CHAPTER 6

A CLOSER LOOK AT THE FISH FAUNA OF ARTIFICIAL HARD SUBSTRATA OF OFFSHORE RENEWABLES IN BELGIAN WATERS

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Abstract

Artificial hard substrata are known to attract many marine species, among which several highly mobile species. In this contribution, we examined the species composition and uniqueness of the fish fauna around offshore wind turbine foundations in Belgian waters. These offshore structures provide shelter, suitable habitat and a source of food for several fish species. A total of 25 fish species were observed around the turbine foundations, 15 of which are also known to dwell around wrecks in the same area. Four species, the Tadpole Fish (*Raniceps raninus*), the Tompot Blenny (*Parablennius gattorugine*) and the Longspined Bullhead (*Taurulus bulbalis*) were previously rarely or, in the case of the Ballan Wrasse (*Labrys bergylta*), only once reported from Belgian waters. This, however, does not necessarily mean that they are rare. We show that, in order to obtain a good insight into the fish fauna, the use of a suite of varied sampling techniques is necessary. Most of the obligate hard substrata fish species that were observed are frequently recorded in the oyster beds and boulder fields of the nearby Eastern Scheldt estuary. We expect that hard substrata-frequenting fish species will increasingly benefit from the continued expansion of offshore wind farms in the Southern North Sea.

1. Introduction

Natural hard substrata in the North Sea include gravel beds and oyster banks, both of which have been degraded either by over-exploitation or disturbance through bottom disturbing fisheries. As a result, they are characterised by relatively low habitat diversity, and very few hard substrata dwelling fish are encountered (RBINS, unpublished data). Since the latter half of the 20th century, artificial hard substrata have become a common habitat type in the North Sea (Zintzen *et al.* 2008; Coolen 2017). They include seawalls, wrecks, oil and gas platforms and, more recently, offshore renewable developments. The increasing demand for marine renewable energy in the Southern North Sea has resulted in a rapid expansion of artificial hard substrata (*e.g.*, Mineur *et al.* 2012). All these offshore structures provide suitable habitat for a fouling community (Bohnsack 1989; Bull & Kendall 1994; Fabi *et al.* 2006; Leitao *et al.* 2007; Krone *et al.* 2013). The large biomass of invertebrates present in the fouling community on the structures represents a potentially valuable food resource that attracts many hard substrata-dwelling fish (Pike & Lindquist 1994; Fabi *et al.* 2006; Leitao *et al.* 2007). The artificial structures also provide meeting points for fish and can serve as spawning and nursery sites (Bull & Kendall 1994). Additionally, the crevices and nooks provide refuge against currents and predators (Jessee *et al.* 1985; Bohnsack 1989; Reubens *et al.* 2013).

In this contribution, we perform a preliminary analysis of the composition and uniqueness of the fish fauna around offshore wind turbine foundations in Belgian waters.

2. Material and methods

2.1. Study site

The Belgian part of the North Sea (BPNS) is located in the Southern Bight of the North Sea and is characterised by shallow waters with a complex system of sandbanks. The seafloor consists of mostly sandy and muddy habitats with some smaller natural hard substrata comprised of shell hash, gravels and boulders (Kerckhof & Houziaux 2003). In the BPNS, artificial hard substrata consist of coastal defence structures, wrecks, buoys and offshore wind turbines. There are over 200 wrecks in the BPNS and these have been estimated to increase the total biomass of the BPNS by a maximum of 4% (Zintzen 2007). There are around 150 navigational buoys deployed on the BPNS (data: Agentschap Maritieme Dienstverlening en Kust, dab Vloot). These floating structures usually provide a habitat for a typical fouling community (Kerckhof 2005). Although these buoys may serve as fish aggregating devices (*e.g.*, Relini *et al.* 2000), we could not find any published data on this for the Southern North Sea. By the end of 2016, 4 wind farms were built in a specially designated zone for renewable energy consisting of 232 turbines and their scour protection resulting in a scattered artificial reef of 0.09 km². By 2020, 5 more wind farms are expected to be constructed (totalling a capacity of 2 GW) and current planning envisions an additional 2 GW between 2020 and 2030 (see chapter 1).

