catch-per-unit effort (CPUE) of fish abundance and weight per 10,000 m² sampled, this amounted to approx. 187 fish and a biomass of 14.6 kg per 10,000 m² swept area.

In all 19 fish species were caught in the trawl survey. The number of fish species caught in each station varied between 6 to 12 and the most abundant species by number and weight were common dab (*Limanda limanda*)(28% by number and 31% by weight), European plaice (*Pleuronectes platessa*)(21% by number and 21% by weight), grey gurnard (*Eutrigla gurnardus*)(12% by number and 12% by weight), haddock (*Melanogrammus aeglefinus*)(14% by number and 10% by weight) and whiting (*Merlangius merlangus*)(13% by number and 17% by weight). Thus, these species combined for 77% of the total number of fish caught and 79.8% of the catch by weight (Appendix 3). Figure 4.1 shows the total biomass of the most common fish species caught at each trawl station in autumn 2022 in relation to all other species caught at the same station.

Other fish species caught at many of the survey stations but generally in small abundances were common dragonet (*Callionymus lyra*), lemon sole (*Microstomus kitt*), sole (*Solea solea*), greater weever (*Trachinus draco*) and lesser weever (*Echiichthys vipera*). This generally corresponds well with these species' preference for the soft bottom habitats (sand and sand/gravel) that are predominant throughout the pre-investigation area (see Figure 2.1) including areas where trawling was undertaken. The key species Atlantic cod was caught in slightly more than half the survey stations (8 trawl stations), but only in a few numbers (24 in all). Except for one large Atlantic cod (length 55 cm), the majority of Atlantic cod ranged between 23-33 cm and were juveniles. Survey results indicated the area (trawl stations) where fish by number and weight were most abundant was in the southeastern part of the phase 1 area of the pre-investigation area (trawl stations TR1 to TR5).

Table 4.2. Total number of fish caught for each species at each trawl station during the autumn survey on October 22nd ,2022.

	Trawl station ID													
Species	TR1	TR2	TR3	TR4	TR5	TR6	TR7	TR9	TR10	TR11	TR12	TR13	TR14	TR15
Ammodytes marinus													1	
Arnoglossus laterna		1	1	2										
Callionymus lyra	2		2	1	3	2		2	4	1	4	1		5
Clupea harengus						4								
Eutrigla gurnardus	27	12	56	35	52	17	3	21	10	11	6	35	21	33
Gadus morhua			6	2	3			2	3	5	1		2	
Hyperoplus lanceolatus												1		
Limanda limanda	120	75	29	60	53		161	28	52	31	63	60	26	23
Melanogrammus aeglefinus	127	109	33	4	8	28	2	37	2		2	3	37	2
Merlangius merlangus	47	18	19	141	50	1		40	5			2	45	
Microstomus kitt	3		2				1	4	1	1	1	1	1	
Pleuronectes platessa	179	85	15	33	37		73	18	33	29	35	34	10	17
Scomber scombrus	1			1										

Scyliorhinus canicula			1											
Solea solea	1				2		1	1			2	1		
Sprattus sprattus	106	26	1	1		6	9							
Trachinus draco				2	7			3		1		1		1
Echiichthys vipera			1	19	21					1				9
Psetta maxima														1
Total	613	326	166	301	236	58	250	156	110	80	114	139	143	91

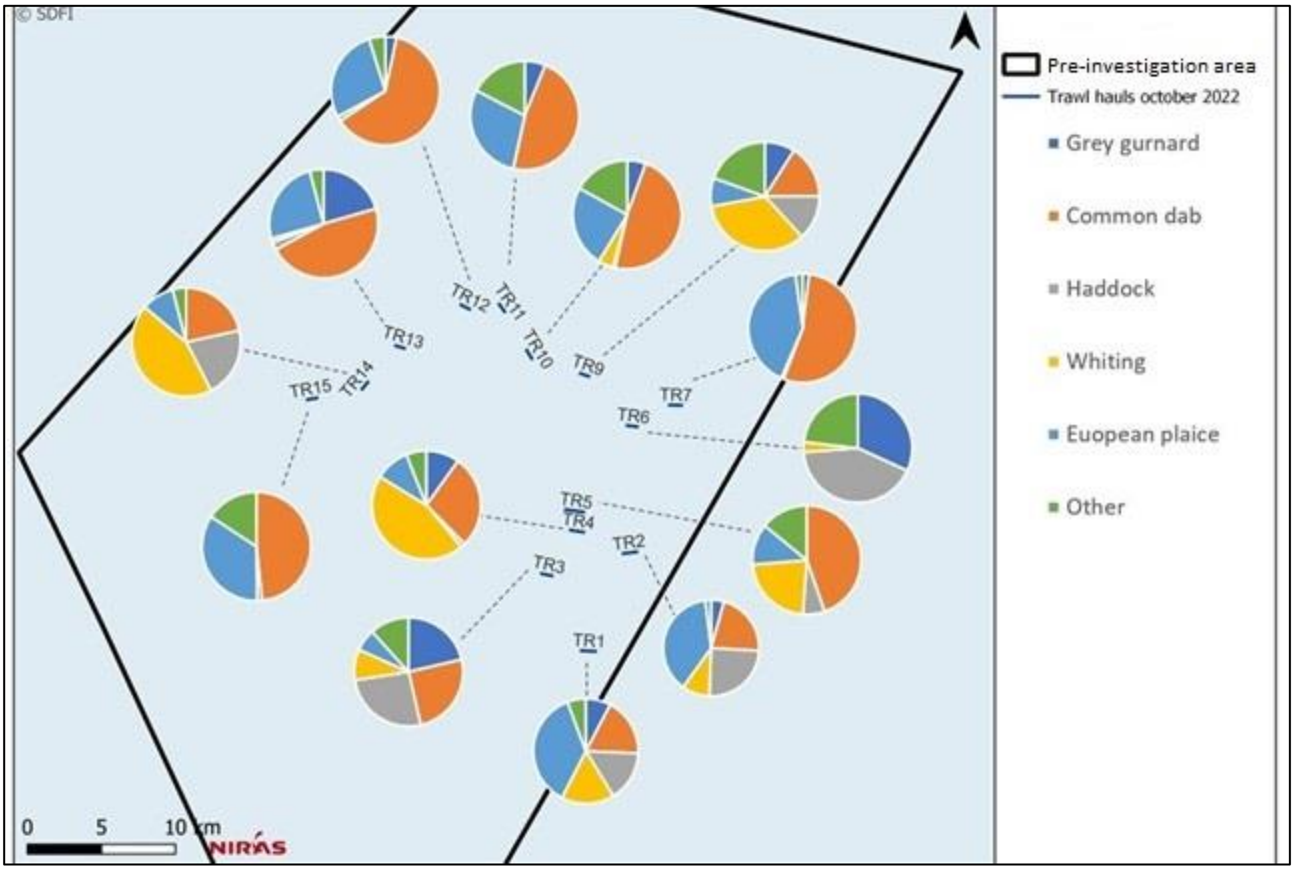


Figure 4.1 Total biomass of the most commonly caught fish species and all other species combined (other) at each trawl station during the autumn survey on October 22nd ,2022.

4.2.2 Spring survey 2023

From March 27-31 2023, the spring fish survey were undertaken using a 4 meter wide beam trawl in 15 soft bottom habitats and a variety of gillnets (see 3.2 for elaboration on gear use) used in 3 areas with mixed and hard bottom habitats. In the trawl survey, a total of 1,434 fish representing 17 different species were caught. This amounted to a total catch of 80.5 kg (Table 4.3 and Appendix 3). The total trawl swept area amounted to 126,668 m^2. Standardized to a catch-per-unit effort (CPUE) of fish abundance and weight per 10,000 m^2 sampled, this amounted to approx. 113 fish and a biomass of 6.4 kg per 10,000 m^2 swept area.

The most abundant species by number and weight caught in beam trawls were European plaice (*Pleuronectes platessa*) (53% by number and 67% by weight), followed by common dab (*Limanda limanda*)(12% by number and 9% by weight) and the small flatfish solenette (*Buglossidium luterum*)(16% by number and 3% by weight). The codfish haddock (*Melanogrammus aeglefinus*) (5% by number and 10% by weight) and whiting (*Merlangius merlangus*)(5% by number and 5% by weight) were present in various abundance in most of the stations. Other species, such as the common dragonet (*Callionymus lyra*), grey gurnard (*Eutrigla gurnardus*), Mediterranean scaldfish (*Arnoglossus laterna*) and Atlantic cod (Gadus morhua) were represented by a few individuals in a few of the survey stations. Figure 4.2 shows the total biomass of the most common fish species caught at each trawl station in spring in relation to all other species caught at the same station.

Similar to results in the autumn survey in 2022, the area (trawl stations) where fish by number and weight appeared to be most abundant was in the southeastern and eastern areas of the phase 1 area of the pre-investigation area (trawl stations TR1 to TR7) in comparison to the sampling stations in the northern part of the phase 1 area of the pre-investigation area Table 4.3.

Table 4.3. Total number of fish caught for each species at each trawl station during the 2023 spring survey undertaken from March 27-31.

