ENERGINET

ENERGY ISLAND BORNHOLM

ENVIRONMENTAL BASELINE NOTE WP-I FISH AND FISH POPULATIONS

28-07-2022

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ENERGINET

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Description	**Environmental Baseline Note for WP-I Fish and Fish Populations**

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CONTENTS

Abbreviation	Explanation
BITS	Baltic International Trawl Survey
CC	Cable corridors
CC1	Cable corridor from Bornholm I wind farm area to Bornholm
CC2	Cable corridor from Bornholm II wind farm area to Bornholm
Client	Energinet
DFA	Danish Fisheries Agency
EIA	Environmental Impact Assessment
ICES	International Council for Exploration of the Sea
IUCN	International Union for Conservation of Nature
OWF	Offshore Wind Farm
OWF1 nord	Bornholm 1 nord
OWF1 syd	Bornholm 1 syd
Pre-investigation area	Gross area for the fish survey including the two wind farm areas and the area in between in Danish waters
SEA	Strategic Environmental Assessment

1 INTRODUCTION

The energy islands mark the beginning of a new era for the generation of energy from offshore wind, aimed at creating a green energy supply for Danish and foreign electricity grids. Operating as green power plants at sea, the islands are expected to play a major role in the phasing-out of fossil fuel energy sources in Denmark and Europe.

After political agreement on the energy islands has been reached, the Danish Energy Agency plays a key role in leading the project that will transform the two energy islands from a vision to reality. The islands are pioneer projects that will necessitate the deployment of existing knowledge into an entirely new context.

In the Baltic Sea, the electrotechnical equipment will be placed on the island of Bornholm, where electricity from offshore wind farms (OWF) will be routed to electricity grids on Zealand and neighbouring countries. The offshore wind farms will be constructed approximately 15 km south-southwest of the coast of Bornholm and have a capacity of 3 GW.

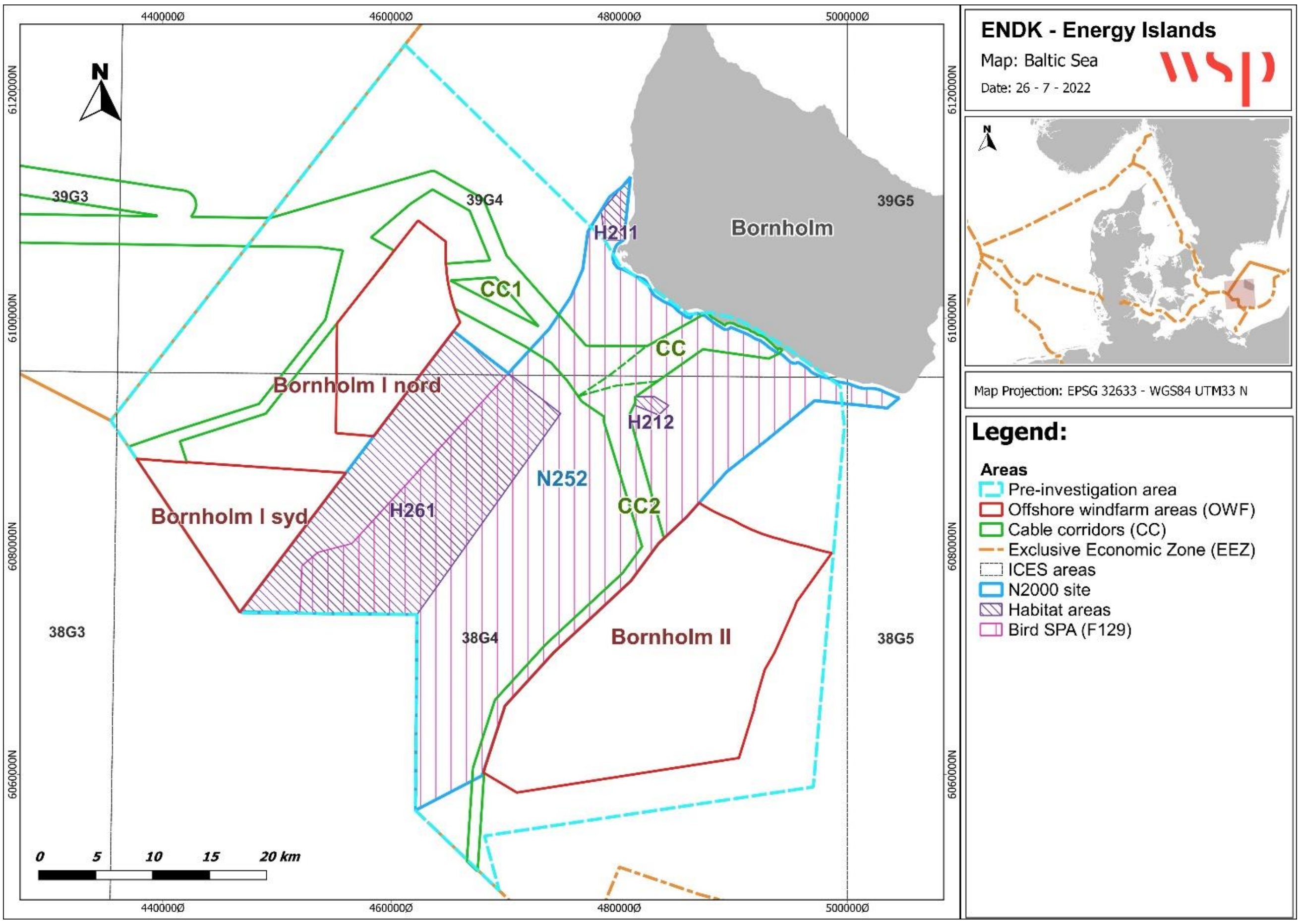

Figure 1-1. Energy Island Bornholm.