2.2. Species list and categorisation

We compiled a list of fish species observed at offshore wind turbine foundations and wrecks in Belgian waters by combining data collected in the frame work of various projects on the artificial hard substrata in which a range of techniques to collect fish fauna were deployed, supplemented with our own observations (table 1). We compared this list to the dataset of 224 fish species observed by the Institute for Agricultural and Fisheries Research (ILVO), Animal Sciences Unit – Fisheries, Oostende, in the BPNS in their long term fisheries monitoring. ILVO has an epifauna and demersal fish monitoring programme in the BPNS running since 1979. Given the vast differences in both sampling effort and techniques we only used presence/absence data.

Table 1. Overview of datasets used with indication of sampling period, sampling techniques used and habitats sampled

Dataset	Period	Technique	Offshore turbines	Wrecks	Soft substrata
BEWREMABI	2001-2003	Dive transects		X	
ILVO	1979-2017	Beam trawl			X
Reubens PhD	2009-2012	Dive transects, line fishing	X	X	X
Own data	2016-2017	Dive transects, line fishing	X		

Based on the habitat preferences recorded in literature (*e.g.*, Camphuysen *et al.* 2017; Froese & Pauly 2018), we scored the substratum preference of the reported fish species. On the one hand, there are species that permanently live on and in the vicinity of hard substrata (obligate hard substrata species) such as the Tompot Blenny and the Tadpole Fish (*Raniceps raninus*). Other species including many gadoid fish prefer to swim closely to hard substrata (hard substrata associated species). In addition, there are accidental passers-by and indifferent species, *i.e.*, species that are found around hard substrata but do not have a specific substratum preference.

Based on literature (*e.g.*, Camphuysen *et al.* 2017; Froese & Pauly 2018), we further assigned the different fish species to relevant habitat groups according to the zone in the water column they inhabit: (1) benthic fish, *i.e.*, fish living on the bottom of the sea, examples are Dab (*Limanda limanda*) and Common Sole (*Solea solea*), (2) benthopelagic fish, *i.e.*, fish that live in close association with the bottom of the sea but do not rest on the bottom, examples are Pouting (*Trisopterus luscus*), Atlantic Cod (*Gadus morhua*) and Sea Bass (*Dicentrarchus labrax*), and (3) pelagic fish, *i.e.*, those fish living at mid-water or surface levels, examples are Mackerel (*Scomber scombrus*) and Horse Mackerel (*Trachurus trachurus*).

3. Results

3.1. Species richness

Within the framework of the different projects, a total of 25 fish species were observed at the different man-made offshore hard substrata (table 2). Of these 25 species, 15 are related to hard substrata and 5 have an outspoken hard substratum preference. Fifteen species were observed both near the turbines and the wrecks. Only bony fish were observed in the various studies, no sharks nor rays. One species, the Tadpole Fish, was not at all listed in the ILVO database. Two other species Tompot Blenny and Longspined Bullhead were previously to this research rarely recorded and the Ballan Wrasse (*Labrys bergylta*) was only once reported in the past. None of the species solely occurs on artificial hard substrata within their distribution area.

4. Discussion

4.1. Remarkable species

Four species were previously tot this research rarely or only once reported in Belgian waters: Tadpole Fish, Ballan Wrasse, Tompot Blenny and Longspined Bullhead. For the first three species, we here provide some further knowledge on their habitat, ecology and geographic distribution. We do not discuss the Longspined Bullhead into detail, as it in fact is a known common inhabitant along the Dutch and Belgian inshore waters (Nijssen & De Groot 1987; Rappé & Eneman 1988) and hence seems to be underrepresented in our database.

Tadpole Fish Raniceps raninus (Linnaeus, 1758)

The Tadpole Fish (fig. 1) lives solitary in areas of rocks and boulders, and hides in crevices during the day. It is most often found in shallow water (1-20 m) but occurs up to a depth of 100 m. It is active at night and localizes prey with a sensitive probe wire.

