ENERGINET

ENERGY ISLAND BORNHOLM

TECHNICAL REPORT WP-I
FISH AND FISH POPULATIONS

29-09-2023

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ENERGINET

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Abbreviation	Explanation
BSH	Bundesamt für Seeschifffahrt und Hydrographie
CC	The Cable Corridor
CTDO	Conductivity-Temperature-Depth-Oxygen
CPUE	Catch Per Unit Effort
DEA	Danish Energy Agency
DM	Dry Matter
EEZ	Exclusive Economic Zone
ENOE	Energy Island Bornholm
LARS	Launch And Recovery System
OWF	Offshore Windfarm
ROV	Remotely Operated Vehicle
SEA	Strategic Environmental Impact Assessment
SPA	Special Protection Area
StUK4	Ökologische Begleitforschung am Offshore-Testfeldvorhaben alpha ventus zur Evaluierung des Standarduntersuchungskonzeptes des BSH
VMS	Vessel Monitoring System
YOY	Young of the Year

1 SUMMARY

INTRODUCTION

The energy islands mark the beginning of a new era for the generation of energy supply from offshore wind aimed at creating a renewable energy supply for Danish and international electricity grids. Operating as renewable power plants at sea, the islands are expected to play a major role in phasing-out fossil fuel energy sources in Denmark and Europe. One energy island is planned in the North Sea and one in the Baltic Sea.

The plan includes offshore planning areas for an offshore wind farm 15 km from Bornholm, and for subsea cables in Danish waters between Bornholm and Zealand, as well as between Bornholm and German waters. The plan also includes onshore planning areas for cables and high voltage stations on Bornholm and Zealand. The total planning area consists of three subareas: Bornholm I Syd (118 km^2), Bornholm I North (123 km^2) and Bornholm II (410 km^2). The OWF will have a production capacity of maximum 3.8 GW. The planning area will contain wind turbines with a maximum height of 330 meters, and maximum seven transformer platforms and subsea cables.

OBJECTIVE AND METHODOLOGY

To determine if the pre-investigation area serves as a possible spawning area for fish, a baseline mapping of fish and fish populations was carried out. Most fish species spawn in spring, after which the eggs hatch and the fish larvae grow up to be small juvenile fish of a certain size that can be sampled in the autumn. Therefore, two surveys were conducted, one in spring (April) and one in autumn (November) to collect data from the year cycle for all occurring species in the area, using beam trawl, multimesh gillnets and trammel nets as well as existing data. The combined data was used to describe the spatial and temporal distribution of fish and fish populations in the pre-investigation area. To determine if the pre-investigation area consisted of possible spawning- and nursery areas, a cohort analysis was conducted, and the gonad ripeness of sampled fish were analyzed and determined.

RESULTS

Flatfish species dominated the catch in both autumn and spring. For the spring catches, flatfish comprised 80 % of the total catch and five out of 17 species were flatfish. For the autumn catches, flatfish comprised 82 % of the catch, with five of the 16 different fish species being flatfish. The most common species occurring in the catches were European flounder and European plaice, making up 55 % and 22 % of the spring catches. In autumn, the two species accounted for 51 % and 29 % of the total catch. Atlantic cod was also represented in the catches comprising almost 10 % of the spring catch and 13 % of the autumn catch.

In the autumn survey, juvenile Atlantic cod was caught in the pre-investigation area, especially in the cable corridor, suggesting that this area is a nursery area for Atlantic cod. This was expected due to the coastal hardbottom habitat found in this area, which is an essential habitat for Atlantic cod to find shelter and food.

In the south-eastern part of the OWF area (Bornholm II) and western part (Bornholm I Syd), spawning or nearly spawning European plaice was caught in the autumn survey. This may indicate that European plaice utilize both the pre-investigation area and the OWF areas and its vicinity as a spawning area. In existing literature, no clear spawning site for European plaice is mapped in the Baltic Sea. However, it is speculated that suitable areas exist in the deeper areas around Bornholm.

The Shannon Wiener Index and Evenness Index was calculated to determine the community structure of fish in the pre-investigation area. The results for both beam trawl, multimesh gillnets and trammel nets suggested that there was an uneven distribution of species with a few species dominating the catches, which was true. European flounder and European plaice making up 55 % and 22 % of the catch for all gear types, respectively. There was a relatively low level of biodiversity, especially in the multimesh gillnets and trammel nets. The low number of species caught here was unexpected in the multimesh gillnets, which are designed to catch a high variety of fish species. However, the results observed here is believed to be the consequence of the low biodiversity in the Baltic Sea due to e.g. low salinity, but also the poor ecosystems health regarding fish in the Baltic.

There was an overlap between stations with high fish abundance and biomass and high biomass of food items such as blue mussels, other bivalves, bristle worms and crustaceans. OWF North I and the northwestern part of the pre-investigation area in general showed indications of being utilizes as a feeding area for beam trawl catches. The results were less clear for multimesh gillnets and trammel nets, where scattered stations in the cable corridor, Rønne Banke and west hereof had some overlap of high fish abundance/biomass and availability of prey.

2 INTRODUCTION

With the Climate Agreement for Energy and Industry of the 22nd of June 2020, the majority of the Danish Parliament decided that Denmark will become the first country in the world to develop two energy islands. One of these islands will be the island of Bornholm located in the Baltic Sea ("Energioe Bornholm"), with wind farms south-west of Bornholm with an installed capacity of up to 3.8 GW. The designated wind farm areas consist of Bornholm I South (118 km^2), Bornholm I North (123 km^2) and Bornholm II (410 km^2) (Figure 2-1). The wind farms areas will contain wind turbines with a maximum height of 330 m, maximum seven transformer platforms, as well as subsea cables. The island of Bornholm will house the transformer station and serve to distribute the produced energy.

As a consequence of these political decisions a series of biological and scientific investigations has to be carried out for a well-defined pre investigation area as part of the baseline mapping of this part of the Baltic Sea. This also includes an investigation of the fish and fish populations.

The pre-investigation area for Energioe Bornholm OWF is located 15 from Bornholm and consists of the three before mentioned offshore windfarm areas (OWF).

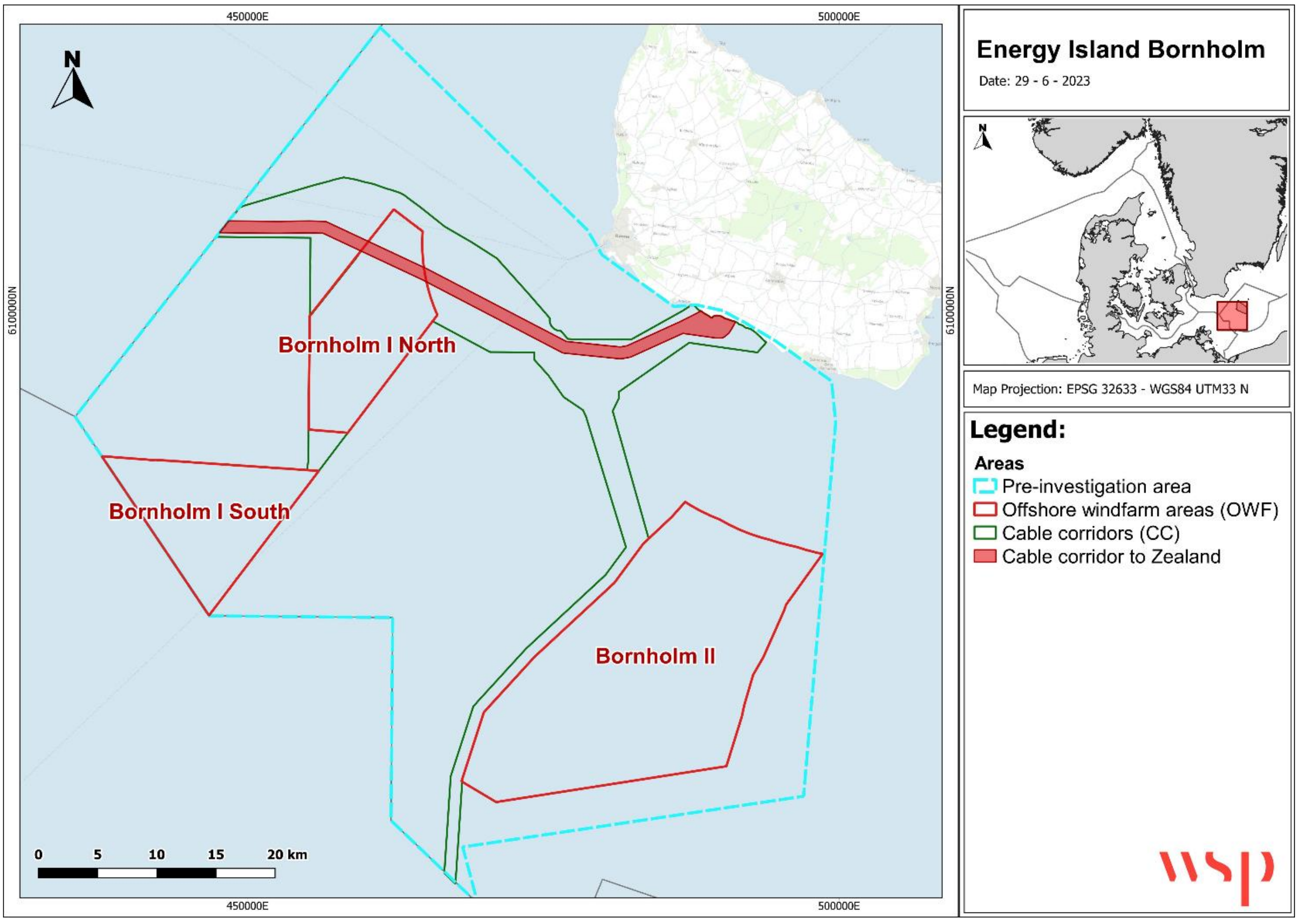


Figure 2-1 Planning areas in the Plan for Program Energy Island Bornholm.

This report presents the methodology, analysis, and results of a baseline mapping of fish and fish populations determining whether the pre-investigation area consist of possible spawning- and nursery areas. Two surveys were conducted, one in spring 2022 (April) and one in autumn 2022 (November), to collect data from the year cycle for all possible occurring species in the area. Data was combined with existing data to describe the spatial and temporal distribution of fish and fish populations in the pre-investigation area.

3 METHODOLOGY

The purpose of this report is to describe the baseline on fish and fish populations based on both field surveys and available existing information on occurrence of these within and around the pre-investigation area of Energy Island Bornholm OWF (ENOE OWF). The report includes mapping of fish species and populations as well as spawning and nursery areas in and around the project area. Materials and methods relevant for the baseline mapping of fish and fish populations are presented below.

To determine if the pre-investigation area serves as a possible spawning area for fish a baseline mapping of fish and fish populations was carried out. Most fish species spawn in spring, and the juvenile fish hatched over spring and summer are of a such a size, that they can be sampled in autumn before some species migrate to deeper and warmer waters. Therefore, two surveys were conducted, one in spring (April) and one in autumn (November),

Prior to planning the fish survey, information regarding the seabed and sediment type is important since these data are used in designing the survey. Sampling with dredging fishing gear is not possible on all surfaces, so mapping of different sediment types is essential for conducting a safe and efficient fish survey. In addition, the sediment types are also an important indicator for which fish species may inhabit the area, as the various fish species have different habitat preferences. Material and methods related to the geophysical data originates from GEUS' Marta database as presented below in section 3.1.1 Abiotic data. Only geophysical parameters relevant to the fish fauna mapping and description are included.
Materials and methods related to the fish surveys conducted by WSP in April/November 2022 are presented in section 3.1.2 Fish Data.

In the present technical report, existing data from various sources have been included as a supplement to the data achieved from the fish survey conducted specifically for this technical report. Existing data for abiotic factors and fish is presented in section 3.1.1 and 3.1.2.

Analysis of the commercial fisheries in the pre-investigation area for ENOE OWF is carried out in the Energy Island Bornholm Technical Report - Fisheries (Rambøll, 2022). The main conclusions regarding fish distribution are included in the present report, and materials and methods for the commercial fisheries is described in section 3.1.2 Fish Data.

This report also includes information based on Fiskeatlas, where historical recordings of the distribution of fish species is archived in a database. Please see section 3.1.2 Fish data for further information.

3.1 EXISTING DATA

In the following section, the materials and methodology used to describe existing data for abiotic data and fish data is presented. This includes data on salinity, depth, sediment types, fish distribution, spawning sites, nursery areas and fish habitats in the pre-investigation area for ENOE OWF.

3.1.1 ABIOTIC DATA

Various fish species have different habitat preferences, and abiotic parameters affect the distribution of fish. Information on salinity, depth, and sediment type aids to predict which fish species utilize the pre-investigation area. Therefore, information on the geophysical morphology of the seabed in or near the pre-investigation area is included in the present environmental baseline note.

SALINITY

Different projects have contributed with existing data on information on salinity in the Baltic Sea, in general, and the pre-investigation area specifically. The projects were chosen, as they provided relatively new data from the pre-investigation area. In addition, the data was sampled and analysed by methods comparable to those used on fish surveys conducted specifically for ENOE OWF. Nord Stream 2 AG (NSP2) has given permission for use of unpublished data and reports from the Northern route in this report (Nord Stream 2, 2018). Furthermore, data describing salinity has been achieved from (Vuorinen, et al., 1998), (Vuorinen, et al., 2015), (Meier, et al., 2006), (Perttilä, 2007), (Baltic Pipe, 2019) and (HELCOM, 2017).

DEPTH

Water depth determines the distribution of certain fish species. The temporal distribution of fish may also vary between seasons, with fish migrating into deeper and warmer waters during winter when coastal waters experience declining temperatures. Therefore, it is relevant to know the depth in the survey area.

The depth of the pre-investigation area was collected from e.g. Nord Stream 2 AG (NSP2), which authorized permission to use unpublished data and reports from the Northern route in this report (Nord Stream 2, 2018). In addition, data on bathymetry was collected from Danmarks Dybdemodel (DDM) provided by the Agency for Data Supply and Infrastructure which offers official data on depth in the entire Danish EEZ for utilization in planning and management in the marine areas of Denmark (Dataforsyningen, 2023)

SEDIMENT TYPES

The overall distribution of seabed sediments in the pre-investigation area is based on data from the national geophysical database provided by GEUS (Marta database, (GEUS, 2022)). To classify the seabed sediments, the following substrate classification method has been used to determine the roughness of the seabed sediment and the stone coverage cf. the Danish raw material order 1680 of 17-12-2018 (BEK 1680, 2018). This clarification is used for implementing the seabed surface mapping. The seabed sediment classification method is based on the following seabed sediment types (substrates):

- **Type 1 – Sand and soft sediments:** Areas that consist of soft sediments such as gyttja or silt, to hard sediments of sand (0.06 – 2.0 mm) and gravel fraction grain size, with a variation of bed forms (often dynamical). This type is further subdivided into 1a (gyttja or silty soft bottom sediments), 1b (hard bottom sediments of sand and gravel) and 1c (clayey sediments).

- **Type 2a – Sand, gravel and small rocks:** Area consisting of coarse sediment types, such as gravel, pebbles and small cobbles with varying content of sand. The sediment contains less than 1% area coverage of larger rocks (>10 cm).
- **Type 2b – Sand, gravel and small rocks and a few larger rocks (area coverage 1-10 %):** Areas consisting of mixed sediment types but dominated by sand with a little content of gravel and rocks. Varying sediment content of gravel/pebble size fraction (<2 cm), small rocks of pebble and cobble grain sizes (2-10 cm) and a spread of larger rocks of cobble to boulder grain sizes with an area coverage of 1-10 % (>10 cm).
- **Type 3 – Sand, gravel, small rocks, and several larger rocks (area coverage 10-25 %):** Areas consisting of mixed sediment types dominated by sand, gravel and smaller rocks. This sediment type consists of a spread of larger rocks with an area coverage of 10-25 % and can be associated with rocky reefs.
- **Type 4 – Rocky areas (reefs), consisting of many larger rocks (area coverage >25 %):** Dense spreading of larger rocks or rock reefs (stone reefs) with forming of cavities / rock shelters, and can have a bathymetric anomaly due to the high ground of large rocks compared to the adjacent sediment.

3.1.2 FISH DATA

Data on fish observations from various sources was included to describe the environmental status. The supplementary data originates from commercial fisheries' logbooks, Fiskeatlas and assessment reports from nearby OWF projects.

All Danish commercial fishing vessels are obliged to keep a logbook of their catches. This is carried out either through an electronic logbook or a statement of fishing area for small vessels, which always fish in the same waters. For vessels longer than 12 meters a Vessel Monitoring System (VMS) is also mandatory, and the system tracks the fishing vessels. The logbook and VMS carry information on e.g., the date, time and place of the fishing journey and of the catches in terms of species and landed weight. Therefore, the logbook and VMS are important sources of information on which species can be found in the specific areas of Danish waters. Analysis of the commercial fisheries in the pre-investigation area for ENOE was carried out in the Energy Island Bornholm Technical Report - Fisheries (Rambøll, 2022), and the report's main conclusions regarding fish distribution is included here.

This report also includes information from Fiskeatlas. Since 2019, data on fish distribution in Danish marine waters has been gathered from a long list of historical and present sources (Fiskeatlas, 2022). The data only share information on species and number of observations – the quantity of each species is not included for the observations. The database is an important source of information on the biodiversity of fish including rare and vulnerable species in Danish waters.

Existing data from various projects has been included in the description of the environmental status in the pre-investigation area. The supplementary data originates from assessment reports from nearby OWF and logistics projects in Denmark and Germany, including OWF Kriegers Flak (NIRAS, 2015), Baltic Pipe (Rambøll, 2019), Adler Grund (IfAÖ, 2004), Wikinger Süd (ALAUDA, 2011), Ventotec Ost 2 (IfAÖ, 2005). Wikinger Nord (ALAUDA, 2011), Arcadis Ost 1 (IfAÖ, 2011), Baltic II" (IfAÖ, 2010) and Femern Belt (FeBEC, 2013b). In addition, Natura 2000 basis analysis for "Adler Grund og Rønne Banke", "Bakkebrædt og Bakkegrund" and "Hvideodde Rev" as well as ICES-data from the Baltic International Trawl Survey (BITS) (ICES, 2007-2011) is included.

All fish species are referred to by their common name (according to latest updates on Fishbase.org) and their Latin name when first mentioned in the text.

3.2 SURVEY DATA

In the following section, the methodology utilized on the fish surveys conducted specifically for this project is described in detail. This includes data on salinity, oxygen and sampling with nets and beam trawl. The handling of fish catches is described as well as data analysis of fish distribution, spawning sites, nursery areas and fish habitats in the pre-investigation area for ENOE OWF.

Two surveys were conducted in spring and autumn, respectively. The reason two separate surveys were carried out were to determine if the pre-investigation area serves as a possible spawning area (the spring survey) and nursery area (the autumn survey). The fish surveys were carried out from the vessel, M/S Skoven, by WSP using beam trawl, multimesh gillnets and trammel nets. Data was used to describe the spatial and temporal distribution of fish and fish populations in the pre-investigation area.

3.2.1 FISH SURVEY

The aim of the present study was to perform a baseline investigation on fish and fish populations based on field surveys. As no Danish standardized method for conducting fish surveys in OWF exists, the German method StUK4 was deemed ideal to describe the spatial and temporal distribution of fish as a baseline for offshore wind parks and other size limited areas (BSH, 2013). Furthermore, the method was suitable when determining if the pre-investigation area serves as nursery and spawning site. The StUK4 method also ensures comparability with other fish surveys conducted in Northern Europe, as the method is referenced to ICES monitoring standards and has been utilized on all German OWFs as well as Thor OWF in the North Sea.

The chosen fishing methods, to map fish species in the pre-investigation area, consisted of fishing with beam trawl and multimesh gillnets. In protected areas where dredging is prohibited and areas with hard bottom, beam trawl was substituted with trammel net.

The pre-investigation area includes protected areas; the Natura 2000 site; "Adler Grund og Rønne Banke" (N252), habitat areas within the N252 (H261, H212, H211), and a bird SPA (Rønne Banke F129) between the OWF, as shown in Figure 3-1. In H261 it is not allowed to use bottom dredging fishing gear. This, combined with the overall heterogeneity of the sediment in the pre-investigation area as a whole, and in order to strengthen the dataset, supplementary methods were added to the survey plan. These supplementary methods included sampling with multimesh gillnets and trammel nets which are described in detail below.

Emphasis was made on investigating whether the area was used as a spawning area and/or nursery area. Therefore, supplementary analyses of the fish catch were added to the StUK4 methodology. In addition to length and weight measurements, processing of fish gonads was therefore included to estimate gonad ripeness and spawning progress. The spring survey was conducted in April 2022 from 20th to 24th of April and the autumn survey took place on November 5th to 10th 2022.

Based on sediment types, the survey was designed to consist of a total of 18 beam trawl stations within the pre-investigation area of ENOE OWF (Figure 3-1). However, due to unexpected boulders on three stations and safety concerns, the beam trawl was substituted with trammel nets. In April, one of the stations with coarse sand and gravel were successfully sampled before the trawl was caught on a boulder and lost. The trawl was subsequently retrieved, however, it was decided that due to safety for gear and crew that no trawling was to take place on sediment types coarse sand and gravel after this. Therefore, the planned 18 beam trawl stations were reduced to 16 in April, while only 15 beam trawl stations were sampled in November as trawling on coarse sand and gravel was avoided. To substitute the beam trawl hauls on coarse sand and gravel, the five planned stations sampled with trammel nets were increased to seven stations in April and eight in November. In addition, a total of 10 multimesh gillnet stations were sampled in April and November 2022.

Depending on their life strategy, some fish species have migratory traits, so in order to cover the temporal variation of the fish communities, the survey was designed with a survey in spring and autumn, respectively. The spring survey was scheduled to coincide with the spawning time of several relevant fish species, and the autumn survey was intended to demonstrate the activities in the pre-investigation area, regarding the fish utilization of the area as spawning area, when the new recruits of the year (Young Of the Year = YOY) had grown into small juveniles.

The station grid was designed to cover a wide range of sediment types and with at least three beam trawl stations on each sediment type with soft sediments. On harder substrates, the beam trawl was substituted with trammel net, as this gear type is also ideal for catching demersal fish species. Multimesh gillnets were used as a supplement to the trawl, as the nets were designed to catch a wide range of species and sizes of fish due to the various mesh sizes.

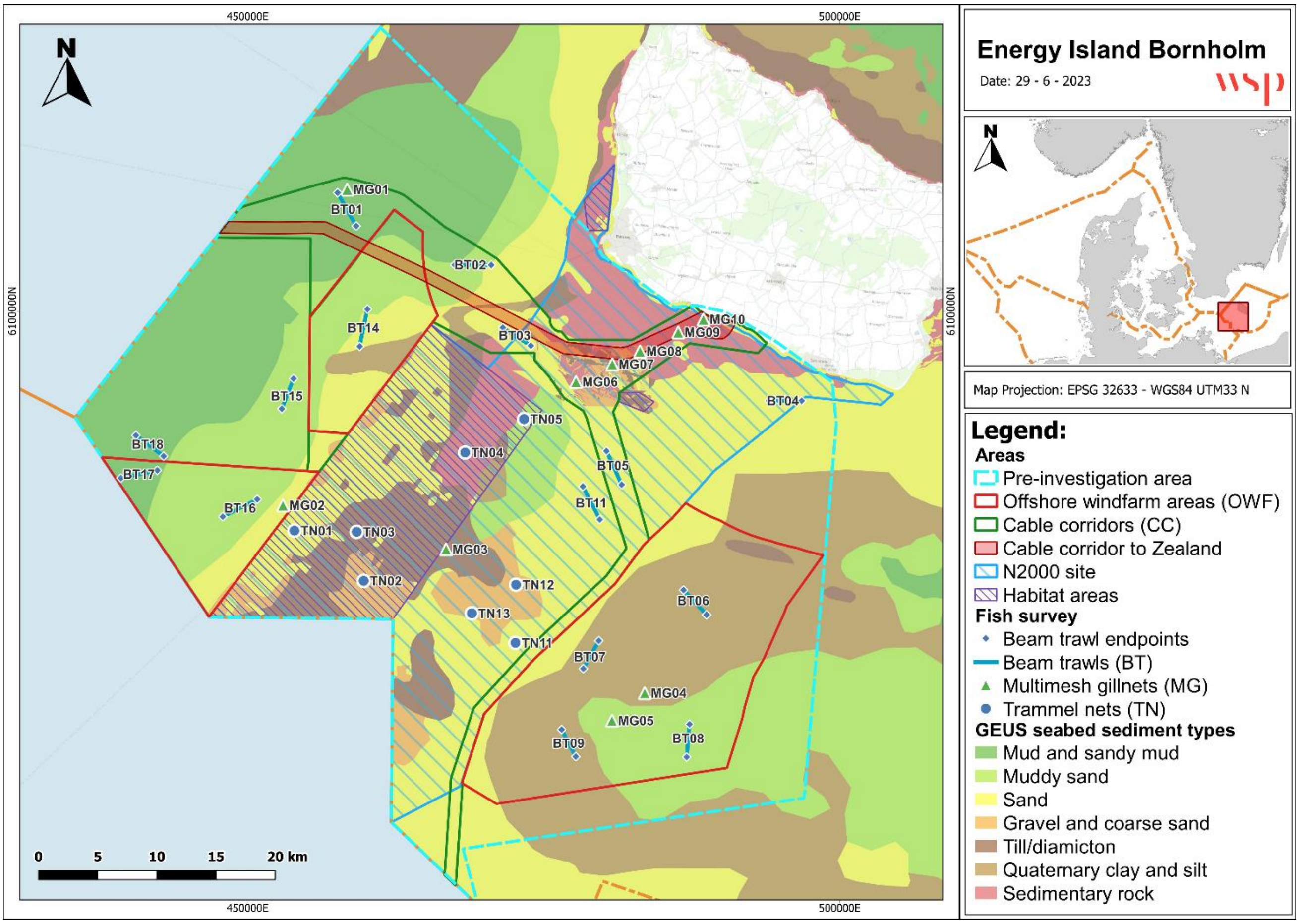


Figure 3-1 Station grid for the fish survey, of the pre-investigation area of ENOE OWF, conducted in April and November 2022. A combination of sampling with beam trawl (BT), trammel nets (TN) and multimesh gillnets (MG) were utilized. Please note that TN11, TN12 and TN13 were originally planned as beam trawl stations, but due to unexpected boulders at the stations and safety concerns, two of the beam trawl stations were substituted with trammel nets in April and all three were substituted in November.

The survey program included the following activities at each station:

1. Beam trawl hauls/setting nets for biological analysis of fish community
2. Depth and position for each start and end point of trawl hauls and one position for nets
3. Measurements of CTDO (salinity, temperature, depth, and oxygen)
4. Air temperature, wind speed and direction, intensity of clouds, and wave height

3.2.2 SAMPLING WITH BEAM TRAWL

The fish survey sampling method with beam trawl is based on the German standard method for describing the spatial and temporal distribution of fish as a baseline for offshore wind farms, StUK4 (BSH, 2013). Due to limited vessel size and engine power, a modified smaller version of the trawl was used in the present study. The smaller trawl was compensated for with longer trawl hauls, so that the overall area covered was identical to the area recommended in the StUK4.

The StUK4 method recommends two surveys – a spring and an autumn survey (BSH, 2013). This ensures sampling of fish within the two seasons where most fish species spawn, but also represents the period before the juveniles migrate into deeper waters when sea temperatures drop during winter. Therefore, this method will give valuable information about the usage of the area as spawning area, as well as provide information determining if the area serves as a nursery area for specific fish species. Furthermore, the StUK4 method will provide a general description of the distribution and density of the fish fauna communities within the project area.

In this project, the StUK4 method has been altered slightly to compare results with e.g., the Thor OWF (Rambøll & WSP, 2021) in the North Sea, where the same trawl was used for fish sampling. The trawl is built by Hvide Sande Vodbinderi and is four meters wide and 16.35 meter long when fully deployed (Figure 3-2). The cod end consists of 2 mm meshes to catch even small fish and juveniles. The trawl is deployed from the side of the vessel with the Launch And Recovery System (LARS) and hauled for 30 minutes at 3-4 knots towing speed, so the overall area sampled is identical to the area recommended in the StUK4. This gives an average towing distance of 4,000 meter with a total area of 16,000 m^2 pr. haul. The trawl is hauled across the seabed which makes it ideal for catching benthic and demersal fish species incl. flatfish and Atlantic Cod. All trawl hauls will be conducted during daylight hours.

Figure 3-2 Beam trawl utilized for the fish survey of the pre-investigation area of ENOE OWF.

3.2.3 SAMPLING WITH TRAMMEL NETS

Due to regulations on no dredging in the habitat area, trammel nets substituted beam trawl here. Trammel nets (Figure 3-3) consists of three layers of netting with the middle net (inner netting) consisting of a smaller mesh size (70-80 mm) and the two outer layers (outer netting) of larger meshes. The purpose of this type of net is, that fish swim into the inner netting and pushes it through the outer netting and thereby, catching the fish in a bag rather than catching the fish by its gills, as in traditional gill nets. The design with outer nettings makes trammel nets very stable when fishing in areas with strong currents. Trammel nets are best suited for catching flatfish such as turbot, plaice and sole. This makes the substitution from beam trawl ideal, as both gear types primarily catch benthic species.

The trammel nets were deployed on the seabed with a sink line and stretches approximately 1,5-2 meter vertically and kept buoyant by a float line. The nets were deployed with anchors in each end and subsequently attached to a buoy with contact information of the discipline manager for the fisheries authorities. The nets were set in the afternoon between 15-18 and retrieved the following morning after approximately 16 hours of fishing.

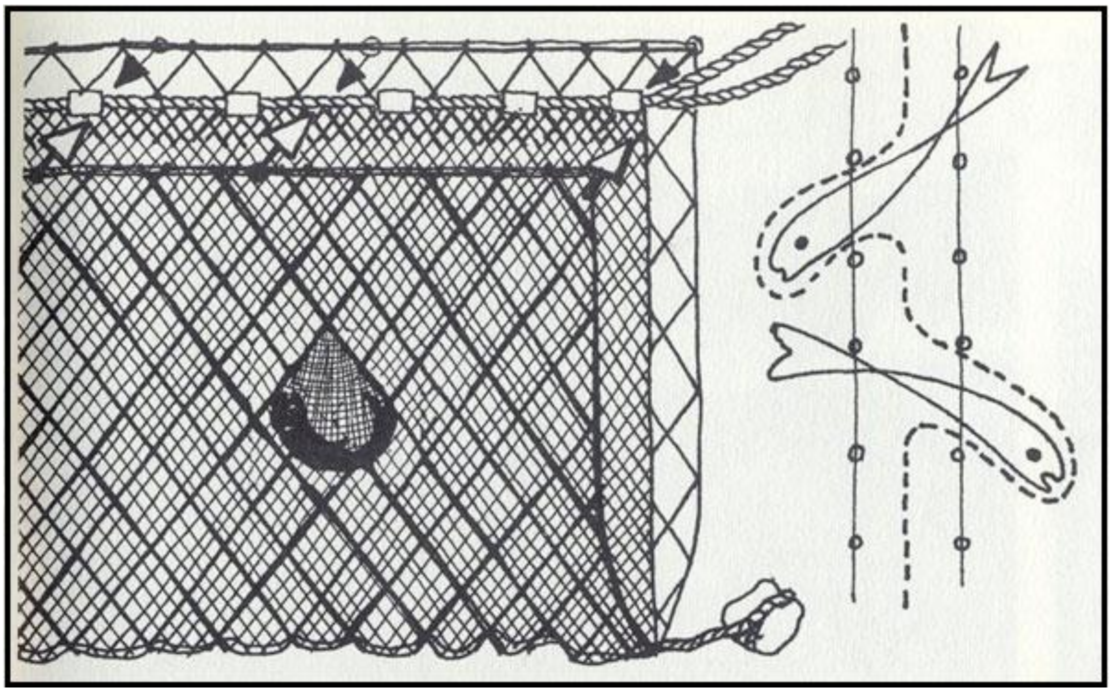


Figure 3-3 Trammel net with three layers of netting. The net layers catch the fish inside a “bag” instead of catching it by the gills (Garmer, 2023).

3.2.4 SAMPLING WITH MULTI MESH GILLNETS

To sample and document a wide range of fish species and sizes present in the pre-investigation area, multi mesh gillnets were used. The muti mesh gillnets are designed for documenting the diversity of fish in an area, as each mesh size is specialized for catching a certain size of fish, and these nets are also used in the NOVANA fish survey program. The nets used in the present study consisted of 12 panels of various mesh sizes, ranging from 6-116 mm (6.5 mm, 8.5 mm, 11 mm, 15 mm, 18.5 mm, 25 mm, 30 mm, 40 mm, 55 mm, 70 mm, 90 mm, 116 mm). The mesh sizes increase geometrically with a factor 1.25. The nets were 1.5 meter high and approximately 100 meter wide (Figure 3-4). The nets have a sink line keeping the nets on the seabed, while the float line keeps the net stretched upwards. The nets are deployed with anchors in each end attached to a buoy with contact information to the discipline manager for the fisheries authorities. The nets were deployed in the afternoon between 15-18 and retrieved the following morning after approximately 16 hours of fishing.

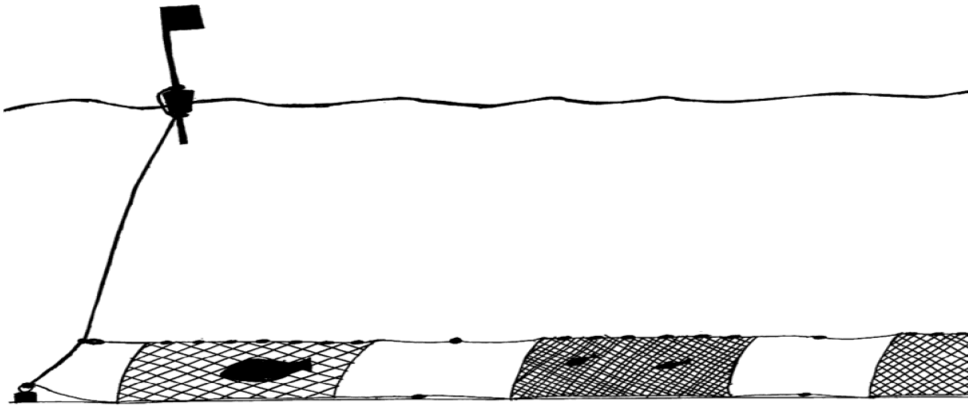


Figure 3-4 Multimesh gillnets with various mesh sizes specialized for catching a wide range of fish sizes.

3.2.5 ANALYSIS OF THE CATCH

All sampled fish were sorted and determined to lowest possible taxonomical level. Each fish was measured from the tip of the snout to the longest caudal fin ray (TL) to nearest lower cm and weighed to nearest lower gram. Where exceptionally large quantities of individuals of the same species were caught at the same station, the weight was given as a total for the species and not individually. Damaged fish were excluded from the measurement to avoid bias of the results.