The environmental baseline note 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 1-1). Furthermore, Natura 2000 sites and the new bird SPA site (Rønne Banke

F129/DK00FC373) between the two wind farm areas are shown. Cable corridors to Zealand and neighbouring countries are not included in this environmental baseline note.

This document provides a description of existing data of the following subjects under WP-I – Fish and Fish Populations:

- Abiotic parameters (depth, sediment types)
- Sediment characteristics
- Key fish species
- Fish spawning sites and nursery areas
- Protected species and habitats

The above parameters are described and mapped purely in relation to their importance for fish and the habitats these live in.

2 METHODOLOGY

The short description methodology used to map and describe existing data for fish distribution, spawning sites, nursery areas and fish habitats in the pre-investigation area for Energy Island Bornholm are presented below.

2.1 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.

2.1.1 SALINITY

Different projects have contributed with existing data on information on salinity in 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 comparable methods as will be used on future surveys for Energy Island Bornholm. 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).

2.1.2 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.

Existing data is collected from different projects and studies in the pre-investigation area. The projects were chosen, as they provided relatively new data from the pre-investigation area and were sampled and analyzed by comparable methods as done for Energy Island Bornholm. 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).

2.1.3 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 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.

2.2 FISH DATA

Data on fish observations from various sources is 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. The logbook carries 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 is an important source of information on which species can be found in the specific areas of Danish waters. Logbook data was obtained from the Danish Fisheries Agency for the relevant ICES rectangles 38G4 and 39G4 (The Danish Fisheries Agency, 2021).

This report also includes information from Fiskeatlas. Since 2019, data on fish distribution in Danish marine waters have been gathered from a long list of historical and present sources (Fiskeatlas, 2020). 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 in each Danish marine area and thereby, relevant for the present assessment.

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).

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 EXISTING DATA

Existing conditions in the pre-investigation area and adjacent areas of the Energy Island Bornholm for abiotic parameters as well as biological parameters are presented below. Abiotic conditions include water depth and seabed substrates, and biological parameters includes fish fauna. Finally, an overview of the benthic habitats is presented.

3.1 ABIOTIC DATA

3.1.1 SALINITY

Salinity is an important parameter determining the fish species diversity in the Baltic Sea, since fewer species are adapted to brackish conditions (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 (Perttilä, 2007) (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) and it is estimated that future freshening will increase due to climate change (Meier, et al., 2006), although the inflows of high saline water has had a slightly higher frequency in the later years (HELCOM, 2017).

3.1.2 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 fluctuates 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 m depth) and is presented in Figure 3-1. 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 and depths of 20 to 55 meters are 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.