Figure 1. Tadpole Fish (*Raniceps raninus*), Eastern Scheldt estuary. Photograph by S. Jansens.

Table 2. Fish species observed at the offshore turbines with their substratum preference (obligate hard substrata species: (2) hard substrata associated species: (1) accidental passers-by and indifferent species: (0) and habitat group

Latin name	Common name	Habitat group	Substratum preference	Turbines	Wrecks	Soft substrata
Blenniidae spec.	Blenny	benthopelagic	1	X		X
Callionymus lyra	Dragonfish	benthopelagic	0	X		X
Dicentrarchus labrax	Sea Bass	benthopelagic	1	X	X	X
Gadus morhua	Atlantic Cod	benthopelagic	1	X	X	X
Gobiinae	gobies	benthopelagic	1	X	X	X
Labridae spec.	Wrasse	benthopelagic	1	X		X
Labrus bergylta	Ballan Wrasse	benthopelagic	1	X		X
Limanda limanda	Dab	benthic	0	X		X
Merlangius merlangus	Whiting	benthopelagic	0	X	X	X
Microstomus kitt	Lemon Sole	benthic	0	X		X
Mullus spec.	Goatfish	benthopelagic	0	X		X
Myoxocephalus scorpius	Bull Rout	benthopelagic	2	X	X	X
Parablennius gattorugine	Tompot Blenny	benthopelagic	2	X	X	X
Pleuronectes platessa	European Plaice	benthopelagic	0	X	X	X
Pollachius pollachius	Pollack	benthopelagic	1	X	X	X
Pollachius virens	Saithe	benthopelagic	1	X	X	X
Raniceps raninus	Tadpole Fish	benthopelagic	2	X		
Scomber scombrus	Mackerel	pelagic	0	X	X	X
Solea solea	Common Sole	benthic	0	X		X
Spondyliosoma cantharus	Black Seabream	benthopelagic	2	X	X	X
Taurulus bubalis	Longspined Bullhead	benthopelagic	2	X		X
Trachinus vipera	Lesser Weever	benthopelagic	0	X	X	X
Trachurus trachurus	Horse Mackerel	pelagic	0	X	X	X
Trisopterus luscus	Pouting	benthopelagic	1	X	X	X
Trisopterus minutus	Poor Cod	benthopelagic	1	X	X	X

Its diet consists of crustaceans such as shrimps, molluscs and smaller bottom fish (Middeldorp 1978; Nijssen & De Groot 1987). In the turbine scour protection it can find both suitable shelter and food.

This species is known in suitable habitats from Norway and Iceland through the North Sea and along the Atlantic coast down to Portugal. It is sporadically caught along the Dutch and Belgian coast (Nijssen & De Groot 1987; Rappé & Eneman 1988) and although there have been a few recorded landings by Belgian fishermen, their exact origin remains unclear.

Ballan Wrasse Labrus bergylta Ascanius, 1767

The Ballan Wrasse (fig. 2) is an omnivorous fish and its diet mainly consists of crustaceans, molluscs and ophiurids although it can also feed on algae (Dipper *et al.* 1977). It is long-lived (up to 29 years), with slow growth and a protogynous hermaphrodite without sexual dimorphism in colour (Dipper *et al.* 1977). They can be found at depths from 1 to 50 m amongst rocks, seaweed and reefs. The rocky turbine scour protection forms a suitable habitat with abundant food.

This species of wrasse is native to the northeastern Atlantic Ocean from Norway to Morocco, including the islands of Madeira, the Azores and the Canary Islands (Quignard & Pras 1986). Despite being locally quite rare, likely due to the scarcity of suitable habitat in the Southern North Sea (Redeke 1941; Poll 1943), this is the most common wrasse in our waters (Rappé & Eneman 1988).