	Trawl station ID														
Species	TR1	TR2	TR3	TR4	TR5	TR6	TR7	TR8	TR9	TR10	TR11	TR12	TR13	TR14	TR15
Agonus cataphractus		1				1									
Ammodytes marinus			3	1	1				3		1		1	8	
Arnoglossus laterna	1	4			2		1						1		
Buglossidium luterum	46	53	4	1	8	46	8	3	9	4	10	9	9	4	11
Callionymus lyra	4	9		1			4	1					4	1	
Eutrigla gurnardus	6	17				4		1	1			2	2	7	1
Gadus morhua			1	1								1		1	
Hippoglossoides platessoides	1	3					1				1				
Hyperoplus lanceolatus													1	1	1
Limanda limanda	40	68	6	3	3	7	12	5	7	3	3	1	2	11	2
Melanogrammus aeglefinus	24	14	1	2	1		5	10			3	6	3	3	1
Merlangius merlangus	4	19	3	1	5	6	4		2		2	7	5	10	5
Microstomus kitt	2				1		4	2	3			2			
Pleuronectes platessa	42	134	44	35	18	49	103	111	30	34	56	36	21	31	17
Raja radiata	1														
Trachinus draco														1	
Echiichthys vipera				1											
Total	171	322	62	46	39	113	142	133	55	41	76	64	49	77	38

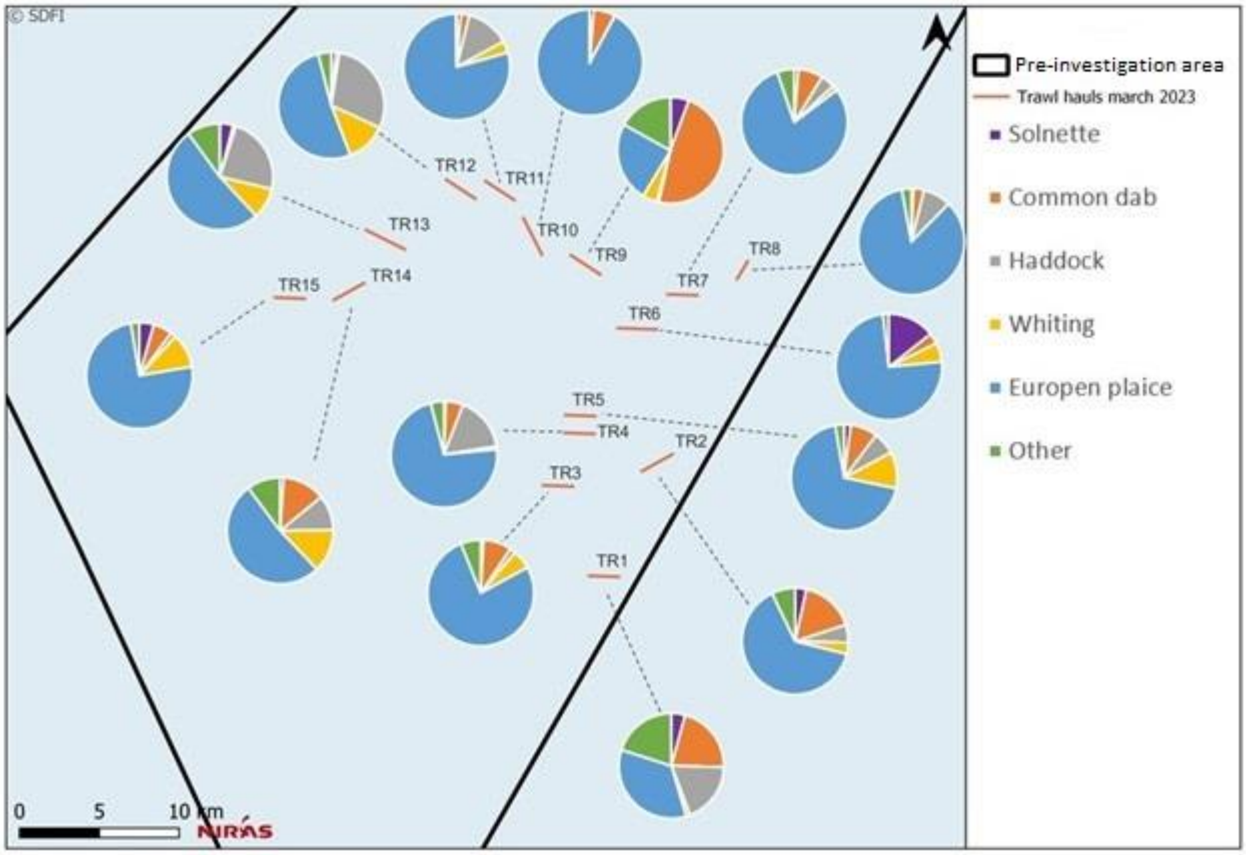


Figure 4.2 Total biomass of the most commonly caught fish species and all other species combined (other) at each trawl station during the 2023 spring trawl survey undertaken from March 27-31.

4.2.3 Autumn trawl survey 2023

In the autumn beam trawl survey undertaken from 21-25 of September, 15 stations were investigated using a 4 meters wide beam trawl. In all, a total of 1,689 individual fish were caught and represented 19 different species (Table 4.4). This amounted to a total weight of 84.9 kg (Appendix 3). The total trawl swept area amounted to 122,548 m^2. Based on standardized catch-per-unit effort (CPUE) of fish abundance and weight per 10,000 m^2 swept area, this amounted to approx. 138 fish and a biomass of 6.9 kg per 10,000 m^2 swept area.

The most abundant species were the flatfish species European plaice (*Pleuronectes platessa*)(30% by number and 55% by weight), common dab (*Limanda limanda*)(15% by number and 13% by weight), solenette (*Buglossidium luterum*)(37% by number and 6% by weight) and Mediterranean scaldfish (*Arnoglossus laterna*)(8% by number and 1% by weight)(Appendix 3). Species that were present in most of the trawl hauls, but only in small abundance were the codfish whiting (*Merlangius merlangus*), and species such as the common dragonet (*Callionymus lyra*) and grey gurnard (*Eutrigla gurnardus*). Other species only observed on occasion and only with a few individuals were Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), lemon sole (*Microsomus kitt*), lesser sandeel (*Ammodytes marinus*), greater sandeel (*Hyperoplus lanceolatus*), lesser weever (*Echiichthys vipera) and hognose (Agonus cataphractus).* Figure 4.3 shows the total biomass of the most common fish species caught at each trawl station in spring in relation to all other species caught at the same station.

Similar to results from the autumn survey in 2022 and the spring survey in 2023, the area (trawl stations) where fish by number and weight were most abundant was in the southeastern and eastern areas of the phase 1 of the pre-investigation area (trawl stations TR1 to TR7) in comparison to the northern part of the phase 1 area of the pre-investigation area (Table 4.3).

Table 4.4. Total number of fish caught for each species at each trawl station during the 2023 autumn survey undertaken from 21-25 September.

	Trawl station ID														
Species	TR1	TR2	TR3	TR4	TR5	TR6	TR7	TR8	TR9	TR10	TR11	TR12	TR13	TR14	TR15
Agonus cataphractus	1	1	1			1	3		1				2	2	
Ammodytes marinus		1	2					2		2		1	2	3	
Arnoglossus laterna	19	19	3	4	4	18	12	1	10	7	6	11	15	8	6
Buglossidium luterum	174	125	12	11	24	106	30		14	12	33	27	30	10	10
Callionymus lyra	1	1	9	5	3	3	2		6	4	1	1	3	3	2
Callionymus reticulatus									1		1				
Clupea harengus						1							2		
Dasyatis pastinace								1							
Eutrigla gurnardus	1		1	1	1		5		4	1	2	5	6	9	4
Hyperoplus lanceolatus									1		2		1		1
Limanda limanda	20	14	11	14	17	17	32	7	10	3	9	17	20	11	7
Lophius piscatorius					1							1			
Melanogrammus aeglefinus							2			1				2	2
Merlangius merlangus	1	1	1	1		1	1			1		2		8	1
Microstomus kitt	3	1			1	1					2	2			
Pleuronectes platessa	50	54	45	36	46	36	47	19	36	28	26	23	26	24	19
Scophthalmus maximus															1
Scophthalmus rhombus							2								
Echiichthys vipera				15	15					2	2			1	9
Total	270	217	85	87	112	184	136	30	83	61	84	90	107	81	62

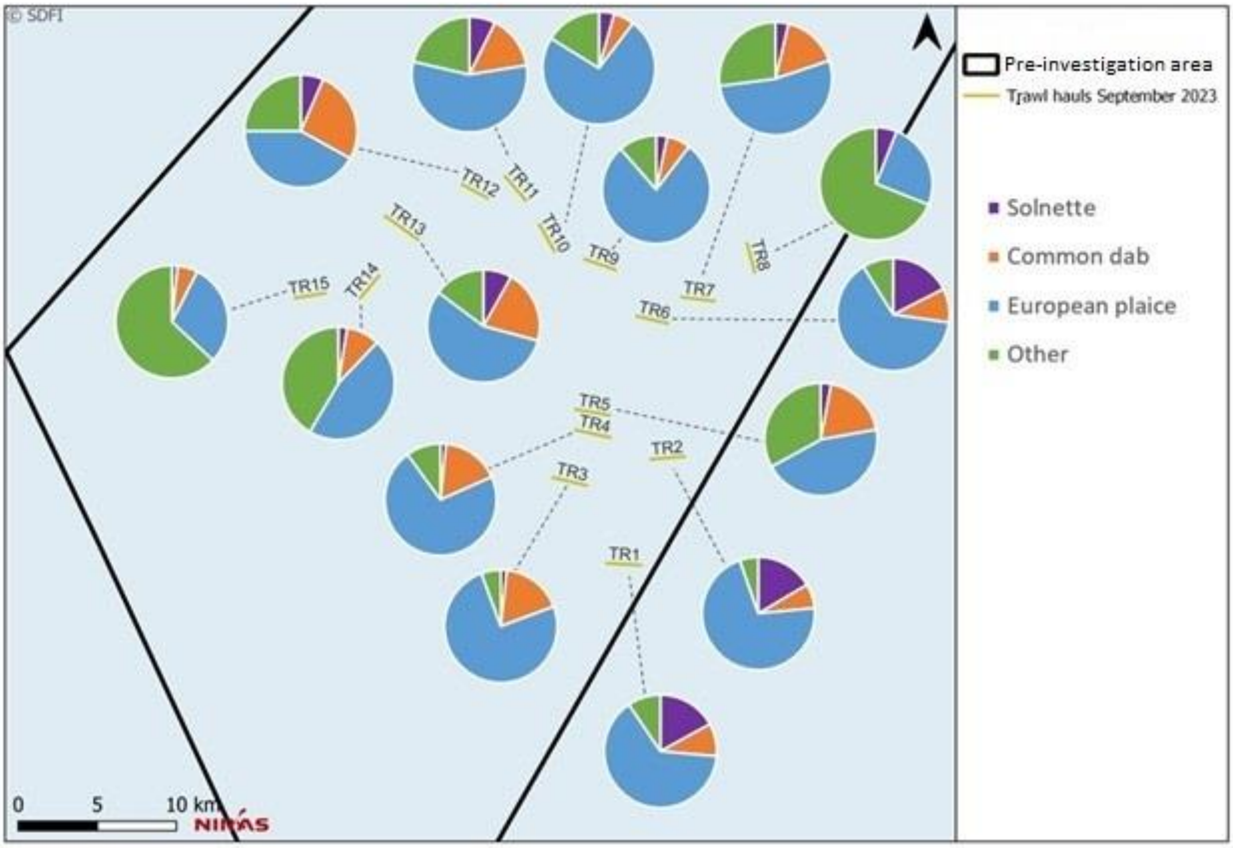


Figure 4.3 Total biomass of the most commonly caught fish species and all other species combined (other) at each trawl station in the 2023 autumn trawl survey undertaken from 21-25 September .

4.3 Gillnet surveys

The spring and autumn gillnet surveys were undertaken with a variety of gillnets with different mesh sizes to sample a variety of fish lengths in 3 mixed and hard bottom areas (see Figure 3.1).