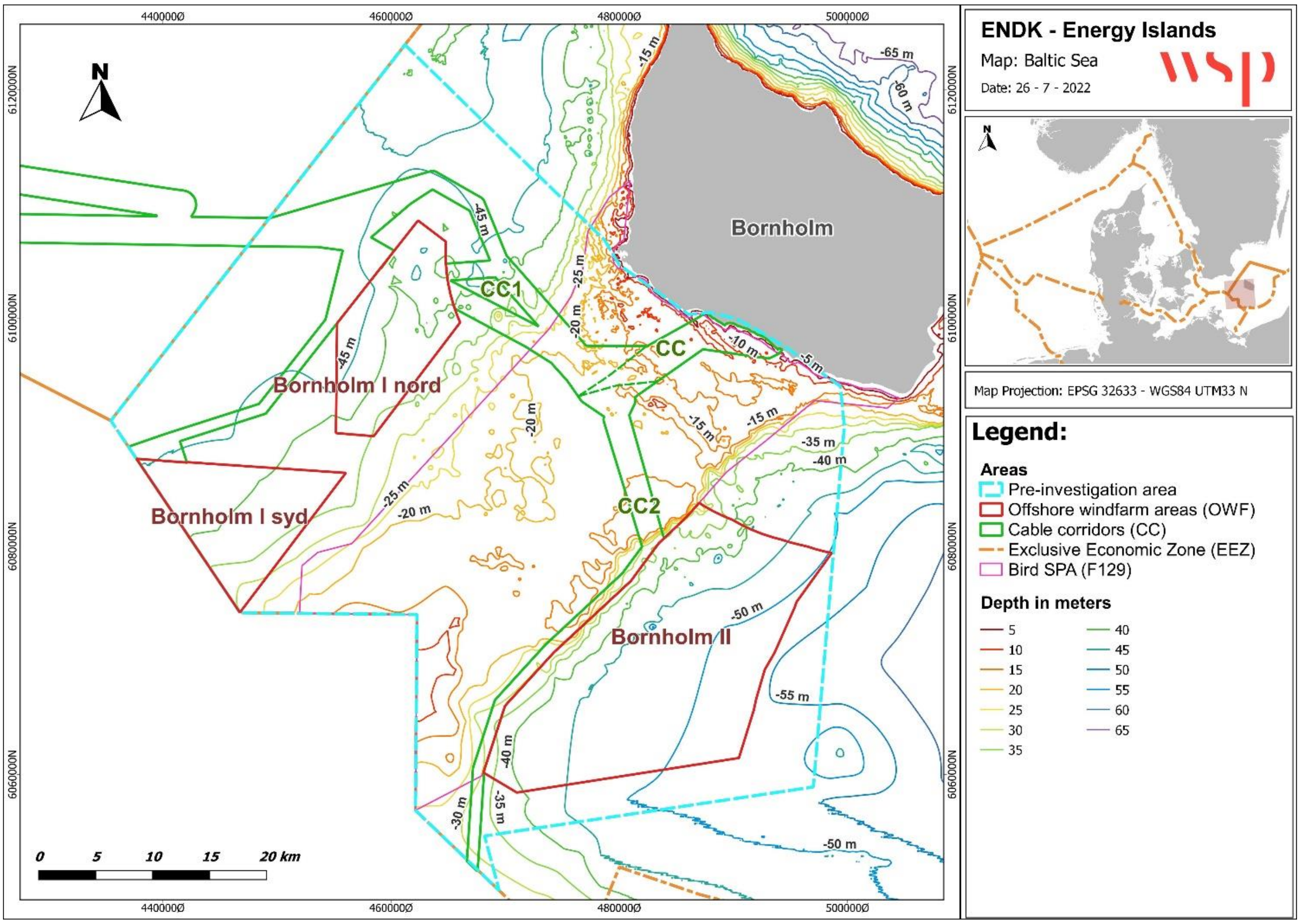

Figure 3-1. Depth map in the pre-investigation area. Data source: Sjöfartsverket 2013.

3.1.3 SEDIMENT TYPES

Fish are attracted to the sediment types, they have adapted to, and some even depend on certain habitat types to complete their life cycles – 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 3-2. The map is based on data from the national geophysical database provided by GEUS (Marta database, (GEUS, 2022)).

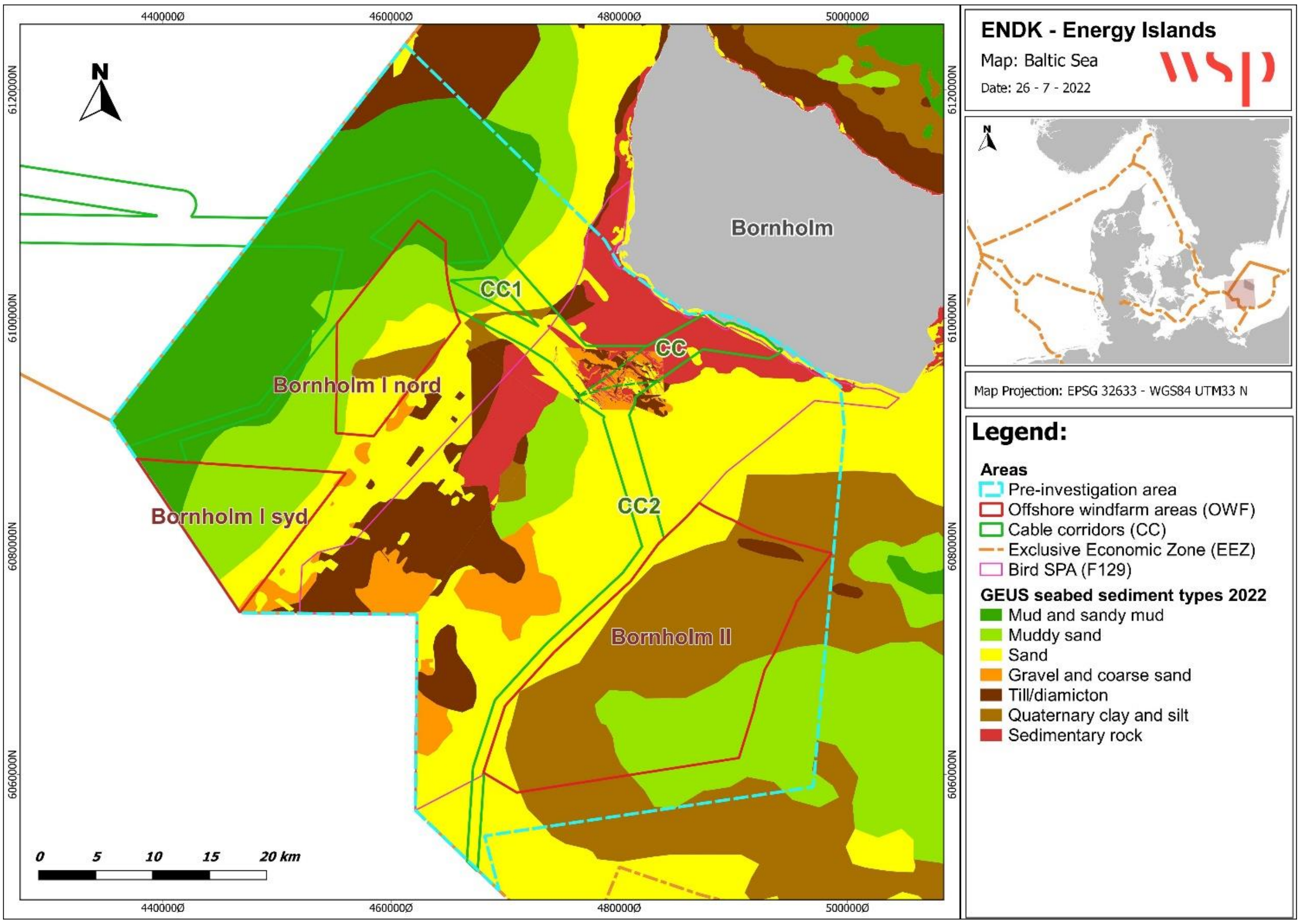

Figure 3-2. Seabed sediment types in the pre-investigation area based on existing data. Data sources: GEUS Martha database (GEUS, 2022).