Tompot Blenny Parablennius gattorugine (Linnaeus, 1758)

Tompot Blennies (fig. 3) live in rocky areas of mostly shallow waters, in areas with a lot of shelters where they guard a territory and where the females lay eggs in rock crevices during the spawning season (March-May) (Dunne & Byrne 1979; Picton & Morrow 2016). This territory is fiercely defended and the eggs are also guarded by the male (brood care) (Naylor & Jacoby 2016). Tompot Blennies can also be found on wrecks, at depths of 30 m or more and in the tidal zone along rocky coasts. The fish are mainly hunting at dusk and at night. The animals are curious and often appear to observe divers (Holstein & Ates 1999). The food consists of crustaceans, worms, echinoderms and other invertebrates, but also sea anemones and seaweeds (algae) would be eaten (Dunne & Byrne 1979; Milton 1983). In addition to providing suitable habitat, shelter and abundant food, the turbine scour protection likely serves as a location to deposit eggs.

Figure 2. Ballan Wrasse (*Labrys bergylta*) caught in the Belgian part of the North Sea. Photograph by H. Hillewaert.

Figure 3. Tompot Blenny (*Parablennius gattorugine*). Photograph by F. Pointel.

This species is uncommon in the Southern Bight of the North Sea and occurs further along the East Atlantic from Ireland to West Africa (Morocco) and in the Mediterranean. The species is known from the Wadden Sea and especially from the Zeeland waters, where the species is mainly seen on stony dikes and on mussel and oyster beds, but is very rare along the Dutch and Belgian coast (Camphuysen & Henderson 2017; Nijssen & De Groot 1987; Rappé & Eneman 1988). However, the number of sightings over the 20th century is increasing. Along the Belgian coast there are recent findings on groynes and in coastal waters (waarnemingen.be). Dutch reports area mostly from the Delta area (Holsteijn & Ates 1999). The species probably benefits from rising water temperatures in winter and the increasing availability of the desired rocky habitat.

4.2. Fish diversity at hard substrata of offshore renewables in Belgium and beyond

The turbine foundations were quickly colonized by a diverse fouling community (Kerckhof *et al.* 2010) that provided a source of food for several fish species (Reubens *et al.* 2011; 2013). Our results show that at least 25 fish species are present near the turbine foundations. We remark that none of the species solely occurs on artificial hard substrata within their total distribution area, because even obligate hard substrata species can occasionally also be found on soft sediments, *e.g.*, when moving from one discrete hard substratum area to another one.

As the size and number of the suitable habitat increases because of the continued expansion of the offshore renewable developments, both further offshore as well as nearer to the shore, we can expect that in the future several additional fish species with affinities to hard substrata will be observed, such as Butterfish (*Pholis gunnellus*), Five- and Four-Bearded Rockling (*Ciliata mustela* and *Enchelyopus cimbrius*), Sea Horses (*Hippocampus hippocampus* and *H. ramulosus*), European Conger (*Conger conger*) and, in particular, wrasses that are the most conspicuous and characteristic species of fish associated with reef habitats, especially the Goldsinny Wrasse (*Ctenolabrus rupestris*) a species already commonly reported in other studies (Krone *et al.* 2016; van Hal *et al.* 2017). Besides the effect of the proliferation of artificial hard substrata in the North Sea, also the increased sampling effort in that habitat may contribute to the discovery of new (hard substratum) species. The numerous planned environmental monitoring programmes targeting the effects of offshore renewables will hence increase the likelihood of detection of those fish and will undoubtedly complete the species list. These artificial substrata may also serve as a nursery for certain species and thus, in part, offset the degradation that has occurred in the natural hard substrata (Veer *et al.* 2015).

The faunal composition around wrecks and other artificial hard substrata is comparable with our findings, with an assemblage consisting of numerically dominant gadoids and a limited number of other species of which the obligate hard substrata species and hard substrata associated species are typical. Similar patterns in the fish assemblage with the dominance of gadoids and some typical rock associated species, including some 'rare' species, are also reported in other studies on the fish fauna of artificial hard substrata elsewhere in the North Sea, *e.g.*, around oil platforms in the northern North Sea Guerin (2010) and, wind turbine foundations in the Netherlands (van Hal *et al.* 2017) and the German Bight (Krone *et al.* 2016). These studies report several rare species, associated with hard substrata that we also observed and some others not yet reported from artificial hard substrata in the BPNS. All these studies, including ours, reveal the presence of several species such as Ballan Wrasse, Longspined Bullhead and the Tompot Blenny.