ABUNDANCE, BIOMASS AND BIODIVERSITY

The abundance of fish was determined as Catch Per Unit Effort (CPUE) of number of fish per 1000 m^2 for beam trawl and number of fish per net per day for multimesh gillnets and trammel nets. The abundance was divided into three categories based on the catches made in the present study. Low abundance: < 5 fish, medium abundance: 5-10 fish and high abundance: > 10 fish.

The same method was used for biomass. The biomass of fish was determined as CPUE of grams of fish per 1000 m^2 for beam trawl and grams of fish per net per day for multimesh gillnets and trammel nets. The biomass was divided into three categories based on the catches made in the present study. Low biomass: < 500 grams of fish, medium biomass: 500-1500 grams of fish and high biomass: > 1500 grams of fish.

Biodiversity was also measured and divided into three categories based on number of species caught per station. This was the same for beam trawl, multimesh gillnets and trammel nets. Stations with < 5 species were listed as having low biodiversity, medium biodiversity was the range between 5-10 species pr. station, while stations with > 10 species had high biodiversity.

DETERMINATION OF GONAD MATURITY STAGE

To determine whether the pre-investigation area of ENOE OWF serves as a possible spawning area, the maturity stage of relevant fish species caught in the beam trawl was determined. As the fish grows from juvenile into adulthood, so does the reproductive system. After they reach adulthood, most marine fish spawn once a year. The reproductive system gradually prepares for the event by increasing the blood flow to the gonads, enlarging them and a colour change is clear (Figure 3-5). Females produce eggs that gradually develop in the ovaries from an undefined mass to visible oocytes and finally to large waterfilled egg cells ready for spawning. The males prepare similarly, but they have milk running from the testes when they spawn. After the spawning event, the gonads of males and females go into a resting phase where they diminish again and prepare for the next spawning event.

The maturity was determined based on the visual appearance of the gonads and comparing this to a maturity index, where every stage of a fish's gonadal maturity was described (Table 3-1). The index describes in several stages whether the fish gonad was ripening, spawning, or was "spent" (regenerating the gonads). When fish are ripening the gonads and getting ready to spawn, they migrate to the relevant spawning site. So, if most individuals of a certain species caught in the pre-investigation area were spawning, this indicates that the area was utilized as a spawning area. The gonad maturity index was determined macroscopically for the Atlantic cod (*Gadus morhua*) according to (Tomkiewicz, et al., 2002) and for relevant flatfish species as well as for the Atlantic herring (*Clupea harengus*) according to (Strand, 2006). The maturity of the gonads was determined for both male and female fish.

Table 3-1 Maturity Index from (Tomkiewicz, et al., 2002). The index is based on macroscopical inspection of the gonads of male and female cod.

STAGE	FEMALE	MALE
I	**Juvenile** Ovaries emerge as tiny, paired organs close to bladder; glassy transparent to orange-reddish translucent in larger specimens. *LT* rarely above 30 cm;	**Juvenile** Testes emerge as a pair of thin strings along air bladder. Lobules tiny, glassy transparent to reddish translucent in larger specimens. *LT* rarely above 30 cm;
II	**Preparation** Ovaries small, but easily distinguishable posterior in body cavity; soft with even surface (flattens on a solid sheet); blurred translucent, reddish-orange. *LT*: 25-60cm;	**Preparation** Testes small, but distinguishable along air bladder. Lobules small, blurred translucent and reddish. *LT*: 20-50cm;
III	**Ripening 1: Oocyte recruitment** Ovaries still small and restricted to posterior body cavity; firmer than II and roe shaped (keep form on a solid sheet), surface uneven; opaque orange-red to dark orange with greyish cast in large females. Tiny opaque oocytes emerge towards end of stage. *LT* rarely below 30 cm;	**Ripening 1: Early spermatogenesis** Testes still small, close to air bladder. Lobules plump and soft, rich in blood vessels, completely or partially opaque, reddish. *LT* rarely below 20 cm;
IV	**Ripening 2: Late vitellogenesis** Ovaries enlarged to mid body cavity; plump and firm with prominent blood vessels; opaque, orange to creamy yellow. Oocytes clearly visible and densely packed.	**Ripening 2: Late spermatogenesis** Testes enlarged and prominent dorsal in body cavity; Lobules plump and brittle; reddish-white. Empty, transparent spermaducts with prominent blood vessels; no sperm release.

V	**Spawning 1: Initiation of spawning** Ovaries extending into anterior body cavity; distended and soft; opaque, orange to creamy yellow. Single glassy, hydrating oocytes among abundant opaque, vitellogenic oocytes (as in IV, but round and larger). Viscous fluid or hydrated eggs in lumen may occur.	**Spawning 1: Initiation of spawning** Testes extending into ventral part of body cavity. Lobules distended and brittle, opaque creamy-white. Spermaducts filled with viscous semen and a viscous droplet may be released from vent.
VI	**Spawning 2: Main spawning period** Ovaries fill most of body cavity; very distended and soft; appear granulated orange- to reddish-grey from mixture of opaque and glassy oocytes. Lumen containing viscous fluid in excess or hydrated eggs.	**Spawning 2: Main spawning period** Testes large and prominent in body cavity (as in V). Lobules still plump, but soft; completely opaque, whitish. Spermaducts filled with fluid, milky semen that easily flows from vent.
VII	**Spawning 3: Cessation of spawning** Ovaries shrunk to posterior body cavity; flabby with prominent blood vessels; unclear reddish- grey. Hydrated oocytes present; opaque oocytes few or absent. Lumen with excess fluid and frequently hydrated eggs.	**Spawning 3: Cessation of spawning** Testes shrunk to dorsal part of body cavity; soft and flabby. Lobules almost empty, opaque, reddish-white. Spermaducts still with fluid semen that easily flows from vent.
VIII	**Regeneration 1: Spent** Ovaries contracted; slack with greyish cast; rich in blood vessels; dim translucent reddish-grey. Vitellogenic oocytes absent, but single hydrated eggs or atretic oocytes (opaque, irregular granules) may occur.	**Regeneration 1: Spent** Testes contracted, close to air bladder; rich in blood vessels. Lobules empty, flabby, reddish potentially with a greyish cast. Spermaducts with signs of previous distension, often with visible remains of semen.
IX	**Regeneration 2: Resting and spawning omission** Ovaries small as in II, but with signs of previous spawning; e.g. greyish cast and somewhat uneven walls; blurred translucent, reddish-grey, but more granulated and opaque than in II.	**Regeneration 2: Resting and spawning omission** Testes small (as in Stage II), but with signs of previous spawning; e.g. lobules slightly larger than in II; spermaducts often with greyish cast.
X	**Degeneration: Reduced fertility** A: Ovaries with fibrous tissue formation; affected areas compact and hard, brownish-yellow opaque; non-affected parts with normal development. Observed in females from 65 cm. B: Other abnormalities.	**Degeneration: Reduced fertility** A: Testes with adipose tissue formation; affected parts undeveloped, hard, yellowish; non-affected parts with normal development. Observed in males from 50 cm. B: Other abnormalities.

Figure 3-5 Gonads of Atlantic cod caught in autumn survey. Left: male in late spermatogenesis estimated to be at stage IV with enlarged testes but without running milk. Right: female in late spermatogenesis estimated to be at stage IV with visible oocytes but without hydrated eggs.

SIZE DISTRIBUTION

The length of all caught fish was measured to determine the size distribution of each species. By measuring the individual fish and determining the cohorts based on length-to-age literature, it is possible to determine whether the pre-investigation area serves a nursery area. Juvenile fish utilize nursery areas to feed and grow until they reach a size where they are less vulnerable to size-related predation. The nursery areas provide a relatively protected environment with plenty of food items, such as invertebrates.

BIODIVERSITY AND EVENNESS BETWEEN SPECIES

To assess the biodiversity of fish in the pre-investigation area, the Shannon Wiener index and evenness were calculated for catches for the spring and autumn survey based on abundance of fish. The calculations were separated for each gear type as the various sampling methods cannot be compared; beam trawl data is based on abundance pr. 1000 m^2, while gillnet catches is based on abundance in net per day.

The Shannon Wiener index is the simplest measure of biodiversity and is a count of the number of different species in a given area. This measure is strongly dependent on sampling size and effort. The Shannon Wiener index increases as both the richness and the evenness of the infauna community increase. The values typically range between 1.5 and 4 in most ecological studies and the index is rarely greater than 4.

To assess the evenness between species, the Pielou's Evenness index was calculated for the catches of each beam trawl station in spring and autumn survey. The index refers to how close in numbers each species is to the other species found at the station. The value of this index ranges between 0 and 1 – the greater the value the greater the evenness in species abundance and numbers. Please see Appendix 2 for further details on the calculations of the Shannon Wiener index and Pielou's Evenness index.

4 EXISTING DATA

Presented below are existing conditions in the pre-investigation area for ENOE OWF including information on abiotic parameters as well as biological parameters. Abiotic conditions include water depth, seabed substrates and CTDO-measurements, and biological parameters includes fish fauna. Local spawning and nursery areas is described along with protected species and habitats in the nearby area.

The existing conditions concerns the pre-investigation area, including the planned windfarm areas (Bornholm I Nord, Bornholm I Syd and Bornholm II) and the cable corridors from the OWF to Bornholm (CC, CC1 and CC2) (Figure 4-1). Furthermore, Natura 2000 sites and the new bird SPA site (Rønne Banke F129/DK00FC373) between the two wind farm areas are shown in the same figure. Cable corridors to Zealand and neighbouring countries are not included in the existing conditions presented here.

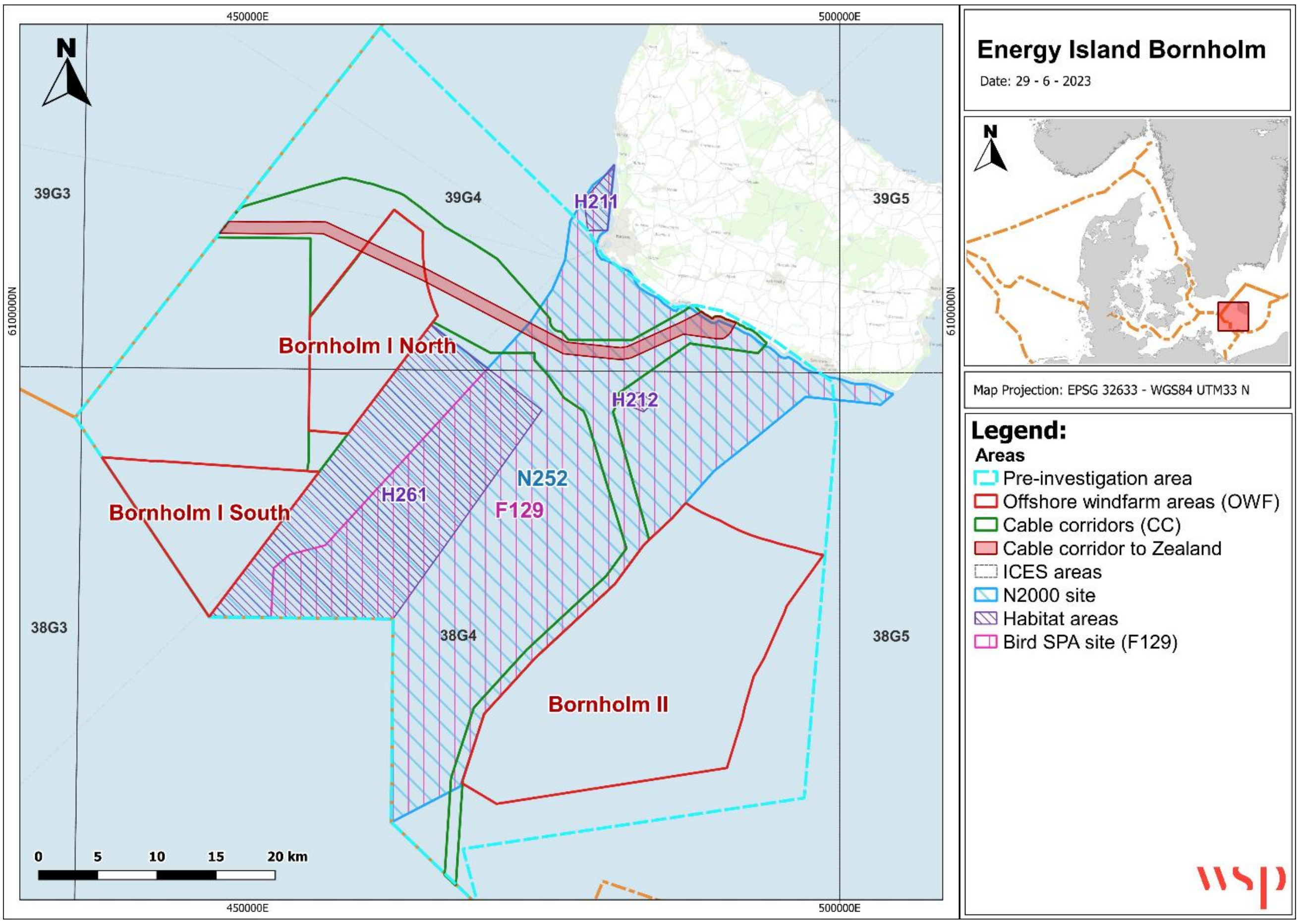


Figure 4-1 The pre-investigation area of ENOE OWF with offshore cable corridors and relevant habitat and N2000 sites.

4.1 ABIOTIC DATA

4.1.1 SALINITY

Salinity is an important parameter for determining the fish species diversity in the Baltic Sea, since fewer species are adapted to the brackish conditions found in these waters (Vuorinen, et al., 2015). A general decline in salinity of the bottom water is observed from approximately 20 psu in the Sound to 2-3 psu in the Bothnian Bay (Perttilä, 2007). Bottom water in the pre-investigation area south of Bornholm generally has salinities between 7.5 to 18 psu (Nord Stream 2, 2018) (Baltic Pipe, 2019).

The salinity in the Baltic is affected by surface freshwater runoffs from the many river outflows and from irregular inflow of high-saline deep water from the North Sea through the Danish Straits (Perttilä, 2007). The inflow of saline and oxygen rich sea water to the deep basins in the Baltic Sea is important for the oxygenation of the deep parts of the Baltic Sea and for the buoyancy and survival of pelagic fish eggs. Since the 1970s, fish biomass in the Baltic Sea has declined due to the decreasing sea surface salinity (Vuorinen, et al., 1998). It is estimated that freshening will increase in the future due to climate change (Meier, et al., 2006), although the inflows of high saline water has occurred at a slightly higher frequency in the later years (HELCOM, 2017).

4.1.2 DEPTH

The water depth is relevant regarding fish and fish populations as most fish species have a preferred depth range. Juvenile flatfish find shallow, sheltered areas, and utilize these areas as nursery areas until they reach a size where they are less vulnerable to size-dependent predation. During winter, several fish species migrate into deeper, warmer, and more stable water environments and away from the coastal areas, where temperatures drop and fluctuate during winter. Thus, the depth is relevant in terms of which species are expected to utilize the area.

Depth in the pre-investigation area varies greatly between sites (0 to 58 meters depth) and is presented in Figure 4-2. The shallowest areas are found in the Bird SPA F129 close to the coast and in the Rønne Banke area between the wind farm areas (Bornholm I and Bornholm II). The deepest parts of the pre-investigation area are found northwest of Bornholm I Nord and southeast of Bornholm II.

The depth range is 33.5 to 47.5 meters and 28 to 45 meters in Bornholm I Nord and Bornholm I Syd, respectively. The largest depth variation found is 20 to 55 meters, which is found in Bornholm II.

The overlapping part of the cable corridors (CC) close to the coast of Bornholm has depths between 0 and 20 meters. The cable corridor from Bornholm to Bornholm I Nord (CC+CC1) has depths between 0 and 47 meters. The cable corridor (CC+CC2) from Bornholm to Bornholm II is slightly shallower with depths between 0 and 36.5 meters.

The depth range in Bird SPA F129 is between 0 to 36.5 meters.

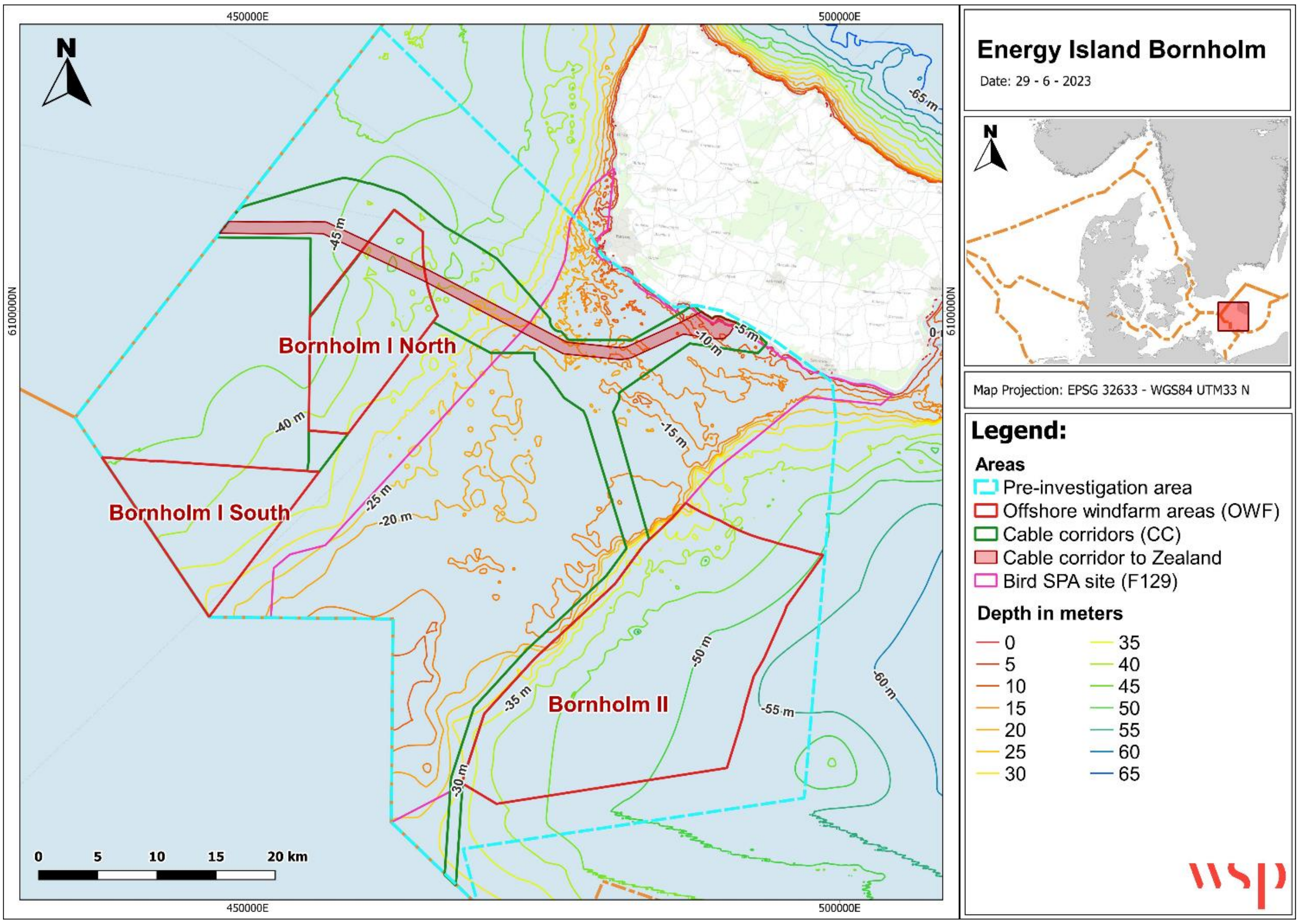


Figure 4-2. Depth map in the pre-investigation area of ENOE OWF. Data source: Sjöfartsverket 2013.

4.1.3 SEDIMENT TYPES

Fish are attracted to the specific sediment types, which they have adapted to, and some even depend on certain habitat types to complete their life cycles. These are defined as essential fish habitats. As an example, flatfish are adapted to sandy or muddy areas, where they bury into the sediment as a cryptic behaviour, hiding from predators or to ambush prey. Other species of flatfish feed on prey buried into the sediment. So generally, flatfish are adapted to sandy areas without much structure.

The overall distribution of seabed sediments in the pre-investigation area is presented below in Figure 4-3. The map is based on data from the national geophysical database provided by GEUS (Marta database, (GEUS, 2022)).

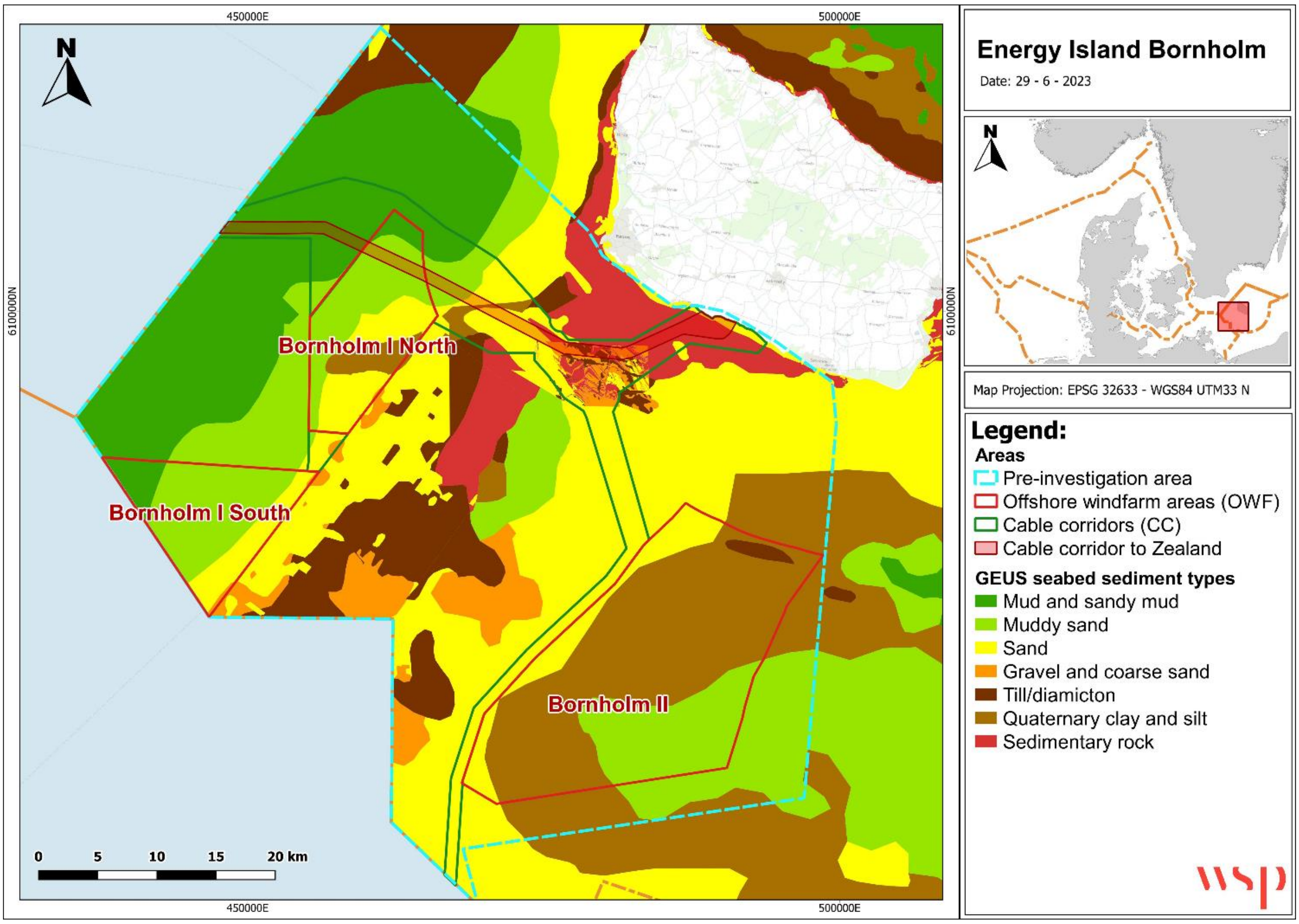


Figure 4-3. Seabed sediment types in the pre-investigation area based on existing data. Data sources: GEUS Marta database (GEUS, 2022).

The sediment types in the pre-investigation area are highly variable ranging from exposed bedrock (sedimentary rock), glacial deposits (stony sediment types) and post-glacial sand and gravel deposits (finer sediments) (Figure 4-3). The deeper parts of the pre-investigation area, furthest to the east and west, are dominated by finer post-glacial sediments, i.e., “mud and sandy mud” and “muddy sand”.

The largest variation in sediment types within the pre-investigation area is observed in the Rønne Banke area between the two wind farm areas. This area is characterized by shallow depth and more till and rocky areas. Stone reef encompasses the sediment types: “till/diamicton” and “sedimentary rock” and are only found in the Rønne Banke area between the two wind farm areas and in the CC area. The GEUS map of sediment types in the pre-investigation area is relatively broad-scale and does not illustrate the high natural variation in the pre-investigation area, since this degree of detail is not considered to be necessary for this report. For a more detailed map on sediment types, please see maps in Environmental Baseline Note WP-E Benthic Flora and Fauna (Rambøll & WSP, 2022).

4.2 FISH DATA

A total of 230 species of fish have been recorded in the Baltic Sea, but due to the salinity gradient along the Baltic Sea, there is a clear difference in species composition and significantly more species occurring in the high saline areas (Kattegat with 175 species) compared to low saline areas (Bothnian Bay with <50 species) (HELCOM, 2012). Brackish waters often experience great fluctuations in the salinity due to saltwater inflow or freshwater outflow regulated by wind direction and storm or rain events. These variations requires great flexibility of the osmotic systems of fish. In addition, salinity also regulate zooplankton community's occurrence and abundance as they only occur in their preferred salinity range (ICES, 2022).

In the areas nearest to the pre-investigation area, Arkona Basin and Bornholm Basin , 103 and 108 species, respectively, have been recorded by HELCOM (in areas with a salinity of at least 0.5 psu, since 1800)) (HELCOM, 2012). Of these species, 35-37% of the species reproduce regularly in the Bornholm Basin and Arkona Basin, while 17-18% occur in the area frequently. Approximately 43-45% of the species only have a temporary occurrence and the remaining species have a more uncertain occurrence) (HELCOM, 2012). Because of the brackish character of the Baltic Sea, several anadromous (saltwater living and freshwater spawning) and catadromous species (freshwater living and saltwater spawning) species migrate back and forth through the Baltic Sea. Of the marine fish species that are characterized as regular reproducing near the pre-investigation area, the Atlantic herring, the European sprat , the Atlantic cod, the European flounder and the European plaice are among the dominating species. For further details on the areas possibility of serving as spawning site, please see section 4.2.2 and 6.

In the commercial fishery, 31 fish species were caught in ICES rectangles 38G4 and 39G4, representing the pre-investigation area (Figure 4-4) (Rambøll, 2022). The most important fish species caught within the two ICES rectangles were European flounder, European plaice, turbot, European sprat, sandeel and Atlantic cod. Catches have decreased greatly over the past decades due to declining quotas on Atlantic cod and Atlantic herring, and Danish commercial fisheries has reported that they move their fishing activities to Kattegat and Skagerrak instead of near Bornholm. Based on Swedish data, the same tendency exist among Swedish commercial fisheries. All fish species registered in the commercial fisheries are listed in Table 4-1.

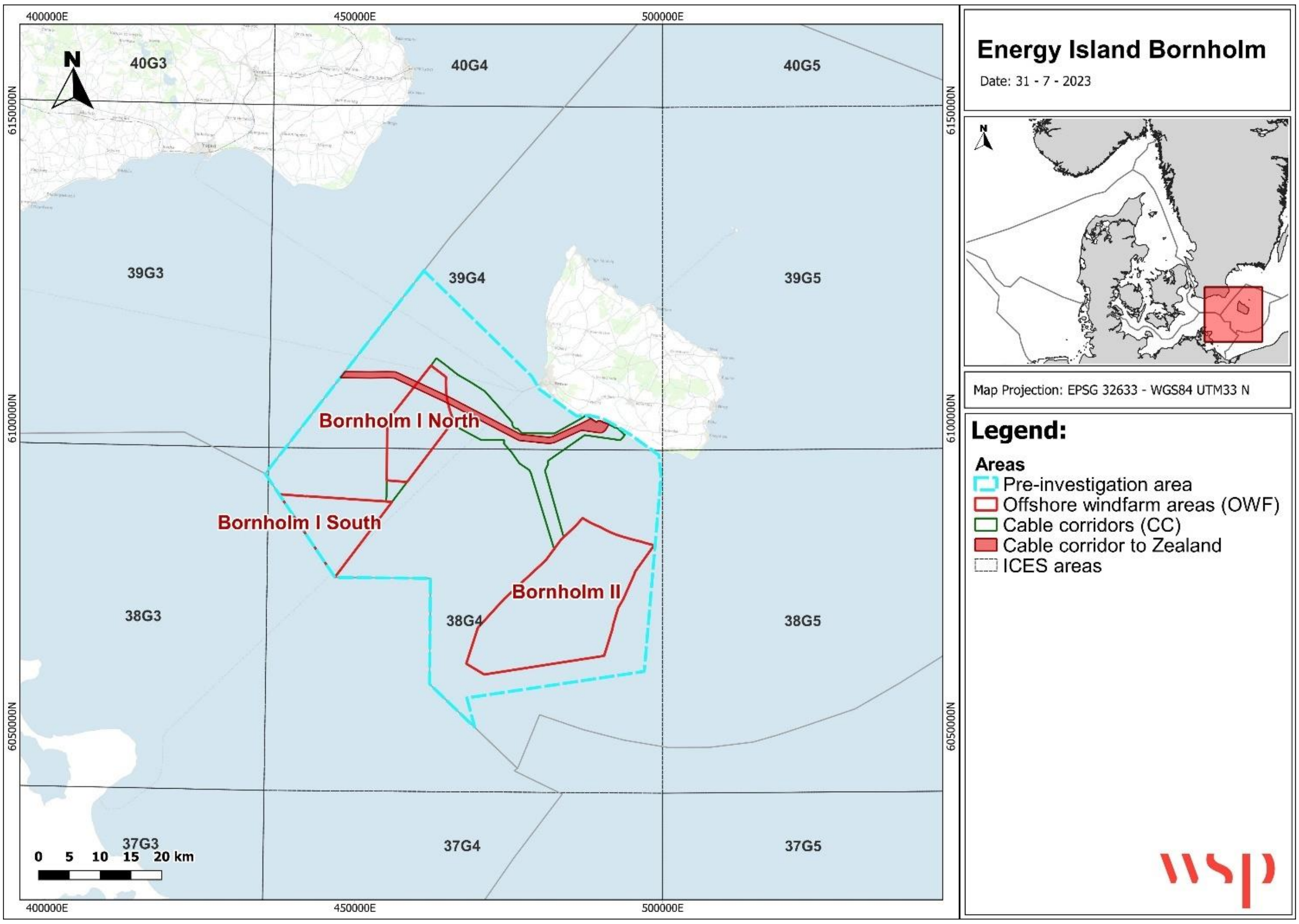


Figure 4-4 The pre-investigation area for ENOE and the grid of ICES squares.

Historically, a total of 73 fish species have been registered in the Fiskeatlas database (Fiskeatlas, 2022). The observed species include numerous observations of common and economically important species such as Atlantic cod, Atlantic herring, European sprat, whiting and the flatfish species, European plaice, turbot, and European flounder. The commonness of these species is further supported by the number of fishery references listing catches of each species. However, rare, and vulnerable species are also observed in the pre-investigation area, such as three species of sturgeon: Danube sturgeon (*Acipenser gueldenstaedtii*), Atlantic sturgeon (*Acipenser oxyrinchus*) and sturgeon (*Acipenser sturio*), as well as the twaite shad (*Alosa fallax*) and the sea lamprey (*Petromyzon marinus*). Please see 4.2.3 for further details on protected and vulnerable species.

In Table 4-1, a total of 80 fish species are listed, each caught in or near the pre-investigation area (Fiskeatlas, 2022).

Fish are an essential link between the low trophic levels of zooplankton and the top predators. In the Baltic Sea, few midlevel forage species (Atlantic herring and European sprat) support a high diversity of larger predators (e.g., Atlantic cod, marine mammals and birds) that are susceptible to fluctuations in prey biomass. Thus, the breeding success, reproductive capacity, and condition of the predators are linked to the food source. For the past 30 years, the ecosystem has been restructured to a more bottom up regulated system, and the abundance of main predators has dropped while, in turn, the biomass of European sprat has increased (Eero, et al., 2012) (Casini, et al., 2014).

Atlantic cod, European sprat and Atlantic herring are all important commercial species, but they are also key species in the ecosystem. The three species share interspecific interactions where European sprat and Atlantic herring prey on Atlantic cod eggs (Neumann, et al., 2017). Thus, large populations of European sprat and Atlantic herring can impact the recruitment success of Atlantic cod. As Atlantic cod mature, Atlantic herring and European sprat become their primary prey items (HELCOM, 2008) and in turn, the Atlantic cod may impact the size of the Atlantic herring and European sprat population. For more details on the key species, please see the following section.