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 3-2). 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. For a more detailed map on sediment types, please see maps in Environmental Baseline Note WP-E Benthic Flora and Fauna (Rambøll & WSP, 2022).

3.2 FISH DATA

A total of 230 species of fish are 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). In the areas nearest to the pre-investigation area, Bornholm Basin and Arkona Basin, a little more than 100 species have been recorded (HELCOM, 2012). Of these species 35-37% of the species have a regular reproduction in the

Bornholm Basin and Arkona Basin, while 17-18% occur in the area regularly. Approximately 43-45% of the species only have a temporary occurrence and the remaining species have a more uncertain occurrence. As a consequence of the brackish character of the Baltic Sea, several anadromous (saltwater living and freshwater spawning) and catadromous species (freshwater living and saltwater spawning) migrate back and forth through the Baltic Sea. Of the marine fish species that are characterized as regular reproducing near the pre-investigation area, herring (*Clupea harengus*), sprat (*Sprattus sprattus*), cod (*Gadus morhua*), flounder (*Platichthys flesus*) and plaice (*Pleuronectes platessa*) are among the most important species. For further details on the importance of the area as spawning site, please see section 3.4.

In the commercial fishery, 31 fish species were caught in ICES rectangle 38G4 and 39G4, which are the only rectangles covering the pre-investigation area. All fish species registered in the commercial fisheries are listed in Table 3-1.

Historically, a total of 73 fish species have been registered in Fiskeatlas database (Fiskeatlas, 2022) (Table 3-1). The observed species include numerous observations of common and economically important species such as cod, herring, sprat, whiting (*Merlangius merlangius*) and the flatfish species plaice, turbot (*Scophthalmus maximus*), and flounder. The commonness of these species is further supported by the number of references that has caught each species. But 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 3.5 Protected fish species and habitats for further details on protected and vulnerable species.

In Table 3-1 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, the ecosystem is a wasp-waist, meaning that few mid-level forage species (herring and sprat) support a high diversity of larger predators (e.g., 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. Such restructuring of the ecosystem has occurred for the past 30 years, where the abundance of main predators has dropped and in turn increased the biomass of sprat (Eero, et al., 2012) (Casini, et al., 2014).

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

Table 3-1 List of fish species registered in and around the pre-investigation area based 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*	Pike-perch	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

3.3 DESCRIPTION OF KEY FISH SPECIES

3.3.1 *COD (GADUS MORHUA)*

The Atlantic cod belongs to the family of *Gadidae* where most species have a characteristic chin hook (Muus & Nielsen, 2006). The cod grows up to 150 cm, although individuals of this size is very rare today due to high fishing pressure. A more usual maximum size is approximately 110 cm and 15 kg. Cod lives from coastal areas to 500-600 m depth near the bottom but can also occur pelagic. Cod occurs in the entire Baltic Sea except for the northern part of the Bothnian Bay (Cohen, et al., 1990). Generally, the cod spawns in January to April and the eggs drift with the water current in the pelagic. Juvenile cod utilize hard bottom areas as nursery area, where they feed on small crustaceans and the diet gradually shifts to be increasing piscivorous. 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 grounds.

3.3.2 *HERRING (CLUPEA HARENGUS)*

The herring is a pelagic, silvery, shoaling fish with soft fin rays. The maximum size is 40 cm although the fish rarely exceeds 20 cm in the Baltic Sea, and it may reach an age of 20 to 25 years (Muus & Nielsen, 2006). Herring occurs 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 item for many other fish. The herring diet consists mainly of copepods, pelagic gastropods and fish larvae. The herring is a common species in the Baltic Sea and is an important food source to e.g., cod. 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 herring mainly spawn around the German peninsula Rügen and both spring and autumn spawners has been observed in the area (Warnar, et al., 2012). High densities of herring larvae have been observed both in the Arkona Basin and Bornholm Basin which most likely origin from spawning near Bornholm (Warnar, et al., 2012).

3.3.3 *SPRAT (SPRATTUS SPRATTUS)*

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 it 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 m depth and in wintertime deeper at approximately 150 m depth. 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 sprat in the Baltic Sea was in May, but the spawning season has changed (Muus & Nielsen, 2006). Now 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 & Kalejs, 2010). After spawning, sprat migrate toward shallow feeding grounds.

3.3.4 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 m, at sea, estuaries and rarely 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 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). It feeds mainly on thin-shelled molluscs and polychaetes. In the Baltic Sea, plaice spawn from November to March in the deep areas where the salinity and temperature 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. 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.

3.3.5 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 (Momigliano, et al., 2017). Flounder with demersal eggs was described as a new species, the Baltic flounder, *Platichthys solemdali,* which 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 otherwice (see section 3.4.4 European and Baltic flounder) (Carl, et al., 2019).

3.3.6 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 m depth on sandy, rocky or mixed bottoms preying on crustaceans but as the turbot grows, the diet also includes fish such as small 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.