4.3.1 Spring gillnet survey 2023

In the spring gillnet survey undertaken from March 27-31, 2023, a total of 342 fish were caught in a total of 40 gillnets (Table 4.5) These represented 12 different species with a total weight of 64.6 kg (Table 4.5). The most abundant species by number and represented in all 3 areas were whiting (139 individuals and a total weight of 23.3 kg) and grey gurnard (67 individuals and a total weight of 7.8 kg). These species were followed by catches of a smaller number of haddock (31 individuals), European plaice (25 individuals), common dab (32 individuals), Atlantic cod (9 individuals), lesser spotted dogfish (23 individuals) and the common dragonet (9 individuals), and only a single or very few individuals of lemon sole, solenette, pouting (*Trisopterus luscus*) and a monkfish (*Arnoglossus laterna*)(Table 4.5).

Table 4.5. Total numbers of fish caught in gillnets by species for the spring survey undertaken from March 27-23, 2023. Total biomass (g) in brackets. Total numbers of fish caught in gillnets by species for the spring survey undertaken from March 27-23, 2023. Total biomass (g) in brackets.

	Location of sampling stations		
	1 – South	2 – East	3 -North

Gillnet type	Biological survey	Turbot	Herring	Plaice	Biological survey	Turbot	Herring	Plaice	Biological survey	Turbot	Herring	Plaice
Number of nets	7	1	4	2	6	1	3	2	7	1	3	3
Arnoglossus laterna	1 (8)											
Buglossidium luterum	1 (16)											
Callionymus lyra	6 (204)				1 (10)				2 (63			
Eutrigla gurnardus	17 (1616)		12 (1059)	1 (120)	1 (138)				19 (2516)		13 (1496)	4 (835)
Gadus morhua					2 (558)		1 (416)	3 (2289)	1 (220)			2 (1483)
Limanda limanda	19 (1747)	1 (81)	10 (693)	1 (106)	1 (160)							
Melanogrammus aeglefinus	1 (84)		2 (324)		3 (1001)		4 (1049)	4 (1224)	8 (2484)		7 (1890)	2 (578)
Merlangius merlangus	15 (1788)		28 (4546)		5 (1042)		17 (3667)	1 (157)	25 (3694)		46 (8058)	2 (306)
Microstomus kitt		1 (179)						1 (283)				2 (552)
Pleuronectes platessa	11 (1472)		4 (659)	3 (792)	3 (617)			1 (229)	1 (268)			2 (573)
Scyliorhinus canicula	6 (3348)		11 (4595)		2 (1316)		3 (1041)		1 (790)			
Trisopterus luscus									1 (179)			

4.3.2 Autumn gillnet survey

In the autumn gillnet survey undertaken from 21-25 of September 2023, a total of 439 fish were caught with a total weight of 119.6 kg in 40 gillnets (Table 4.6). In all, there were 22 different species caught. The most abundant species also represented in all 3 areas were the codfish: whiting (150 individuals and 31.7 kg), haddock (120 individuals and 34.1 kg) and Atlantic cod (16 individuals and 6 kg), as well as the lesser-spotted dogfish (30 individuals. and 20.2 kg) and grey gurnard (43 individuals and 4.7 kg). Other species that were represented by a few individuals in the mixed and hard bottom areas were monkfish, common dab, European plaice, pouting (*Trisopterus luscus*), Norway pout (*Trisopterus esmarki*), turbot, striped red mullet (*Mullus surmuletus*) and common dragonet (Table 4.6).

Table 4.6. Total numbers of fish caught in gillnets by species for the autumn survey undertaken from September 21-25, 2023. Total biomass (g) in brackets.

	Location of sampling stations											
	1 - South				2 - East				3 -North			
Gillnet type	Biological survey	Turbot	Herring	Plaice	Biological survey	Turbot	Herring	Plaice	Biological survey	Turbot	Herring	Plaice
Number of nets	7	1	4	2	6	1	3	2	7	1	4	2
Arnoglossus laterna	1 (9)											
Callionymus lyra	9 (234)				1 (15)							
Dasyatis pastinace				1 (1004)								
Eutrigla gurnardus	15 (1618)		9 (1005)	2 (277)	8 (820)		5 (566)		2 (164)		2 (202)	
Gadus morhua	2 (219)		3 (763)	1 (895)	4 (1405)		1 (151)	2 (1542)			1 (270)	2 (806)
Limanda limanda	9 (782)		3 (398)	1 (221)			1 (162)		1 (131)	1 (69)		1 (170)
Lophius piscatorius							1 (565)	1 (1971)		1 (2145)	1 (763)	1 (912)
Melanogrammus aeglefinus	14 (3684)	1 (401)	53 (14271)	5 (1801)	4 (1204)		20 (6040)	3 (1118)	8 (2455)	1 (332)	7 (1409)	4 (1430)
Merlangius merlangus	33 (6804)		85 (17641)	7 (1477)	2 (639)		7 (1987)		3 (485)		12 (2482)	1 (188)
Merluccius merluccius	1 (902)						1 (458)					
Microstomus kitt	1 (6)			1 (143)	1 (12)							
Mullus surmuletus			3 (599)									
Pleuronectes platessa	2 (313)			5 (1296)			2 (892)					2 (741)
Pollachius pollachius											1 (483)	

Pollachius virens									1 (520)		1 (538)	
Scophthalmus maximus				1 (3470)								
Scomber scombrus			1 (464)	1 (205)	1 (482)							
Scyliorhinus canicula	1 (358)		3 (1121)		7 (5153)		5 (3844)		11 (8133)		3 (1621)	
Sprattus sprattus	2 (27)											
Trachurus trachurus	1 (5)											
Trisopterus esmarki									1 (9.4)			
Trisopterus luscus	4 (182)		1 (76)								11 (1480)	

4.4 Spawning area

To investigate the potential use of the pre-investigation area as a spawning area, the gonad maturity of a number of adult fish caught during fish surveys in the phase 1 area was investigated. Existing data of spawning areas of different species indicated that European plaice, haddock, sandeel and potentially Atlantic cod spawning in areas of the North Sea that are close to or overlap with the pre-investigation area (see section 2.4). In the following section, only the fish species from fish surveys that were abundant and had potentially spawning individuals were investigated and described. For sandeel, catches in the surveys were low and their spawning period is generally during the winter months, however, knowledge of their high abundance in the pre-investigation area due to suitable habitats, fishery data and existing distribution of spawning data (section 2.4), together with a spawning behaviour of laying demersal eggs locally suggest that this fish species spawn in the pre-investigation area, and they were not investigated further.

Atlantic cod

During the 2022 autumn fish survey only 1 adult cod (57 cm) was caught and analysed for gonad maturity. Similarly, in the 2023 spring and autumn surveys there were very few adult cod caught. This amounted to the gonad maturity analysis of only 3 cod (37-41 cm in length) in the spring survey and only 4 cod (38-48 cm in length) in the autumn survey.

Results showed that the cod investigated in the 2022 autumn survey was a female with regressing/degenerated ovaries and thus not in a stage of spawning. In the 2023 spring survey, all 3 cod analysed were males with immature gonads (testis) and not in a stage of development for immediate spawning. Similarly, in the autumn 2023 the 4 cod analysed because their length suggested they could be adults were all males. Three of the individuals had immature or highly regenerated testis, and 1 individual (48 cm in length) had degenerated and what appeared to be recovering testis (whitish/pinkish in colour).

Because spawning cod exhibit a considerable amount of site fidelity and migrate to particular spawning areas, the lack of Atlantic cod spawning in the pre-investigation area is therefore likely a stable phenomenon over time, unless a hypothetical North Sea spawning population that would utilizing the area is presently at a very low level.

Based on the very few adult Atlantic cod in all the surveys and the absence of spawning individuals, it is highly unlikely that the pre-investigation area is a spawning area for Atlantic cod.

European plaice

In all, the gonad maturity of 90 European plaice over 2 fish surveys in the pre-investigation area were investigated for signs of spawning individuals. Results of the gonad analysis of plaice are given in Table 4.7.

Table 4.7. Results of gonad maturity analysis of European plaice from fish surveys (2022 autumn and 2023 spring and autumn surveys) in the pre-investigation area.

Survey	No. of individuals	Sex	No. of individuals	Lengths (cm)	Gonad maturity	Description
2022 Autumn survey	17	females	6	29-37 cm	Degenerated/ potentially recovering ovaries	All fish had pinkish-reddish and translucent small ovaries. Some blood vessels visible - eggs not visible to naked eye.
		males	11	28-33 cm	Immature and/or degenerated testis	Very small testis near cavity wall (immature) or whitish testis, more or less symmetrical
2023 Spring survey		females	11	27-38 cm	Degenerated/ potentially resting ovaries (post-spawned)	Pinkish and translucent shrunken ovaries - eggs not visible to naked eye
		males	29	26-32 cm	Immature and/or degenerated testis	Very small testis near cavity wall (immature) or whitish testis, more or less symmetrical
2023 Autumn survey	10	females	3	33-38 cm	Degenerated/ potentially recovering ovaries	All fish had pinkish-reddish and translucent small ovaries. Some blood vessels visible - eggs not visible to naked eye.
		males	7	29-34 cm	Immature and/or degenerated testis	Very small testis near cavity wall (immature) or whitish testis, more or less symmetrical

Autumn 2022 and 2023

During the period where autumn fish surveys were undertaken (September and October) European plaice typically do not spawn in the North Sea. During this period, however, a total of 27 individuals that were considered adults (17 in 2022 and 10 in 2023) were analysed for gonad maturity. Of these, the majority were males (18 males). Results of the females that were analysed indicated that in all cases the ovaries were small and pinkish-reddish in colour and translucent, and the eggs were not visible. This could indicate that ovaries are either resting or recovering. Results of gonad maturity assessment for the male plaice during this time, showed that all males had very small testes that were either immature or more or less symmetrical, whitish and potentially resting. Thus, in all cases there were no indications of males that were ready to spawn.

Spring 2023

Most fish including European plaice spawn in late winter and early spring and therefore there was an anticipation that spawning individuals of plaice would be observed in the pre-investigation area. In all, the gonad maturity of 40 individual fish (11 females and 29 males) in lengths (26-38 cm) that could indicate individuals may be mature were analysed. For females (lengths 27-38 cm), results showed that in all cases the ovaries were small and degenerated and potentially resting (post-spawned). Similarly, all the males analysed during the spring surveys had testis that were very small and near the body cavity wall indicating immature fish or more very thin and more or less symmetrical and whitish indicating resting testis. Thus, there were no clear indications of either spawning females or males of European plaice in the pre-investigation area during the spring survey. Additionally, there were not many large individuals in the catches that would indicate mature plaice were gathering or had gathered in the pre-investigation area to undertake spawning.