Table 4-1 List of fish species registered in and around the pre-investigation area based on existing studies (Sources: (Danish Fisheries Agency, 2021) ICES square 34G4+38G4[1], (Fiskeatlas, 2022)[2], (IfAÖ, 2010)[3], (IfAÖ, 2004)[4], (ALAUDA, 2011)[5] (IfAÖ, 2005)[6], (ALAUDA, 2011)[7], (IfAÖ, 2011)[8], (NIRAS, 2015)[9],

SPECIES - Latin	SPECIES - English	REFERENCE	SPECIES – Latin	SPECIES - English	REFERENCE
Abramis brama	Freshwater bream	2	*Microstomus kitt*	Lemon sole	2
Acipenser gueldenstaedtii	Danube sturgeon	2	*Molva molva*	Ling	1,2
Acipenser oxyrinchus	Atlantic sturgeon	2	*Mullus surmuletus*	Surmullet	2,8
Acipenser sturio	Sturgeon	2	*Mullus barbatus*	Red Mullet	8
Agonus cataphractus	Hooknose	2,6,9	*Myoxocephalus scorpius*	Shorthorn sculpin	1,2,4,6,9
Alosa fallax	Twaite shad	1,2,9	*Neogobius melanostomus*	Round goby	2
Ammodytes tobianus	Small sandeel	2,4,5,7	*Nerophis ophidion*	Straightnose pipefish	2
Anguilla anguilla	European eel	1,2,4,6,8,9	*Oncorhynchus mykiss*	Rainbow trout	2
Aphia minuta	Transparent goby	2,9	*Osmerus eperlanus*	European smelt	2,5,6,7,9
Belone belone	Garfish	1,2,9	*Perca fluviatilis*	European perch	1,2
Brama brama	Atlantic pomfret	1	*Petromyzon marinus*	Sea lamprey	2
Chelidonichthys lucerna	Tub gurnard	2,8	*Pholis gunnellus*	Rock gunnel	2,4,
Chelon labrosus	Thicklip grey mullet	2	*Platichthys flesus*	European flounder	1,2,4,5,6,7,8, 9
Clupea harengus	Atlantic herring	1,2,4,5,6,7,8, 9	*Pleuronectes platessa*	European plaice	1,2,4,5,6,7,8, 9
Coregonus maraena	Maraena whitefish	2	*Pollachius pollachius*	Pollack	1,2
Ctenolabrus rupestris	Goldsinny wrasse	2,9	*Pollachius virens*	Saithe	1,2
Cyclopterus lumpus	Lumpfish	1,2,9	*Pomatoschistus flavescens*	Two-spotted goby	2,4,9
Enchelyopus cimbrius	Fourbeard rockling	2,6,7,8,9	*Pomatoschistus microps*	Common goby	2
Engraulis encrasicolus	European anchovy	2	*Pomatoschistus minutus*	Sand goby	2,4,6,8,9
Esox lucius	Northern pike	2	*Pungitius pungitius*	Ninespine stickleback	2
Eutrigla gurnardus	Grey gurnard	2,5,7,8	*Rutilus rutilus*	Roach	2
Gadus morhua	Atlantic cod	1,2,4,5,6,7,8, 9	*Salmo salar*	Atlantic salmon	1,2,7,9
Gasterosteus aculeatus	Threespined stickleback	2,4,6,9	*Salmo trutta*	Sea trout	1,2,9
Glyptocephalus cynoglossus	Witch flounder	1	*Sander lucioperca*	Pikeperch	2
Gobius niger	Black goby	2,4,6,9	*Scomber scombrus*	Atlantic mackerel	1,2
Hippoglossoides platessoides	American Plaice	2	*Scophthalmus maximus*	Turbot	1,2,4,5,6,7,8, 9
Hippoglossus hippoglossus	Atlantic halibut	1	*Scophthalmus rhombus*	Brill	1,2,9
Hyperoplus lanceolatus	Great sandeel	2,4,6,9	*Silurus glanis*	Wels catfish	2
Lampetra fluviatilis	River Lamprey	9	*Solea solea*	Common sole	1,2,8
Lampris guttatus	Opah	2	*Sparus aurata*	Gilthead seabream	2

Leucaspius delineatus	Belica	2	*Spinachia spinachia*	Sea stickleback	4
Leuciscus idus	Ide	2	*Sprattus sprattus*	European sprat	1,2,5,6,7,8,9
Limanda limanda	Common dab	1,2,5,6,7,8,9	*Syngnathus typhle*	Broadnosed pipefish	2
Liparis sp.	Snailfish sp.	2	*Taurulus bubalis*	Longspined bullhead	2,9
Liparis liparis	Striped seasnail	4,6,9	*Trachinus draco*	Greater weever	1,2,8
Lota lota	Burbot	2	*Trachurus trachurus*	Atlantic horse mackerel	2,4,5,6,7,8
Lumpenus lampretaeformis	Snake blenny	2,9	*Trisopterus luscus*	Pouting	2
Melanogrammus aeglefinus	Haddock	1,2	*Trisopterus minutus*	Poor cod	2
Merlangius merlangus	Whiting	1,2,4,5,6,7,8	*Xiphias gladius*	Swordfish	1,2
Merluccius merluccius	European hake	1,2	*Zoarces viviparus*	Eelpout	2,4,6,9

4.2.1 DESCRIPTION OF KEY FISH SPECIES

ATLANTIC COD *(GADUS MORHUA)*

The Atlantic cod belongs to the family of *Gadidae* where most species have a characteristic chin hook (Muus & Nielsen, 2006). The Atlantic cod grows up to 150 cm, although individuals of this size are very rare today due to high fishing pressure. A more usual maximum size is approximately 110 cm and 15 kg. Atlantic cod lives from coastal areas to 500–600 meters depth near the bottom but can also occur in the pelagic zone. Atlantic cod occurs in the entire Baltic Sea except for the northern part of the Bothnian Bay (Cohen, et al., 1990). In the Baltic Sea, the Atlantic cod spawns February to September and the eggs drift with the water current in the pelagic zone. Juveniles utilize hard bottom areas as nursery area, where they feed on small crustaceans, before gradually shifting their diet to become piscivorous. Atlantic cod utilize the deep areas of Arkona and Bornholm Basin near the pre-investigation area as spawning sites, and hard bottom and shallow areas in the pre-investigation area as nursery areas. The population of Atlantic cod in the Baltic Sea is suffering and may be close to a collapse. Please see later sections on cod for more details.

ATLANTIC HERRING *(CLUPEA HARENGUS)*

The Atlantic herring is a pelagic, silvery, schooling fish with soft fin rays. The maximum size is 40 cm, although the length rarely exceeds 20 cm in the Baltic Sea. Atlantic herring typically reaches an age of 20 to 25 years (Muus & Nielsen, 2006). Atlantic herring occur throughout the entire Baltic Sea, consisting of several stocks; the west Baltic spring spawners, the central Baltic stock, the north Baltic stock and autumn spawners in the west Baltic, although the latter is very low in numbers (Jørgensen, et al., 2005) (FeBEC, 2013b) (ICES, 2017) (Munk & Carl, 2019). This species is an important food source for many other fish, and especially for e.g., Atlantic cod. The diet of the Atlantic herring mainly consists of copepods, pelagic gastropods and fish larvae. The Atlantic herring are demersal spawners, and the eggs are attached to gravel, so the spawning sites are characterized by this sediment type (Pihl & Wennhage, 2002) (Rajasilta, et al., 1989). The Baltic Sea Atlantic herring mainly spawn around the German island, Rügen (see Figure 4-5), and both spring and autumn spawners have been observed in the area, which has been the largest and most important spawning area for the Atlantic herring in the Baltic Sea (Warnar, et al., 2012). High densities of herring larvae have been observed both in the Arkona Basin and Bornholm Basin, which most likely originate from spawning near Bornholm (Warnar, et al., 2012).

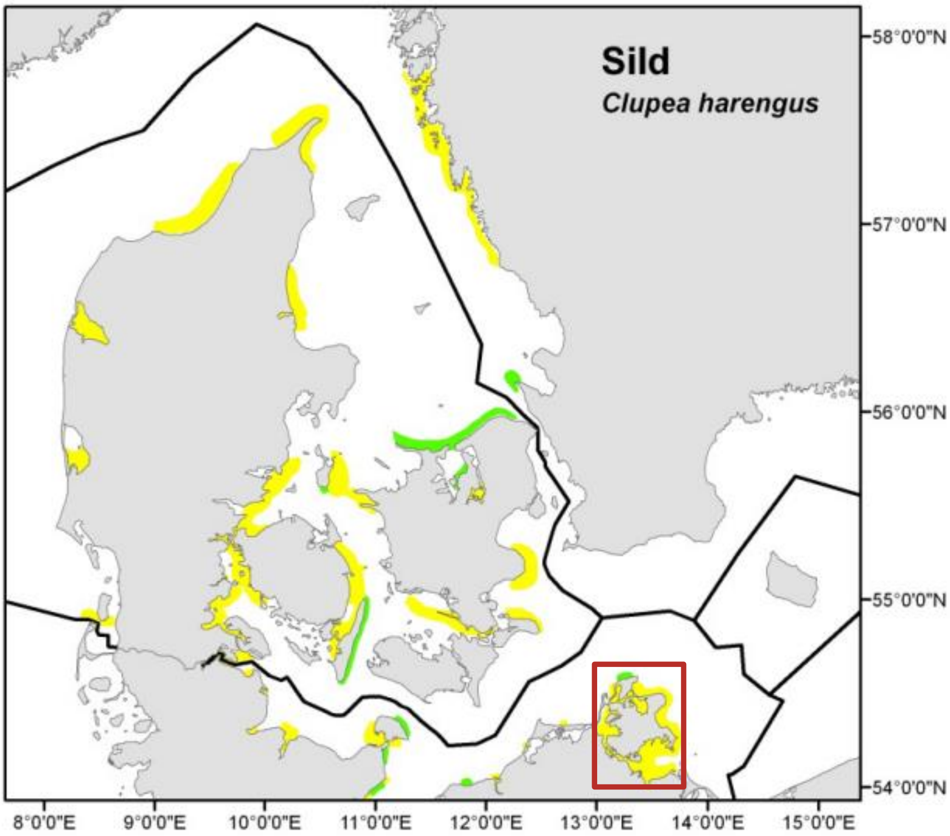


Figure 4-5 Currently known spawning areas for the Atlantic herring in Kattegat and inner Danish waters. The red square marks the location of the island of Rügen (Warnar, et al., 2012).

EUROPEAN SPRAT *(SPRATTUS SPRATTUS)*

The European sprat is a pelagic fish very similar in appearance to herring. It grows up to 16 cm and occurs in fjords and coastal areas including estuaries (Muus & Nielsen, 2006). During daytime, sprat schools densely near the bottom while at night, the fish follow the diel migration of copepods and sprat tend to spread out and swim near the surface to prey on the copepods. During summer it occurs at 5-50 meters depth and in wintertime deeper at approximately 150 meter depth. The European sprat occurs in most of the Baltic Sea, except for the northern part of the Bothnian Bay (Hoffmann & Carl, 2019). Historically, the main spawning season for the European sprat in the Baltic Sea was in May, but the spawning season has changed (Muus & Nielsen, 2006). Now the European sprat spawn from February to August. However, variations between years do occur, most likely due to variations in salinity, temperature and food availability (Haslob, 2011) (Ojaveer, E.; Kalejs, M., 2010). After spawning, the European sprat migrate towards shallow feeding areas.

EUROPEAN PLAICE *(PLEURONECTES PLATESSA)*

The European plaice is a flatfish from the family of *Pleuronectidae.* Plaice occurs on sandy or muddy bottoms, from a few meters down to about 200 meters of depth. It thrives in the open seas and in estuaries and is rarely seen entering freshwaters (Muus & Nielsen, 2006). The habitat range of the European plaice in the Baltic Sea covers the southern areas, and densities drop significantly east of Bornholm with the decreasing salinity. Occasionally, plaice is observed around Gotland and few specimens have been reported from the Bothnian Bay, and Gulf of Finland (Ojaveer & Drevs, 1995) (Curry-Lindahl, 1985). The diet of the European plaice predominantly consists of thin-shelled molluscs and polychaetes. In the Baltic Sea, the European plaice spawns from November to March at depths (typically around 60 meters) where the salinity (minimum 12 ppm) and temperature (5-7 degrees Celsius) are suitable. The pelagic eggs have a certain buoyancy, and if the salinity is too low, the eggs will sink into areas where oxygen levels are too low, and the eggs will die. The larvae drift with the water current into shallow softbottom sheltered areas with ample food resources known as nursery areas. The most important nursery area for plaice in Danish EEZ is on the east coast of Jutland. However, there are several smaller nursery areas along the Danish, Swedish and German coastline as well (Coull, et al., 1998) (HELCOM, 2021). As the water temperature drops over winter, the juveniles migrate into deeper waters only to return to the shallows the following spring to further eat and increase in size. The older the fish grows, the deeper it migrates during winter, until it reaches maturity and migrates to the spawning sites.

EUROPEAN FLOUNDER *(PLATICHTHYS FLESUS)* AND BALTIC FLOUNDER *(PLATICHTHYS SOLEMDALI)*

The European flounder resembles the plaice in many ways, and the two species can hybridize in Danish and Norwegian waters into what is known as "plounders", which are sterile offspring between the two species. Flounder prefer brackish waters and are common near river mouths and fjord inlets, i.e., the entire Baltic Sea region (Muus & Nielsen, 2006). It can even tolerate freshwater periodically and can be found in actual rivers and streams. Flounder prefer muddy to sandy substrate where it buries into the sediment. It feeds on polychaetes and small crustaceans and even insects in brackish or freshwater areas. In the Baltic Sea, there are two different spawning strategies for flounder: one with demersal eggs and the other with pelagic eggs (Solemdal, 1967) (Nissling, et al., 2002). These two strategies have been shown to belong to two closely related but distinct species; the European flounder, and the Baltic flounder (Momigliano, et al., 2017). Flounder with demersal eggs was described as a new species, the Baltic flounder, *Platichthys solemdali,* which is endemic to the northern part of the Baltic Sea and mainly found in the Gulf of Finland (Momigliano, et al., 2018). The Baltic flounder is not believed to occur in Danish waters or the pre-investigation area, although ICES mapping of the species' distribution based on abiotic factors shows otherwise (see section 4.2.2 European and Baltic flounder) (Carl, et al., 2019).

TURBOT *(SCOPHTHALMUS MAXIMUS)*

Turbot is a flatfish in the *Scophthalmidae* family, holding 20 species all confined to the North Atlantic region (Muus & Nielsen, 2006). The turbot is more round compared to most other flatfish, and it has spiny lumps on both sides of the body, which makes it easily recognizable. In the Baltic Sea, the species is common even north of Gotland, but rare in the Bothnian Bay (Kullander & Delling, 2012). The species lives on 20–70-meter depth on sandy, rocky, or mixed bottoms preying on crustaceans, but as the turbot grows, the diet also includes fish such as small Atlantic cod, other flatfish and sandeel. The maximum size of the turbot is approximately 100 cm and 25 kg, but the species rarely exceeds 60 cm in the Baltic Sea (Carl & Josset, 2019). Spawning occurs in the eastern Skagerrak and southern part of Kattegat, and thus, not near the pre-investigation area. The juveniles live in shallow sandy nursery areas until winter, where they swim into deeper areas.

4.2.2 SPAWNING AND NURSERY AREAS

Existing literature suggests that the pre-investigation area is utilized by various fish species for spawning and as a nursery area for juveniles. In the following sections, the utilization of the area for each relevant species is described.

ATLANTIC COD

The Atlantic cod in the Baltic Sea consist of a western and eastern population with fairly different characteristics in regard to spawning area and time. Due to the special hydrographical conditions (e.g., low salinity) in the Baltic Sea, the Atlantic cod spawning only occurs in deeper areas (20-40 meter depth) and the most important spawning site for the western population is believed to be Kiel Bay (Hüssy, K., 2011) (Figure 4-6 left). The Arkona Basin west of Bornholm is considered less important for the western population of the Atlantic cod (Hüssy, K., 2011) (Bleil & Oeberst, 2002). In Arkona Basin, the western population of the Atlantic cod spawn from February to September, although summer spawners observed here may be migrants from the eastern population.

The spawning of the eastern population of the Atlantic cod in the Baltic Sea is limited to the deep areas (>60 meter) including the Bornholm Deep and Gdansk Deep (Bagge, et al., 1994) (Wieland, et al., 2000) (Bleil, M.; Oeberst, R.; Urrutia, P., 2009) (Figure 4-6 right). However, due to low oxygen levels, the most important spawning area for the eastern population of the Atlantic cod is now Bornholm Deep, while the Gotland Basin has ceased to contribute to the reproduction of the Atlantic cod (Hinrichsen, et al., 2016). Evidence of spawning, for the Atlantic cod from the eastern population, in Arkona Basin, and at least temporarily in the Belt Sea, has also been documented (Stroganov, et al., 2017).

The spawning season for the Atlantic cod, in in the Arkona basin and Bornholm basin, varies interannually since it is strongly influenced by the water temperature, just as well as the duration of the spawning season. For this reason, rising sea temperatures, due to climate change, can be expected to account for an earlier start of the spawning season, as well as a shorter spawning season, and this is a variable parameter calculating an expected spawning time through more stable years, climate wise.

The peak spawning period is longer for females than males, and there is a pronounced size effect with larger females arriving at the site before the smaller ones. This means that larger females have a longer spawning period because they produce more batches, which seems to be controlled by the maturation cycle. Atlantic cod from the western populations do not follow any size dependent timing (Tomkiewicz, 1999) (Bleil & Oeberst, 1997).

The Atlantic cod larvae and small juveniles < 5 cm live pelagically until they settle (Hüssy, K.; St John, M.A.; Böttcher, U.;, 1997) and prefer hard bottom habitats that provide shelter and good feeding areas. Information is limited on the nursery areas for the western population of the Atlantic cod in the Baltic Sea.

The nursery areas for the eastern population of the Atlantic cod in the Baltic Sea are known to be around Bornholm Deep and Arkona Basin, although juvenile cod (>3cm) are present in all areas of the central Baltic Sea (Bagge, et al., 1994) (Nielsen, et al., 2013). In addition, high densities of juvenile Atlantic cod have been observed on Rønne Banke southwest of Bornholm and Hanö Bay north of Bornholm (ICES, 2007-2011). The observations of juvenile Atlantic cod on Rønne Banke is supported by interviews with commercial fishermen from Bornholm, who also reported seeing juvenile Atlantic cod on the north-east coast of Bornholm (Nielsen, B. & Kvaavik, C. (Eds.), 2007). Conditions for the Baltic Atlantic cod have changed greatly over the past decades, and most publications on the distribution of juvenile Atlantic cod are based on 3-4 decades of retrospective data. Thus, there is a need for supplementary fish surveys to document the present conditions.

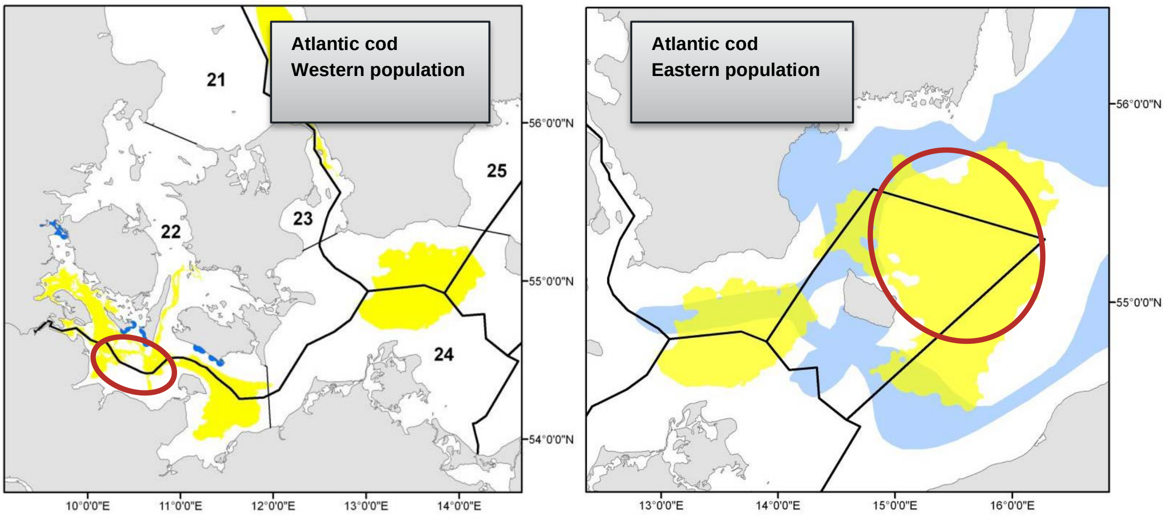


Figure 4-6 The known spawning (yellow) and nursery areas (blue) for the western (left) and eastern (right) population of Atlantic cod in the Baltic Sea. Modified after (Warnar, et al., 2012). Red circles indicate the most important spawning areas for the western Atlantic cod (Hüssy, K., 2011) and eastern Atlantic cod (Hinrichsen, et al., 2016).

ATLANTIC HERRING

In Danish waters, the Atlantic herring is naturally divided into smaller populations that vary morphologically and have different spawning seasons, migration routes, way of life and growth. The Atlantic herring is a demersal spawner, and the eggs are attached to hard substrate or vegetation in relatively shallow areas (Pihl & Wennhage, 2002) (Figure 4-7). The main spawning area of the west Baltic spring spawning herring is around the German Island of Rügen (Munk & Carl, 2019), but autumn spawners also occur, although they are rare (FeBEC, 2013b) (ICES, 2017). Generally, the Atlantic herring have a very flexible utilization of spawning areas (Corten, 2001), and as most areas around Bornholm meet the criteria, it is likely that the areas are utilized sporadically (Figure 4-7). Juvenile Atlantic herring have been observed in higher densities in the Arkona Basin and in the Bornholm Deep, which most likely originate from spawners around Bornholm (Warnar, et al., 2012).

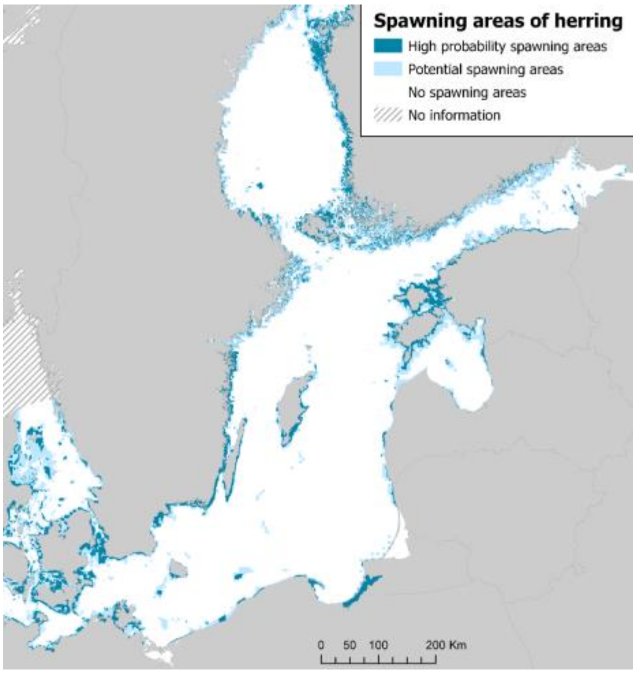


Figure 4-7 High probability (blue) and potential (light blue) spawning areas of Atlantic herring in photic hard bottom areas with vegetation. Source (HELCOM, 2021)

EUROPEAN SPRAT

The European sprat is a pelagic spawner, and the special hydrographical conditions (e.g., low salinity etc.) limits suitable spawning areas in the Baltic Sea. The same limitations exist for the Atlantic cod in the area, and therefore, the spawning areas for the two species coincide. The European sprat also spawns in the deep areas of the western Baltic Sea, i.e., Arkona Basin west of Bornholm, Bornholm Deep east of Bornholm as well as Gdansk Deep and Gotland Deep (Ojaveer, E.; Kalejs, M., 2010) (Baumann, et al., 2006) (Köster, et al., 2005) (Figure 4-8 left). However, eggs of the European sprat have a higher buoyancy and float at lower salinities compared to that of the eggs of the Atlantic cod. Therefore, spawning also occurs for the European sprat in the Gulf of Riga (Ojaveer, E.; Kalejs, M., 2010). Recent surveys indicate that the European sprat no longer spawn in the Gulf of Finland (HELCOM, 2021) (Figure 4-8 right). the European sprat spawn from February to August, however, variations between years occur most likely due to variations in salinity, temperature and food availability (Haslob, 2011) (Ojaveer, E.; Kalejs, M., 2010). The juvenile the European sprat remain pelagic and when small, they remain in coastal areas (Baumann, et al., 2007). Larger juveniles do not have specific nursery areas but occur in most of the Baltic Sea (Baumann, et al., 2008).

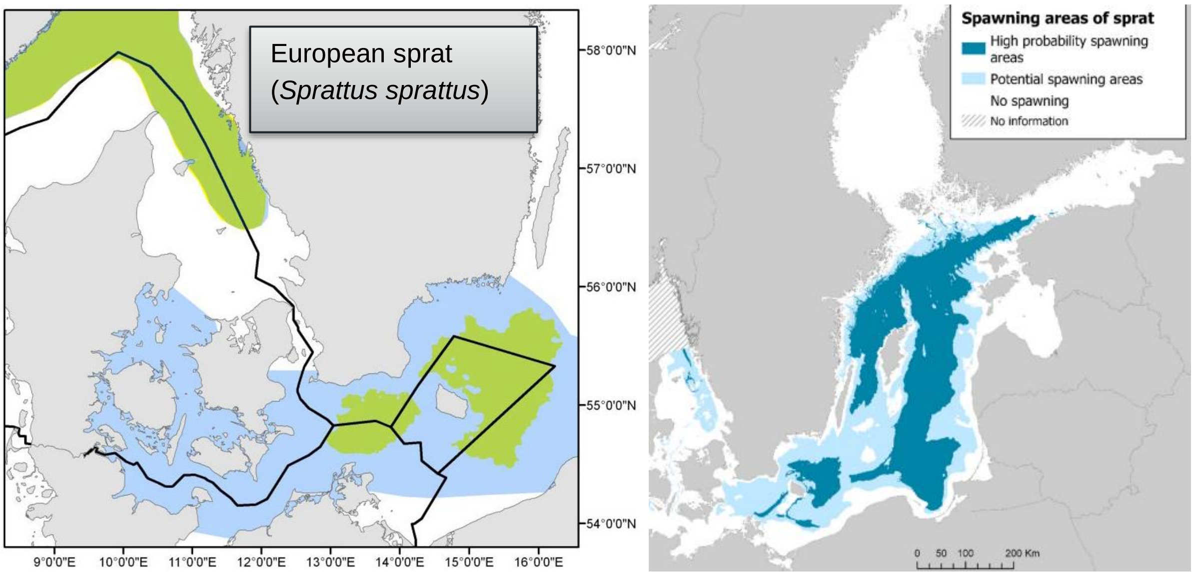
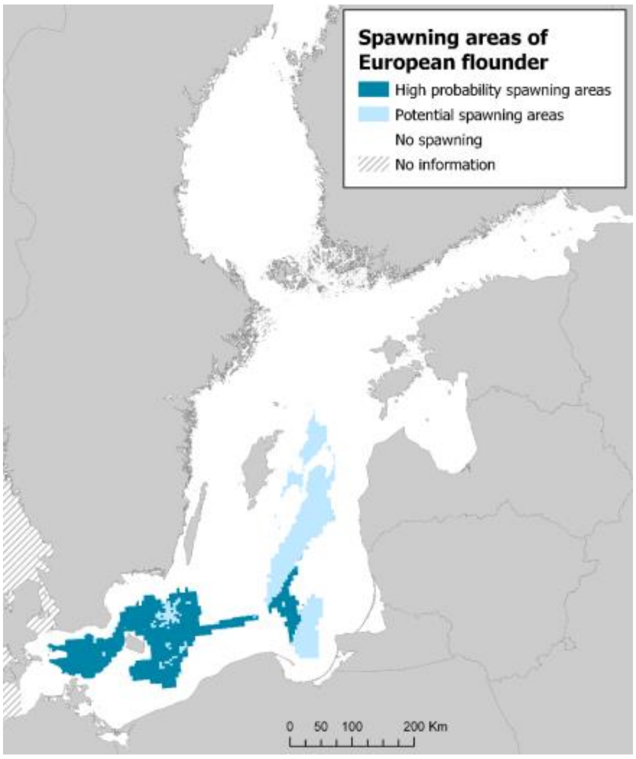


Figure 4-8 Left: The known spawning (green) and nursery areas (blue) for sprat in the western Baltic Sea. Source: (Warnar, et al., 2012). Right: High probability (blue) and potential (light blue) spawning areas of sprat with salinity > 6 ppm and > 30 meters depth (but for the Arkona Basin > 20 meters depth. Source (HELCOM, 2021).

EUROPEAN AND BALTIC FLOUNDER

The two different reproductive strategies (demersal and pelagic) for flounder in the Baltic Sea have long been known, and recently the taxonomical status of flounders in the Baltic Sea was revisited. These two strategies cover two distinct, but closely related species and the demersal spawner was described as the Baltic flounder (Momigliano, et al., 2018). The spawning areas for the European flounder are connected to deeper areas (> 30 meter deep) with saline water above 10 ppm and good oxygen conditions. Therefore, spawning European flounder is primarily found in the Arkona Basin, Bornholm Deep and to a certain degree in the Gdansk Deep and Gotland Deep where the eggs obtain neutral buoyancy (Figure 4-9). The Baltic flounder, on the other hand, prefers coastal/shallow (< 30 meter deep) areas with salinity of > 6 ppm and can reproduce successfully as far north as the Bothnian Sea and the Gulf of Finland, which are also the species preferred habitat range (Momigliano, et al., 2018). The two species share nursery areas when the larvae drift into shallow, sheltered bottoms from June to September, primarily on sandy substrates (HELCOM, 2021) (Figure 4-10). During winter they migrate into deeper waters when water temperature drops.



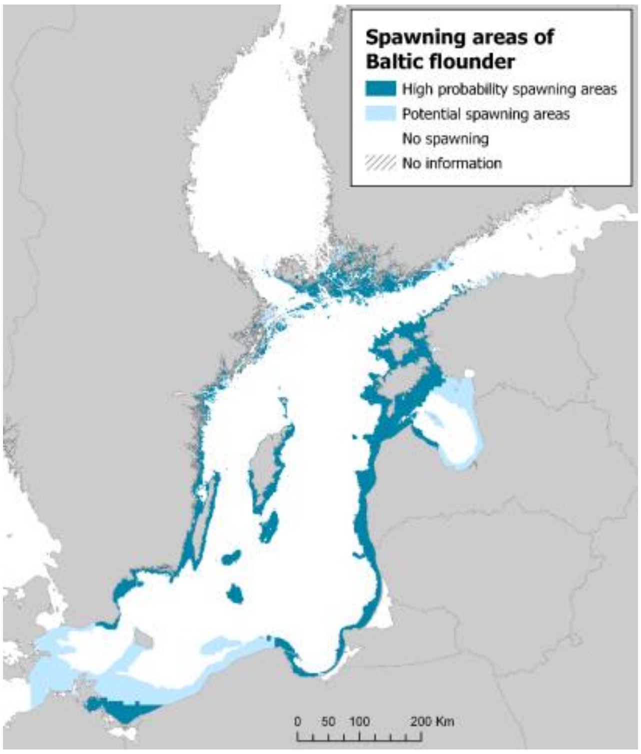


Figure 4-9 Left: High probability (blue) and potential (light blue) spawning areas of European flounder with salinity > 10 ppm, > 30-meter depth and good oxygen conditions. Source (HELCOM, 2021). Right: High probability (blue) and potential (light blue) spawning areas of Baltic flounder with salinity > 6 ppm and < 30 meters depth, due to the demersal nature of the eggs. Source (HELCOM, 2021).

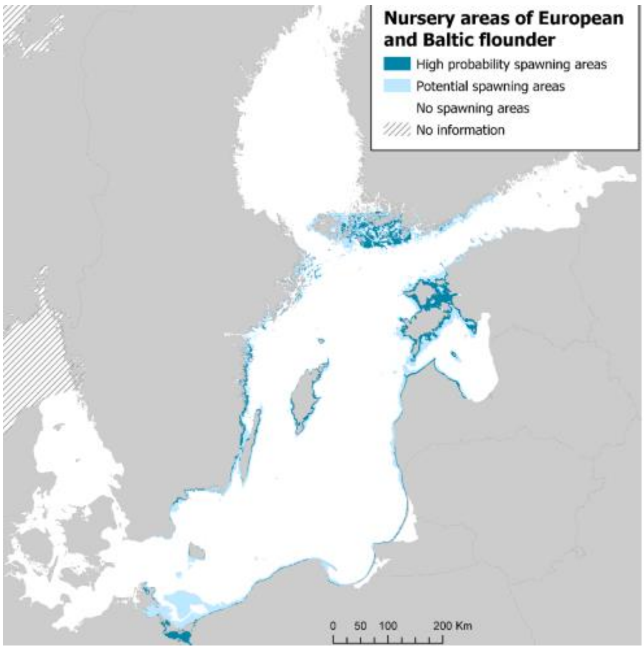


Figure 4-10 High probability (blue) and potential (light blue) nursery areas for European and Baltic flounder regarding salinity, wave exposure, water depth, slope of the bottom, surface temperature, bottom currents and distance to high probability spawning area for flounder. Source (HELCOM, 2021).

4.2.3 PROTECTED FISH SPECIES AND HABITATS

The Habitat Directive ensures the conservation of rare, threatened, or endemic plant- and animal species as well as rare or characteristic habitat types. The directive holds a list of animals, plants, and habitat types which the member states are obliged to protect both inside and outside of the Natura 2000 areas. The lists are the Annex II species, Annex IV species and Annex V species, where Annex II is the least restricted and Annex V the most restrictive.

The species on Annex II are attached with such strict regulations that habitats have been appointed where the species are protected, and these sites must be managed in accordance with the ecological needs of the species. Species on Annex IV are covered by a strict regime, and they must be protected across their entire natural range within the EU, both within and outside Natura 2000 classified sites. For the species listed on Annex V, the member states must ensure that any exploitation of the areas complies with a favourable conservation status for the listed species.

PROTECTED FISH SPECIES

Annex II enfolds six fish species including the sea lamprey, and in addition, several more fish species are listed as decreasing, vulnerable or endangered on the International Union for Conservation of Nature's (IUCN) Red List, which was last updated in Denmark in 2019 (Carl & Møller, 2019) (Table 4-2). Several of these species are registered in the pre-investigation area of ENOE OWF according to Fiskeatlas (Fiskeatlas, 2022).

Table 4-2 List of Danish marine fish species listed in the Habitats Directive Annex II, IV and X or on the IUCN's Red List (Carl & Møller, 2019), CR = Critically Endangered; LC = Least Concern; EN = Endangered, NT = Not Threatened, VU = Vulnerable. *Fiskeatlas registrations in the pre-investigation area of ENOE OWF.

Latin name	Species	Habitats Directive			IUCN Red List	Registered in the pre-investigation area*
		II	IV	V		
Acipenser gueldenstaedtii	Danube sturgeon				CR	x
Acipenser oxyrinchus	West Atlantic sturgeon				NT	x
Acipenser sturio	European Sturgeon	x	x		CR	x
Alosa alosa	Allis shad	x		x	LC	
Alosa fallax	Twaite shad	x		x	LC	x
Anguilla anguilla	European eel				CR	x
Gadus morhua	Atlantic cod				VU	x
Hippoglossum hippoglossus	Atlantic halibut				EN	
Lampetra fluviatilis	River lamprey	x		x	LC	
Petromyzon marinus	Sea lamprey	x			LC	x
Salmo salar	Atlantic salmon	x		x	LC	x

Species in Annex IV include European sturgeon (*Acipenser sturio*), which, according to Fiskeatlas registrations, has been observed in the pre-investigation area of ENOE OWF on two occasions (Fiskeatlas, 2022). The Fiskeatlas data only holds information on the frequency of the observations and not timing or number of individuals observed. In addition to the sturgeon, also Atlantic sturgeon (*Acipenser oxyrinchus*) and Danube sturgeon (*Acipenser gueldenstaedtii*), also known as Russian sturgeon, have been observed on four occasions each. The observations of the critically endangered sturgeon are all believed to originate from reared and released individuals (pers. comm. Henrik Carl, Fiskeatlas). Attempts to restore the natural population of sturgeons are currently taking place in German, French and Dutch rivers (Kirschbaum, 2011) (Brevé, 2018) and it is believed that few of the sturgeons have travelled from their release sites to Danish waters to forage. The largest threat to sturgeons is bycatch in the commercial fishery and loss of habitat in the rivers where they spawn. The sturgeon does not spawn in Denmark and never has (Møller & Carl, 2019).