3.4 SPAWNING AND NURSERY AREAS

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

3.4.1 ATLANTIC COD

The Atlantic cod in the Baltic Sea consist of a western and eastern population with fairly different characteristics with regards to spawning area and time. Due to the special hydrographical conditions (e.g., low salinity etc.) in the Baltic Sea, cod spawning only occurs in deeper areas (20-40 m depth) and the most important spawning site for the western population is believed to be Kiel Bay (Hüssy, 2011) (Figure 3-3 left). The Arkona Basin west of Bornholm is considered less important for the western population of cod (Hüssy, 2011) (Bleil & Oeberst, 2002). In Arkona Basin, the western population of cod spawn from February to September, although summer spawners observed here may be migrants from the eastern population. The cod larvae and small juveniles < 5 cm live pelagically until they settle (Hüssy, et al., 1997) and prefer hard bottom habitats that provide shelter and good feeding grounds. Information is limited on the nursery areas for the western population of cod in the Baltic Sea.

The spawning of the eastern population of cod in the Baltic Sea is limited to the deep areas (>60 m) including the Bornholm Deep and Gdansk Deep (Bagge, et al., 1994) (Wieland, et al., 2000) (Bleil, et al., 2009) (Figure 3-3 right). However, due to low oxygen levels, the most important spawning ground for the eastern population of cod is now Bornholm Deep, while the Gotland Basin has ceased to contribute to the reproduction of cod (Hinrichsen, et al., 2016). Evidence of spawning cod from the eastern population in Arkona Basin and at least temporarily in the Belt Sea has also been documented (Stroganov, et al., 2017). Some cod from the eastern population has even migrated as far as Arkona Basin west of Bornholm to spawn (Thaulow-Petersen, 2009), even though this area was formerly only used by the western population of cod. The nursery areas for the eastern population of 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 cod have been observed on Rønne Banke southwest of Bornholm and Hanö Bay north of Bornholm (ICES, 2007-2011). The observations of juvenile cod on Rønne Banke is supported by interviews with commercial fisherfolk from Bornholm, who also reported seeing juvenile cod on the north-east coast of Bornholm (Nielsen, B. & Kvaavik, C. (Eds.), 2007). Conditions for the Baltic cod have changed greatly over the past decades, and most publications on the distribution of juvenile cod are based on 3-4 decades of retrospective data. Thus, there is a need for supplementary fish surveys to document the present conditions.

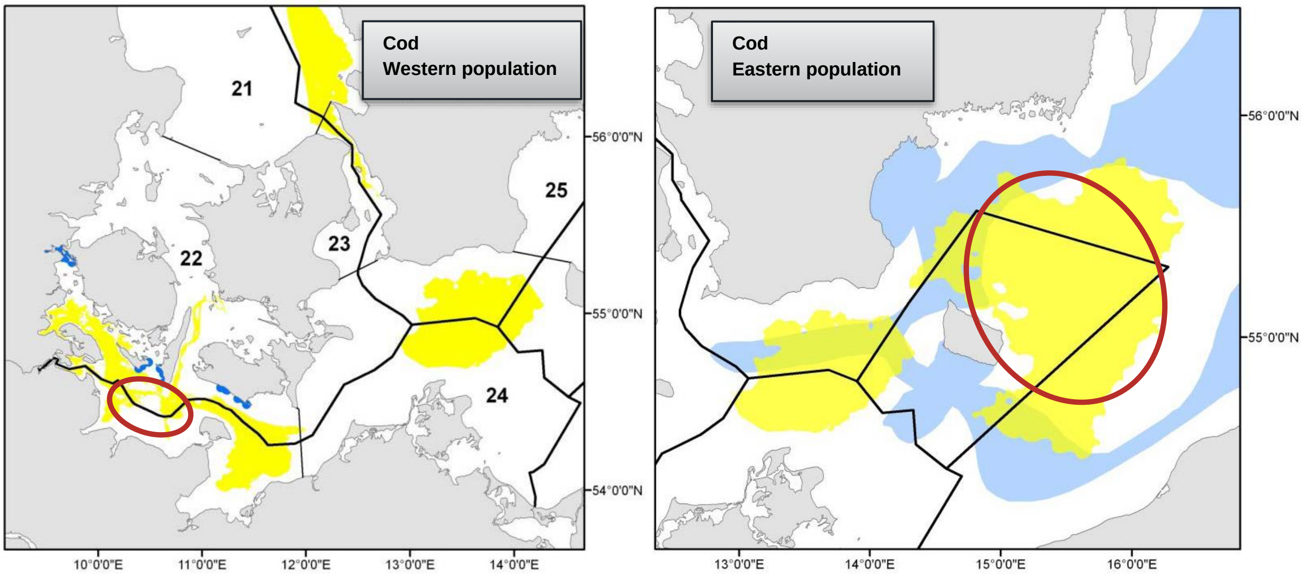

Figure 3-3 The known spawning (yellow) and nursery areas (blue) for the western (left) and eastern (right) population of Atlantic cod in the Baltic Sea. Modified after (Warnar, et al., 2012). Red circles indicate the most important spawning areas for the western cod (Hüssy, 2011) and eastern cod (Hinrichsen, et al., 2016).

3.4.2 ATLANTIC HERRING

In Danish waters, the herring is naturally divided into smaller populations that vary morphologically and have different spawning season, migration routes, way of life and growth. Herring is a demersal spawner, and the eggs are attached to hard substrate or vegetation in relatively shallow areas (Pihl & Wennhage, 2002) (Figure 3-4). The main spawning area or 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, herring have a very plastic utilization of spawning grounds (Corten, 2001), and as most areas around Bornholm meet the criteria, it is likely that the areas are utilized sporadically. Juvenile 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).