Based on the results of gonad maturity of European plaice in the pre-investigation area, particularly during the spring survey where the potential presence of spawning individual plaice would be greatest, there were no indications that there were spawning individuals, and that the pre-investigation area was used as a spawning area. This was also supported by the relative low number of large mature adult plaice in the catches. Existing data from ICES monitoring surveys and the presence of larvae in the area (Figure 2.7) does, however, indicate that the region around the pre-investigation area may be used as a spawning area for European plaice in the North Sea. As mentioned, spawning areas of most fish fluctuate from year to year according to annual variations in temperature and hydrographic conditions. Thus, although results of gonad maturity of plaice in this study do not support the potential use of the pre-investigation area these results are only based on sampling in a short window of time and relatively small area.

Haddock and whiting

In the pre-investigation area haddock and whiting were caught in both spring and autumn surveys and in both gillnets and trawl hauls. Particularly, haddock and also whiting were caught at most of the survey stations, especially in the autumn trawl survey in 2022. The vast majority of haddock and whiting caught in the trawl surveys were juveniles and it appears that the pre-investigation area functions more as a potential nursery ground then spawning ground for these species.

The gonad maturity of the largest individuals of haddock (4 individuals from 34-38 cm in length) and whiting (5 individuals 27-30 cm in length) were investigated in the spring fish survey. All the individuals were males and in all cases their testes were small (immature) or appeared to be in a stage of resting due to their thin cylindrical form and whitish colouring. Although there were not enough adult individuals of these two codfish species and thus only little data on gonad maturity status, of the individuals examined, there were immediate signs of spawning (ripe or recently spent testis) and thus no indications that individuals of these 2 fish species spawn in the pre-investigation area.

Overall, and all instances where gonad maturity was examined, there was no indications that spawning was either about to take place or had just taken place in any of the individual fish that were investigated. Thus, there were no indications that the pre-investigation area is used for spawning area for any of these species.

4.5 Size distribution and nursery area

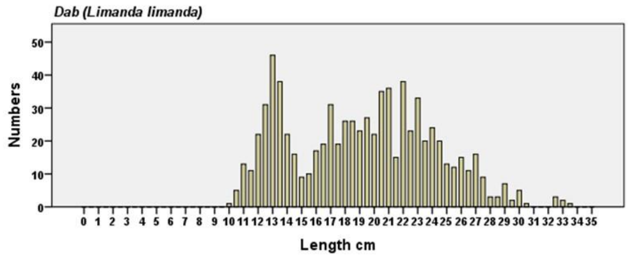
Size distribution of catches in spring and autumn was used to investigate whether the pre-investigation area is used by juvenile fish as nursing area.

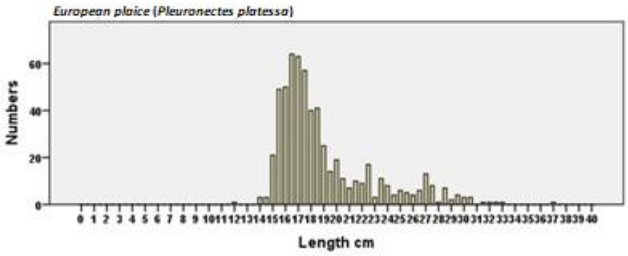
In this section, the length of the fish caught in the spring and autumn surveys were used to assess if the pre-investigation area was used as nursery area for juvenile fish. The length frequency for the most abundant and relevant fish species (dab, European plaice, and the codfish, Whiting, Atlantic cod and Haddock) in the catches from the autumn trawl survey in 2022, and spring and autumn trawl surveys of 2023 and an assessment of the pre-investigation area as a potential nursery area for these species is given below.

European dab and plaice

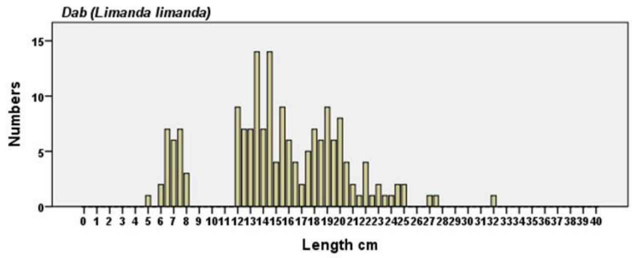
The length frequency of common dab in the catches of all 3 trawl surveys indicated a large number of juveniles between the lengths of 10-15 cm, and as small as 5-8 cm (probably young-of-the-year juveniles from the same year) were represented in the survey area. Similarly, large numbers of juvenile European plaice between the lengths of 11-25 cm and slightly larger were also represented in the catches in all 3 surveys. These lengths would typically represent juveniles between the ages of 0-2 years for common dab and 1-3 years of age for European plaice (Muus & Nielsen, 2006). Length frequencies for both common dab and European plaice also indicated some adults in the populations, albeit not many large adults in the European plaice population. Thus, the considerable abundances and small sizes of both common dab and European plaice reflects the large presence of soft bottom habitats that characterize the majority of the pre-investigation area, and which are used as nursery habitat for these fish species.

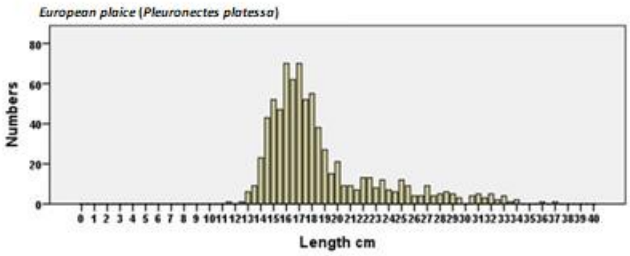
Autumn survey 2022



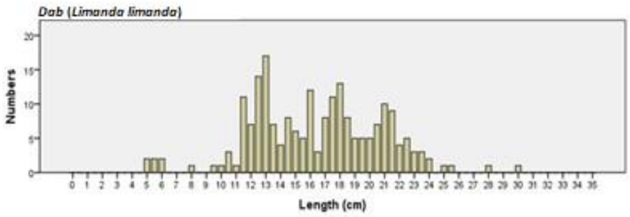


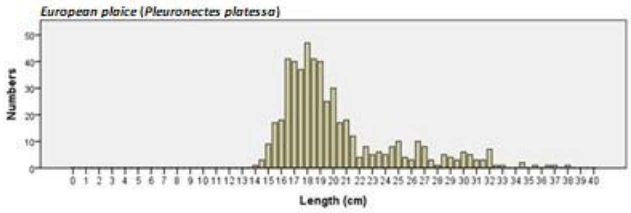
Spring survey 2023





Autumn survey 2023



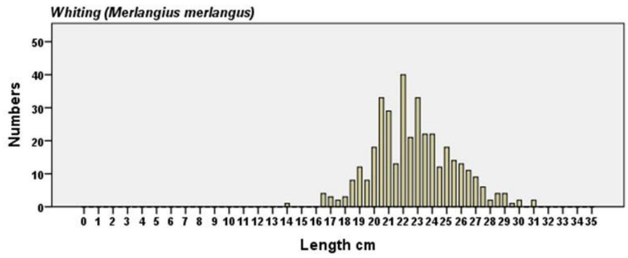


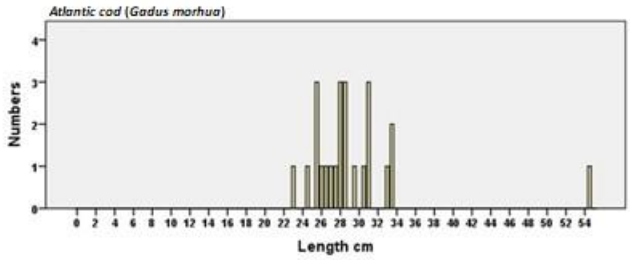
Codfish (haddock, Atlantic cod and whiting)

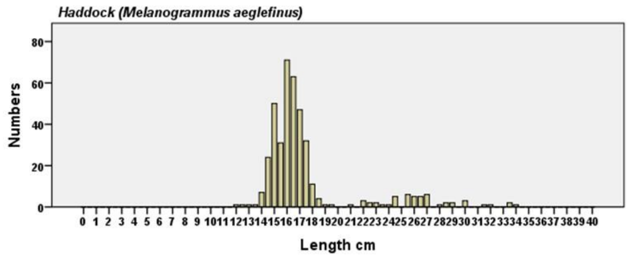
Length frequencies of the different codfish (haddock, Atlantic cod and whiting) if the pre-investigation area indicate the consistent abundance of juvenile haddock (15-25 cm) in all 3 surveys, and the presence of juvenile Atlantic cod, however only in very low abundances in all surveys. For whiting, except for the presence of a few juveniles (12-17 cm in length) in the spring trawl survey, the lengths of the whiting were predominantly greater than 17 cm, which is a length where this species typically become mature (Hislop, J. et al, 2015).

Overall, these results suggest that for haddock, the pre-investigation area appears to be used as a nursery area, while this is less apparent for both whiting and Atlantic cod. In all three surveys there were almost no large adults of these 3 primary codfish species represented in the catches.