The Annex II-species, sea lamprey (*Petromyzon marinus*), has been registered in the pre-investigation area ENOE OWF on eight occasions. All the observed individuals were in their parasitic juvenile stage attached to cod sucking blood from the host. The lamprey cuts a hole in the host with its horn-like teeth and excretes a secrete dissolving the tissue and preventing the blood from coagulating. All species of lamprey spawn in freshwater.

The Twaite shad, an additional Annex II-species, has also been registered in the pre-investigation area. According to the Fiskeatlas, the species has been observed on 38 different occasions – more precisely, it has been observed seven times in the Bornholm I Nord and Bornholm I Syd, two times in the Bornholm II, two times in the CC near Bornholm, and the species were observed the remaining 27 occasions in the additional pre-investigation area outside of OWF and CC. In addition, two observations of twaite were made in the commercial fisheries in 2010 in ICES-rectangle 39G4. The Twaite shad is widespread in the Baltic Sea but the area near Bornholm and the pre-investigation area are not a particularly suited habitats for the species. Twaite shad spawns in large river mouths (Muus & Nielsen, 2006), and thus, not near the planned Energy Island.

The European eel (*Anguilla anguilla*) is assessed as critically endangered according to the IUCN Red List, and the species is regularly observed in and near the pre-investigation area. The population – based on returning glass eel – has experienced a large decline for the past 50 years and is now estimated to decreased over the past four or five decades to merely 1% of the population size in the 1970s, and in 2009 further decline (ICES, 2009). The species reproduce in the Sargasso Sea, and eel larvae are transported with oceanic currents to the European coasts where they metamorphose into glass eel. When they reach freshwater streams, they later change appearance into what is known as yellow eels. After 5-20 years in fresh or brackish water, they transform into silver eels and migrate back to the Sargasso Sea.

The Atlantic cod in the Baltic Sea is in severe distress and considered vulnerable (Carl & Møller, 2019). The eastern population of cod in the Baltic Sea has exhibited a decline in biomass since the 1980s and a deteriorating nutritional condition since the 1990s (Casini, et al., 2016). This has occurred while the oxygen level in the Baltic Sea has decreased, and prey biomass has diminished (Neuenfeldt, et al., 2020). The Baltic strain of the Atlantic cod is now historically malnourished and growth impaired (Hüssy, et al., 2018). Even though a fishing ban was introduced in 2019, the Atlantic cod stock shows no sign of recovery and natural mortality is still high (ICES, 2019). A parasitic liver worm transmitted from the grey seal has been observed in the Atlantic cod in the Baltic Sea since the early 2010s (Haarder, et al., 2014), which has coincided with further deterioration of the poor health status and stock decline of the fish (Eero, et al., 2012). The parasite migrates to the liver after the Atlantic cod has ingested smaller infected prey items such as sprat, and larger individuals, thus, accumulating a larger parasitic burden over time (Zuo, et al., 2016). Recent studies have shown up to 19 liver worms per gram liver tissue in Baltic strain of the Atlantic cod, and it is possible that the most heavily infected fish exhibit impaired swimming performance with a reduced chance of catching prey and avoiding predators (Plambech Ryberg, et al., 2020).

PROTECTED HABITATS

Local Natura 2000 sites and Habitat areas are shown in Figure 4-11. The pre-investigation area occupies N252 / Habitat area H261 “Adler Grund and Rønne Banke” south of Bornholm, between Bornholm I Nord, Bornholm I Syd and Bornholm II. The area is appointed for its protected habitat type, reef (1170), and sandbanks (1110), as well as protection of the Baltic Sea population of harbour porpoise (1351) (MST, 2021). There are no fish species that constitutes the reason for designation, however, the reefs constitute an important spawning- and nursery area for several fish species. The reef area has been closed for dredging fishing gear since 2017 as this destructive fishing method poses a threat to the habitat type. The ban on dredging fishing gear has a beneficial effect on cod and herring/sprat, which are the main feed objects of harbour porpoise.

The Natura 2000 site 212 and Habitat area H212 ”Bakkebrædt and Bakkegrund” is also positioned in the pre-investigation area, between Bornholm I Nord and Bornholm II near the CC. The area is appointed for its protected habitat type reef (1170) and sandbanks (1110) (MST, 2021). Both “Adler Grund and Rønne Banke” and ”Bakkebrædt and Bakkegrund” are important habitats for fish species that find shelter and prey on the reef. Dredging has been banned here since 2016.

Natura 2000 site 211 and Habitat area H211 ”Hvideodde Rev” is positioned just north of the pre-investigation area south west of Bornholm. The area is appointed for its protected habitat type reef (1170) (MST, 2021). Dredging is not permitted here due to the threat it poses against the protected reefs.

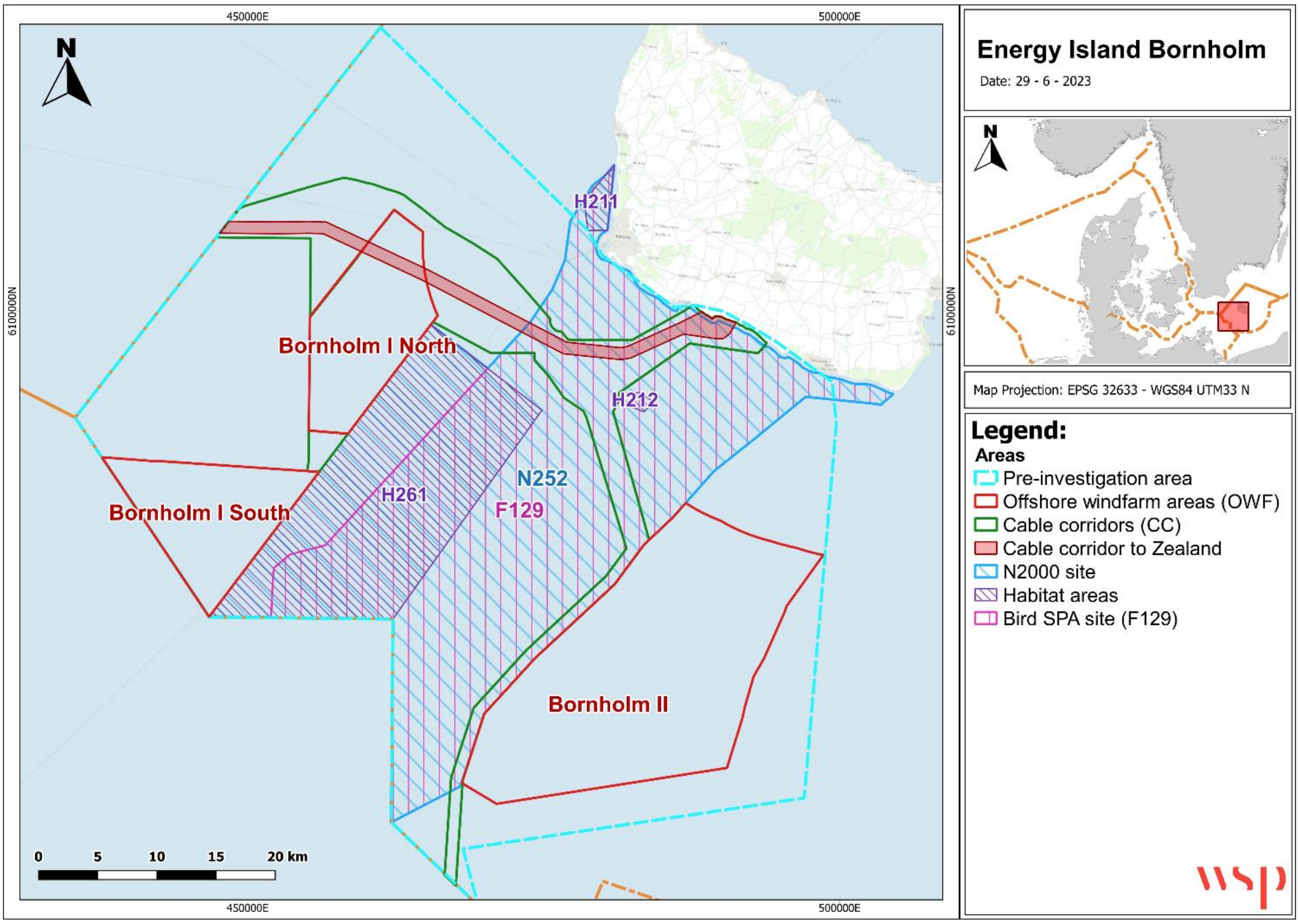


Figure 4-11 Natura 2000 sites and Habitat areas in the pre-investigation area of ENOE OWF.

5 SURVEY DATA

Presented below are data collected from the pre-investigation area for ENOE OWF during the spring and the autumn surveys. This data includes information on both abiotic and biological parameters. Abiotic conditions include CTDO-measurements, and biological parameters include fish fauna. Finally, indications of fish utilizing the pre-investigation area as spawning or nursery areas are described.

5.1 ABIOTIC DATA

Measurements of CTDO showed a slightly higher oxygen content in spring compared to the autumn (Table 5-1). For both spring and autumn, the oxygen levels were within regular levels. Oxygen deficiency was not registered in the 2022 NOVANA data west of Bornholm (Hansen, 2022). The range of salinity varied greatly in spring from 10 to 16 PSU. Temperature also varied more in spring compared to the autumn.

Table 5-1 Range of oxygen, salinity, temperature, and depth at sea surface, survey data 2022

	Oxygen (mg, L)	Salinity (PSU)	Temperature (°C)	Depth, m
Spring	12.8-14.1	10.0-16.0	6.1-9.2	1.0
Autumn	9.5-10.7	12.0-15.0	10.2-14.8	1.0

5.2 FISH DATA

In the following sections, an analysis of fish catches from spring and autumn survey, respectively is presented. The data also illustrates whether the pre-investigation area was used as nursery and/or spawning areas. Key species from the catches in the spring- and autumn surveys are elaborated.

The density of fish is generally known to be low in the Baltic Sea. The fish catches from the present study were naturally biased towards benthic and demersal species, as the majority of the fish were caught in the beam trawl. Trawling was only possible on sandy or muddy areas where benthic and demersal species dominate. However, since the aim of the report was to carry out a baseline mapping of fish and fish populations, occurring in the pre-investigation area of ENOE OWF, and to assess whether the area serves as a spawning- and/or nursery area, beam trawl, supplemented by multimesh gillnets and trammel net, was ideal.

Fish species that were dominant in the catches here or are of commercially importance have been described in more detail and data of these species were analyzed further. Species caught in low numbers were believed to be of less ecological importance or merely passing through the area, and these species were not analyzed in further detail.

5.2.1 OVERALL CATCHES

A total of 1,449 fish were caught – 526 in spring and 922 in autumn, representing 22 different species. In spring, a total of 17 species were caught, and in autumn 16 species. The spring catches amounted to 100 kg, and the autumn catches to 177 kg – a total of 277 kg.

The spring catches in beam trawl, gillnets and trammel nets was dominated by flatfish which comprised 80 % of the catch, with flatfish comprising five out of 17 species. The most abundant species in the spring catches were European flounder and European plaice (Table 5-2), making up 55 % and 22 % of the catch, respectively. In terms of weight, Atlantic cod, turbot, and shorthorn sculpin were also important species in the catch.

The autumn catches in beam trawl, multimesh gillnets and trammel nets consisted mainly of flatfish, which comprised 82 % of the catch, representing five of the 16 different fish species. The dominant species in the autumn catches were European flounder and European plaice (Table 5-3), making up 51 % and 29 % of the catch in terms of number, respectively. In terms of weight, European flounder and European plaice also comprised the majority of the catches with 58 % and 25 % of the total weight of the catch. Atlantic cod comprised approximately 13 % of the total weight of the catch in the autumn survey.

The number of species caught was slightly higher in the spring survey (17 species) compared to the autumn survey (16 species). The variation in abundance between stations was greater in autumn, where a total of 924 fish were caught, whereas spring catches amounted to a total of 526 fish. In the spring catches, the average weight on the various stations was higher for trammel nets (approximately 2,500 gram) than for multimesh gillnets (1,650 gram). In the autumn catches, however, the opposite was the case with the average weight of the catch in multimesh gillnets being slightly higher (1,928 gram) than for trammel nets (1,837 gram).

Table 5-2 Fish catches from the spring survey in beam trawl, multimesh gillnet and trammel net.

SPECIES	LATIN NAMES	BEAM TRAWL	MULTIMESH GILLNET	TRAMMEL NET	TOTAL
Atlantic cod	*Gadus morhua*	16	30	5	51
Atlantic herring	*Clupea harengus*		9		9
Common dab	*Limanda limanda*	3			3
Common sole	*Solea solea*	3			3
Eelpout	*Zoarces Viviparus*		1		1
European flounder	*Platichthys flesus*	237	13	41	291
European plaice	*Pleuronectes platessa*	105	3	7	115
Fourbeard rockling	*Enchelyopus cimbrius*		5		5
Great sandeel	*Hyperoplus lanceolatus*	1			1
Hooknose	*Agonus cataphractus*	2			2
Round goby	*Neogobius melanostomus*		2		2
Sand goby	*Pomatoschistus minutus*	15			15
Sea stickleback	*Spinachia spinachia*	1			1

Shorthorn sculpin	*Myoxocephalus scorpius*	11	4		15
European Sprat	*Sprattus sprattus*		1		1
Turbot	*Scopthalmus maximus*	8		1	9
Whiting	*Merlangius merlangus*		2		2
Total		402	70	54	526

Table 5-3 Fish catches from the autumn survey in beam trawl, multimesh gillnet and trammel net.

SPECIES	LATIN NAMES	BEAM TRAWL	MULTIMESH GILLNET	TRAMMEL NET	TOTAL
Atlantic cod	*Gadus morhua*	45	51	12	**108**
Atlantic herring	*Clupea harengus*		7		**7**
Common dab	*Limanda limanda*	2			**2**
Common sole	*Solea solea*	1			**1**
Eelpout	*Zoarces viviparus*		1		**1**
European flounder	*Platichthys flesus*	433	4	30	**467**
European plaice	*Pleuronectes platessa*	259	7	4	**270**
Fourbeard rockling	*Enchelyopus cimbrius*	1			**1**
Garfish	*Belone belone*	1			**1**
Great sandeel	*Hyperoplus lanceolatus*		1		**1**
Hooknose	*Agonus cataphractus*	2			**2**
Sand goby	*Pomatoschistus minutus*	10			**10**
Shorthorn sculpin	*Myoxocephalus scorpius*	7	2		**9**
Three-spined stickleback	*Gasterosteus aculeatus*	25			**25**
Turbot	*Scopthalmus maximus*	13			**13**
Whiting	*Merlangius merlangus*	1	3		**4**
Total		**800**	**76**	**46**	**922**

5.2.2 BEAM TRAWL CATCHES

The average biomass for beam trawl catches pr. station was significantly greater (almost doubled) in the autumn, with 857 grams of fish pr. 1,000 m^2, compared to spring, with 412 grams of fish pr. 1,000 m^2.

Overall, flatfish comprised 81 % of the catches with beam trawl and the dominating species in spring and autumn were European flounder and European plaice. And the species were caught on 86 % of the stations in the spring survey and all stations in the autumn survey.

Atlantic cod was also a dominant species in both the spring- and autumn catches, and in the spring turbot, and shorthorn sculpin as well.

The largest biomass and abundance were fished at station BT07 in the southeastern corner of the pre-investigation area (quaternary clay and silt) in the spring and in the autumn BT15 (muddy sand), in the western part of the pre-investigation area had the highest biomass and highest abundance of fish, although the biomass was generally low (<500 gram) on most stations in both spring and autumn. Station BT02 (autumn) and BT13 (spring) had the highest biodiversity scores.

SPRING

ABUNDANCE

The catch was converted into Catch Per Unit Effort (CPUE) of 1,000 m^2 to consider the different trawl lengths. The density of fish per 1,000 m^2 varied from 0.2 to 10.2 fish for the various stations. Station BT07, in the south-eastern part of the area (Figure 5-1), was the beam trawl station with the highest abundance of fish, with 10.2 fish per 1,000 m^2 Table 5-4). The sediment type in station BT07 was quaternary clay and silt. This was more than 40 times the abundance caught at station BT01 (Figure 5-1), where only 0.2 fish per 1,000m^2 was caught, and therefore had the lowest density of fish. All the other stations had a low density of fish (<5 fish pr. 1,000 m^2).

The spring catches in beam trawl, gillnets and trammel nets consisted mainly of flatfish which comprised 80 % of the catch with five species out of a total of 17 being flatfish. The most abundant species in the spring catches were European flounder and European plaice (Table 5-4), making up 55 % and 22 % of the catch, respectively. In terms of weight, Atlantic cod, turbot, and shorthorn sculpin were also dominant species in the catch.

Table 5-4 The total fish abundance from beam trawl catches in the pre-investigation area of ENOE OWF spring survey 2022. The catch has been converted to Catch Per Unit Effort (CPUE = 1,000m^2). No fish were caught in stations BT17 and BT18.

NO/1,000 M^2	BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08	BT09	BT11	BT13	BT14	BT15	BT16
Atlantic cod		0.24	0.09		0.08	0.09					0.26	0.31	0.27	
Common dab		0.08											0.18	
Common sole		0.08										0.08		0.08
European flounder	0.23	0.49	0.44	1.18		0.70	9.11	0.27	3.31	0.32	2.01	0.39	1.09	1.77
European plaice		3.17		0.63	0.16	0.09	0.93		0.19	0.32	0.61	0.16	1.64	1.00
Great sandeel											0.09			
Hooknose							0.09				0.09			
Sand goby				0.73			0.09		0.10		0.35		0.09	
Sea stickleback				0.09										
Shorthorn sculpin				0.45							0.52			
Turbot				0.09	0.16					0.24	0.17			

Total	**0.2**	**4.1**	**0.5**	**3.2**	**0.4**	**0.9**	**10.2**	**0.3**	**3.6**	**0.9**	**4.1**	**0.9**	**3.3**	**2.8**	
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock															

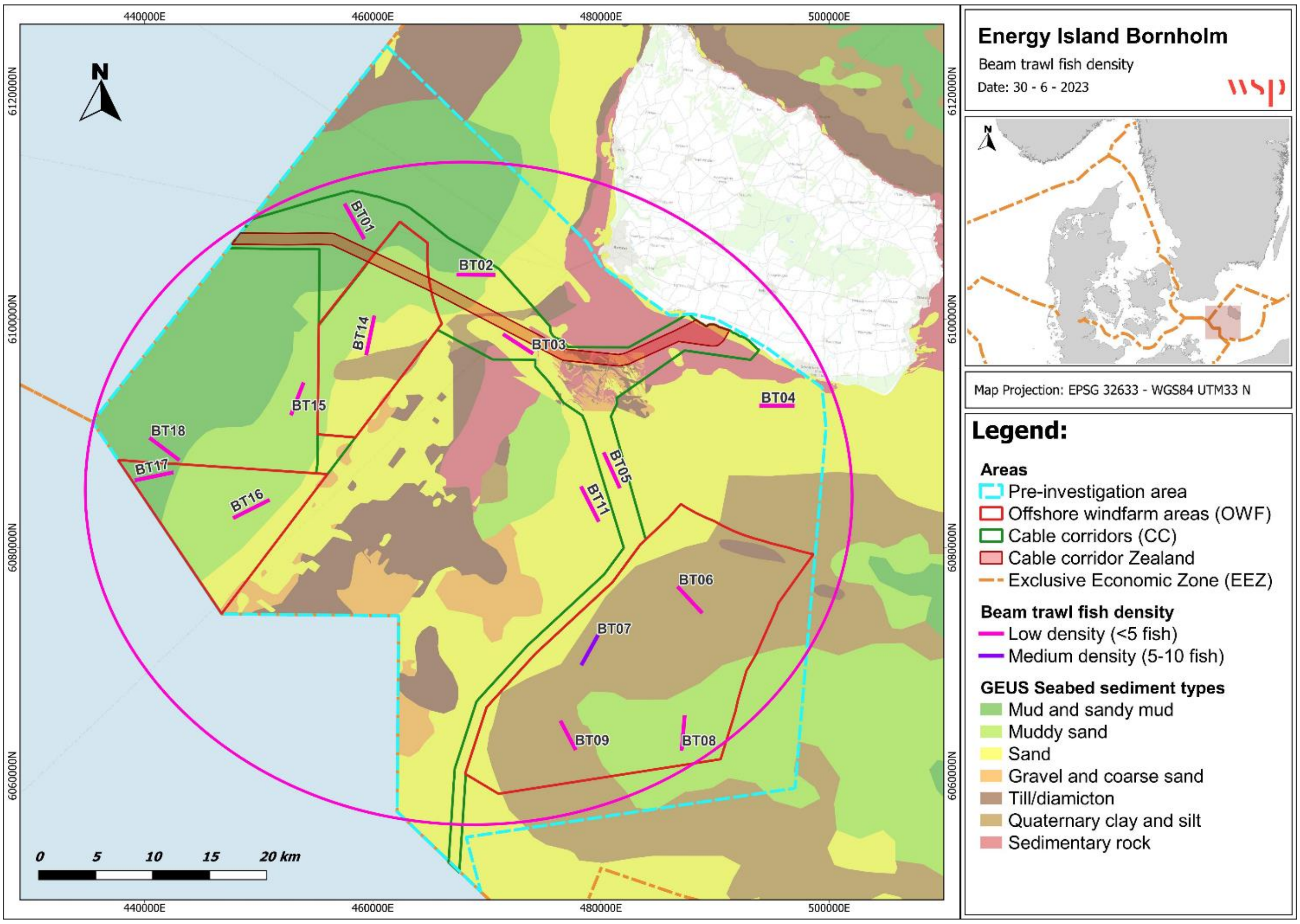


Figure 5-1 The fish density from beam trawl catches in the pre-investigation area of ENOE OWF spring survey 2022.

BIOMASS

The weight of the spring catch was also converted into CPUE per 1,000m^2 (Table 5-5). Again, station BT07 was the station with the largest biomass of 1.7 kilo fish pr. 1,000m^2. Stations BT01 and BT08, in the central part of the area (Figure 5-2), were the stations with the lowest value of less than 50 grams of fish pr. 1,000m^2.

Table 5-5 The total fish biomass from beam trawl catches in the pre-investigation area of ENOE OWF spring survey 2022. The catch has been converted to CPUE = 1,000m^2. No fish were caught in stations BT17 and BT18.

GRAM / 1,000 M^2	BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08	BT09	BT11	BT13	BT14	BT15	BT16
Atlantic cod		28.41	70.14		28.10	1.75					33.41	61.49	22.31	

Common dab		10.55											25.49	
Common sole		6.09										21.02		14.16
European flounder	80.00	83.19	110.99	172.08		122.10	1560.0 0	49.41	602.94	57.05	440.84	79.78	198.49	355.36
European plaice		350.19		80.24	30,11	10.50	105,55		16.55	71.41	115.46	13.23	190.75	105.89
Great sandeel											1.05			
Hooknose							0.74				2.62			
Sand goby				0.73			0.09		0.10		0.35		0.09	
Sea stickleback				0.27										
Shorthorn sculpin				48.05							79.77			
Turbot				15.87	42.16					95.34	228.81			
Total	**80.0**	**478.4**	**181.1**	**317.2**	**100.4**	**134.4**	**1666.4**	**49.4**	**619.6**	**223.8**	**902.3**	**175.5**	**437.1**	**475.4**
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock														

The biomass of catches was converted into CPUE, gram per 1,000 m^2, and varied from 0-1.67 for the various stations. A predominant number of the stations had a low biomass in catches (<500 gram). However, station BT07 (1,666.4 gram), had the highest biomass and BT09 (619.6 gram) and BT13 (902.3 gram) a medium biomass (500-1,500 gram). The stations with medium to high biomass were all located in the south-eastern corner of the pre-investigation area, where sediment types were gravel and coarse sand, and quaternary clay and silt. See Figure 5-2 for an overview of the biomass for the various stations.

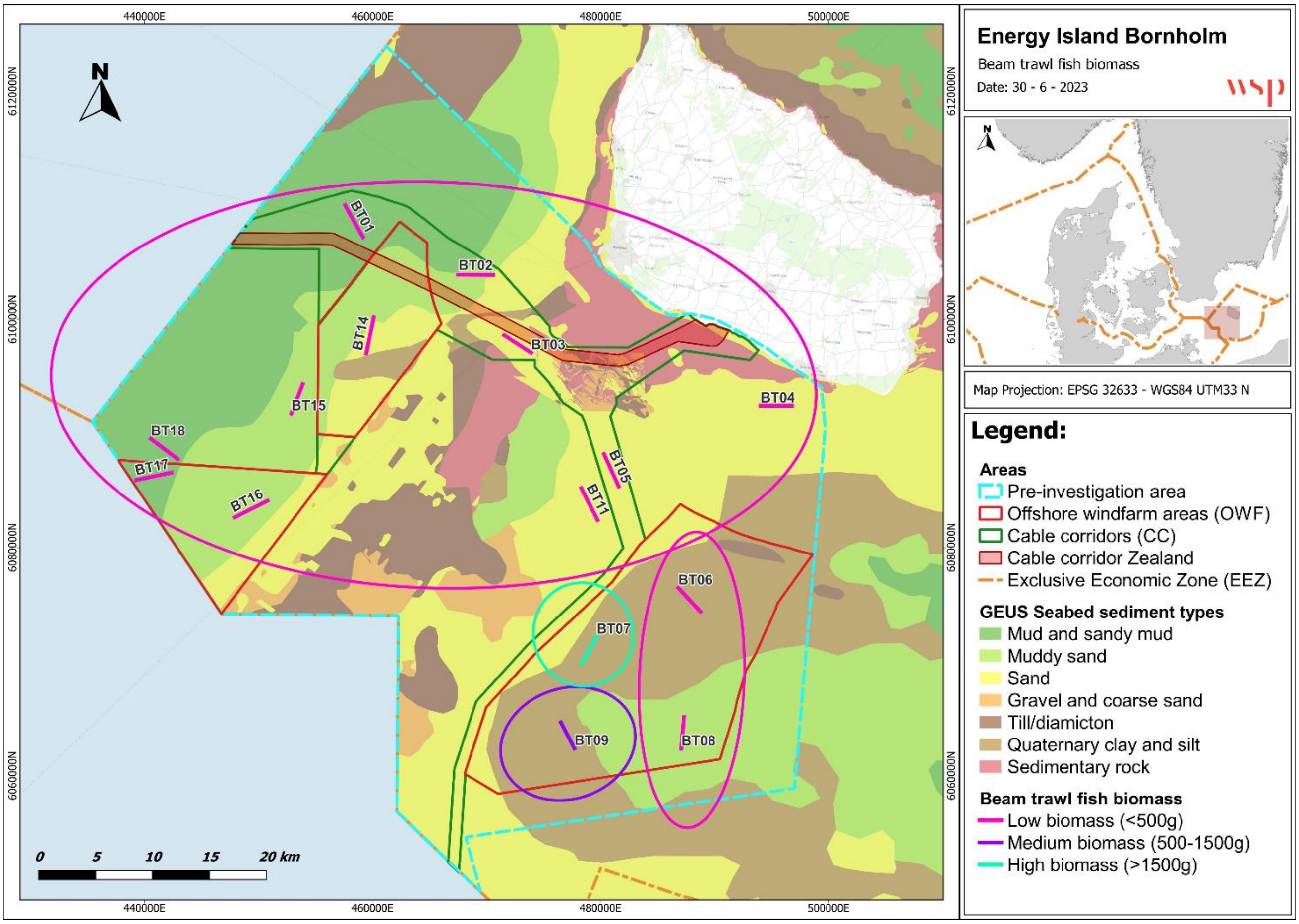


Figure 5-2 The fish biomass from beam trawl catches in the pre-investigation area of ENOE OWF spring survey 2022.

BIODIVERSITY

The biodiversity on beam trawl stations varied from one to eight species per station (Figure 5-3). Most stations had a low score (<five species). However, four stations (BT02, BT04, BT13 and BT15) had a medium score (5-10 species). These stations were located in areas where sediment type consisted primarily of sand, muddy sand and gravel, and coarse sand. BT13 had the highest biodiversity, with a seabed sediment type consisting of gravel and coarse sand.

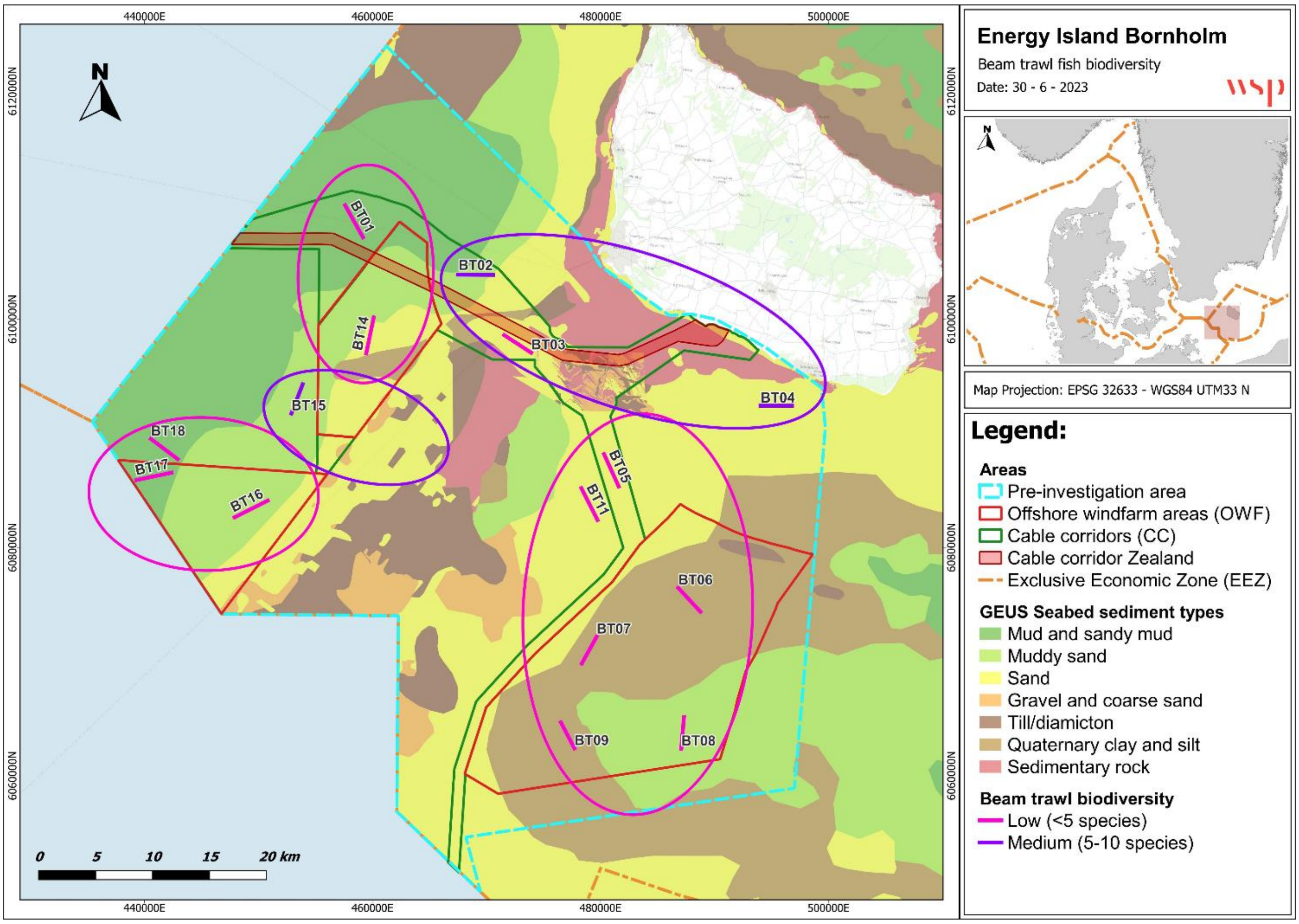


Figure 5-3 The biodiversity on beam trawl stations in the pre-investigation area of ENOE OWF spring survey 2022.

AUTUMN

ABUNDANCE

The beam trawl catches were converted into CPUE of 1000 m^2 to consider the different trawl lengths. The catches varied between <1 fish and up to 12 fish per 1000 m^2. Station BT15, in the western part of the area, was the station with the highest abundance of fish, with 12 fish per 1000 m^2 (Figure 5-4). This was nearly 13 times the abundance caught on station BT8 where <1 fish per 1000 m^2 was caught.

The autumn catches in beam trawl, multimesh gillnets and trammel nets consisted mainly of flatfish, which comprised 82 % of the catch, representing 5 of the 16 different fish species. The most abundant species, in the autumn catches, were European flounder and European plaice (Table 5-6), making up 51 % and 29 % of the catch in terms of number, respectively. In terms of weight, European flounder and European plaice also comprised the majority of the catches with 58 % and 25 % of the total weight of the catch. Atlantic cod comprised approximately 13 % of the total weight of the catch in the autumn survey.

Table 5-6 The total fish abundance in the pre-investigation area for ENOE OWF from the autumn survey 2022, caught with beam trawl. The catch has been converted to Catch Per Unit Effort (CPUE = 1,000 m²).

STATION	BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08	BT09	BT11	BT14	BT15	BT16	BT17	BT18
Area (m^2)	**9092**	**10660**	**12172**	**12124**	**10464**	**11756**	**11064**	**11504**	**10812**	**11924**	**10488**	**11128**	**13024**	**13364**	**11596**
Atlantic cod		0.38	0.08			0.26		0.35			0.19	0.45	1.15	0.75	0.09
Common dab	0.11		0.08												
Common sole		0.09													
European flounder	3.41	3.75	0.90	0.41	1.62	2.38	6.78	0.26	1.66	1.26	1.14	6.02	2.30	3.89	2.50
European plaice	3.19	4.60	0.16	0.41	0.29	0.51	0.36	0.35	0.37	0.75	2.67	3.06	1.15	2.32	3.10
Fourbeard rockling															0.09
Garfish												0.09			
Hooknose		0.09					0.09								
Sand goby		0.28			0.10							0.36	0.08	0.00	0.09
Shorthorn sculpin		0.09	0.16		0.10	0.00	0.18			0.08					
Three-spined stickleback												2.07			0.17
Turbot		0.09	0.08	0.33	0.38					0.25					
Whiting														0.07	
Total	**6.71**	**9.38**	**1.48**	**1.15**	**2.48**	**3.15**	**7.41**	**0.96**	**2.03**	**2.35**	**4.00**	**12.04**	**4.68**	**7.03**	**6.04**
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock															

There was generally a low abundance of fish on the sampled stations, however, there were no clear tendencies towards low abundance occurring on certain sediment types (Figure 5-4).