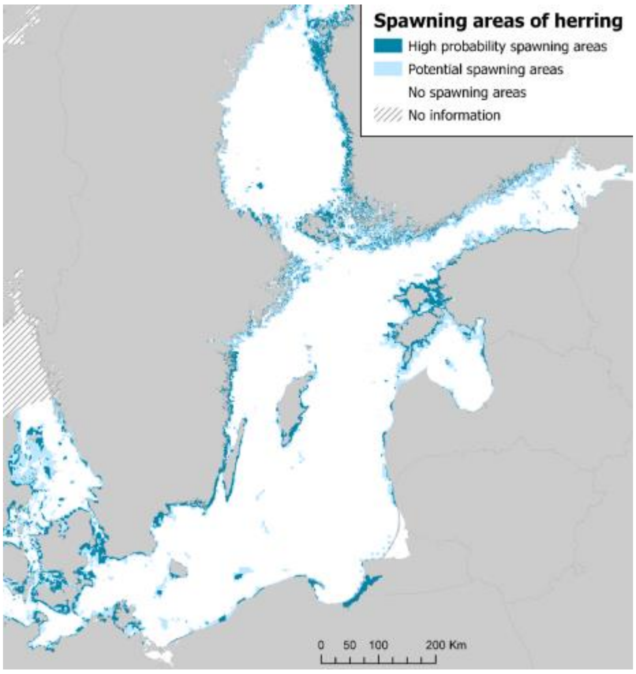

Figure 3-4 High probability (blue) and potential (light blue) spawning areas of herring in photic hard bottom areas with vegetation. Source (HELCOM, 2021)

3.4.3 SPRAT

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 Atlantic cod in the area, and therefore coincides the spawning grounds for the two species. 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 & Kalejs, 2010) (Baumann, et al., 2006) (Köster, et al., 2005) (Figure 3-5 left). However, sprat eggs have a higher buoyancy and float at lower salinities compared to cod eggs. Therefore, spawning also occurs for sprat in Gulf of Riga (Ojaveer & Kalejs, 2010). Recent surveys indicate that sprat no longer spawn in the Gulf of Finland (HELCOM, 2021) (Figure 3-5 right). 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 & Kalejs, 2010). Juvenile sprats 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).

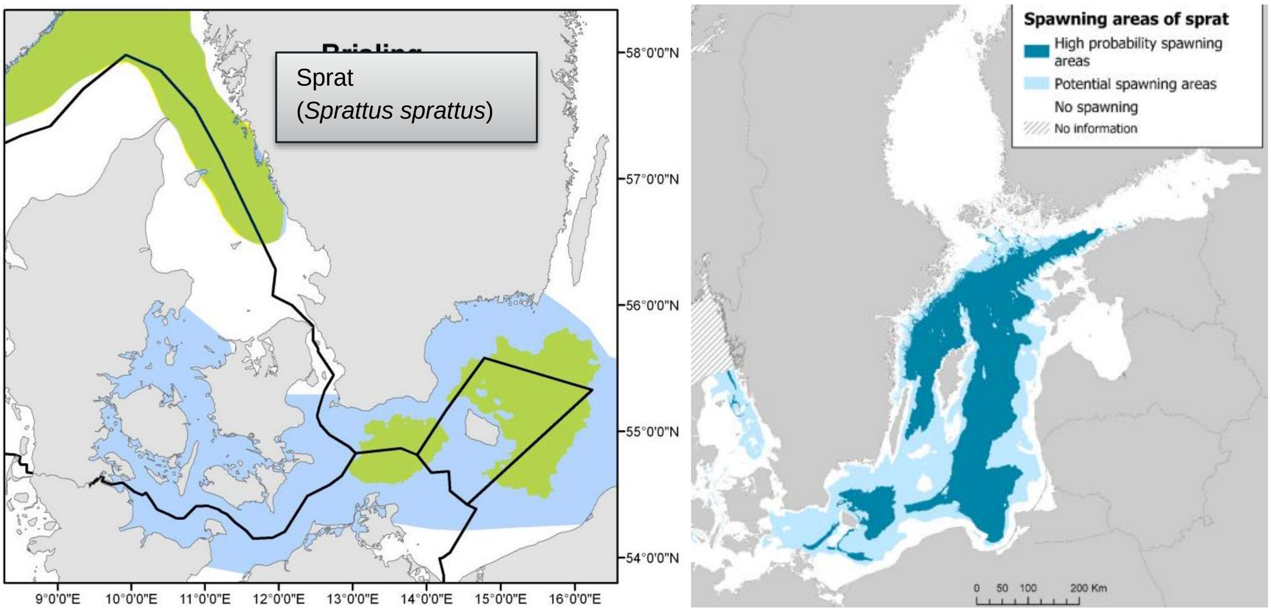

Figure 3-5 Left: The known spawning (green) and nursery areas (blue) for sprat in the western Baltic Sea. Source: (Warnar, et al., 2012). Right: High probability (blue) and potential (light blue) spawning areas of sprat with salinity > 6 ppm and > 30 m depth (but for the Arkona Basin > 20 m depth. Source (HELCOM, 2021)

3.4.4 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 m depth) 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 3-6). The Baltic flounder, on the other hand, prefers coastal/shallow (< 30 m 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 3-7). During winter they migrate into deeper waters when water temperature drops.