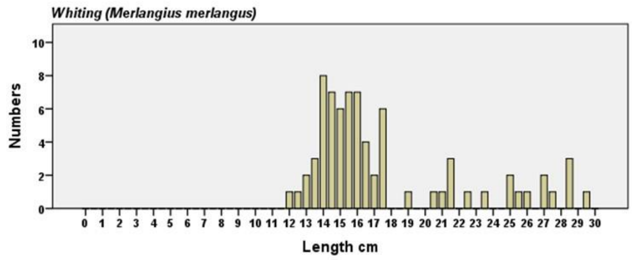
Autumn survey 2022

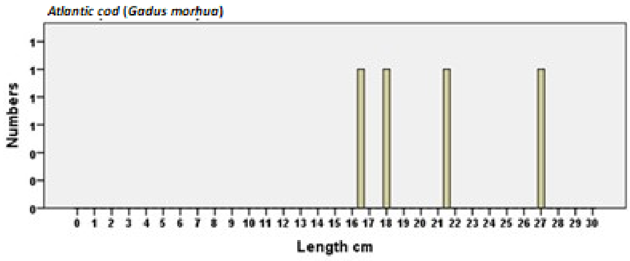


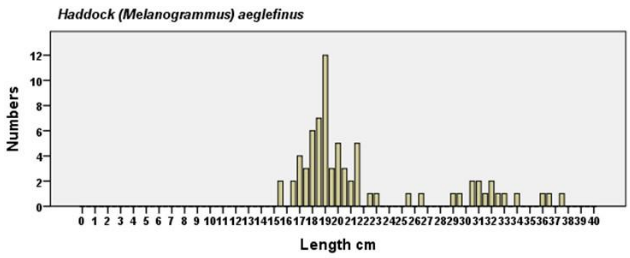




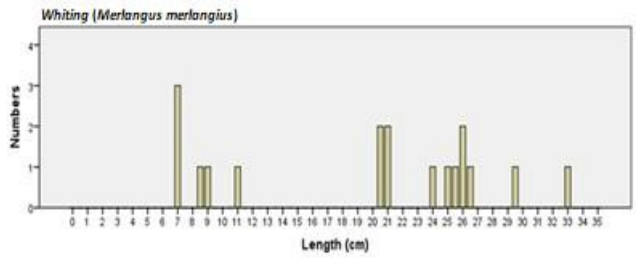
Spring survey 2023







Autumn survey 2023



4.6 Diversity and Evenness index analysis

To assess the biodiversity of fish in the pre-investigation area in different surveys and in different areas within the phase 1 area, the Shannon Wiener index and evenness were calculated for the spring and autumn surveys based on the number of species and abundance of fish. Calculations were separated for trawl and gillnets as the sampling methods cannot be compared; trawl data is based on abundances per swept area (10000 m^2), and gillnet data is based on abundances and number of species in nets per day. As mentioned in methods section the Shannon Wiener index value is highest at any species richness if the species are present in equal numbers, and conversely, will be reduced and represented by a low value if one or few species dominate i.e. the value is based on richness and evenness in the fish community. The evenness value is a measure of how "even" the number of individuals is distributed across all species present. This index value ranges between 0 and 1, where low values represent the presence of dominating species, while 1 is found in communities with perfect distribution of individuals across species.

In general, the Shannon Wiener index value range is between 1 and 4 in ecological studies and represents a greater biodiversity the higher the value.

4.6.1 Trawl

Using the number of species (species count) and fish abundance the Shannon Wiener and Evenness index was estimated for each of the 15 trawl transects, undertaken in the three surveys: Autumn 2022, spring 2023 and autumn 2023. Additionally, within each survey, the samples were aggregated in order to estimate each of the three aforementioned metrics on the total survey results.

Through a one-way ANOVA testing the three surveys there was found to be no significant difference for either of the three metrics: Species count ($p=0,59$), Shannon Wiener index ($p=0,17$) and Evenness ($p=0,37$). However, there was a slight tendency towards a richer and more diverse fish community in the autumn compared to the spring (Table 4.8). This trend is indicated by the comparatively low Shannon Wiener p-value, and visually through the generally lower minimum, maximum and each quantile value, of the spring data compared to the autumn data

When comparing individual trawl transects the species count was found to be much different from that of the total number of fish species within each survey. The number of species in the autumn 2022 survey transects ranged between 6-12 species, which was much lower than the total count of 19 species (). The same was found in the spring (3-11 species, total 17) and autumn (5-11 species, total 19) survey transects of 2023 (Table 4.8). This suggests differing species heterogeneity among the local areas covered by the transects, possibly due to differences in varying local habitats and the accompanied fish community composition.

Across all three surveys relatively comparable Shannon Wiener index values were observed. However, comparing mean values of the 15 transect locations, there was a small tendency for lower diversity values at trawl transect TR6, TR7, TR8 and TR10 (0,8-1,2), medium values at transects TR1, TR2, TR3, TR4, TR11 and TR12 (1,3-1,5) and higher values at transects TR5, TR9, TR13, TR14 and TR15 (1,6-1,9)(Table 4.8). This suggests a slight geographic grouping of biodiversity differences: lower in the northeast, medium in the southeast and higher biodiversity in the northwest parts of the phase 1 area (figure 3.3). As these mean values are estimated across the three surveys, the temporal/seasonal impact on biodiversity appear to be of lower importance, meaning that the aforementioned geographic groupings could be the result of potential differences in local habitat composition. Conversely, the Shannon wiener index of the aggregated survey-specific data, which includes a temporal effect, shows little difference in biodiversity. The highest index value is observed in the autumn 2022 survey (1,9), and the lowest in spring 2023 survey (1,6).

The Evenness index shows a near identical trend as the Shannon index, for both within survey transects, the transect mean values across surveys and the total survey estimate. However, when each transect is compared to the corresponding transect between surveys, the two autumn surveys show greater overall value and likeness, when compared to the spring values (Table 4.8).

In summary, the trawl surveys within the phase 1 area of the pre-investigation area showed comparable values in Shannon Wiener and Evenness indexes, showing no significant differences in biodiversity. However, slight geographic grouping of biodiversity was observed, indicating differences in the northwest, northeast and southeast survey areas.

Table 4.8. Summary of the biodiversity metric analysis (Species count, Shannon Wiener and Evenness index) for the autumn 2022 (top left), spring 2022 (top right) and autumn 2023 (bottom left) trawl surveys. The three metrics were estimated for each transect including a 'total' analysis, which investigated the aggregated data of all transect within a survey period

Autumn 2022

Transect	No. of species	Shannon Wiener	Evenness
TR1	10	1,7	0,7
TR2	7	1,6	0,8
TR3	12	1,8	0,7
TR4	12	1,6	0,6
TR5	10	1,9	0,8
TR6	6	1,3	0,7
TR7	7	0,9	0,5
TR8	-	-	-
TR9	10	1,8	0,8
TR10	8	1,4	0,7
TR11	8	1,4	0,7
TR12	8	1,2	0,6
TR13	10	1,4	0,6
TR14	8	1,6	0,8
TR15	8	1,6	0,8
Total	19	1,9	0,70

Spring 2023

Transect	No. of species	Shannon Wiener	Evenness
TR1	11	1,7	0,7
TR2	10	1,7	0,7
TR3	7	1,1	0,6
TR4	9	1,0	0,5
TR5	8	1,6	0,8
TR6	6	1,2	0,7
TR7	9	1,1	0,5
TR8	7	0,7	0,4
TR9	7	1,4	0,7
TR10	3	0,6	0,5
TR11	7	1,0	0,5
TR12	8	1,4	0,7
TR13	10	1,8	0,8
TR14	11	1,9	0,8
TR15	7	1,4	0,7
Total	17	1,6	0,6

Autumn 2023

Transect	No. of species	Shannon Wiener	Evenness
TR1	9	1,1	0,5
TR2	9	1,2	0,5
TR3	9	1,5	0,7
TR4	8	1,6	0,8
TR5	9	1,6	0,7
TR6	9	1,3	0,6
TR7	10	1,7	0,7
TR8	5	1,0	0,6
TR9	9	1,7	0,8
TR10	10	1,7	0,7
TR11	10	1,6	0,7
TR12	10	1,8	0,8
TR13	10	1,8	0,8
TR14	11	2,1	0,9
TR15	11	2,0	0,8
Total	19	1,7	0,6

4.6.2 Gillnets

In contrast to the trawl survey, the gillnet survey was only conducted in the spring and autumn of 2023. The gillnet surveys were focused on three sampling areas of mixed/hard bottom habitats, where 4 different net types of varying mesh sizes were applied.

Species count, Shannon Wiener and Evenness index were compared across surveys and sampling areas, using a two-way ANOVA that investigated the impact of survey, pre-investigation area and their interaction on either of the three aforementioned responses. No significant difference was found for either of the three metrics, however a strong trend for higher autumn species count were found (*p=0,073*, which were driven by overall high values at the North station (Table 4.9). However, when observing the full species count across the two surveys, the autumn survey had a much greater species count (22) than the spring survey (12)(Table 4.9). Additionally, all but one of the species caught in the spring was also caught in the autumn survey. Given that some of the species that are only present in the autumn are migrating species such as Atlantic Mackerel (*Scomber scombrus*), there might be a seasonal difference in some species present, due to species-specific traits such as spawning and/or feeding migrations.

Although not statistically significant, there was a small trend (*p=0,19*) towards higher Shannon wiener index in the autumn survey, where generally larger median and quantile values were found across all sampling areas (Figure 4.1). Interestingly, the opposite pattern is found with regard to the Evenness index, with non-significant higher values across sampling areas, rather than surveys. In both surveys the trend suggested a higher evenness at the '1-South' area, in comparison to the '1-North' area in the phase 1 area.

In summary, the gillnet surveys within the phase 1 area of the pre-investigation area, showed an overall statistical insignificant relationship between surveys/sampling areas in the three metrics: Species count, Shannon Wiener and Evenness index. However, due to the small sample size, there might be patterns present that could not be identified statistically. Through statistical trends and numerical comparison, a few cases indicated a higher species richness and biodiversity in the autumn, and potential differences in biodiversity among sampling areas.

Table 4.9. Summary of the biodiversity metric analysis for the spring (left) and autumn (right) gillnet survey in 2023. The three metrics were estimated for each gillnet-area combinations, including a 'total' analysis, investigating the aggregated data within the areas.