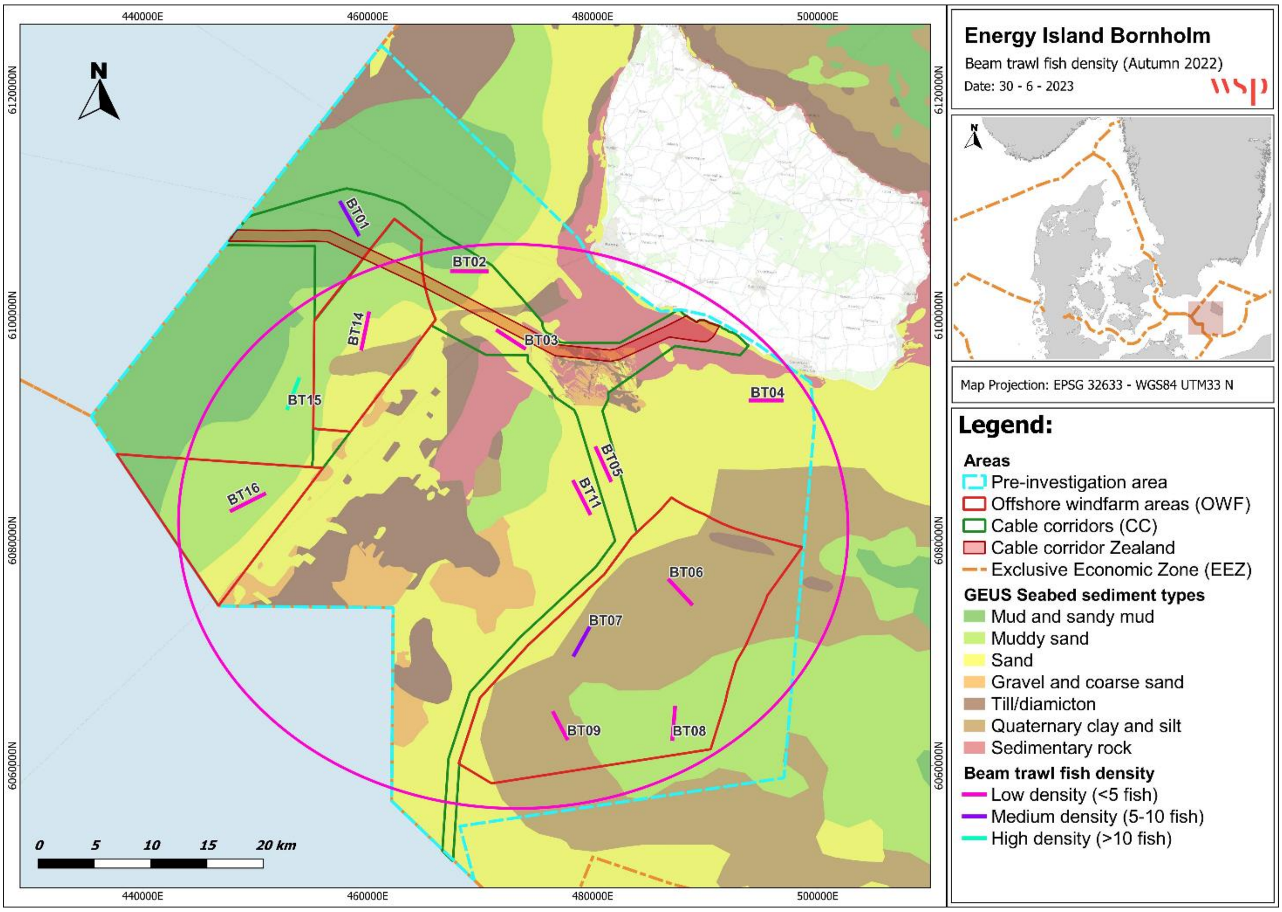


Figure 5-4 The fish abundance in CPUE 1,000 m² for each sampled station in the autumn survey.

BIOMASS

The weight of the beam trawl autumn catch was also converted into CPUE per 1,000m² (Table 5-7). Again, station BT15, in the western part of the area, had the highest value, with a total of 1,908 gram of fish per 1,000 m². Station BT4, BT8 and BT3 had the lowest biomass of just 157-251 gram of fish per 1,000 m², respectively (Figure 5-5).

Table 5-7 The total fish biomass from beam trawl catches in the pre-investigation area of ENOE OWF autumn survey 2022. The catch has been converted to CPUE = 1,000m².

G FISH PR. 1,000 M²	BT01	BT02	BT03	BT04	BT05	BT06	BT07	BT08	BT09	BT11	BT14	BT15	BT16	BT17	BT18
Area, m²	**9092**	**10660**	**12172**	**12124**	**10464**	**11756**	**11064**	**11504**	**10812**	**11924**	**10488**	**11128**	**13024**	**13364**	**11596**
Atlantic cod		39.4	24.65			24.67		56.5			33.85	27.68	119.8	165.1	0.862
Atlantic herring															
Common dab	13.2		23.41												
Common sole		8.912													
Eelpout															
European flounder	586.8	748.6	151.2	72.58	410.9	437.6	1396	55.63	320.5	324.1	228.4	1379	544.8	869.1	583.4
European plaice	448.2	681.5	18.9	44.95	34.4	56.82	70.5	49.98	56.42	169.8	397.1	490.7	321.3	488.6	498.4
Fourbeard rockling															12.07
Garfish												4.493			
Great sandeel															

Hooknose		2.814					1.356								
Sand goby		0.281			0.478							0.359	0.077		0.086
Shorthorn sculpin		9.381	8.216		9.557		49.26			19.29					
Three-spined stickleback												6.201			0.69
Turbot		26.27	24.65	39.18	107					51.58					
Whiting														11.6	
Total	**1048**	**1517**	**251**	**156.7**	**562.4**	**519.1**	**1517**	**162.1**	**376.9**	**564.8**	**659.3**	**1908**	**985.9**	**1534**	**1096**
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock															

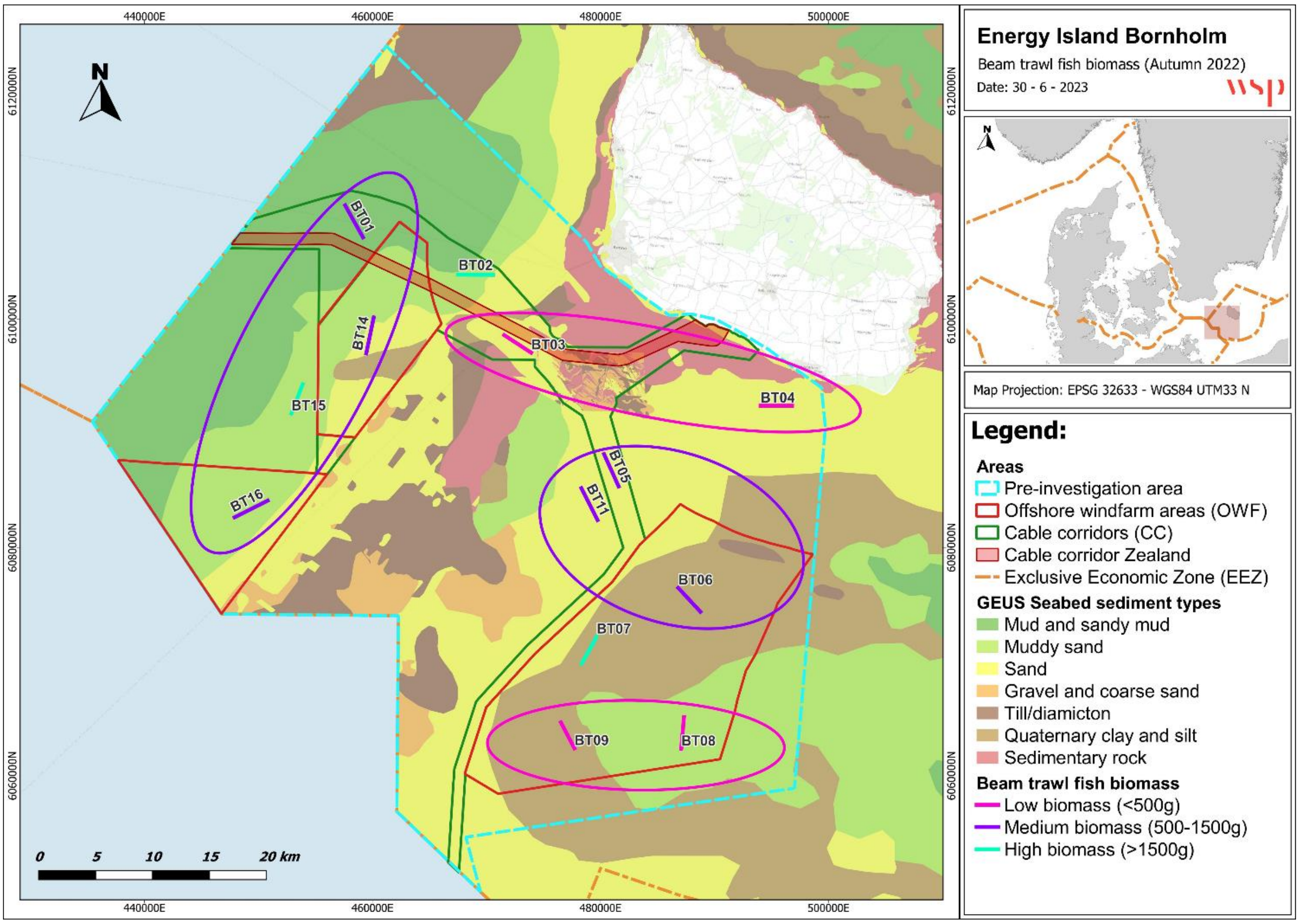


Figure 5-5 Fish beam trawl biomass in CPUE 1,000 m² for each sampled station in the autumn survey of the pre-investigation area of ENOE OWF.

BIODIVERSITY

The biodiversity on beam trawl stations varied from zero to eight species per station for the various stations in the autumn survey (Figure 5-6). Most stations had a low score (<5 species). However, in the autumn, six stations (BT2, BT3, BT5, BT7, BT15, and BT18) had a medium score (5-10 species), which were higher in comparison to the spring survey, where only four stations had a medium number of species. In the autumn, stations BT3, BT5, BT13 and BT15 were more diverse than in the spring, whereas stations BT4 and BT13 were less diverse than in the spring. BT02 was the station with the highest biodiversity, of eight species, with sediment type consisting of muddy sand.

The dominating species in the autumn catches were the European flounder and European plaice, which were registered from catches at all stations in the autumn survey.

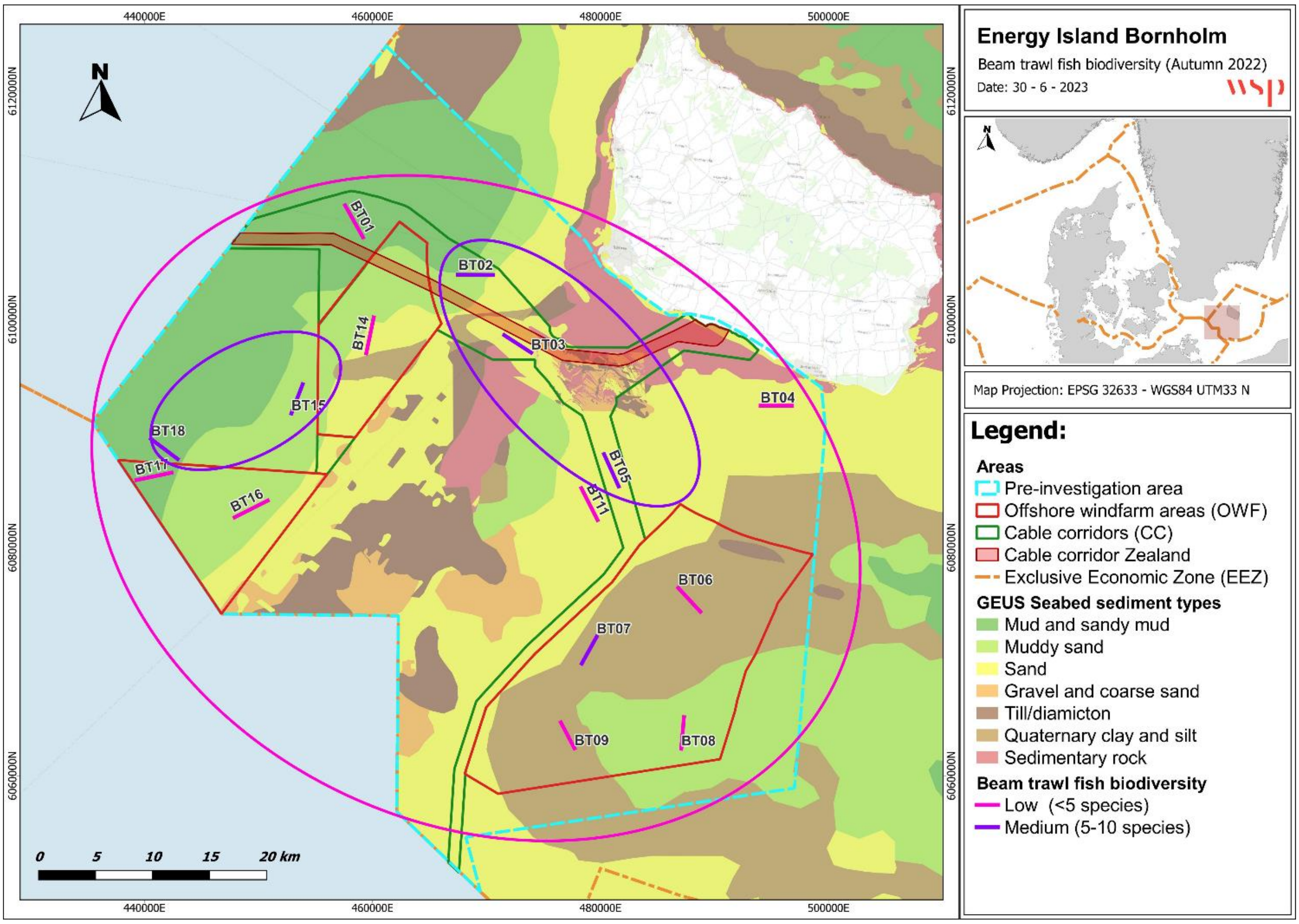


Figure 5-6 Biodiversity of catches with beam trawl in the autumn survey of the ENOE OWF pre-investigation area.

5.2.3 MULTIMESH GILLNETS

The spring catches in multimesh gillnet were dominated by European flounder and Atlantic cod (Figure 5-8). European plaice and Atlantic herring were also important species in the catches with net. In the autumn, Atlantic cod dominated the catch with multimesh gillnet. European flounder and European plaice were also important species in the autumn. In the spring catches, the average weight on the various stations was approximately 1.650 gram). In the autumn catches, the average weight of the catch in multimesh gillnets was slightly higher 1.928 gram.

SPRING

ABUNDANCE

In the spring survey, the European flounder and the Atlantic cod dominated the catch in the multimesh gillnets, followed by the European plaice (Figure 5-8). The catch was converted into Catch Per Unit Effort (CPUE) to analyse the catch according to the fishing effort i.e., fish caught per net per day. The quantity of fish varied from 1-13 fish in multimesh gillnet per net per day for the various stations. Station MG04 had the highest catch, with a total of 13 fish per net per day, 70 % hereof was constituted by Atlantic herring. Station MG04 had a CPUE in catches of 13, which was 13 times the CPUE at MG09, which had the lowest CPUE of one.

The total catch in multimesh gillnets varied from 1-13 fish for the various stations (Figure 5-8). Station MG01 and MG04 were the gillnet station with the highest quantity of fish, with 12-13 fish per net per day, respectively. This was 12-13 times the quantity caught on TN11, where only one fish per net per day was caught. Atlantic herring was the dominant species MG04, comprising seven of the 13 caught fish. On MG01 Atlantic cod and fourbearded rockling were the most abundant species with each four out of 12 fish caught. MG01 and MG04 was located on sediment types “mud and sandy mud” and “Gravel and coarse sand”. Station MG09 had the lowest abundance, with only one fish per net per day. MG09 was located on the sediment type ”sedimentary rock and sand” (Figure 5-7).

Table 5-8 Total catches in multimesh gillnets in spring survey 2022 in the pre-investigation area of ENOE OWF. The CPUE is number of fish per net per day.

CPUE	**MULTIMESH GILLNET**									
Station	**MG01**	**MG02**	**MG03**	**MG04**	**MG05**	**MG06**	**MG07**	**MG08**	**MG09**	**MG10**
Atlantic cod	4	3	3	3	2	5	3	6		1
Atlantic herring	1	1		7						
Eelpout						1				
European flounder	2	2		1		4	2	1		1
European plaice		3								
Fourbeard rockling	4			1						
Round goby										2
Shorthorn sculpin			1				1		1	1
Sprat					1					
Turbot										
Whiting	1			1						
Total	**12**	**9**	**4**	**13**	**3**	**10**	**6**	**7**	**1**	**5**
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock										

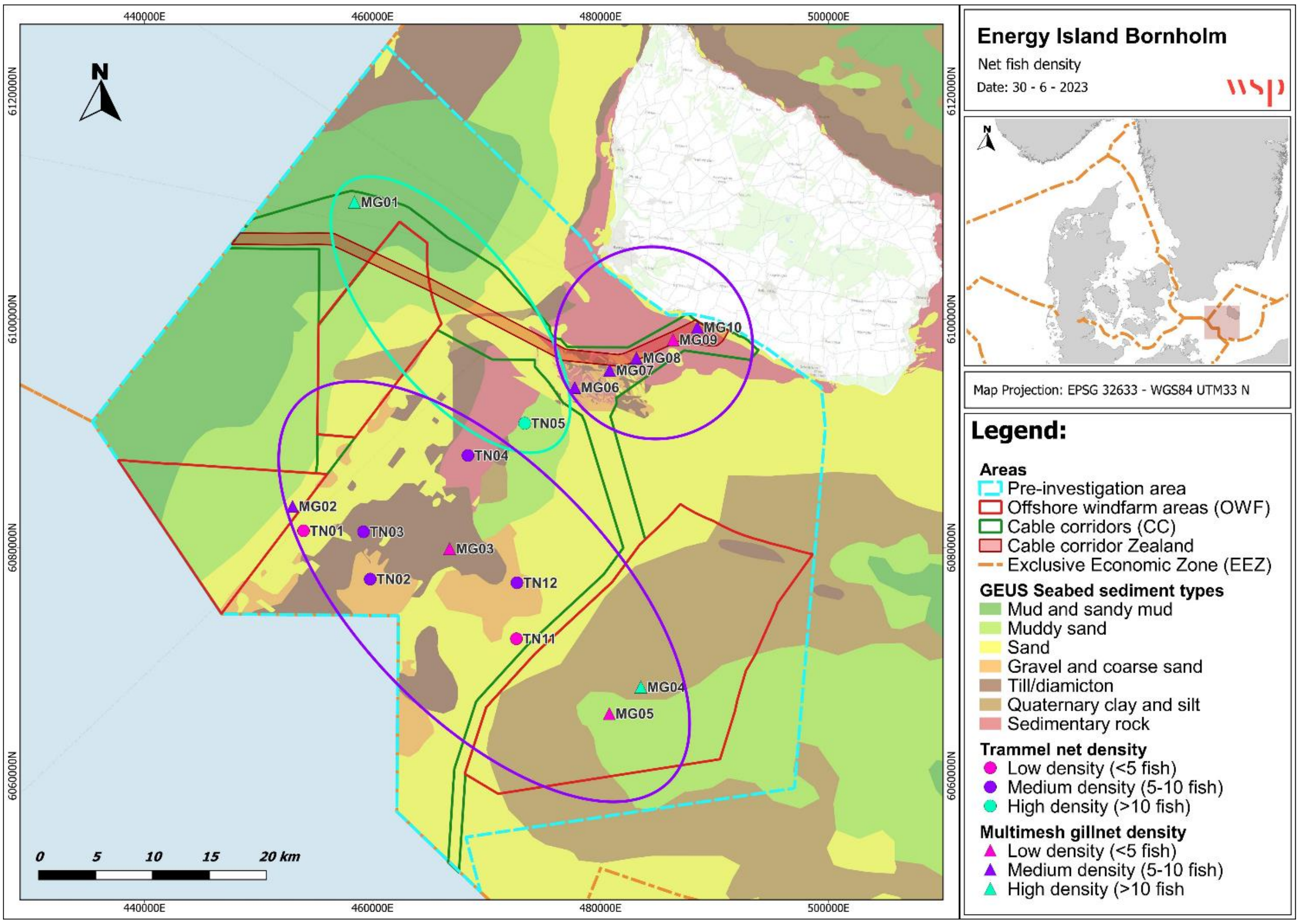


Figure 5-7 The fish density from catches with multimesh gillnets and trammel net in the pre-investigation area of ENOE OWF spring survey 2022. Purple and cyan rings indicate overall trends of medium and high density of fish, respectively.

BIOMASS

The biomasses caught in multimesh gillnets were converted into Catch Per Unit Effort (CPUE) of gram per net per day to calculate the fishing effort and total fish biomass caught at each station. The total biomass of fish caught in nets varied from 50 gram to nearly 4,500 gram per net per day between the sampling stations in the spring survey (Table 5-9).

For catches in multimesh gillnets, MG06 was the station with the highest weight, consisting of mainly Atlantic cod, followed by European flounder, with 3,470 gram per net per day. This was nearly 70 times the total biomass of fish caught on station MG09, where only 50 grams were landed in total.

Table 5-9 The total biomass of fish caught in multimesh gillnets in spring survey 2022 in the pre-investigation area of ENOE OWF. The CPUE is gram per net per day.

	MULTIMESH GILLNET									
CPUE	**MG01**	**MG02**	**MG03**	**MG04**	**MG05**	**MG06**	**MG07**	**MG08**	**MG09**	**MG10**
Atlantic cod	655	674	1453	540	760	2495	865	3140		410

Atlantic herring	75	52		375						
Eelpout						110				
European flounder	360	350		235		865	630	325		355
European plaice		376								
Fourbeard rockling	250			125						
Round goby										300
Shorthorn sculpin			114				50		50	85
Sprat					20					
Turbot										
Whiting	180			235						
Total	**1520**	**1452**	**1567**	**1510**	**780**	**3470**	**1545**	**3465**	**50**	**1150**
Dominant seabed sediment type **GEUS Seabed sed** Mud and sandy Muddy sand Sand Gravel and coa Till/diamicton Quaternary clay Sedimentary ro										

The biomass caught in nets varied from 50 grams at station MG09 to 3,470 grams at MG08. Most stations had a high biomass, and there were no clear tendencies towards stations with high biomasses, being located in a specific type of sediment and the high biomasses occurred in all sediment classifications (Figure 5-8).

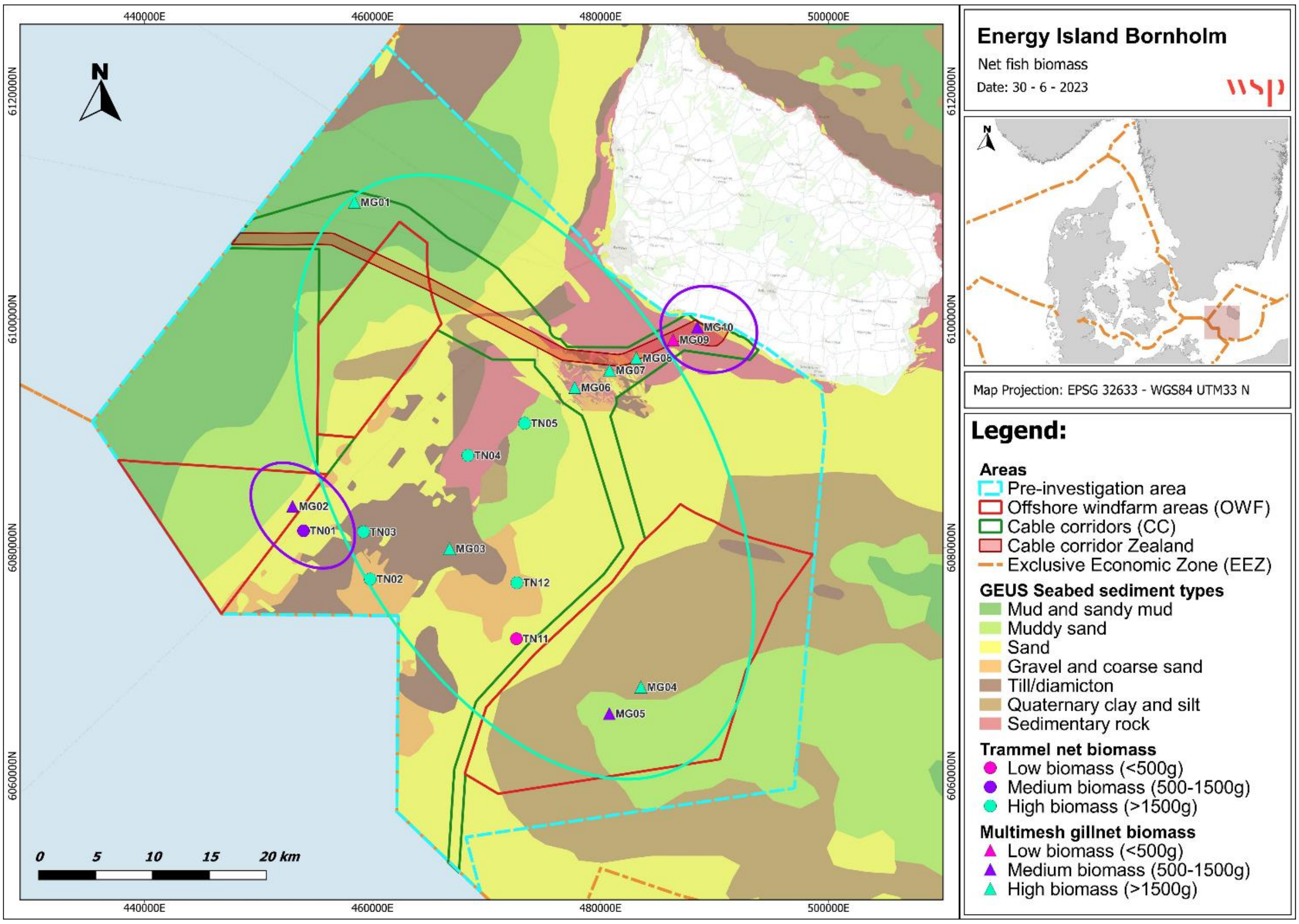


Figure 5-8 The biomass from multimesh gillnets and trammel nets catches in the pre-investigation area of ENOE OWF spring survey 2022. Cyan and purple rings indicate areas of medium to high biomass.

BIODIVERSITY

The biodiversity measured was based on the number of species caught on each station. Stations with < 5 species were listed as having low biodiversity, medium biodiversity was the range between 5-10 species, while > 10 species was high biodiversity.

The biodiversity of gillnet catches in spring catches varied from one to five species per station for the various stations (Table 5-8). Most stations in the pre-investigation area had a low biodiversity score (<5 species). The species varied between stations. On station MG01 and MG04, five species were caught on each stations, which were then categorized as medium score, which was the highest scores for the area (Figure 5-9). These stations were placed in areas with the sediment types, “mud and sandy mud”, and “quaternary clay and silt”. The lowest biodiversity with only on species per station was observed on MG09 (Shorthorn sculpin), which were located on sediment type “sedimentary rock”.

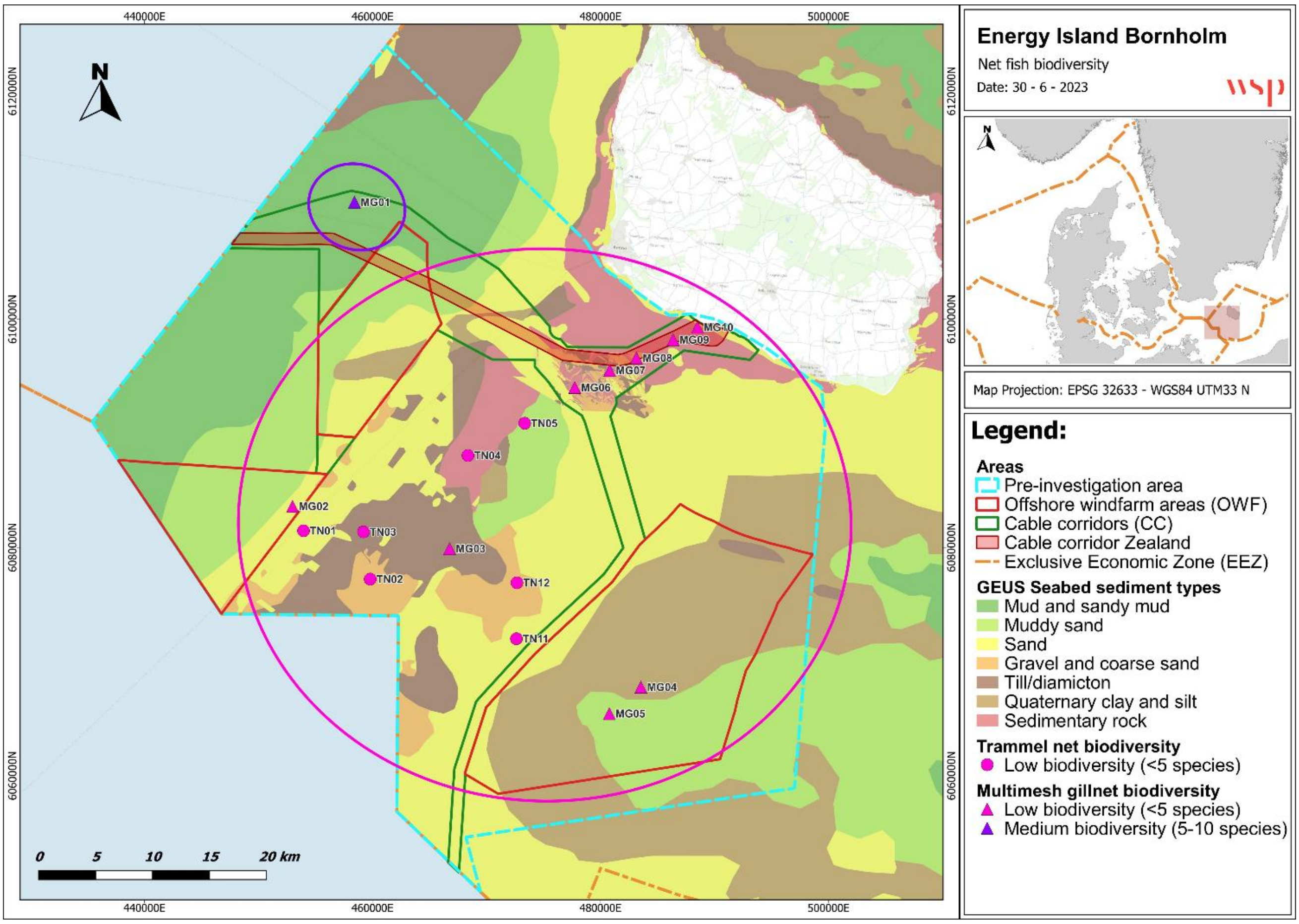


Figure 5-9 The biodiversity measures from trammel nets and multimesh gillnets in the pre-investigation area of ENOE OWF spring survey 2022. Pink ring indicates area of low biodiversity.

ADDITIONAL NOTES

In the spring catches, round goby was caught in low numbers. The round goby (*Neogobius melanostomus)* is a demersal species living near the ocean floor (Muus, et al., 1997). In the southern Baltic Sea, the species feed primarily on blue mussels (*Mytilus edulis*) and small invertebrates. The eggs attach to shells and macroalgae and the presence of substrate species are important to the success of the eggs. The round goby is invasive in Danish waters, both in fresh and salt water, and in 2017-2019, the round goby was one of the most frequently caught species in Danish waters in the recreational fisheries (Støttrup, et al., 2020). The consequences of the invasive species are yet unknown. However, the spread of the round goby is expected to have some consequences for the local populations of shrimp, and the species that feed on shrimp, as the round goby competes for food with other fish species.

AUTUMN

ABUNDANCE

In the autumn survey, the fish density from catches with multimesh gillnets varied from 0-15 fish per net per day (Table 5-10). Station MG01 had the highest abundance of fish, with 15 fish per net per day. No fish were caught on station MG3 in the autumn catches with multimesh gillnets. The sediment type, where most fish were caught in the autumn survey was “mud and sandy mud”, and the sediment type where no fish were caught was on “till/diamicton”.

In general, a medium to high density of fish was observed in and near the cable corridor in the hardbottom areas south of Bornholm in gillnet catches (Figure 5-10). Gillnet stations at Rønne Banke demonstrated a low density of fish in the gillnets. This was surprising, as hard bottom areas with high structural complexity usually results in high abundance of fish, biomass and biodiversity.

Table 5-10 The total fish abundance from catches with multimesh gillnets in the pre-investigation area of ENOE OWF autumn survey 2022. The catch has been converted to Catch Per Unit Effort (abundance of fish per net per day).

	MULTIMESH GILLNET									
CPUE	MG1	MG2	MG3	MG4	MG5	MG6	MG7	MG8	MG9	MG10
Atlantic cod	5	2		5	7	5	5	12	4	6
Atlantic herring				2	4				1	
Eelpout						1				
European flounder	2			1			1			
European plaice	7									
Shorthorn sculpin									2	
Whiting	1				2					
Total	**15**	**2**	**0**	**8**	**13**	**6**	**6**	**12**	**7**	**7**
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock										

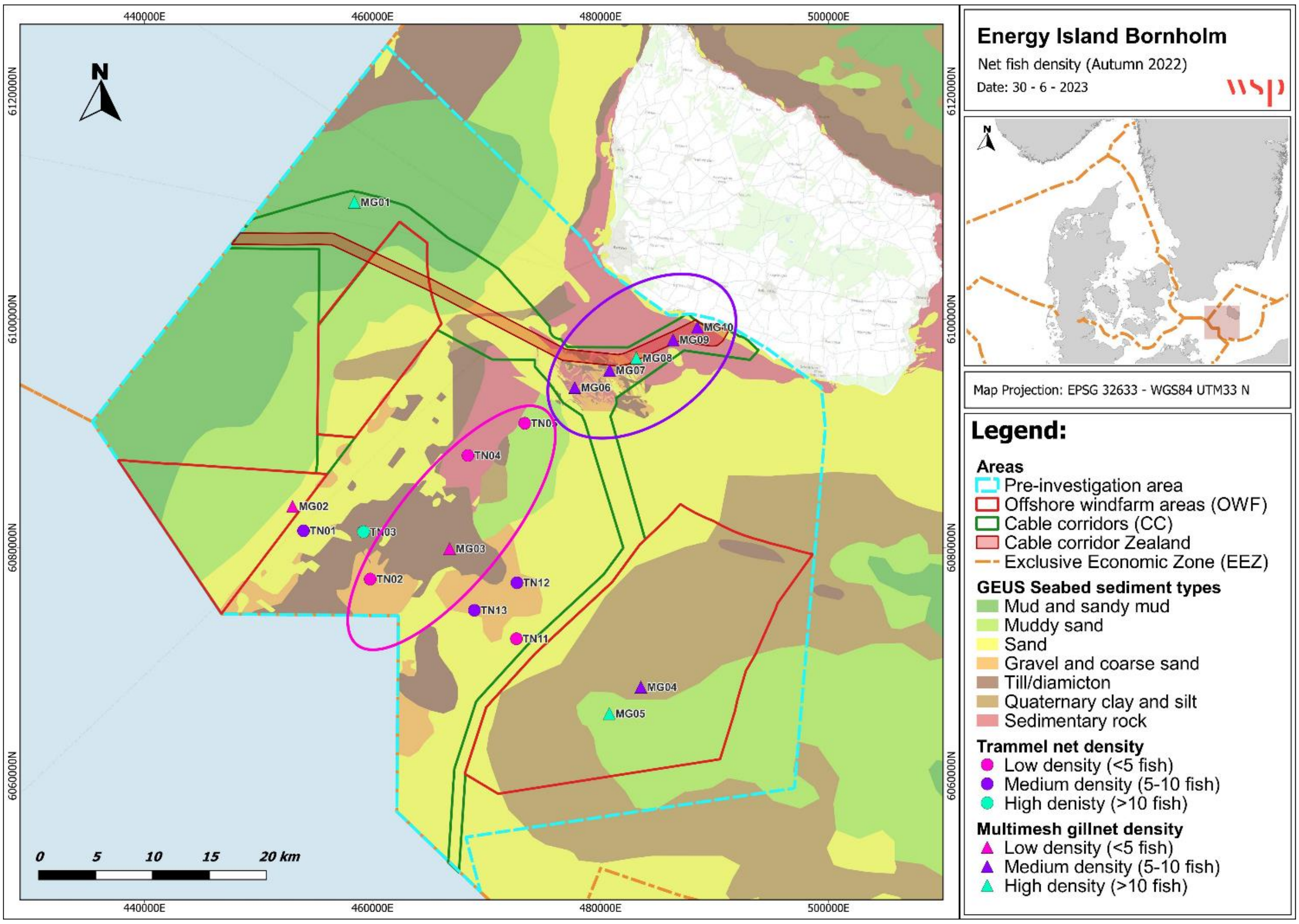


Figure 5-10 The fish abundance in CPUE number of fish per net per day for each sampled station in the autumn survey.