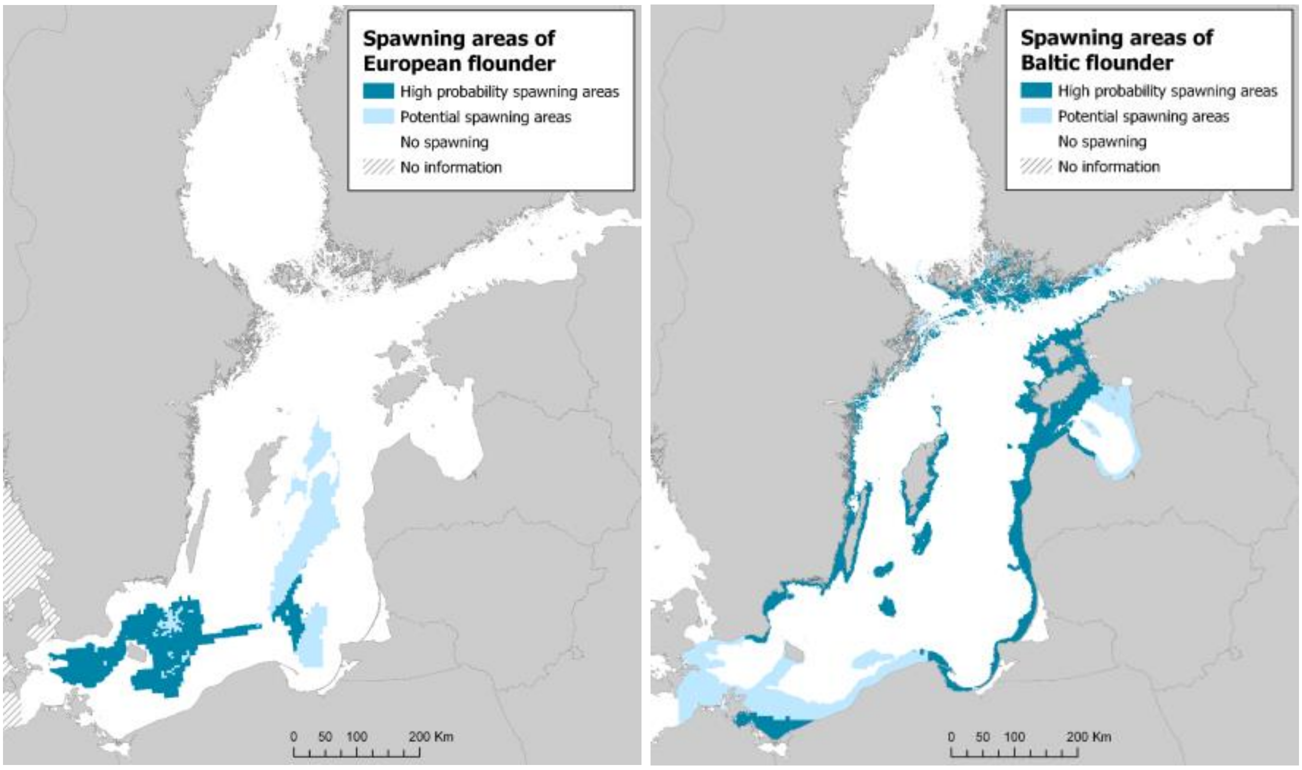

Figure 3-6 Left: High probability (blue) and potential (light blue) spawning areas of European flounder with salinity > 10 ppm, > 30 m depth and good oxygen conditions. Source (HELCOM, 2021). Right: High probability (blue) and potential (light blue) spawning areas of Baltic flounder with salinity > 6 ppm and < 30 m depth due to the demersal nature of the eggs. Source (HELCOM, 2021).

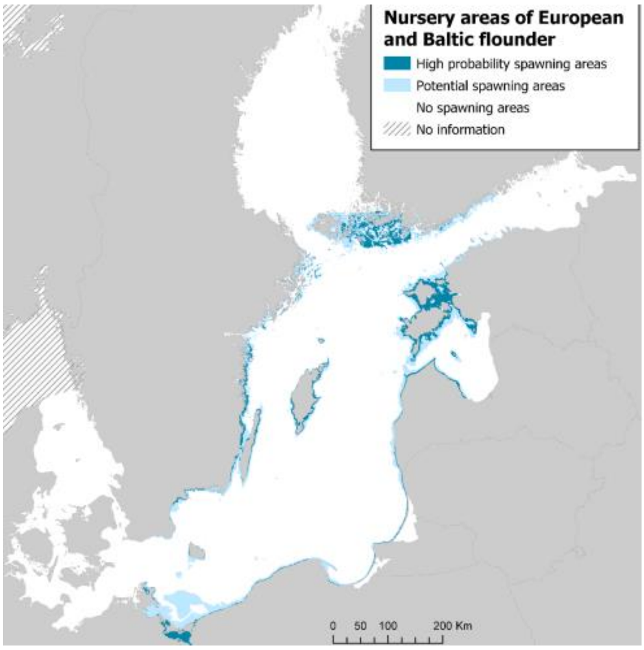

Figure 3-7 High probability (blue) and potential (light blue) nursery areas for European and Baltic flounder with respect to salinity, wave exposure, water depth, slope of the bottom, surface temperature, bottom currents and distance to high probability spawning area for flounder. Source (HELCOM, 2021).

3.5 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 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.

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, that was last updated in Denmark in 2019 (Carl & Møller, 2019) (Table 3-2). Several of these species are registered in the pre-investigation area of the Energy Island Bornholm according to Fiskeatlas (Fiskeatlas, 2022).