Spring 2023

phase 1 area	Gillnet type	No. of species	Shannon Wiener	Evenness
1 - South	Biological Survey	9	1,8	0,8
	Herring	6	1,5	0,9
	Turbot	2	0,7	1,0
	Plaice	3	1,0	0,9
	Total	10	1,8	0,8
2 - East	Biological Survey	8	1,9	0,9
	Herring	4	0,9	0,7
	Turbot	0	0	0
	Plaice	5	1,4	0,9
	Total	9	1,5	0,7
3 - North	Biological Survey	8	1,4	0,7
	Herring	3	0,8	0,7
	Turbot	0	0	0
	Plaice	6	1,7	1,0
	Total	9	1,3	0,6
Survey	Total	12	-	-

Autumn 2023

phase 1 area	Gillnet type	No. of species	Shannon Wiener	Evenness
1 - South	Biological Survey	7	1,5	0,8
	Herring	9	1,8	0,8
	Turbot	3	1,1	1,0
	Plaice	6	1,6	0,9
	Total	12	2,1	0,9
2 - East	Biological Survey	8	1,8	0,9
	Herring	9	1,6	0,7
	Turbot	0	0	0
	Plaice	3	1,0	0,9
	Total	12	1,8	0,7
3 - North	Biological Survey	14	2,0	0,8
	Herring	9	1,2	0,6
	Turbot	7	1,7	0,9
	Plaice	10	2,0	0,9
	Total	18	1,8	0,6
Survey	Total	22	-	-

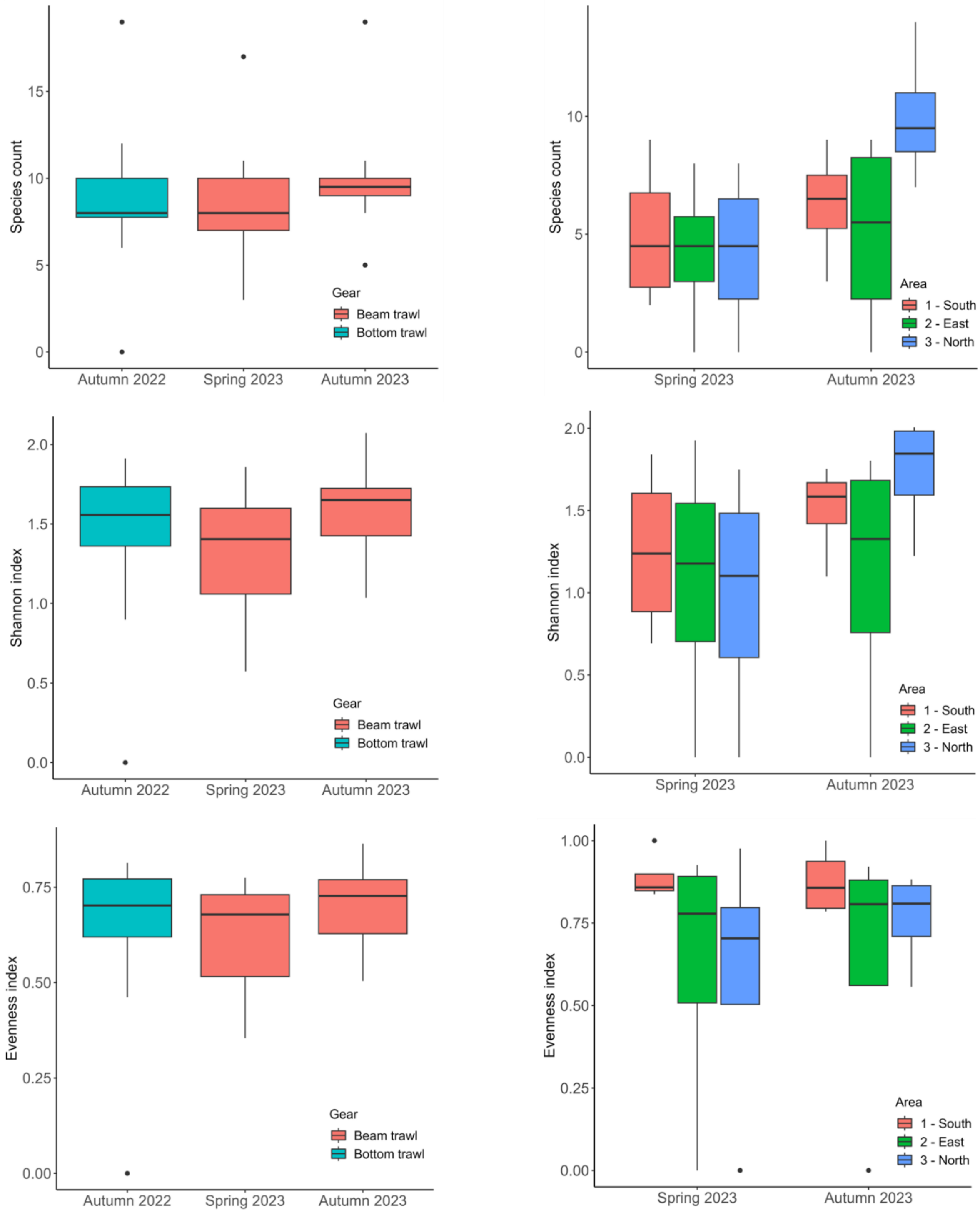


Figure 4.1. Boxplots illustrating the survey-specific diversity data distribution (top: species count, middle: Shannon Wiener, bottom: Evenness) for each of the two sample types: Trawl (left) and gillnets (right). The 'box' represents the data quantiles (75th percentile, median, and 25th percentile) while the ends of the vertical lines pinpoint the minimum and maximum data values, point represent outliers within the dataset.

5. Conclusion

There has been registered 230 different fish species in the North Sea and thus there is a potential for a relatively large number of fish species to be found in the pre-investigation area. The number of fish species in an area is however dependent on available and preferred habitats and healthy population conditions that promote an abundance of fish.

The North Sea pre-investigation area is primarily made of soft bottom areas, with only patches of hard bottoms that include mixed bottoms of sand and gravel with large stones. Data from monitoring fish surveys and the commercial fisheries area have observed 56 different species in the pre-investigation area, whereas fish surveys with bottom trawls and multi-mesh gillnets to screen the pre-investigation area in this investigation have sampled 34 species. Almost all the benthic living species caught in this study prefer soft bottom or mixed bottom habitats where patches of preferred soft bottom are mixed with hard bottom areas. The dominating and key fish species in the pre-investigation area are the flatfish European plaice and common dab that combined made up 51,5% of the fish by abundance. Other abundant fish species include haddock (8%), whiting (7.8%) and grey gurnard (7.1%) and solenette (14.3%) by number. Other fish species caught at many of the survey stations but generally in small abundances were common dragonet, lemon sole, sole, greater weever and lesser weever. There were very few Atlantic cod observed in the pre-investigation area and this was consistent across all three survey periods. Despite, very few sandeel observed in the survey catches, commercial fishery data indicates that sandeel area also very abundant I the pre-investigation area and key species because of its abundance and role as a prey fish for many predatory species and seabirds. Seasonally there was no significant difference by number of species, biodiversity index, or Evenness between spring and autumn survey data, however, there was a slight tendency towards a richer and more diverse fish community in the pre-investigation area during the autumn compared to the spring. Geographically, there were also indications that the northwest part of the pre-investigation area has a slightly greater fish biodiversity than the southern and eastern parts of the pre-investigation area.

There was no indication that spawning was either about to take place or had just taken place in any of the individual fish of Atlantic cod or European plaice where gonad maturity was assessed. This was also the case in in the few adult individuals of haddock and whiting that were also investigated. Historical data, however, indicates that particularly European plaice have spawning areas in the region around the pre-investigation area. Thus, because spawning areas for many species vary from year to year due to changes in water temperature, and hydrographic conditions during the spawning period, it can´t be ruled out that European plaice spawn in some years in the pre-investigation area.

The size distribution of Atlantic cod, haddock, whiting, European plaice and common dab, indicate that the pre-investigation area is potentially used as a nursery area for these species.

6. Data and knowledge gaps

All fish survey gear is selective and the use of bottom trawls (particularly beam trawls) and benthic gillnets are limited to primarily sampling the fish communities close to or on the sea bottom, and thus sampling of pelagic fish and their species diversity will be underestimated. Furthermore, the gillnet and trawl surveys were only conducted over five days in March and September 2023, and on one day in October 2022. Marine ecosystems are dynamic and species composition can change seasonally or even daily; thus, the limited timeframe of the surveys only represent a short window of time for sampling short- and long-term changes in the diversity of the marine fish species in the pre-investigation area.

Moreover, the geographical coverage of the surveys was limited as trawl hauls and gillnets only covered a small area of the entire pre-investigation area. Although, it cannot be expected that the surveys will provide a complete spectrum of the marine fish species present in the pre-investigation area, results did however indicate, which benthic species are present in both the spring and autumn seasons, and which benthic species appear to be dominant both in abundance and spatially.

Although the gonad development in adult individuals of the most common and important species was investigated to determine if spawning was taking place, because spawning periods can vary spatially within populations and among different species, the timing of the surveys in spring and autumn may not have coincided with the spawning periods of local populations and some species. Thus, the critical spawning times for some species may have been missed and potential spawning adults not sampled in the surveys. While it is known from literature that the pre-investigation area potentially overlaps with spawning areas of some species in the North Sea, the results of the collected spawning data were not able to confirm this, possibly as a result of the limited temporal and spatial coverage of the surveys and the variation in the distribution of spawners from year to year.

In summary, the data on which fish species were present, their abundance (numbers), length frequencies indicating age structure, and maturity status provide a limited spatial and temporal sample of what species are present in the pre-investigation area and what stage of a fish's life cycle (juvenile, adult and spawning) the pre-investigation area may support.

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Appendix 1

Trawl and gillnet method data

Autumn survey 2022. Start-stop positions, length and time of haul, swept area and sampled volume of the 14 trawl transects.

Transect	Zone	Start (deg°decimal)		Stop (deg°decimal)		Length	Trawl width	Trawl height	Area	Volume	Approx.
		X-WGS84	Y-WGS84	X-WGS84	Y-WGS84	m	m	m	m²	m³	Min.
TR1	32	6,58338	56,42382	6,59865	56,42364	879,8	14,5	2,1	12757	26789,2	11
TR2	32	6,62562	56,48365	6,64009	56,48493	773,4	14,5	2,1	11215	23551,4	10
TR3	32	6,53690	56,46968	6,54806	56,46860	696,6	14,5	2,1	10100	21210,4	10
TR4	32	6,58095	56,49582	6,56680	56,49674	875,8	14,5	2,1	12699	26667,9	12
TR5	32	6,56059	56,50914	6,58036	56,50802	1219,5	14,5	2,1	17683	37134,1	16
TR6	32	6,63576	56,56097	6,62490	56,56146	699,3	14,5	2,1	10139	21292,8	11
TR7	32	6,68362	56,57484	6,67082	56,57479	786,3	14,5	2,1	11402	23943,2	11
TR9	32	6,58070	56,59050	6,57164	56,59203	605,7	14,5	2,1	8783	18445,0	11
TR10	32	6,51745	56,60012	6,51160	56,60497	649,7	14,5	2,1	9421	19784,3	10
TR11	32	6,48568	56,62793	6,47968	56,63228	611,2	14,5	2,1	8862	18611,1	10
TR12	32	6,44694	56,62867	6,43752	56,63105	660,2	14,5	2,1	9573	20104,1	11
TR13	32	6,37692	56,60341	6,36759	56,60473	613,1	14,5	2,1	8890	18669,7	10
TR14	32	6,33824	56,58197	6,33240	56,57769	595,7	14,5	2,1	8637	18138,4	11
TR15	32	6,28297	56,57119	6,27286	56,56996	610,9	14,5	2,1	8857	18600,5	10

Spring survey 2023. Start-stop positions, length and time of haul, swept area and sampled volume of the 15 trawl transects.