BIOMASS

The biomass of the autumn catch was also converted into CPUE per 1000 m^2. The highest biomass was observed in the cable corridor in the coastal areas near Bornholm on stations MG08, MG09, and MG10, where catches exceeded 1,500 grams of fish per net per day (Table 5-11). Station MG08 had the largest biomass of 4,100 grams of fish per net per day (see Table 5-11). The biomass was also high on several stations on Rønne Banke. Hardbottom areas are known to be highly productive, so the high biomass observed here was expected. Stations MG03 and MG2 had the lowest biomass of fish, as zero fish was caught on MG03, and less than 400 grams were caught on MG02.

Table 5-11 The total biomass of fish caught in multimesh gillnets in autumn survey 2022. The CPUE is gram per net per day.

	MULTIMESH GILLNET									
CPUE	MG1	MG2	MG3	MG4	MG5	MG6	MG7	MG8	MG9	MG10
Atlantic cod	620	365		1460	2335	955	775	4105	1705	1495
Atlantic herring				160	350				130	
Eelpout						180				

European flounder	250			475			170			
European plaice	630									
Great sandeel										20
Shorthorn sculpin									300	
Whiting					535					340
Total		**365**		**2095**	**3220**	**1135**	**945**	**4105**	**2135**	**1840**
Dominant seabed sediment type **GEUS Seabed sedimen** Mud and sandy muc Muddy sand Sand Gravel and coarse s Till/diamicton Quaternary clay anc Sedimentary rock										

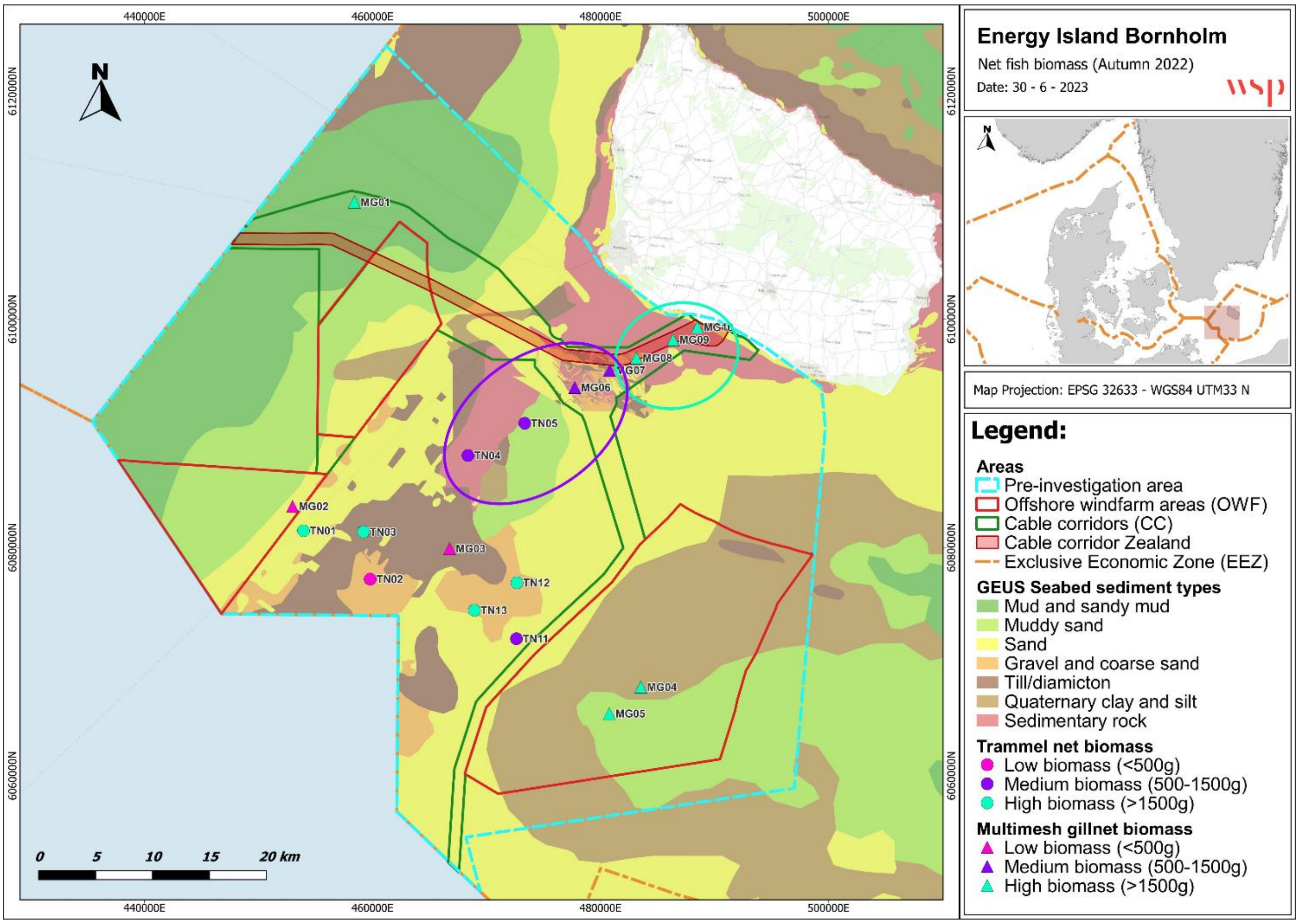


Figure 5-11 Fish biomass in CPUE gram fish per net per day for each sampled station in the autumn survey. Purple and cyan rings indicate areas of medium and high biomass.

BIODIVERSITY

The biodiversity varied from zero to four species per station for the various stations in the autumn survey (Table 5-10). In the autumn, all stations had a low score (<5 species) (Figure 5-12). As the multimesh gillnets have been developed to catch a great variation of fish species and sizes, the very low levels of biodiversity were unexpected. However, the results observed here indicate the low biodiversity in the Baltic Sea due to low salinity in general, and the poor ecosystem health in terms of fish fauna.

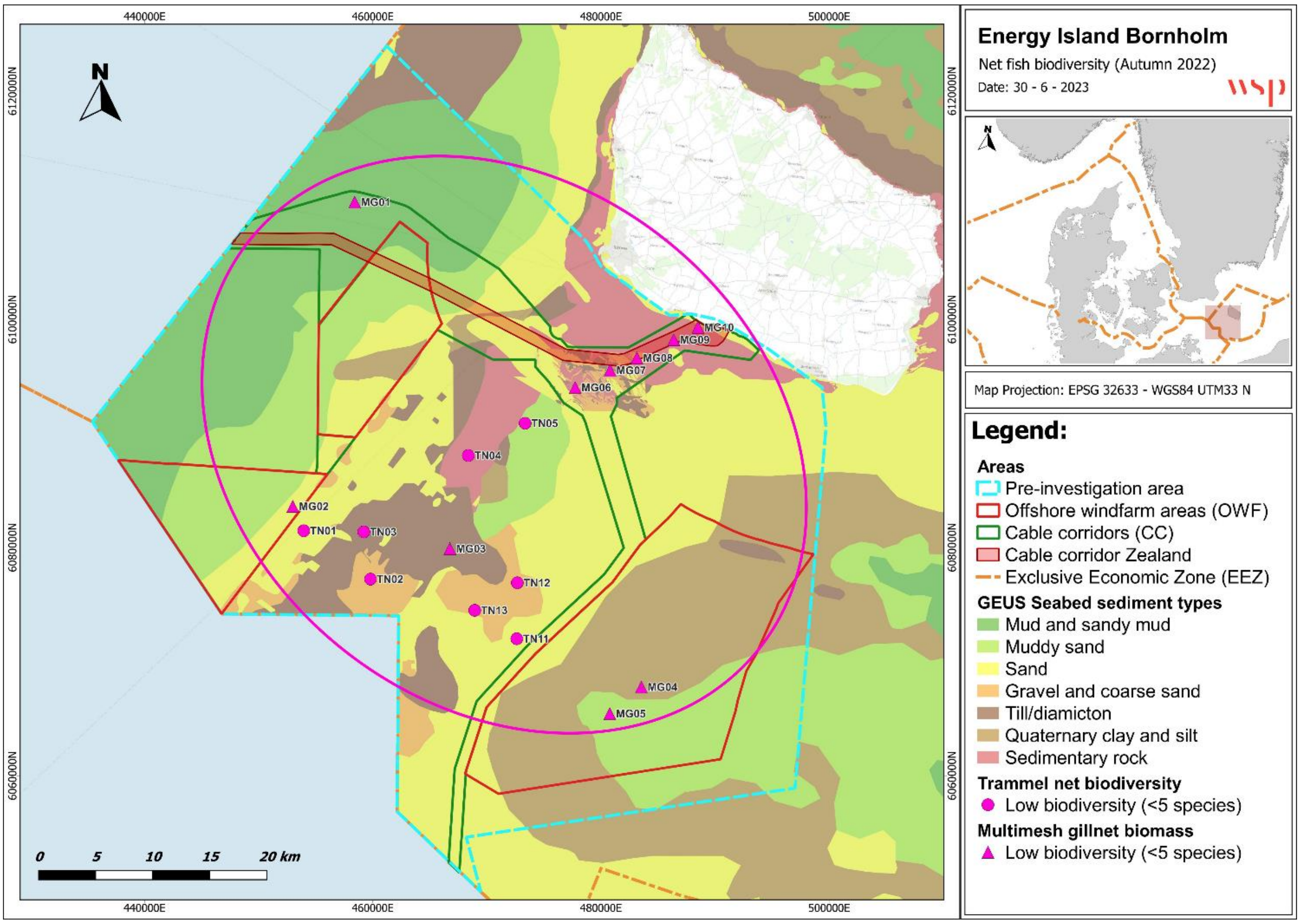


Figure 5-12 Biodiversity of catches with trammel net and multimesh gillnet in the autumn survey of the ENOE pre-investigation area.

5.2.4 TRAMMEL NET

As for the multimeshed gillnett, the spring catches in trammel net were dominated by European flounder and Atlantic cod. European plaice and Atlantic herring were also important species in the catches with net. In the autumn, Atlantic cod dominated the catch in trammel net. European flounder and European plaice were also important species in the autumn.

In the spring catches, the average biomass on the various stations was higher for trammel nets (approximately 2.500 gram) than for multimesh gillnets (1.650 gram). In the autumn catches, however, the opposite was the case with the average biomass of the catch in trammel nets (1.837 gram) being slightly lower than for multimesh gillnets (1.928 gram).

SPRING

ABUNDANCE

In the spring survey, the European flounder and the Atlantic cod dominated the catch in the trammel nets, followed by European plaice (Table 5-12). The catches were converted into Catch Per Unit Effort (CPUE) to analyse the catch according to the fishing effort i.e., fish caught per net per day.

The total catch in trammel nets varied from 1-16 fish for the various stations (Table 5-12). Station TN05 was the trammel net station with the highest quantity of fish, with 16 fish per net per day. This was 16 times the quantity caught on TN11, where only one fish per net per day was caught. The catch at TN05 consisted primarily of the species European flounder, comprising 14 out of 16 individuals. The station with the lowest abundance of fish was located on sediment type "sand," while the stations with the highest abundance of fish was located on "muddy sand" (Figure 5-13).

Table 5-12 Total catches in trammel nets in spring survey 2022 in the pre-investigation area of ENOE OWF. The CPUE is number of fish per net per day.

CPUE	TRAMMEL NET						
Station	**TN01**	**TN02**	**TN03**	**TN04**	**TN05**	**TN11**	**TN12**
Atlantic cod				3			2
Atlantic herring							
Eelpout							
European flounder	2	6	7	5	14	1	6
European plaice	2		1	2	2		
Fourbeard rockling							
Round goby							
Shorthorn sculpin							
Sprat							
Turbot							1
Whiting							
Total	**4**	**6**	**8**	**10**	**16**	**1**	**9**
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock							

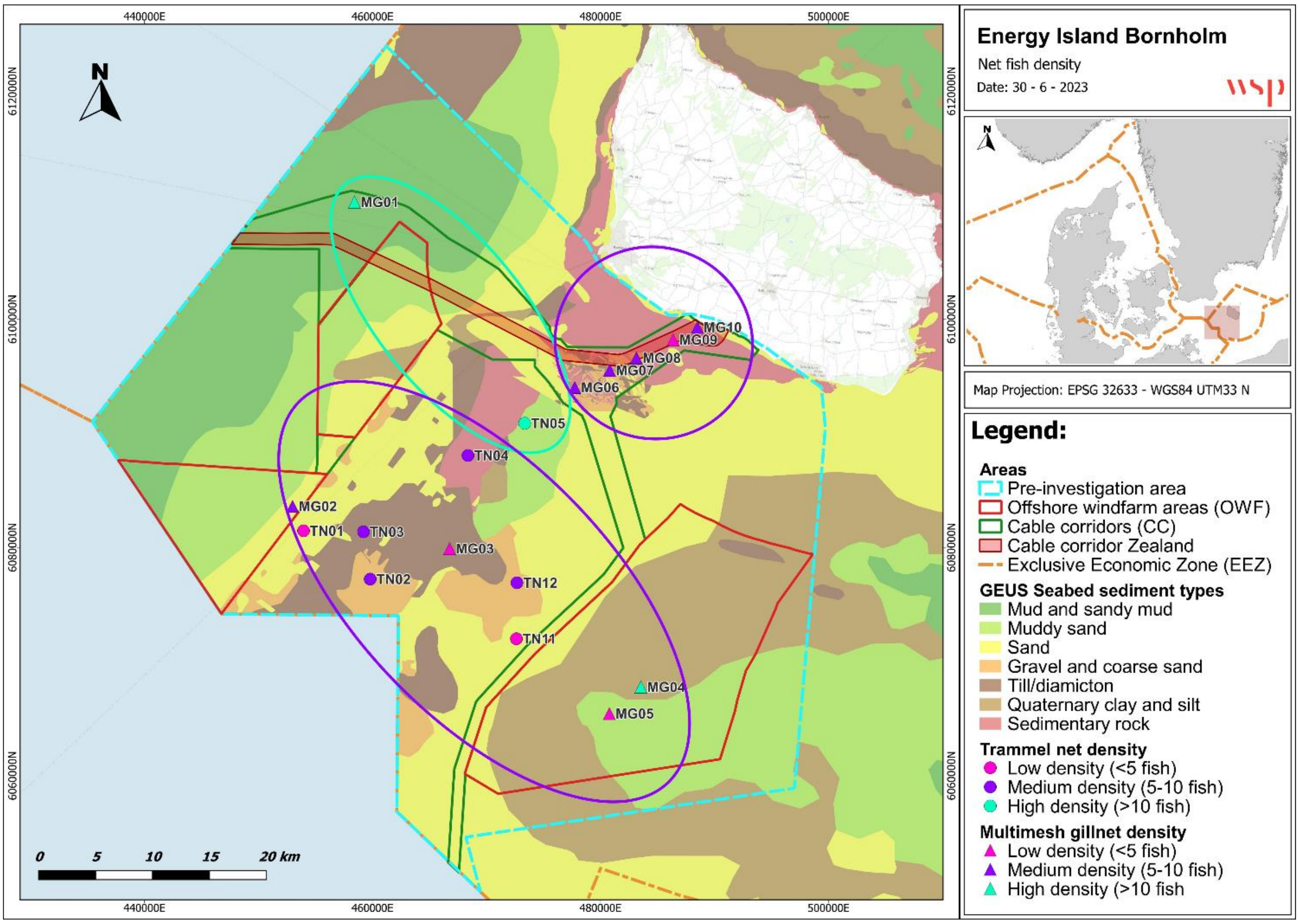


Figure 5-13 The fish density from catches with trammel net and multimesh gillnets in the pre-investigation area of ENOE OWF spring survey 2022. Purple and cyan rings indicate overall trends of low-medium-high density of fish.

BIOMASS

The biomasses caught in trammel nets and multimesh gillnets were converted into Catch Per Unit Effort (CPUE) of gram per net per day to calculate the fishing effort and total fish biomass caught at each station. The total biomass of fish caught in nets varied from 175 gram to nearly 4,415 gram per net per day between the sampling stations in the spring survey (Table 5-13).

For catches in trammel net, the highest biomass was caught at station TN05, with 4,415 grams, consisting of mainly European flounder followed by European plaice. The total biomass landed at TN05 was more than 25 times higher than that of at station TN11, where fish biomass of merely 175 gram was caught, which exclusively consisted of European flounder.

Most stations had a high biomass (<1,500 gram), and there were no clear tendencies towards stations with high biomasses, being located in a specific type of sediment (Figure 5-14).

Table 5-13 The total biomass of fish caught in trammel nets in spring survey 2022 in the pre-investigation area of ENOE OWF. The CPUE is gram per net per day.

	TRAMMEL NET						
CPUE	TN01	TN02	TN03	TN04	TN05	TN11	TN12
Atlantic cod				2385			1520
Atlantic herring							
Eelpout							
European flounder	424	1758	2046	1390	3810	175	1705
European plaice	432		230	555	605		
Fourbeard rockling							
Round goby							
Shorthorn sculpin							
Sprat							
Turbot							415
Whiting							
Total	**856**	**1758**	**2276**	**4330**	**4415**	**175**	**3640**
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock							

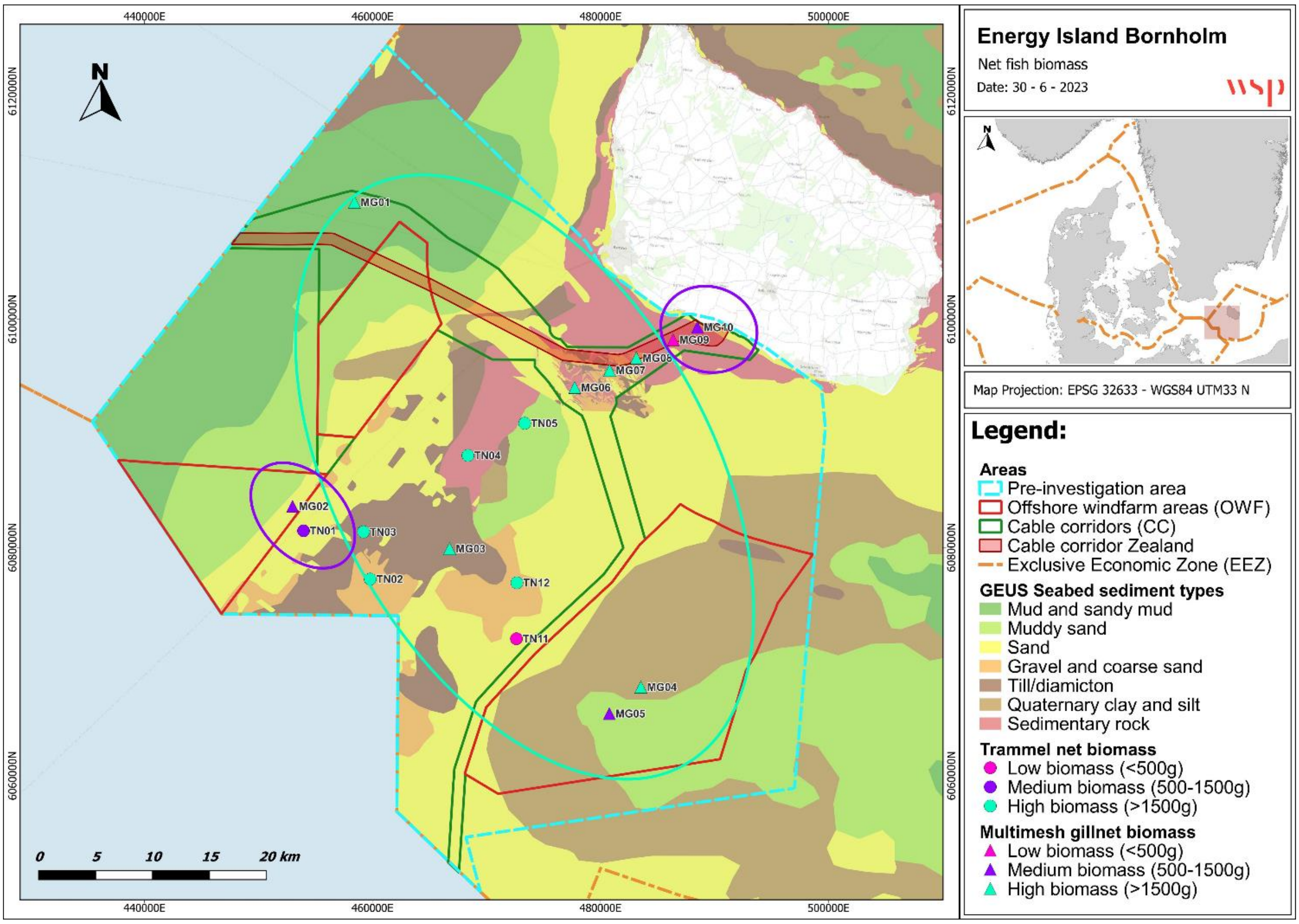


Figure 5-14 The biomass from multimesh gillnets and trammel nets catches in the pre-investigation area of ENOE OWF spring survey 2022. Purple and cyano rings indicated areas of medium and high biomass, respectively.

BIODIVERSITY

The biodiversity of catches varied from one to three species per station for the various stations. So, all stations in the pre-investigation area had a low biodiversity score (<5 species) (Figure 5-15). However, both the station with one species and three species were located in sediment types “gravel and coarse sand”, so no clear trend was observed with regards biodiversity.

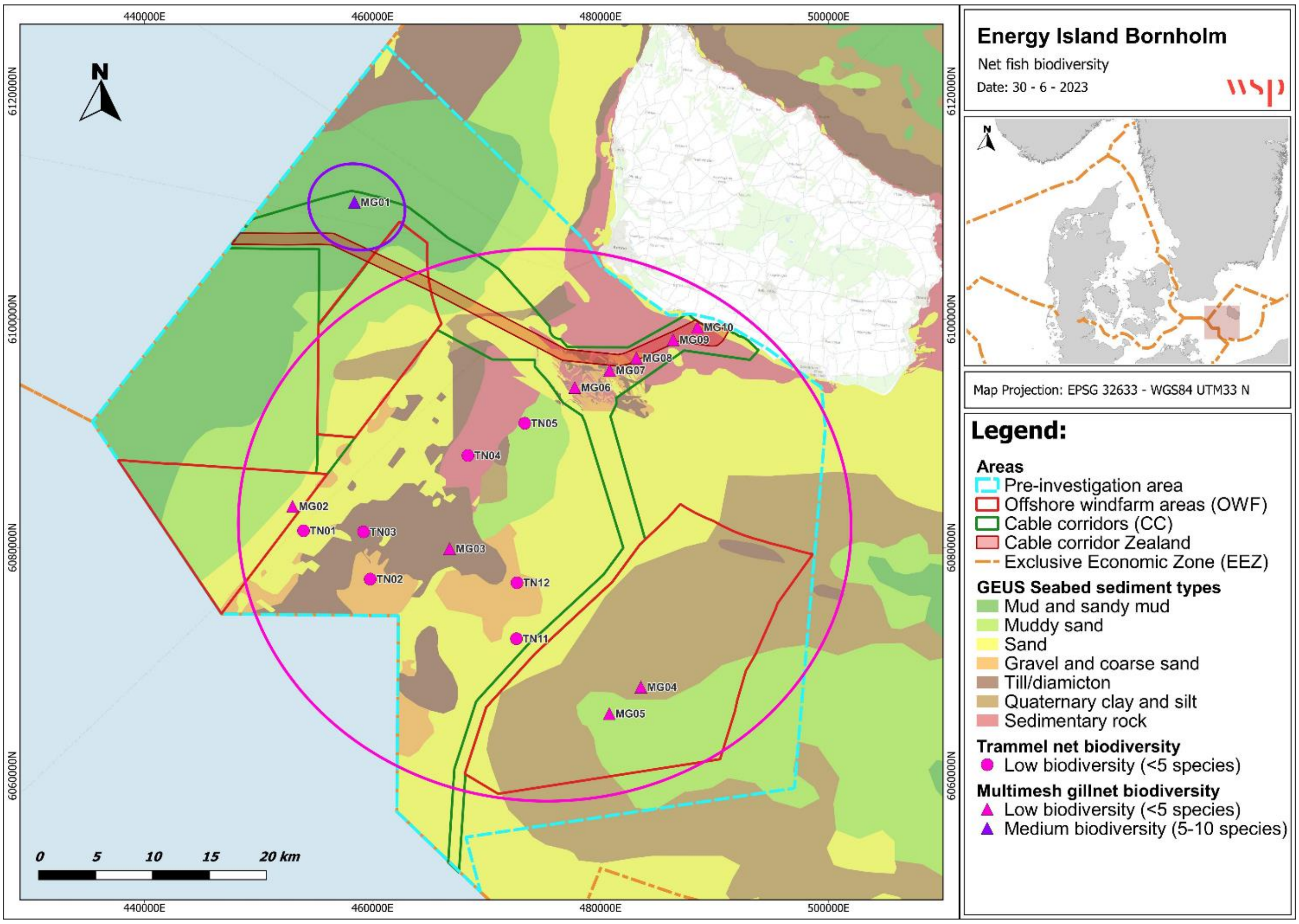


Figure 5-15 The biodiversity measures from trammel nets and multimesh gillnets in the pre-investigation area of ENOE OWF spring survey 2022. Pink and purple rings indicated areas of low and medium biodiversity, respectively.

AUTUMN

ABUNDANCE

European flounder dominated the catches in trammel nets in the autumn survey (Table 5-14). Atlantic cod was also an important species in the catches, and European plaice was caught in low numbers. No other species were caught in the trammel nets.

The fish density in trammel nets varied from 0-18 fish per net per day (Figure 5-16). Station TN3 had the highest abundance of fish, with 18 fish per net per day. On station TN2, zero fish were caught in the autumn catches with trammel nets.

In general, a medium to high density of fish was observed in and near the cable corridor in the hardbottom areas south of Bornholm in gillnet catches, while a low density of fish was observed in the central southern part of the pre-investigation area (Figure 5-16).

Table 5-14 The total fish abundance from catches with multimesh gillnets and trammel nets in the pre-investigation area of ENOE OWF autumn survey 2022. The catch has been converted to Catch Per Unit Effort (abundance of fish per net per day).

	TRAMMEL NET							
CPUE	TN1	TN2	TN3	TN4	TN5	TN11	TN12	TN13
Atlantic cod			10		1	1		
Atlantic herring								
Eelpout								
European flounder	6		5	3	2	2	8	4
European plaice			3					1
Shorthorn sculpin								
Whiting								
Total	**6**	**0**	**18**	**3**	**3**	**3**	**8**	**5**
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock								

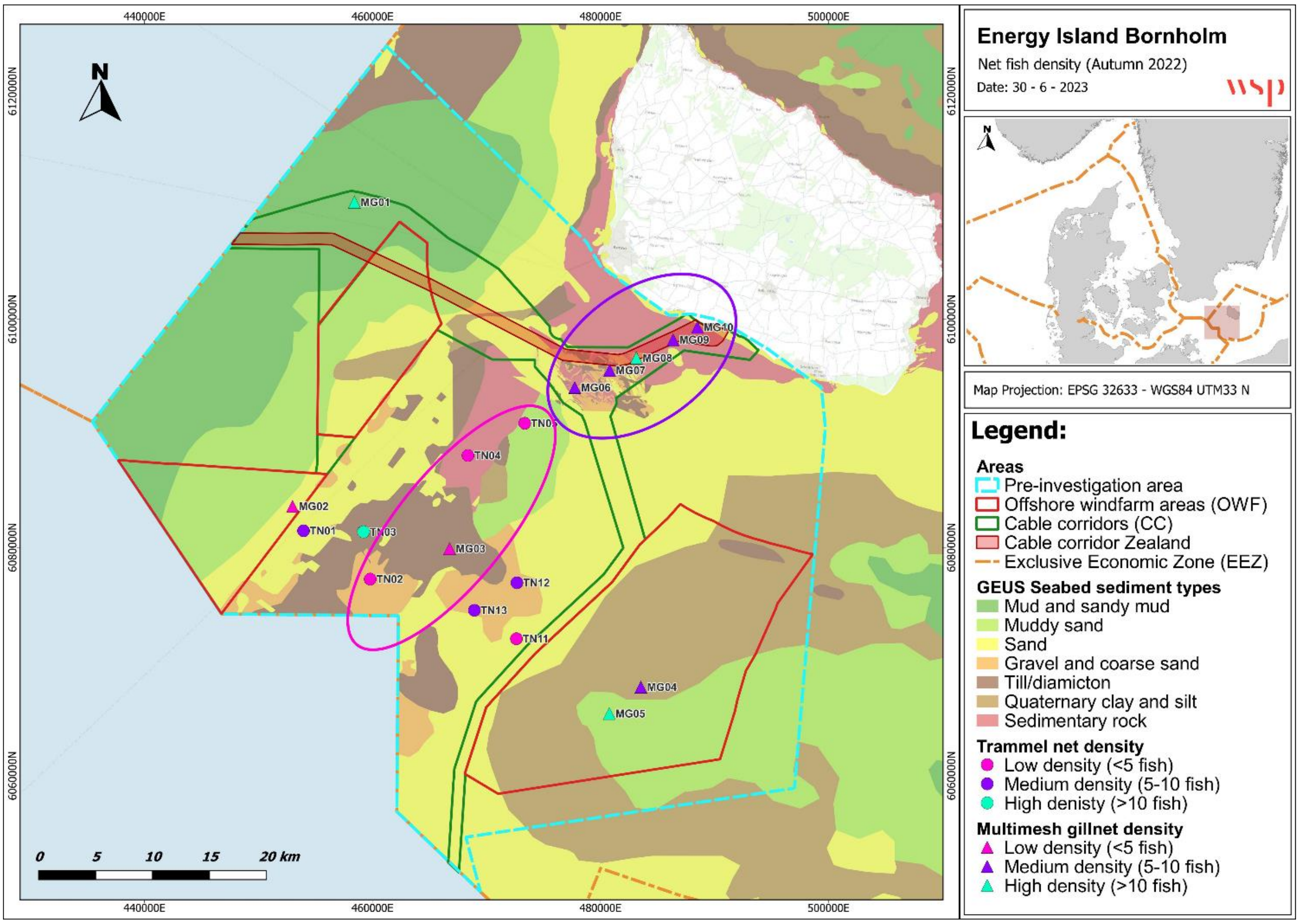


Figure 5-16 The fish abundance in CPUE number of fish per net per day for each sampled station in the autumn survey.

BIOMASS

The biomass of the autumn catch was also converted into CPUE per 1000 m^2. Station TN03, which were located on sediment type “till/diamicton” had the highest biomass of 4.000 grams of fish per net per day (see Table 5-15). On one station, no fish was caught, TN2, located on “gravel and coarse sand”.

The highest biomass was observed in the central southern part of the pre-investigation area, where catches exceeded 1,500 grams of fish per net per day (Figure 5-17). The biomass was also high on several stations on Rønne Banke. Hardbottom areas are known to be highly productive, so the high biomass observed here was expected.

Table 5-15 The total biomass of fish caught in multimesh gillnets and trammel nets in autumn survey 2022. The CPUE is gram per net per day.