Table 3-2 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.

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	Atlantic sturgeon				NT	x
Acipenser sturio	Sturgeon	x	x		CR	x
Alosa alosa	Allis shad	x		x	LC	
Alosa fallax	Twaite shad	x		x	LC	x
Anguilla anguilla	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 Sturgeon (*Acipenser sturio*), which, according to Fiskeatlas registrations, has been observed in the pre-investigation area of Energy Island Bornholm 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. 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 (Henrik Carl pers. comm.). 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 of the Energy Island Bornholm on eight occasions. All of 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 lampreys spawns 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, which more precisely 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-rectangel 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 be merely 1% of the population size in the 1970s for the past 4-5 decades and in 2009 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 cod is now historically malnourished and growth impaired (Hüssy, et al., 2018). Even though a fishing ban was introduced in 2019, the 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 Baltic cod 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 cod has ingested smaller infected prey items such as sprat, and larger individuals, thus, accumulates 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 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).

Any possible impact from the Bornholm Energy Island OWF may affect the surrounding areas. Local Natura 2000 sites and Habitat areas are shown in Figure 3-8. 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) (MST, 2021). In addition, the reason for appointment of the area is also protection of the Baltic Sea population of harbour porpoise (1351). No fish species are the reason for protection of the area; 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 beneficiary 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 habitat for fish species that find shelter and prey on the reef, and dredging has been banned 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.

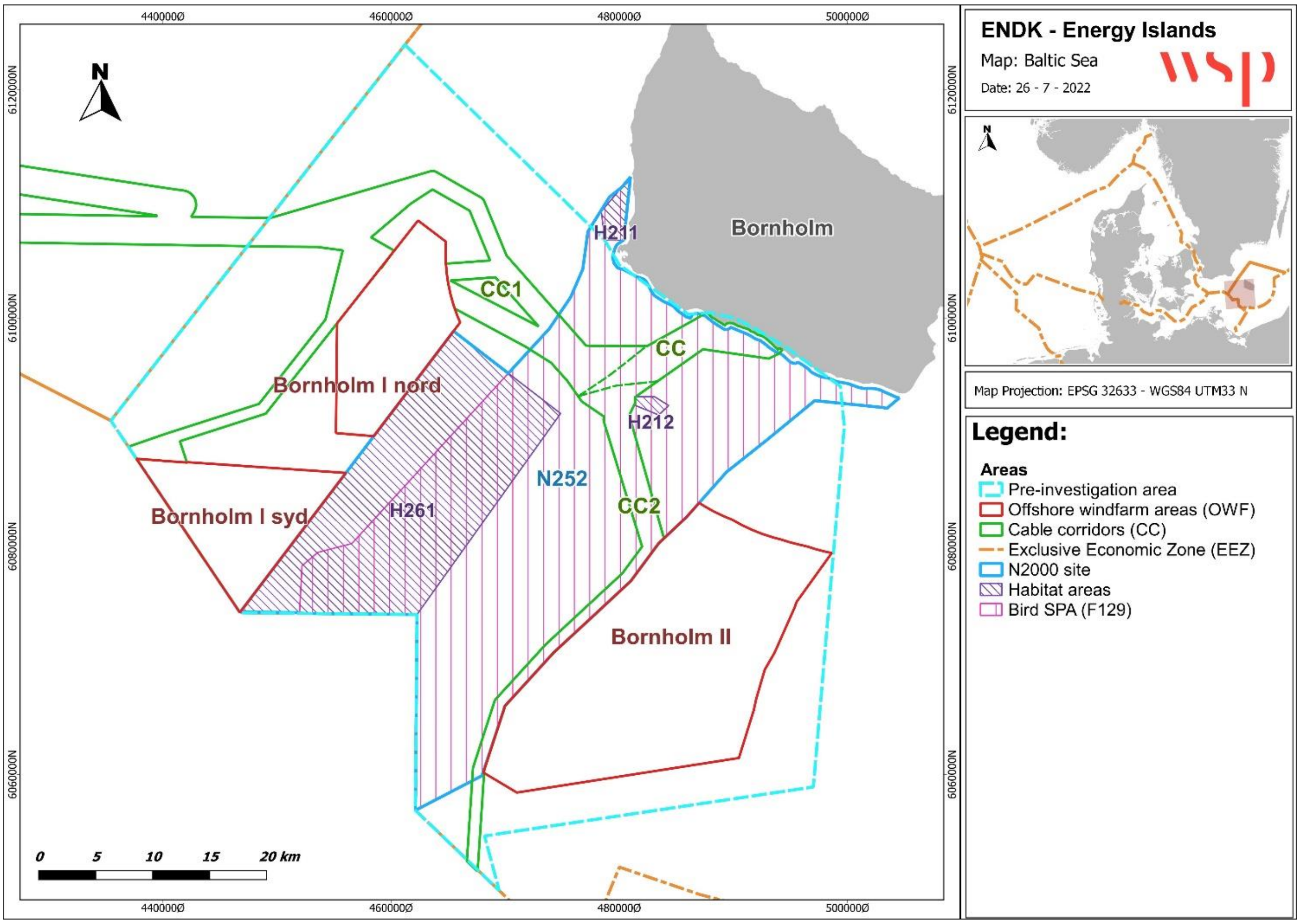

Figure 3-8 Natura 2000 sites and Habitat areas in the pre-investigation area

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