Transect	Zone	Start (deg°decimal)		Stop (deg°decimal)		Length	Trawl width	Trawl height	Area	Volume	Approx.
		X-WGS84	Y-WGS84	X-WGS84	Y-WGS84	m	m	m	m²	m³	Min.
TR1	32	6.58293	56.42395	6.61408	56.42332	1923	4	0.5	7692	3846	30
TR2	32	6.62675	56.48420	6.65967	56.48742	2058	4	0.5	8232	4116	30
TR3	32	6.56027	56.46775	6.52615	56.47212	2158	4	0.5	8632	4316	30
TR4	32	6.58242	56.49653	6.54883	56.49958	2097	4	0.5	8388	4194	30
TR5	32	6.58188	56.50910	6.54802	56.51100	2095	4	0.5	8380	4190	30
TR6	32	6.63580	56.56112	6.60323	56.56363	2022	4	0.5	8088	4044	30
TR7	32	6.68402	56.57500	6.64907	56.57562	2149	4	0.5	8596	4298	30
TR8	32	6.72528	56.60433	6.72227	56.58807	1824	4	0.5	7296	3648	30
TR9	32	6.58138	56.59048	6.55000	56.59642	2036	4	0.5	8144	4072	30
TR10	32	6.49713	56.61808	6.51745	56.60012	2361	4	0.5	9444	4722	30
TR11	32	6.48565	56.62790	6.46160	56.64373	2296	4	0.5	9184	4592	30
TR12	32	6.44692	56.62873	6.41600	56.63698	2110	4	0.5	8440	4220	30
TR13	32	6.37697	56.60347	6.34138	56.60943	2281	4	0.5	9124	4562	30
TR14	32	6.33953	56.58260	6.31383	56.56813	2259	4	0.5	9036	4518	30
TR15	32	6.28333	56.57070	6.25102	56.56878	1998	4	0.5	7992	3996	30

Autumn survey 2023. Start-stop positions, length and time of haul, swept area and sampled volume of the 15 trawl transects.

Transect	Zone	Start (deg°decimal)		Stop (deg°decimal)		Length	Trawl width	Trawl height	Area	Volume	Approx.
		X-WGS84	Y-WGS84	X-WGS84	Y-WGS84	m	m	m	m²	m³	Min.
TR1	32	6.34998	56.25435	6.37055	56.25410	1921	4	0.5	7684	3842	30
TR2	32	6.37498	56.29028	6.39513	56.29163	1822	4	0.5	7290	3645	30
TR3	32	6.33549	56.28060	6.31490	56.28286	2562	4	0.5	10249	5125	30
TR4	32	6.34888	56.29721	6.32766	56.29937	1777	4	0.5	7108	3554	30
TR5	32	6.34827	56.30479	6.32726	56.30636	1994	4	0.5	7974	3987	30
TR6	32	6.38193	56.33676	6.36290	56.33882	1885	4	0.5	7541	3770	30
TR7	32	6.41018	56.34490	6.39014	56.34585	2028	4	0.5	8112	4056	30
TR8	32	6.43462	56.35533	6.42937	56.36490	1855	4	0.5	7421	3711	30
TR9	32	6.34849	56.35440	6.32955	56.35760	2060	4	0.5	8240	4120	30
TR10	32	6.31061	56.36005	6.30098	56.36871	1987	4	0.5	7948	3974	30
TR11	32	6.29174	56.37690	6.27857	56.38482	2175	4	0.5	8701	4351	30
TR12	32	6.26808	56.37723	6.25251	56.38148	2215	4	0.5	8858	4429	30
TR13	32	6.22627	56.36214	6.20539	56.36976	2156	4	0.5	8624	4312	30
TR14	32	6.20295	56.34933	6.19200	56.34159	2084	4	0.5	8335	4168	30
TR15	32	6.17020	56.34272	6.15181	56.34070	2116	4	0.5	8463	4232	30

Data on the gillnet positions within area 1, 2 and 3 during the Spring and autumn surveys in 2023.

		Spring				Autumn			
Area	Gillnet set	X center	Y-center	Depth (m)	Wind force	X center	Y-center	Depth (m)	Wind force
1	Garn 1-1	6.4124	56.3677	40.00	9.00	6,432991	56,667685	40	6.0
	Garn 1-2	6.4121	56.3706	41.00	9.00	6,435319	56,670381	41	6.0
	Garn 1-3	6.4208	56.3717	41.00	9.00	6,442503	56,672539	40	6.0
	Garn 1-4	6.4180	56.3693	41.00	9.00	6,442531	56,667914	41	6.0
	Garn 1-5	6.4244	56.3685	40.00	9.00	6,447735	56,668252	40	6.0
	Garn 1-6	6.4161	56.3647	41.00	9.00	6,443110	56,665804	40	6.0
	Garn 1-7	6.4118	56.3647	41.00	9.00	6,435085	56,664539	40	6.0
2	Garn 2_1	6.6458	56.6049	41.00	7.00	6,643353	56,604573	41	9.0
	Garn 2_2	6.6484	56.6074	40.00	7.00	6,651049	56,604605	41	9.0
	Garn 2_3	6.6519	56.6102	41.00	7.00	6,648914	56,607297	41	9.0
	Garn 2_4	6.6445	56.6097	41.00	7.00	6,647488	56,610149	41	9.0
	Garn 2_5	6.6339	56.6070	41.00	7.00	6,644775	56,608863	41	9.0
	Garn 2_6	6.6506	56.6029	41.00	7.00	6,645938	56,604929	41	9.0
	Garn 2_7	6.6546	56.6080	41.00	7.00	6,650780	56,608740	41	9.0
3	Garn 3_1	6.4379	56.6669	39.00	5.00	6,412522	56,369597	39	10.0
	Garn 3_2	6.4402	56.6689	40.00	5.00	6,407656	56,371899	40	10.0
	Garn 3_3	6.4400	56.6716	40.00	5.00	6,415669	56,374125	39	11.0
	Garn 3_4	6.4499	56.6707	40.00	5.00	6,421147	56,370856	40	11.0
	Garn 3_5	6.4475	56.6649	39.00	5.00	6,415815	56,365606	39	11.0
	Garn 3_6	6.4310	56.6655	40.00	5.00	6,404235	56,366724	39	11.0

Appendix 2

Notat om metode af fiskeundersøgelser

Energiø Nordsøen – Strategisk miljøvurdering og miljøundersøgelser

Notat om metode mv til færdiggørelse af fiskeundersøgelser

Energinet Eltransmission A/S

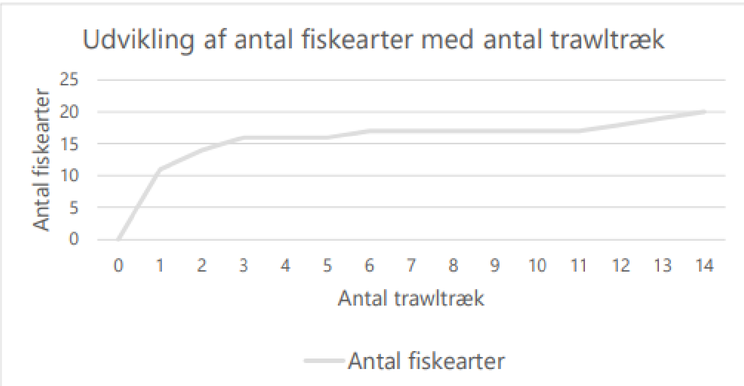
Dato: 1. december 2022

3 De udførte trawl-undersøgelser i oktober 2022

Det var planen, at fiskeundersøgelserne i Nordsøen i oktober 2022 skulle have omfattet fuldt TV3 trawl-program med 15 trawltræk på blød- og delvist blandetbunds-område samt gællegarnsundersøgelser på hård bund. Der var afsat en periode fra 6. til 21. oktober til undersøgelsen, der vurderes at kunne udføres på 4-5 sejldage.

Vejrforholdene i perioden var dårlige, men der viste sig et vejrvindue den 22. oktober, hvor store dele af den planlagte undersøgelse blev gennemført. 14 ud af de planlagte 15 trawl-træk blev således gennemført, og det blev sikret, at relevante mikrohabitater var dækket af trawl-undersøgelsen. Det sidste træk samt gællegarnsundersøgelse kunne ikke gennemføres inden for den tidsbegrænsning, der lå for arbejdet på en enkelt dag, og den 22. oktober var den eneste dag i perioden med egnet vejr til fiskeundersøgelsen. Hermed var det ikke muligt at gennemføre garnundersøgelse som kræver mindst 2-3 dage med sætning af garn og røgtning dagen efter.

Figur 1 viser sammenhængen mellem samlet antal arter af fisk fanget i forhold til antallet af trawltræk i området. Man kan se, at kurven begynder at flade ud allerede efter tredje træk, og at der efter seks træk er fanget i alt 17 fiskearter. De sidste 8 træk har bidraget med tre arter ud over de 17, således at det samlede antal fangede fiskearter blev 20. Da vi samtidigt sørgede for at dække variationen af mikrohabitater inden for området, vurderer vi, at et femtende træk næppe ville have bidraget væsentligt til resultatet.



Figur 1 Sammenhæng mellem antal fiskearter fanget og antallet af trawltræk ved TV3 trawlundersøgelse i fase 1-området for implementering af Program Energiø Nordsøen.

Appendix 3

Trawl survey catch data

Autumn trawl survey 2022

Total weight (gram) for each fish species at each trawl station in the 2022 autumn trawl survey.