Published data on the fish fauna of natural hard substrata such as boulder and stony reefs are rare for the BPNS. However, studies on the natural hard substrata elsewhere show a similar species pool that can benefit from natural hard substrata restoration efforts (Støttrup *et al.* 2014). Additionally, most of the obligate hard substrata fish species that we observed are frequently recorded in the oyster beds and boulder fields in the nearby Eastern Scheldt estuary where many additional fish species are observed by divers (Bob Rumes,RBINS, personal communication). However, within the limited part of the North Sea in which this study was conducted, offshore wind farms do represent artificial hard substrata that are unique for certain habitat features. The fact that offshore wind turbines introduce huge vertical surfaces indeed is new to the offshore waters in the southern North Sea and may hence attract unique fish species not encountered in natural hard substrata in that area.

Many factors influence the number of reported species for the different habitat types. The species assemblage may depend upon environmental variables such as the design and the material of the structures (Bohnsack & Sutherland 1985; Relini *et al.* 2007). The hard substrata from artificial reefs provide shelter for predation and/or prevailing currents for fish species (Langhamer 2012; Reubens *et al.* 2014). The fouling community on the structures in its turn further increases the structural complexity and also provides food and shelter, and may hence itself influence the nature of the fish community (Hueckel & Buckley 1989; Hueckel *et al.* 1989). It is expected that the number of fish species associated with a certain habitat will – in part – be determined by the variation in prevailing aforementioned ecosystem features of this habitat. We could thus rank the different offshore artificial hard substrata in the BPNS in broad categories. Buoys would provide meeting points with only minor food resources. Turbines without scour protection would provide meeting points with better food resources given the longer life cycle of the turbines, the fact that they stretch the entire water column, and their larger scale. Wrecks and turbines with scour protection may finally also serve as spawning and nursery sites and, their crevices and nooks provide refuge against currents and predators.

On the other hand, the number of fish species reported is positively related to the use of various types of sampling techniques as well as to the sampling effort. Each sampling method has a specific catch selectivity (at species level) and will hence render its own specificity to the dataset. The deployment of scuba divers, for example, is very limited, both in space and time, and requires the ability to recognise the species. Line fishing is known to be a selective fishing method and is influenced by type and size of baits, hook design, hook size, fishing strategy and fish ecology (Erzini *et al.* 1996; Løkkeborg & Bjordal 1992; McClanahan & Mangi 2004; Ralston 1990), which may explain the low number of species observed by this technique. This sampling technique – and effort – dependent representation of fish species in the databases most likely explains the underrepresentation of the Longspined Bullhead in our database. A combination of sampling methods hence is expected to yield the best impression of the ecosystem and biodiversity, but such an approach is rare. Furthermore, also variation in time cannot be ignored. Seasonal and year-to-year patterns in fish presence may be observed, certainly in temperate waters, as many species migrate towards deeper water when temperature drops (Fabi & Fiorentini 1994). The deployment and combination of different techniques over a longer time frame hence are advised to obtain a comprehensive view of the fish communities associated with hard substrata. The findings presented in this study should thus be interpreted with care: it has to be considered as a minimum estimate of the total species number in the different hard substrata. Nevertheless, the unique availability of fish data collected with different techniques targeting different habitat types in a restricted area (*i.e.*, BPNS), may be considered reliable for preliminary assessing the contribution of artificial hard substrata to the local fish communities.

5. Conclusions

Artificial hard substrata offer habitat to hard substrate fish among which some species previously rarely observed from the BPNS. We show that the deployment of offshore wind turbines alters the habitat for fish due to the introduction of hard substrata in an otherwise sandy area. This has proven an advantage for several special species that previously could not survive in this area. Where scour protection is present, it provides similar functions to the natural boulder and gravel fields thus increasing the surface area available for species of hard substrata. Additionally, we demonstrated that the use of a suite of varied sampling techniques is necessary to gain a proper insight in the fish biodiversity.

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