	TRAMMEL NET							
CPUE	TN1	TN2	TN3	TN4	TN5	TN11	TN12	TN13
Atlantic cod			1681		225	330		
Atlantic herring								

Eelpout								
European flounder	2060		1585	935	665	780	2345	1285
European plaice			740					225
Great sandeel								
Shorthorn sculpin								
Whiting								
Total	2060		4006	935	890	1110	2345	1510
Dominant seabed sediment type **GEUS Seabed sediment types** Mud and sandy mud Muddy sand Sand Gravel and coarse sand Till/diamicton Quaternary clay and silt Sedimentary rock								

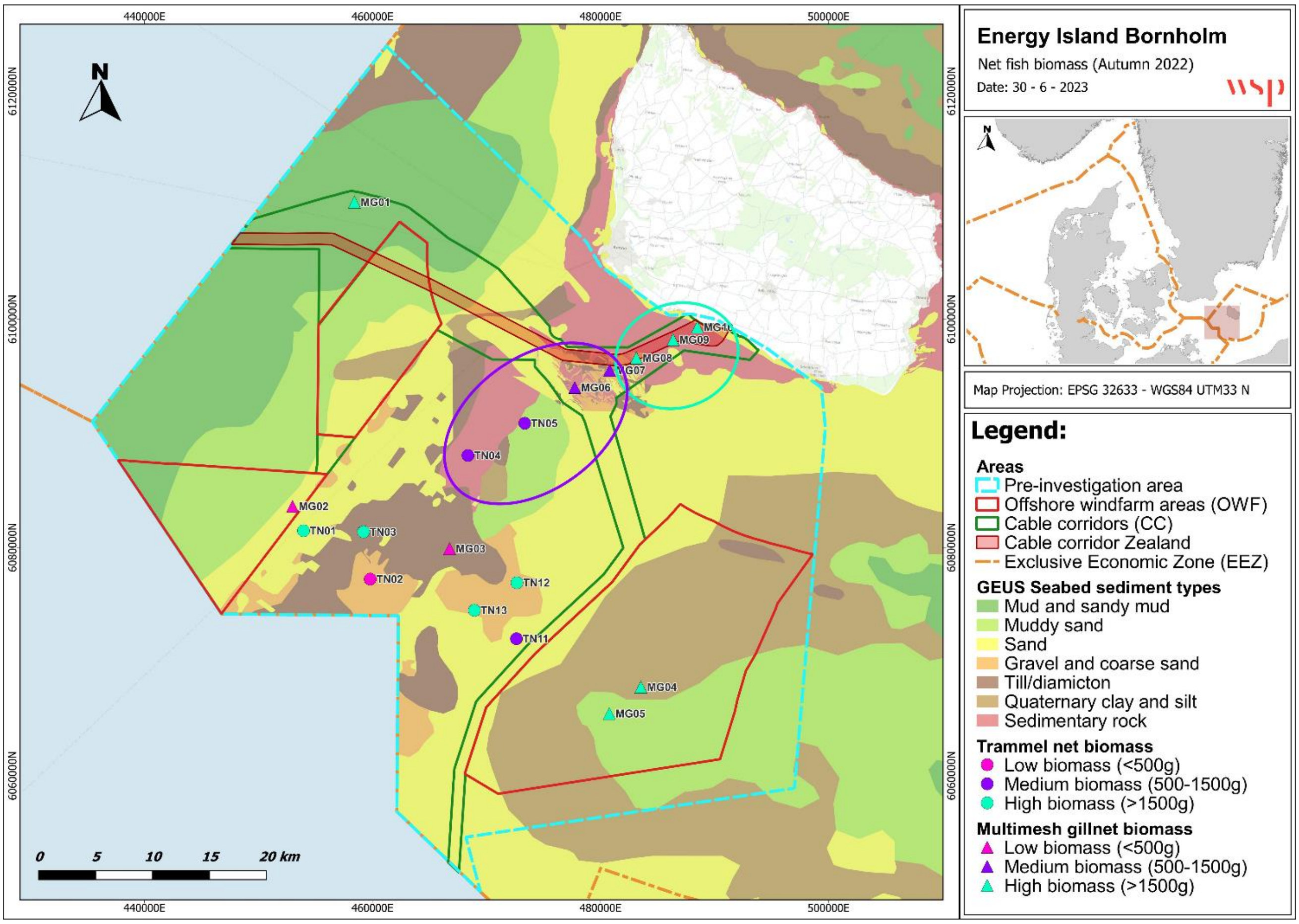


Figure 5-17 Fish biomass in CPUE gram fish per net per day for each sampled station in the autumn survey. The purple and cyan rings indicate areas of medium and high biomass.

BIODIVERSITY

The biodiversity on trammel net varied from zero to four species per station in the autumn survey (Figure 5-18). In the autumn. This means that all stations had a low biodiversity score (<5 species). The trammel nets are most suited for catching flatfish in exposed areas, so high biodiversity was unexpected. However, an average of 1.6 species per station was lower than expected. The results observed here may indicate the low biodiversity in the Baltic Sea due to low salinity in general, and the poor ecosystem health in terms of fish fauna.

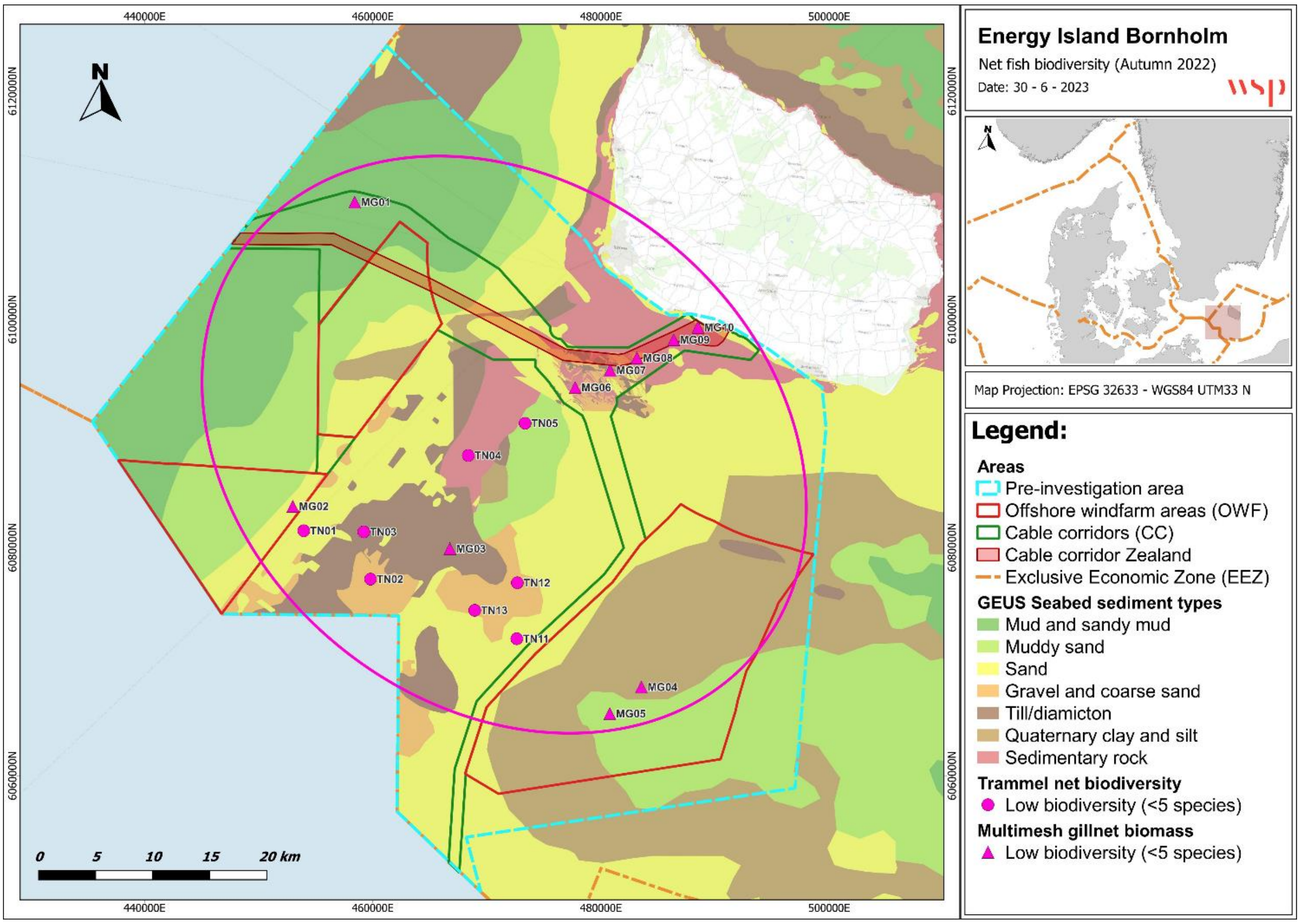


Figure 5-18 Biodiversity of catches with trammel net and multimesh gillnet in the autumn survey of the ENOE pre-investigation area.

6 SPAWNING AREA

Individuals physiologically ready to spawn were caught in the pre-investigation area indicating that the area may be used for spawning area, i.e., European flounder, European plaice and turbot, Atlantic herring and Atlantic cod. However, according to existing literature, most species (including Atlantic cod, European sprat, European flounder, European plaice, and turbot) have their main spawning areas in the deeper areas of the Baltic Sea (40-100 meters of depth) due to the buoyancy of the eggs and the low salinity in the Baltic Sea. This chapter presents an assessment of whether the pre-investigation area was utilized as spawning area. In the following section, only catches of species with spawning individuals were described. Species, where no spawning individuals were caught, is not believed to utilize the pre-investigation area as spawning site.

6.1 SPRING

Most fish species spawn in spring in order to time the hatching of fish larvae with zooplankton blooms. It was, therefore, expected that if the pre-investigation area was utilized as a nursery area, then data collected in springtime would provide the needed information on this. The text only includes species where individuals ready to spawn were caught in the survey.

6.1.1 EUROPEAN FLOUNDER

In the spring survey, 21 out of a total of 291 European flounder (7 %) caught were physiologically ready to spawn (water filled eggs in females or running milk in males) (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.
). However, 236 individuals (81 %) were recovering post-spawned. According to the literature, the European flounder spawn from February to May, which suggest that the European flounder ended the spawning event early in this area of the Baltic Sea this year (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.
). Most of the individuals that were ready to spaw or were post-spawning were caught at the stations BT11 and BT15 on sand and muddy sand at approximately 45-50 meters of depth. The numerous post-spawning individuals (>100) were caught in stations BT7 and BT9 located in quaternary clay and silt at 45-50 meters of depth in the South-eastern part of the pre-investigation area. Based on the large number of post-spawning and the few spawning individuals of both sexes, the large variation in sizes (20-40 cm), and existing literature pointing towards the south-eastern part of the pre-investigating area as being a high probability spawning area for European flounder (HELCOM, 2021) (please see 4.2.2), it is highly likely that European flounder utilizes the south-eastern part of the OWF area as spawning site.

6.1.2 EUROPEAN PLAICE

Within the pre-investigation area, several spawning European plaice were also caught (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.
). However, all but one were males and the individuals were relatively small (1-3 years). As with the young Atlantic cod, the spawning young adult males may not yet have the proper experience in timing the spawning event with the larger and older females, as the large females caught in the spring survey were all post-spawned. In addition, existing

literature suggest that the European plaice spawn from November to March (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.
). Most (22 out of 24) spawning male European plaice were caught in the muddy sand stations of BT02 and BT15 (app. 40-50 meters of depth). However, of all the stations, the largest amount of the European plaice was caught in BT02 and BT15 here, indicating that this area serves as a suitable habitat for the European plaice rather than point towards utilization as a spawning area. Despite of the spawning male of the European plaice observed in the spring captures, it cannot be rouled out that the pre-investigation area is a spawning area for plaice.

6.1.3 TURBOT

A total of four spawning turbot were caught, but with only a total of nine turbot caught in the entire spring survey, the spawners make up nearly half of the observations (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.
). The remaining five individuals were still in the process of ripening their gonads. It is likely that turbot use the pre-investigation area as spawning area, however, based on merely four spawning individuals, it is difficult to conclude anything.

6.1.4 ATLANTIC COD

One third of the caught Atlantic cod were ready to spawning (12 out of 36) (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.
). The catch predominantly consisted of young males, and all were of smaller sizes (30-40 cm), indicating that they belonged to the 2-3 years age group. Furthermore, quite a few male Atlantic cod with ripening gonads, meaning they were getting ready to spawn, were also caught in the area. Although sexually mature, or nearly mature, they may not yet have had the needed experience for spawning in the right location. The stations with young spawning male Atlantic cod were primarily located in the hard bottom area at Rønne Banke (MG6, MG7 and MG8), suggesting that caught Atlantic cod were practising spawning in their nursery area, which emphasises that this was a test for the young fish. Additionally, the timing was also somewhat delayed compared to the mature females caught in the spring survey, which were post-spawning (see (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.
at the end of this chapter) and section 4.2.2). Based on the observations of spawning male Atlantic cod it is highly likely that the central part of the pre-investigation area, Rønne Banke, may be utilized as spawning area for Atlantic cod.

6.1.5 ATLANTIC HERRING

A total of nine herring were caught in the spring survey, and seven of these were spawning (78%). The seven spawners were all females with large egg cells visible. An additional two individuals were getting ready to spawn (22 %). According to existing literature herring primarily use Rugen as spawning area in the Baltic, however, the species does have a plastic utilization of spawning areas, and spawners around Bornholm do occur some years. The findings from the spring survey supports that occasional spring spawners near Bornholm, and it can be concluded that Atlantic herring may utilize the pre-investigation area as spawning area.

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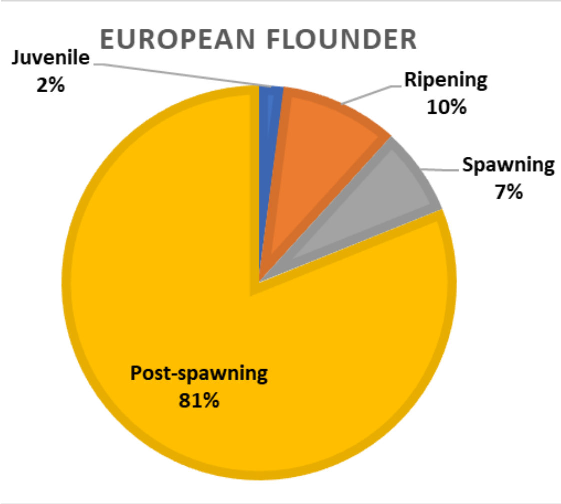
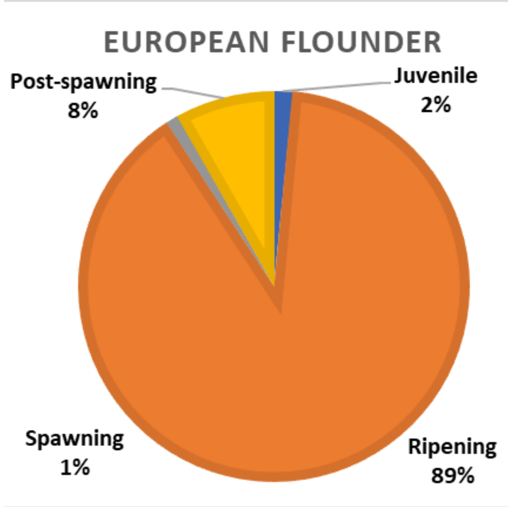
<tr><td>
</td><td>
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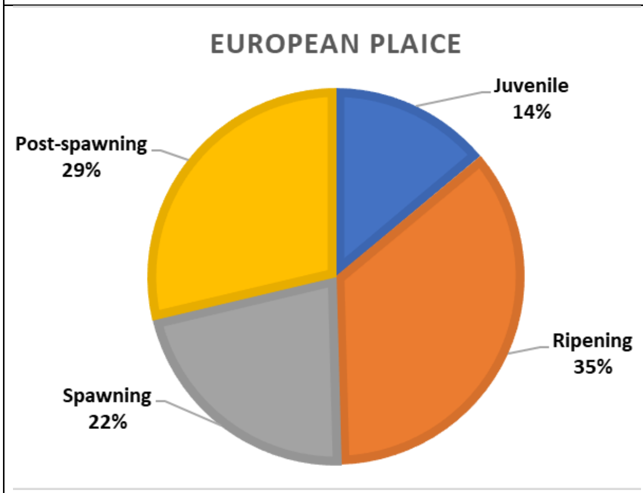
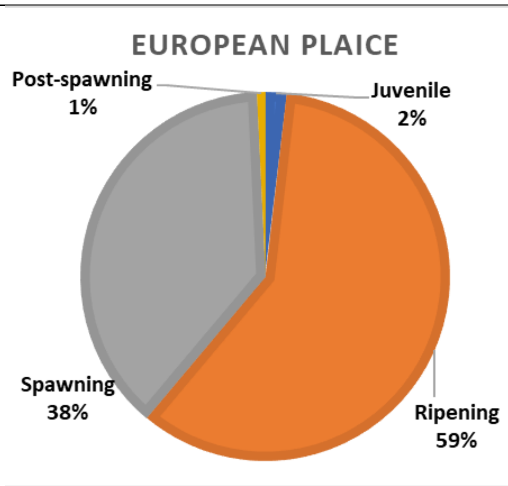
<tr><td>
</td><td>
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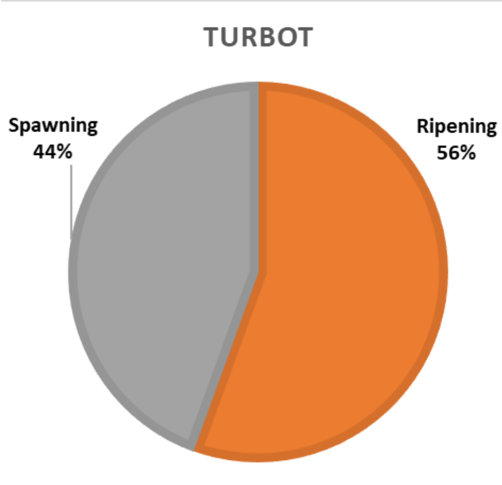
<tr><td>
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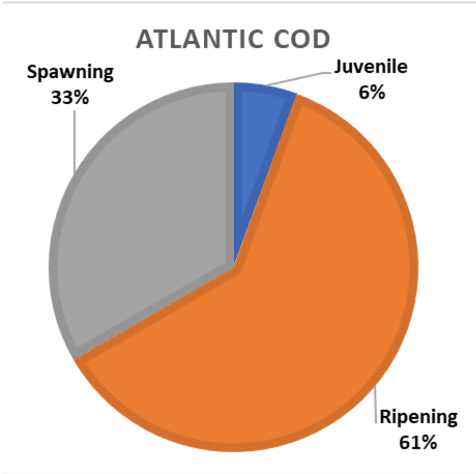
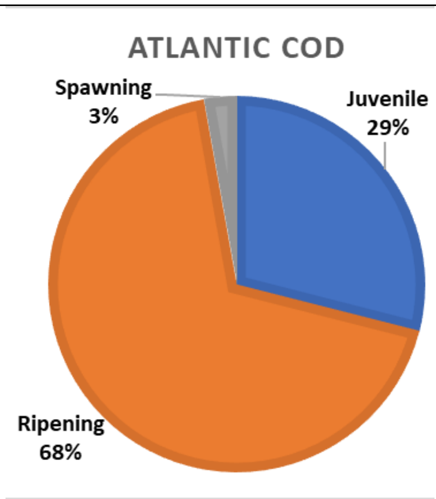
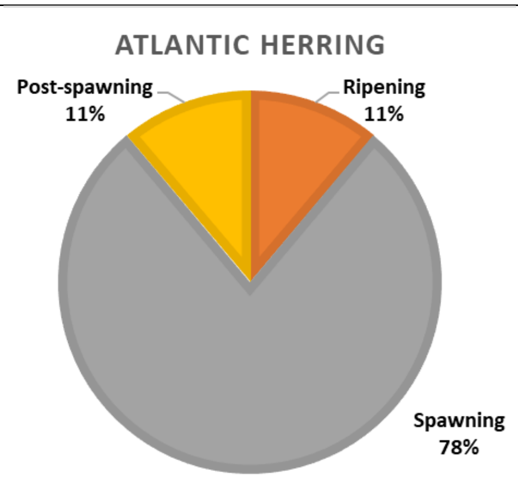
Spring 2022	Autumn 2022
	
	

Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.

6.2 AUTUMN

Very few fish species spawn in autumn, however, European plaice is known to spawn from November. It was, therefore, expected to catch European plaice and possibly with ripening gonads and possibly a few spawning individuals. According to local fishermen, Atlantic herring have been observed spawning near Bornholm, but the population of these Atlantic herring does not spawn near Bornholm every year, and no scientific mapping of this populations exists (Warnar, et al., 2012). In the autumn survey, no spawning herring were caught, but a total of seven Atlantic herring were caught and which were in early or late stages of ripening of the gonads.

In the following section, only catches of species with spawning individuals were described. Species, where no spawning individuals were caught, is not believed to utilize the pre-investigation area as spawning site.

6.2.1 EUROPEAN PLAICE

In the autumn survey, a total of 103 spawning European plaice (38 %) were observed out of a total of 270 individuals caught (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.

). One single spawning female was caught and the rest were males. Approximately 93 % (96 individuals) of the spawning individuals were small males estimated to be two-four years old (17-26 cm). It is likely that the small spawning males were practicing spawning for the first time, which would explain the absence of larger spawning females. According to existing literature, the European plaice spawn from November to March, so the small males spawning for the first time were a bit early compared to the rest of the population in the area (Figure 6-1) (Muus & Nielsen, 2006)

The 17 of the 18 larger females (> 30 cm) caught during the autumn had large oocytes (egg cells) visible to the naked eye indicating that they were close to the first spawning event. The last of the large female was already spawning. Approximately 69 % (58 of 84 individuals) of the spawning and pre-spawning European plaice were caught in the western-southwestern part of the pre-investigation area, at the stations BT1, BT2, BT15, BT17 and BT18 on "muddy sand" and "mud and sandy mud" at app. 35-50 meters of depth. In existing literature, no clear spawning site for plaice is mapped in the Baltic Sea. However, it is speculated that suitable areas exist in the deeper areas around Bornholm (Nissling, et al., 2002). This supports the data collected here, stating that the European plaice spawn in, or near the pre-investigation area e.g., the southwestern part of the OWF (Bornholm II Syd).

6.2.2 EUROPEAN FLOUNDER

A total of 467 European flounders were caught during the autumn survey. In total 416 out the of these 467 specimens (89 %) were in early or late stages of gonad ripeness, however, only three individuals (< 1 %) were ready to spawn with ripe gonads (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.

). Some of the largest females were still post-spawned and recovering from the last spawning event. According to existing literature, flounder spawn from February to May, so no spawning flounder were expected in the catches in autumn (Table 6-1). Based on the findings in the autumn survey, no conclusions can be made with regards to spawning area for European flounder. However, as stated above for spring data, it is highly likely that European flounder utilize south-eastern part of the OWF as spawning area.

6.2.3 ATLANTIC COD

Approximately 68 % of the Atlantic cod caught in the autumn survey were in early or late stages of gonad ripeness, i.e. 73 individuals out of 107 (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.

. Merely three individuals were ready to spawn. According to existing literature, cod spawn from February /march until September, so no spawning cod were expected in the autumn catches (Figure 6-1 Maturity of the species where spawning individuals were caught. No spawning turbot or Atlantic herring were caught in autumn.

). However, the very broad spawning period would explain the great variance in maturity stages of Atlantic cod caught in this study. Based on these results no conclusions can be made with regards to spawning area for Atlantic cod.

However, as stated above for spring data, it is likely that Atlantic cod utilize certain parts of the pre-investigation area, Rønne Banke, as spawning area, although only mature small males where caught here.

Table 6-1 Spawning time and strategy for 10 common fish of the Baltic Sea. Source (Muus & Nielsen, 2006), (Worsøe, et al., 2002), (Warnar, et al., 2012) (Whitehead, et al., 1986) (Florin & Franzen, 2010).

COMMON NAME	LATIN NAME	SPAWNING TIME												SPAWNING STATEGY
		J	F	M	A	M	J	J	A	S	O	N	D	
Atlantic cod	***Gadus morhua***		x	x	x	x	x	x	x	x				**Pelagic**
Atlantic herring	***Clupea harengus***		x	x	x					x	x	x		**Benthic**
Common dab	***Limanda limanda***				x	x	x	x	x					**Pelagic**
Eelpout	***Zoarces viviparus***								x	x				**Viviparous**
European flounder	***Platichthys flesus***			x	x	x	x							**Pelagic**
European plaice	***Pleuronectes platessa***	x	x	x								x	x	**Pelagic**
Fourbeard rockling	***Enchelyopus cimbrius***		x	x	x	x								**Pelagic**
Great sandeel	***Hyperoplus lanceolatus***				x	x	x	x	x					**Benthic**
Sprat	***Sprattus sprattus***		x	x	x	x	x	x	x					**Pelagic**
Turbot	***Scopthalmus maximus***					x	x	x	x					**Pelagic**

7 SIZE DISTRIBUTION AND NURSERY AREA

The size distribution was analysed for the three most abundant fish species – the European flounder, the European plaice and the Atlantic cod, for both the spring and the autumn survey. In general, individuals of European plaice and European flounder below 10-15 cm is characterized as juveniles and less than 1-2 years old. For Atlantic cod, juveniles are usually below 30 cm and 2 years or less depending on the area, although the high fishing pressure the past 40 decades has caused the species to mature earlier than previously and at a smaller size. In this study, spawning Atlantic cod of just 18 cm were found in the autumn survey, which is why Atlantic cod below 18 is assessed as juveniles here.

When analysing the length of individuals in a fish population it is possible to find and track individuals of same length and, thus, roughly the same age. Usually, when the dataset is large enough, each year class or cohort can be seen as peaks of individuals when mapping them based on size (such as in Figure 7-1). The cohorts can them be tracked year by year as they grow each year.

In this chapter, the length of the fish caught in the spring and autumn surveys were used to evaluate if the pre-investigation area was utilized as nursery area for juvenile fish.

7.1 EUROPEAN FLOUNDER

Overall, the European flounder was the most dominant species in the combined catches with 291 individuals caught in spring and 467 in autumn. This means that there is an adequate dataset for determining the if the pre-investigation area is used as nursery area for this species . Most flounder caught measured between 20 and 35 cm which, according to size-at-age-literature, indicates that the individuals were 2-5 years old (Figure 7-1). No peaks for each yearclass of European flounder was observed in the cohort analysis for both the spring and autmn catches (Figure 7-1). The population rather consisted of a many medium aged individuals (approximately 25-30 cm i.e., 3-6 years old) and with fewer individuals younger and older than that. Only two individuals of less than 10 cm were caught – on of 5 cm in spring and one of 8.5 cm in autumn. These two individuals were considered juveniles in relation to the maturity index. The juvenile caught in the spring surveyis expected to be offspring from last year, while the individual caught in the autumn survey most likely is a young of the year (YOY). Such YOY will expectedly utilize much more sheltered and shallower areas compared to the deeper and more exposed areas of the pre-investigation area. The low number of juveniles caught in the pre-investigation area indicates that the area most likely does not serve as a nursery area for the European flounder.

7.2 EUROPEAN PLAICE

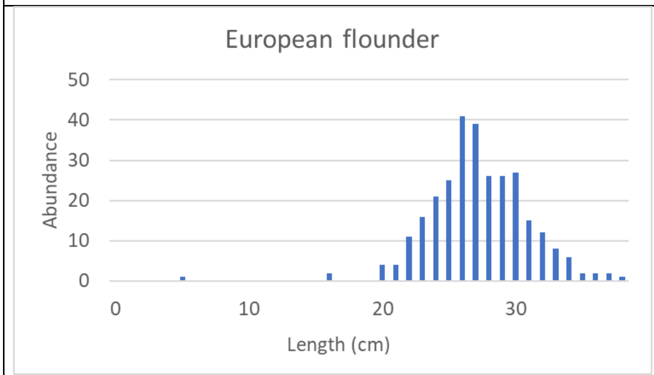
In the spring survey, the caught of European plaice, where a total of 115 individuals were caught, ranged from 12 to 34 cm in length (Figure 7-1). Of these, only one individual was believed to be a juvenile from last year based on the maturity index and length (12 cm). In the spring data, a peak of individuals or cohort of 18-20 cm (2-3 years old) European plaice was visible in Figure 7-1, and the same cohort was observed in data from the autumn survey, ranging from 20-22 cm. The most obvious peak in number of individuals or cohort observed in the catches was app. 22-25 cm in the spring survey, which had grown into 23-27 cm in the autumn survey. According to size-at-age literature, this cohort was approximately 3-4 years old (Muus & Nielsen, 2006). No specimens with lengths below 10 cm were caught in the spring survey, which indicates that the area is not utilized as nursery area for European plaice. The European plaice have a prolonged spawning season in the Baltic Sea, from March into November, due to the low and constant temperatures in the deeper areas of the Baltic (Muus & Nielsen, 2006). The European plaice utilizes shallow, sheltered, and sandy areas as nursery areas after settling (Poxton & Nasir, 1985), and the pre-investigation area of ENOE OWF does not fit the profile for such a nursery area.

7.3 ATLANTIC COD

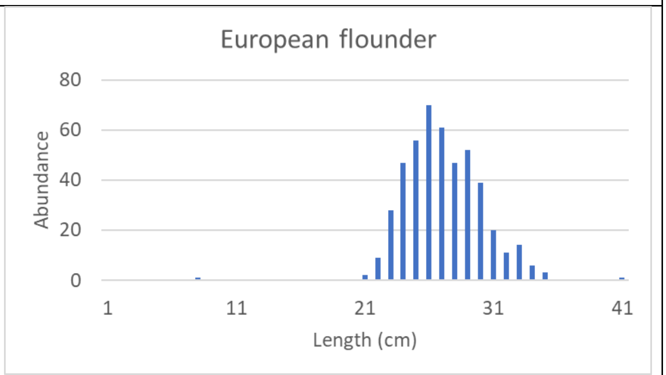
Of all the species caught during the two surveys, the Atlantic cod was the species that demonstrated the largest size variation in the captures, as the sizes varied from 7 to 60 cm in the spring captures and from 5 to 61 cm in the autumn survey (Figure 7-1). The largest individuals were approximately 5 years old. Although many of the individuals measured 20-40 cm of lengths, it was difficult to assign an accurate cohort for these cod due low abundance of each length of Atlantic cod.

Two juvenile individuals were caught in the spring survey of less than 18 cm, which based on the maturity of the Atlantic cod caught here, was the size where the smallest cod was fully matured and spawning. The two juveniles in the spring survey were 5 and 17 cm, respectively, while 23 juveniles were caught in the autumn survey (5-17 cm). Individuals < 10 cm were YOY having entered the population in autumn when they were large enough to be caught in the sampling gear utilized for this study. Juvenile Atlantic cod were caught in the hard bottom area in the CC at stations MG8, and at BT15, BT16 and BT17 on the muddy sand and mud and sandy mud in the south-western part of the pre-investigation area. Juvenile Atlantic cod are known to utilize stone reefs and other hard bottom areas for nursery areas due to the shelter and food availability here. However, Atlantic cod does not settle until they are app. 3-6 cm of length where they swim towards the seabed and seek shelter in various structures (Muus & Nielsen, 2006). It is possible that the Atlantic cod of just 5 cm, caught on the soft bottom, have just recently settled and is now looking for a suitable nursery area. Based on the observations made here and existing literature, it is expected that cod utilize the hardbottom area in the CC as nursery area due to the high level of structural relief and availability of shelter and food.

Spring 2022



Autumn 2022



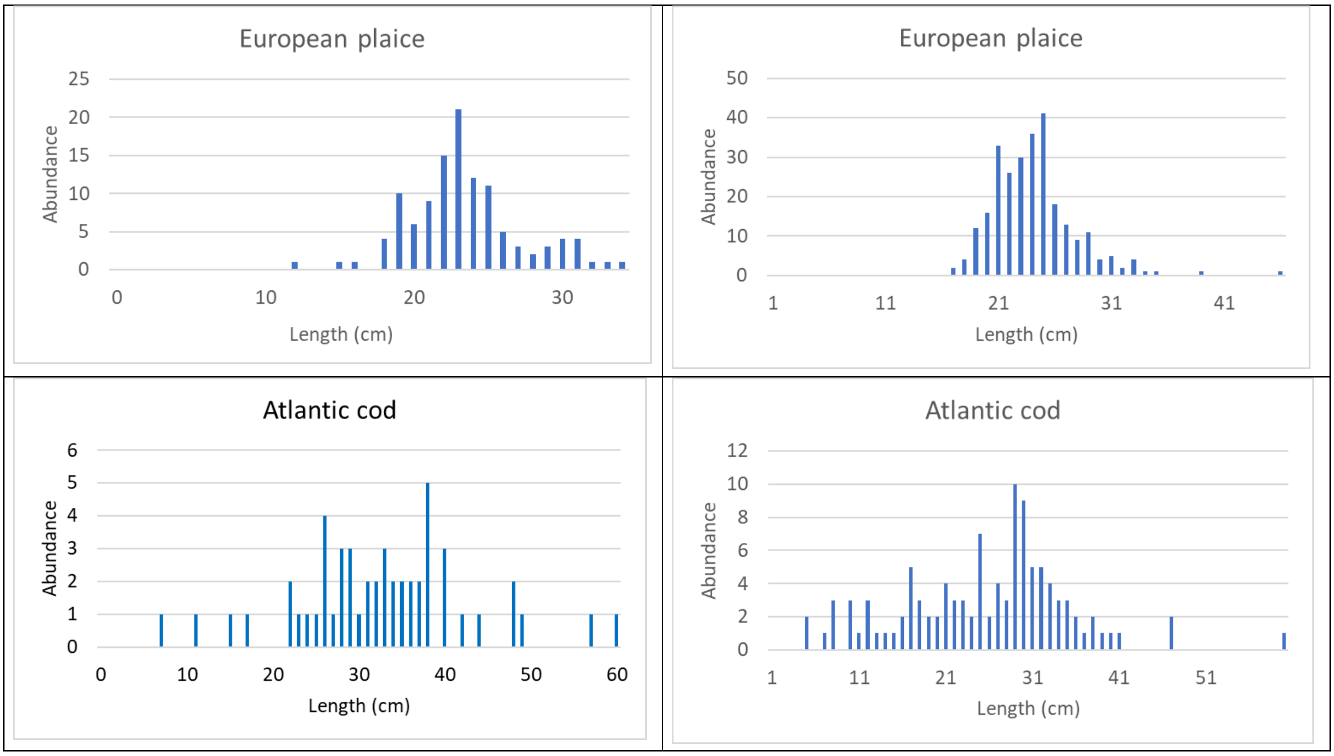


Figure 7-1 The size distribution of the three most abundant fish species in the beam trawl catches in spring and autumn 2022. Please note the differences in abundances between graphs.

8 SPECIES DIVERSITY AND EVENNESS

An evaluation of the fish species diversity and evenness is presented below based on the Shannon Wiener index and Evenness index.

The Shannon Wiener index was used to measure the diversity of fish species and the community structure in the pre-investigation area based on beam trawl, multimesh gillnets and trammel nets. The index considers the number of species living in the area and how dominating each species is. A low Shannon Wiener index indicates a low number of species and/or strong dominance of one or a few species. On the other hand, a high Shannon Wiener index indicates a high species richness with great evenness between species. The index value rarely exceeds 4.

The Evenness index is an estimate of how even the individuals are distributed between species. The values may range between 0 and 1. If values are low (near 0), it indicates that one or few species dominate the community, and if values are high (near 1), a more even distribution of individuals between species occurs.

8.1 BEAM TRAWL

For the spring survey, the number of fish species caught per station with beam trawl varied from 0 to 8 species with an average of 3.2 species (Table 8-1). For the autumn survey, the range was similar; 0 to 8 species. However, the average number of species per station was slightly higher for the autumn catches, with an average of 4.3 species. This indicates a low biodiversity in the area, which is well established for the Baltic Sea.

The Shannon Wiener index for the beam trawl sampled stations varied from 0.0 to 1.6 in the spring survey, with an average of 0.7 within the pre-investigation area of ENOE OWF. For the autumn survey, the index ranged from 0.4 to 1.3 with an average of 0.8, which was slightly higher than in the spring (Table 8-1). The relatively low values indicate the low number of species caught on each station and that a few species dominated the catches (i.e. flounder and plaice).

The stations with the highest Shannon Wiener index were BT03, BT05, BT13, BT14 and BT15 for spring and autumn. The stations were located near Rønne Banke (sandy bottom) and in the western part of the pre-investigation area (soft bottom). BT13 located in the southern part of the pre-investigation area (gravel and coarse sand) also had one of the highest values of Shannon Wiener index found in this survey.