	Weight (gram) for each trawl number													
Species	Tr1	Tr2	Tr3	Tr4	Tr5	Tr6	Tr7	Tr9	Tr10	Tr11	Tr12	Tr13	Tr14	Tr15
Ammodytes marinus													7	
Arnoglossus laterna		15	13	57										
Callionymus lyra	60		83	43	111	46		83	128	39	148	41		160
Clupea harengus						512								
Eutrigla gurnardus	2457	751	4321	2881	4,279	928	242	1407	679	580	374	2349	1,215	2,626
Gadus morhua			1084	359	944			2128	1713	1233	221		385	
Hyperoplus lanceolatus												33		
Limanda limanda	5678	3765	5064	8052	8437		6843	2521	5825	4430	7101	5317	2394	2340
Melanogrammus aeglefinus	4925	4306	5285	386	1227	1222	93	2076	82		170	264	2327	73
Merlangius merlangus	5164	1628	1844	13044	4249	89		5334	538			143	4857	
Microstomus kitt	490		213				150	525	216	210	161	285	59	
Pleuronectes platessa	11658	6643	1325	2975	2309		5246	1322	2960	2732	3186	2889	1084	1668
Scomber scombrus	128			290										
Scyliorhinus canicula			952,0											
Solea solea	15				24		18	15			25	20		
Sprattus sprattus	1097	324	5	11		116	107							
Trachinus draco				355	1020			310		140		90		365
Echiichthys vipera			25	633	560					10				240
Total weight (gram)	31672	17432	20214	29086	18885	2913	12699	15721	12141	9374	11386	11431	11114	4849

CPUE weight (g) of fish caught per 10000 m^3 *in the beam trawl survey, Autumn 2022.*

	Weight (gram) CPUE per 10000m^2													
Species	Tr1	Tr2	Tr3	Tr4	Tr5	Tr6	Tr7	Tr9	Tr10	Tr11	Tr12	Tr13	Tr14	Tr15
Ammodytes marinus													3,9	
Arnoglossus laterna		6,4	6,1	21,4										
Callionymus lyra	22,4		39,1	16,1	29,9	21,6		45,0	64,7	21,0	73,6	22,0		86,0
Clupea harengus						240,5								
Eutrigla gurnardus	917,2	318,9	2037,2	1080,3	1,2	435,8	101,1	762,8	343,2	311,6	186,0	1258,2	0,7	1,4
Gadus morhua			511,1	134,6	254,2			1153,7	865,8	662,5	109,9		212,3	
Hyperoplus lanceolatus												17,7		
Limanda limanda	2119,5	1598,6	2387,5	3019,4	2272,0		2858,0	1366,8	2944,3	2380,3	3532,1	2847,9	1319,9	1258,0
Melanogrammus aeglefinus	1838,4	1828,3	2491,7	144,7	330,4	573,9	38,8	1125,5	41,4		84,6	141,4	1282,9	39,2
Merlangius merlangus	1927,6	691,3	869,4	4891,3	1144,2	41,8		2891,8	271,9			76,6	2677,7	
Microstomus kitt	182,9		100,4				62,6	284,6	109,2	112,8	80,1	152,7	32,5	
Pleuronectes platessa	4351,8	2820,6	624,7	1115,6	621,8		2191,0	716,7	1496,1	1467,9	1584,8	1547,4	597,6	896,8
Scomber scombrus	47,8			108,7										
Scyliorhinus canicula			448,8											
Solea solea	5,6				6,5		7,5	8,1			12,4	10,7		
Sprattus sprattus	409,5	137,6	2,4	4,1		54,5	44,7							
Trachinus draco				133,1	274,7			168,1		75,2		48,2		196,2
Echiichthys vipera			11,8	237,4	150,8					5,4				129,0
Total	11822,7	7401,7	9530,2	10906,7	5085,7	1368,1	5303,8	8523,2	6136,7	5036,8	5663,5	6122,8	6127,5	2606,7

Spring trawl survey 2023

Total weight (gram) for each fish species at each trawl station in the spring trawl survey.

	Weight (gram) for each trawl number														
Species	Tr1	Tr2	Tr3	Tr4	Tr5	Tr6	Tr7	Tr8	Tr9	Tr10	Tr11	Tr12	Tr13	Tr14	Tr15
Agonus cataphractus		1				1									
Ammodytes marinus			30	6	1				7		1		2	10	
Arnoglossus laterna	10	32			23		12						5		
Buglossidium luterum	324	499	33	20	63	404	88	59	94	37	98	83	125	50	102
Callionymus lyra	121	288		52			156	14					132		
Eutrigla gurnardus	206	719				50		124	63			18	120	309	14
Gadus morhua			190	46								107		36	
Hippoglossoides platessoides	5	11					20				15				
Hyperoplus lanceolatus													50	17	46
Limanda limanda	1615	2442	309	188	262	92	513	273	650	190	184	63	27	590	135
Melanogrammus aeglefinus	1432	788	63	595	219		290	731			969	1741	734	487	40
Merlangius merlangus	100	515	211	35	352	165	114		192		260	732	290	593	242
Microstomus kitt	355				61		168	110	156			109			
Pleuronectes platessa	2630	9389	2777	2585	2193	2110	5470	7284	2165	2664	5801	3078	1598	2356	1748
Raja radiata	833														
Trachinus draco														91	
Echiichthys vipera				40											
Total weight (gram)	7631	14684	3613	3567	3174	2822	6831	8595	3327	2891	7328	5931	3083	4539	2328

CPUE weight (g) of fish caught per 10000 m^3 in the beam trawl survey, spring 2023.

Species	Weight (gram) CPUE per 10000m^2														
	Tr1	Tr2	Tr3	Tr4	Tr5	Tr6	Tr7	Tr8	Tr9	Tr10	Tr11	Tr12	Tr13	Tr14	Tr15
Agonus cataphractus		1,3				1,7									
Ammodytes marinus			34,6	6,7	1,7				8,2		1,2		2,0	10,8	
Arnoglossus laterna	12,6	39,2			27,0		14,1						5,3		
Buglossidium luterum	421,2	605,9	38,6	23,6	74,9	499,1	102,4	80,9	115,4	39,2	106,7	98,3	137,0	55,8	127,0
Callionymus lyra	157,3	349,9		61,8			181,5	19,7					144,7	43,5	
Eutrigla gurnardus	267,4	873,4				61,8		170,2	77,4			21,2	131,5	341,4	17,9
Gadus morhua			219,6	55,1								126,4		40,3	
Hippoglossoides platessoides	5,9	13,5					23,5				16,0				
Hyperoplus lanceolatus													55,2	18,9	58,1
Limanda limanda	2098,9	2967,0	358,0	224,1	312,6	113,3	597,0	374,0	798,1	201,2	200,3	74,1	29,7	652,9	169,4
Melanogrammus aeglefinus	1861,7	957,2	73,0	709,3	261,3		337,4	1001,9			1055,1	2062,8	804,5	539,0	50,3
Merlangius merlangus	130,0	625,6	244,4	42,2	420,0	204,0	132,6		235,8		283,1	867,3	317,8	656,3	302,8
Microstomus kitt	461,5				72,4		195,4	150,8	191,6			129,1			
Pleuronectes platessa	3419,1	11405,5	3217,1	3081,8	2616,9	2608,8	6363,4	9983,6	2658,4	2820,8	6316,4	3646,9	1751,4	2607,3	2187,2
Raja radiata	1082,9														
Trachinus draco														101,2	
Echiichthys vipera				43,5											
Total	9918,5	17838,5	4185,3	4204,6	3786,8	3488,7	7947,3	11781,1	4084,9	3061,2	7978,8	7026,1	3379,1	4966,2	2912,7

Autumn trawl survey 2023

Total weight (gram) for each fish species at each trawl station in the 2023 autumn trawl survey.

	Weight (gram) for each trawl number														
Species	Tr1	Tr2	Tr3	Tr4	Tr5	Tr6	Tr7	Tr8	Tr9	Tr10	Tr11	Tr12	Tr13	Tr14	Tr15
Agonus cataphractus	5	10	14			4	42		7				10	43	
Ammodytes marinus		19	30					38		38		16	34	31	
Arnoglossus laterna	138	125	21	33	28	110	126	12	100	73	55	109	111	87	59
Buglossidium luterum	1234	1055	110	89	206	885	288		158	143	290	265	301	130	95
Callionymus lyra	13	26	244	129	101	44	40		183	113	20	20	105	94	53
Callionymus reticulatus									3		3				
Clupea harengus						11							60		
Dasyatis pastinace								6150							
Eutrigla gurnardus	22		47	30	18		194		230	79	65	382	192	358	161
Hyperoplus lanceolatus									24		63		34		31
Limanda limanda	681	445	1128	932	1345	494	1252	540	338	193	600	1077	777	491	331
Lophius piscatorius					1530							227			
Melanogrammus aeglefinus							267			189				405	271
Merlangius merlangus	84	3	3	10		126	135			3		132		1091	5
Microstomus kitt	425	159			283	154					600	128			
Pleuronectes platessa	4652	4547	4810	3984	3135	3224	4128	2248	3736	2380	2226	1708	2070	2380	1681
Scophthalmus maximus															2850
Scophthalmus rhombus							1296								
Echiichthys vipera				358	345					29	42			21	158
Total weight (gram)	7254	6389	6407	5565	6991	5052	7768	8988	4779	3240	3964	4064	3694	5131	5695

CPUE weight (g) of fish caught per 10000 m^3 in the beam trawl survey, autumn 2023.

Species	Weight (gram) CPUE per 10000m^2														
	Tr1	Tr2	Tr3	Tr4	Tr5	Tr6	Tr7	Tr8	Tr9	Tr10	Tr11	Tr12	Tr13	Tr14	Tr15
Agonus cataphractus	6,0	13,7	13,9			4,9	51,9		8,0				11,7	51,6	
Ammodytes marinus		26,1	29,1					50,9		48,1		18,1	39,4	37,2	
Arnoglossus laterna	179,3	171,1	20,6	46,1	34,5	146,1	155,1	16,3	120,9	91,7	62,9	123,2	128,7	104,6	69,8
Buglossidium luterum	1606,1	1446,7	107,5	125,1	258,2	1173,5	354,4		191,5	179,4	333,3	299,5	349,0	156,0	112,3
Callionymus lyra	16,9	35,7	238,1	180,9	127,7	58,5	48,8		222,1	142,2	23,0	22,1	121,8	112,8	62,9
Callionymus reticulatus									4,1		3,8				
Clupea harengus						15,1							69,6		
Dasyatis pastinace								8287,0							
Eutrigla gurnardus	28,6		45,9	42,2	22,8		238,9		279,1	99,4	74,7	430,7	222,6	429,5	190,2
Hyperoplus lanceolatus									29,1		72,4		39,4		36,7
Limanda limanda	886,3	611,0	1100,6	1311,2	1686,7	655,4	1543,7	727,6	410,2	242,8	689,6	1215,8	901,0	589,1	391,1
Lophius piscatorius					1918,7							255,8			
Melanogrammus aeglefinus							328,8			237,2				485,9	320,2
Merlangius merlangus	109,5	4,7	2,7	13,4		167,0	166,4			3,1		148,7		1308,6	5,4

Microstomus kitt	553,1	218,1			354,9	204,2					689,0	144,5			
Pleuronectes platessa	6054,3	6237,0	4693,0	5605,0	3931,5	4275,4	5089,0	3029,1	4533,8	2994,6	2558,2	1928,2	2400,3	2855,3	1986,3
Scophthalmus maximus															3367,6
Scophthalmus rhombus							1597,7								
Echiichthys vipera				503,7	433,2					36,0	48,3			25,7	186,7
Total	9440,1	8764,1	6251,4	7827,6	8768,2	6700,1	9574,7	12110,9	5798,8	4074,5	4555,2	4586,6	4283,5	6156,3	6729,2