The Evenness index values calculated for the pre-investigation area range between 0 to 1 (Table 8-1). The spring survey had an average Evenness index of 0.6 pr. station. Similarly, the Evenness for the autumn catches was 0.5. This indicates that the species caught in the spring and autumn survey were equally distributed between species in the two surveys. For spring and autumn catches, a high evenness occurred on stations BT01, BT04, BT08 and BT11, located in softbottom habitats, in the central part of the pre-investigation area. The high evenness illustrates that one or a few species dominated the catches. On the other hand, stations with low evenness were BT07, BT15 and BT16 located on muddy sediments, in the southern part of the pre-investigation area. The low evenness indicates that a higher number of species were caught on the station and that no species dominated the catches.

To summarize, the Shannon Wiener index calculated for the pre-investigation area of ENOE OWF show low values, indicating a low species diversity. Similarly, low levels of Evenness indicates that a few species dominate the catches.

No pattern is clear concerning the Shannon Wiener and Evenness index. The index may be low in spring and high for the autumn catches at the same station.

Table 8-1 Number of species, Shannon Wiener (biodiversity) and evenness index for all beam trawl stations based on abundance. * Not fished with beam trawl due to risk of damaging gear on stone reefs.

	SPRING			AUTUMN		
	No. of species	Shannon Wiener	Evenness	No. of species	Shannon Wiener	Evenness
BT 01	1	0.0	1	3	0.8	0.2
BT 02	5	0.8	0.3	8	1.1	0.3
BT 03	2	0.5	0.6	6	1.3	0.6
BT 04	6	1.5	0.5	3	1.1	1
BT 05	3	1.1	0.9	5	1.1	0.5
BT 06	3	0.6	0.5	3	0.7	0.5
BT 07	4	0.4	0.2	4	0.4	0.2
BT 08	1	0.0	1	3	1.1	1
BT 09	3	0.3	0.3	2	0.5	0.7
BT 10	*	*	*	*	*	*
BT 11	3	1.1	1	4	1.1	0.5
BT 12	*	*	*	*	*	*
BT 13	8	1.6	0.5	*	*	*
BT 14	4	1.2	0.7	3	0.8	0.4
BT 15	5	1.2	0.4	6	1.3	0.3
BT 16	3	0.7	0.3	4	1.1	0.3
BT 17	0	0	1	4	1.0	0.3
BT 18	0	0	1	6	1.0	0.2
Average	3.2	0.7	0.6	4.3	0.9	0.5

8.2 MULTIMESH GILLNETS

The number of species caught in multimesh gillnets ranged from 1 to 5 species in the spring survey (Table 8-2). The number of species were a bit lower in the autumn survey where only 0 to 4 species were caught. This is nearly half the number of species caught in the beam trawl, although the multimeshed gillnets are designed to catch several different species. However, this is believed to be the result of a generally low biodiversity in the Baltic Sea and a low biomass of fish due to poor ecosystem health.

The Shannon Wiener index ranged between 0 and 1.4 with an average of 0.9 for the spring survey (Table 8-2). For the autumn survey, the Shannon Wiener index varied from 0 to 1.2 with an average of 0.5. The relatively low values indicate a low number of species and/or that a few species dominate the catches.

The average Evenness for the spring survey was 0.8, ranging from 0.6 to 1 (Table 8-2). For the autumn survey the average was 0.8 and values varied between 0.6 and 1. The high numbers indicate that most individual belonged to one or a few species and that on or a few species dominated the catches.

To summarize, the results found for Shannon Wiener and Evenness indicated that very few species were caught in the multimesh gillnets and that one or a few species dominated in terms of individuals. In other words, most species occurred in very low numbers, while a few species dominated. The results seen here is believed to be the result of low biodiversity and biomass of fish in the Baltic Sea.

Table 8-2 Number of species, Shannon Wiener (biodiversity) and evenness index for all Multimesh gillnet stations based on abundance.

	SPRING			AUTUMN		
	No. of species	Shannon Wiener	Evenness	No. of species	Shannon Wiener	Evenness
MG 01	5	1.4	0.8	4	1.2	0.7
MG 02	4	1.3	0.9	1	0	1
MG 03	2	0.6	0.8	0	0	1
MG 04	5	1.3	0.6	3	0.9	0.7
MG 05	2	0.6	0.9	3	1.0	0.8
MG 06	3	0.9	0.7	2	0.4	0.6
MG 07	3	1.0	0.9	2	0.4	0.6
MG 08	2	0.4	0.6	1	0	1
MG 09	1	0	1	3	0.9	0.8
MG 10	4	1.3	0.9	2	0.4	0.6
Average	3.1	0.9	0.8	2.1	0.5	0.8

8.3 TRAMMEL NETS

The number of species caught in trammel nets ranged from 1 to 3 species in the spring and autumn survey, which is even lower than for multimeshed gillnets (Table 8-3).

The Shannon Wiener index ranged between 0 and 1 with an average of 0.5 for the spring survey (Table 8-3). For the autumn survey, the Shannon Wiener index varied from 0 to 1 with an average of 0.3. The low values indicate a low number of species and/or that a few species dominate the catches.

The average Evenness for the spring survey was 0.8, ranging from 0.5 to 1 (Table 8-3). For the autumn survey the average was 0.9 and values varied between 0.7 and 1. The high numbers indicate that most individuals belonged to one or a few species and that on or a few species dominated the catches.

To summarize, the results found for Shannon Wiener and Evenness indicated that very few species were caught in the trammel nets and that one or a few species dominated in terms of individuals. In other words, most species occurred in very low numbers, while a few species dominated. The results seen here is believed to be the result of low biodiversity and biomass of fish in the Baltic Sea.

Table 8-3 Number of species, Shannon Wiener (biodiversity) and evenness index for all trammel net stations based on abundance. * Fished with beam trawl before this substrate was avoided with dredging gear and the station was instead sampled with trammel net.

	SPRING			AUTUMN		
	No. of species	**Shannon Wiener**	**Evenness**	**No. of species**	**Shannon Wiener**	**Evenness**
TN 01	**2**	**0.7**	**1**	**1**	**0**	**1**
TN 02	**1**	**0**	**1**	**0**	**0**	**1**
TN 03	**2**	**0.4**	**0.5**	**3**	**1.0**	**0.8**
TN 04	**3**	**1**	**0.9**	**1**	**0**	**1**
TN 05	**2**	**0.4**	**0.5**	**2**	**0.6**	**0.9**
TN 11	**1**	**0**	**1**	**2**	**0.6**	**0.9**
TN 12	**3**	**0.8**	**0.7**	**1**	**0**	**1**
TN 13	*	*	*	**2**	**0.5**	**0.7**
Average	**2**	**0.5**	**0.8**	**1.5**	**0.3**	**0.9**

9 FEEDING AREAS

This chapter gives an overview of the distribution of relevant feed organisms for fish in the pre-investigation area. Fish will naturally spread out according to the quality of the habitat, which includes the availability of food. Therefore, it is relevant to evaluate the availability of the various food resources, which was mapped in the benthic baseline report (WSP, 2023).

The dominant fish species observed in the pre-investigation area were flatfish, especially European plaice and European flaounder, which feed primarily on prey in or on the sediment. Generally, flatfish feed on worms and small mussels, including the polychaete *Pygosio elegans* (*P. elegans*) and blue mussels.

In biomass data, from the field survey of benthic flora and fauna, which was conducted for the technical report for ENOE OWF, there was a delimited area of higher biomass in the survey samples (WSP, 2023). The infaunal biomass was highest in the western part of the OWF area, consisting of the sediment types; sand and muddy sand (Figure 9-1).

9.1 BLUE MUSSELS

The fish food sources in the pre-investigation area were dominated by blue mussels, which had high coverages and standing biomass, especially in the hard sediment type areas (sediment type 2, 3 and 4), where blue mussel coverage on larger stones were up to 100% (see Figure 9-1).

Highest blue mussel coverage/biomass was found from >10 m depth as macroalgae, in general, dominated the coverage of rocks at lower depths (0-10 m). However, blue mussels were also observed under the macroalgae (where possible) at these depths, even if not visible on ROV video due to the dense coverage of the macroalgae. Furthermore, blue mussels were found on dynamic sandy areas with relative low coverage (<1-15%) as small ballistic, mobile balls/clusters consisting of blue mussel communities transported along the sandy area with the current (Nature type 1b and sediment type 1b) (see Figure 9-1 for 5-10% coverage of blue mussels on the outskirts of sediment type 1b).

The map in Figure 9-1 illustrates that blue mussels, as one of the main food source in the pre-investigation area for fish, are present in highest numbers in the central part of the pre-investigation area – in the SPA area. This is also illustrated in the pie charts of the distribution of infauna classes in the subareas within the pre-investigation area, where blue mussels comprised the majority of the biomass here and, thus, separated into its own group to illustrate the dominance (see Figure 9-2).

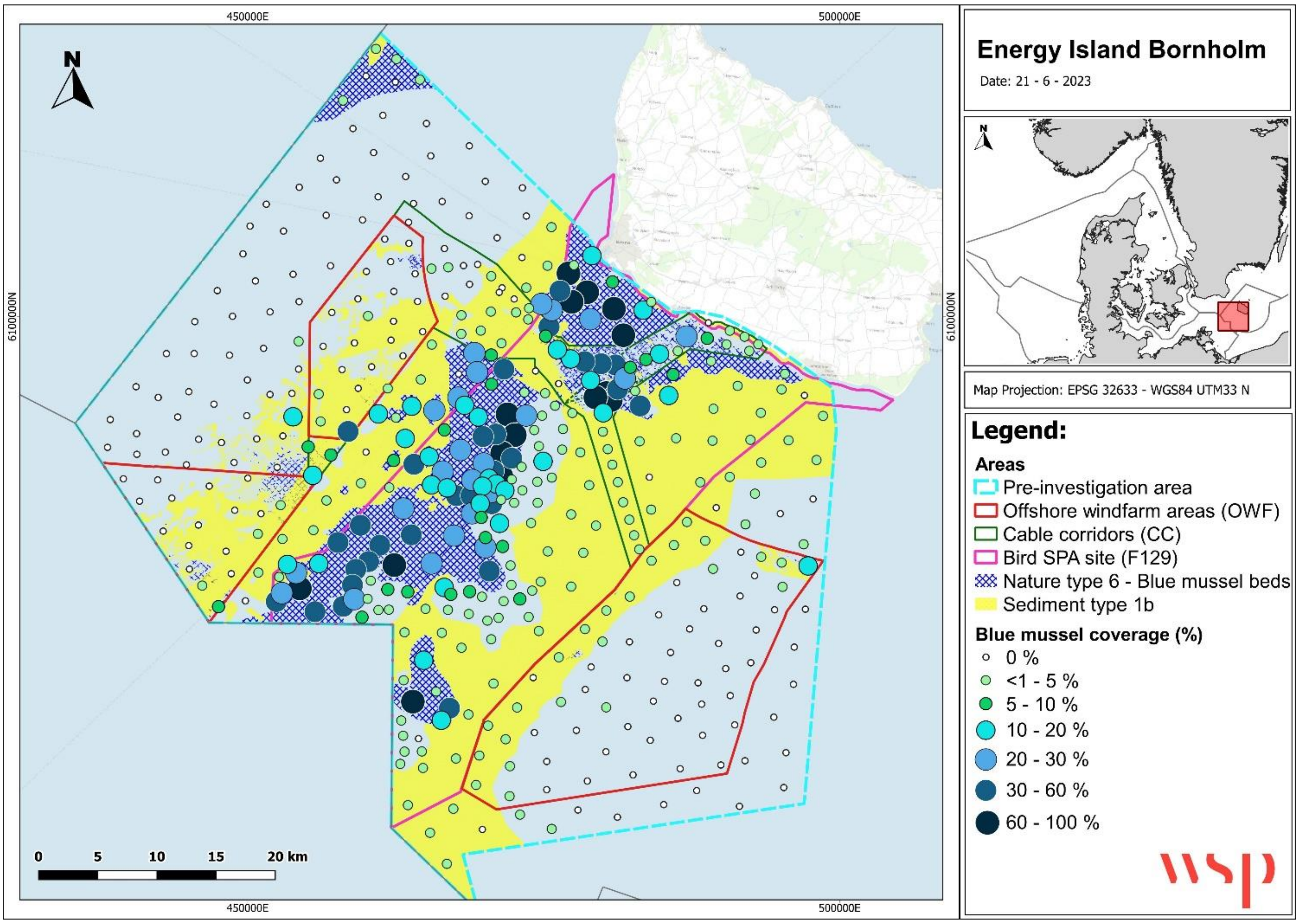


Figure 9-1 Map of blue mussel distribution in the pre-investigation area at ROV stations and as Nature type 6 – Blue mussel beds, which are based on distribution of hard sediment types (Sediment type 3 and 4). Blue mussel (*Mytilus* spp.) overall coverage in the pre-investigation area without station numbers (see next figure for station numbers). Overall coverage % is the coverage of the total video view of the seabed often given as a range in the logbooks in Appendix 3. The maximum coverage % in the range is shown in this figure. (Source: (WSP, 2023)).

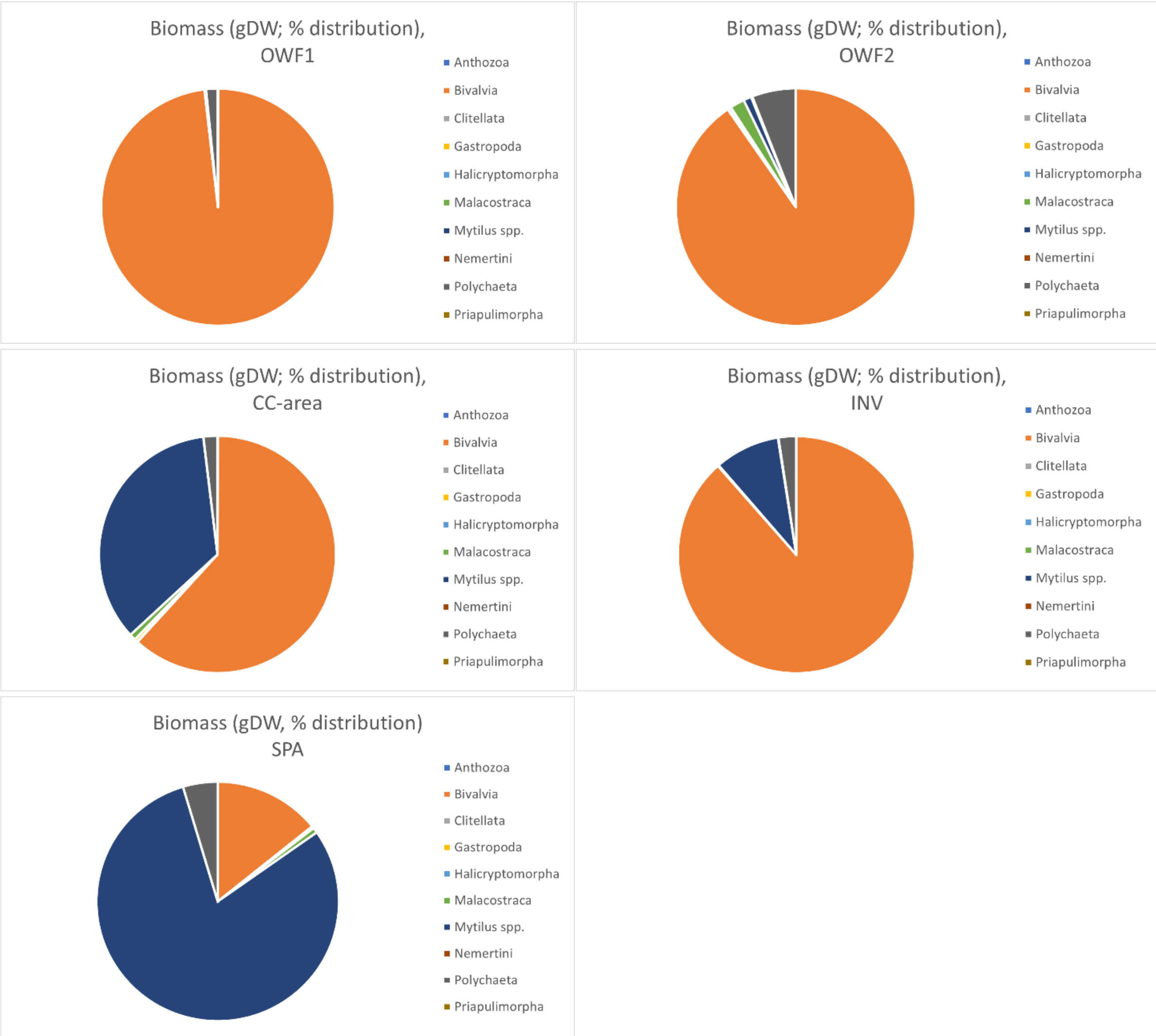


Figure 9-2 Class distribution of infauna biomass in g dry weight (DW)/m^2, where the bivalve species blue mussels *(Mytilus* spp.*)* is separated from "Bivalvia" (orange color in pie charts) and included as its own group (dark blue color in pie charts). (Source: (WSP, 2023)).

9.2 OTHER FOOD SOURCES

Other food sources for fish in the pre-investigation area include other bivalves (excl. blue mussels in Figure 9-3), bristle worms, crustaceans and snails. The distribution of these fauna classes in the pre-investigation area is shown in maps in Figure 9-3 and as pie charts in Figure 9-2.

Bivalves excl. blue mussels were especially high in biomass in OWF I North and in the northwestern part of the Pre-investigation area in general. Bristle worms were also high in biomass in the northwestern part of the pre-investigation area and in OWF I North. However, high biomasses of bristle worms were also observed in and on the edge of OWF II.

Crustaceans had the highest biomasses in the central part of the pre-investigation area, i.e. Rønne Banke, and for crustaceans also south east of this.

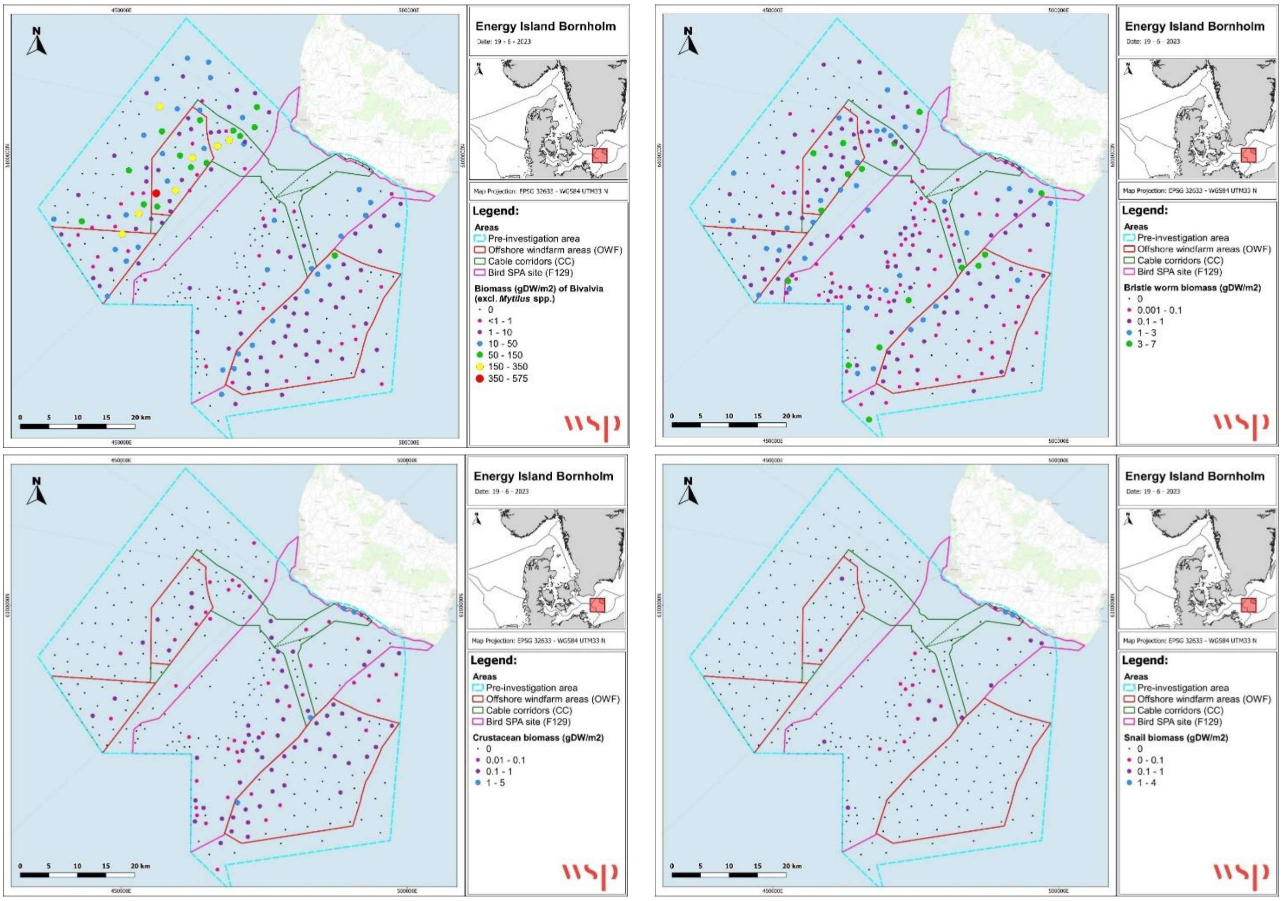


Figure 9-3 Biomass maps of bivalves (excl. blue mussels) (upper left), Bristle worms (upper right), Crustaceans (lower left) and Snails (lower right) (gDW/m²).

9.3 FISH OVERLAP

9.3.1 BEAM TRAWL

When comparing the biomasses of potential food groups with the results from the autumn fish survey, which was conducted very close to each other time vice, the two datasets showed similarities. There was especially a high level of overlap between food availability (blue mussels, other bivalves and bristle worms) and fish densities in the OWF I North and in the northwestern part of the pre-investigation area in general (Figure 9-4). This overlap suggests what this area is utilizes as fish feeding areas. In the beam trawl, the abundance of fish was high in BT15 (> 10 fish), and medium (5-10 fish) in BT01, BT02, BT17 and BT18, which overlapped with areas of high food availability.

Food availability (blue mussels, other bivalves and bristle worms) and biomass of fish overlapped in areas of high biomass (> 1,500 gram fish) in stations BT02, BT15 and BT17 (Figure 9-5). Beam trawl stations with medium biomass (500-1500 gram fish) per station included BT18, BT11, BT14 and BT16 were all positioned in the north western part of the pre-investigation area and, thus, overlapping with areas of high prey availability, indicating that the area serves as feeding area.

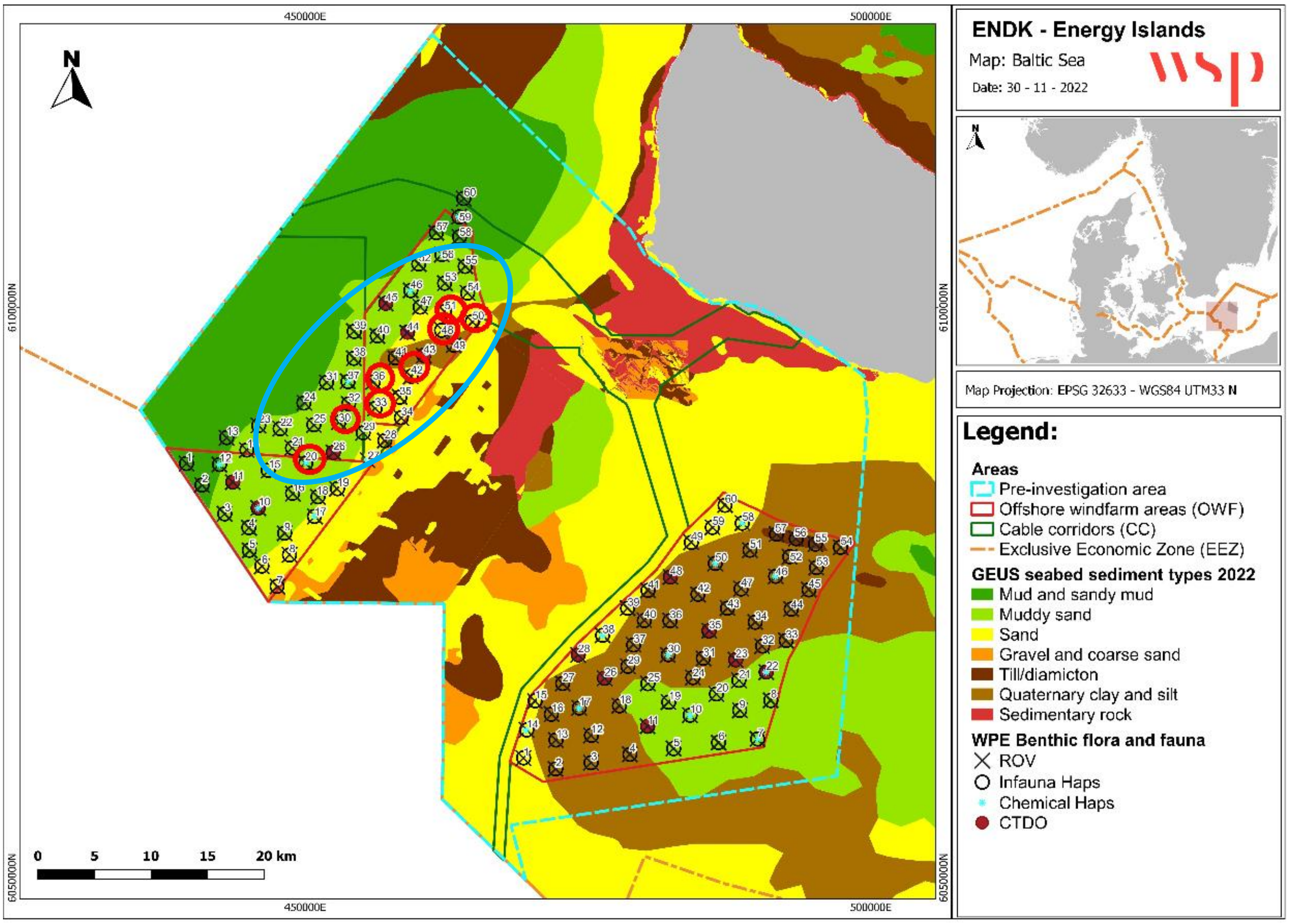


Figure 9-4 Map of infauna samples in the pre-investigation area of ENOE OWF with HAPS: Red markings demonstrate samples (of 42 partial samples) with an infauna biomass sum per sample of >1,5 gram, November 2022.

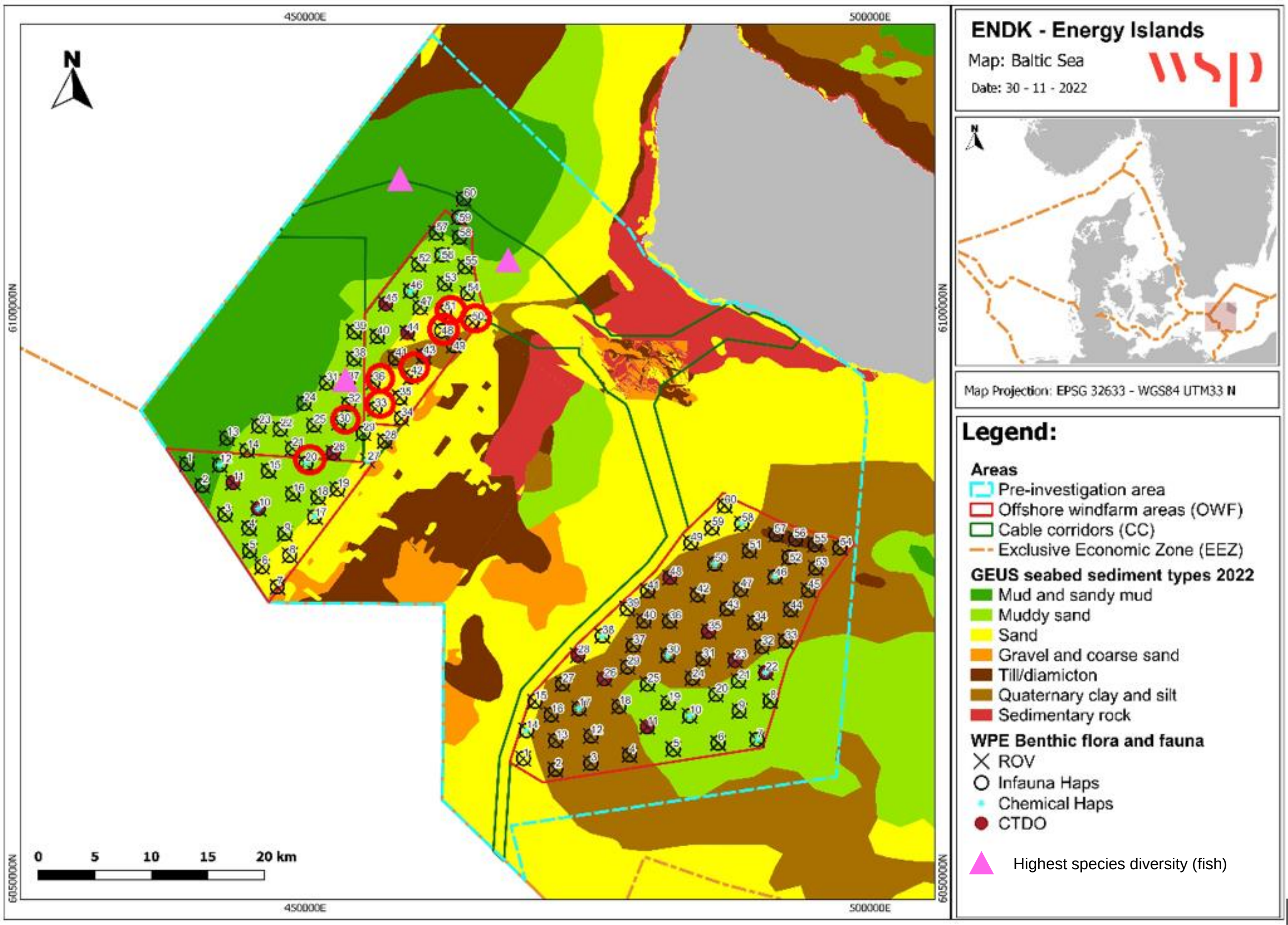


Figure 9-5 Map of coalition between highest infauna biomass samples and highest biodiversity of fish species total. Red circles indicate areas of high biomass.

9.3.2 MULTIMESH GILLNET AND TRAMMEL NET

For the results found in multimesh gillnets it is somewhat more difficult to determine feeding areas for fish, however, a few stations are relevant in this aspect. There was an overlap of food availability of bristle worms and crustaceans and high abundance of fish (> 10 fish) in multimesh station MG08 located in the cc area. No trammel net with high abundance of fish with stations overlapped with high food availability.

Stations with high fish biomass (> 1500 grams of fish) overlapping with high food availability included multimesh gillnet stations MG08 and MG09, as well as trammel net stations TN12 and TN13, located in the cc and Rønne Banke area, respectively.

10 CONCLUSIONS

The biodiversity of all species, including fish, is generally low in the Baltic Sea compared to other Danish waters. This is especially caused by the low salinity in the area, as some fish are not physical adapted to brackish waters. Brackish waters often experience great fluctuations in the salinity due to saltwater inflow or freshwater outflow due to wind direction, storm or rain events, and these variations requires great flexibility of the osmotic systems of fish. In addition, salinity also regulate zooplankton community's occurrence and abundance as they only occur in their preferred salinity range. In the area nearest to the pre-investigation area, the Bornholm Basin, and the Arkona Basin, between 103 and 108 fish species have been recorded. Approximately one third of these species reproduce regularly in the area, 17-18 % occur here frequently, while remaining 45 % are just passing through when migrating back and forth to freshwater/saltwater.

In the 80s and 90s a regime shift changed the system from an ecosystem dominated by Atlantic to one dominated by sprat and Atlantic herring. The decrease in cod biomass has occurred simultaneously while the oxygen level in the Baltic Sea has decreased, and prey biomass has diminished. In addition, a parasitic liver worm transmitted from grey seals has been observed in Baltic cod since the early 2010s, which has coincided with further deterioration of the poor health status and stock decline of cod.

In the fish surveys conducted here, a total of 22 different species were caught. The dominating species were flatfish especially European plaice, European flounder, but other flatfishes were also caught i.e. turbot, dab and sole, but other species such as Atlantic cod, sculpins, Atlantic herring, and gobies were also recorded on most stations. The non-indigenous round goby was also observed in low numbers in the spring survey. The invasive species may result in consequences for the availability of prey for the native species. The abundance and biomass of fish caught in the surveys conducted for the present study was relatively low. On some stations no fish were caught, and in most trawl stations the catches only amounted to a few hundred grams. The gillnet catches were somewhat larger ranging from 50 grams up to 4,5 kg.

The low occurrence of fish is also reflected in the commercial fishery. Danish fishermen report that they have moved their main fishing grounds to the Kattegat and Skagerrak-area instead of near Bornholm. Although no interviews of Swedish fisherfolk was conducted for the ENOE project, the data shows the same tendency for the Swedish commercial fishery. Even though a fishing ban was introduced for cod in 2019, the Atlantic cod stock shows no sign of recovery and natural mortality is still high, and the biomass of cod >35 cm is presently at the lowest level observed since the 1950s.

Some spawning or nearly spawning European flounder were recorded in the present study. Based on the findings here and existing literature, it is likely that European flounder utilizes the south-eastern part of the OWF area as spawning site. Spawning, or nearly spawning, European plaice were also observed in the surveys conducted here. No proper spawning site for European plaice is described in existing literature, but according to models on abiotic conditions there may be appropriate areas near Bornholm. Based on this, it is possible that European plaice spawn in or near the pre-investigation area e.g., the southwestern part of the OWF (Bornholm II Syd). Based on observations from the surveys and from existing literature, it is expected that juvenile Atlantic cod utilize the hardbottom area in the CC as nursery area due to the high level of structural relief and availability of shelter and food.

Generally, the Shannon Wiener index calculated for the pre-investigation area of ENOE OWF show low values, indicating a low species diversity. The number of fish species caught per station varied from 0 to 8 species for both spring and autumn. The stations with the highest Shannon Wiener index were located in the CC near Rønne Banke and in the western part of the pre-investigation and OWF area. The average evenness index for beam trawl was 0.6-0.5 for spring and autumn, respectively. This indicates a community, where few species dominate the catches. For multimesh gillnets and trammel nets, the Evenness index was on average 1 both for spring and autumn. This is due to very low catches in the nets with only a few species represented on each station. The biased results is believed to be the result of very low biomass and biodiversity of fish in the Baltic Sea.

There were overlap in areas with high fish abundance and biomass and biomasses of relevant prey items such as blue mussels, other bivalves, bristle worms and crustaceans. This suggests that the areas function as feeding area for especially flat fish species, that are known to eat all of these prey groups. Areas functioning as feeding area include OWFI North, the northwestern part of the pre-investigation area as well as scattered areas in the cc and at east of Rønne Banke.

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