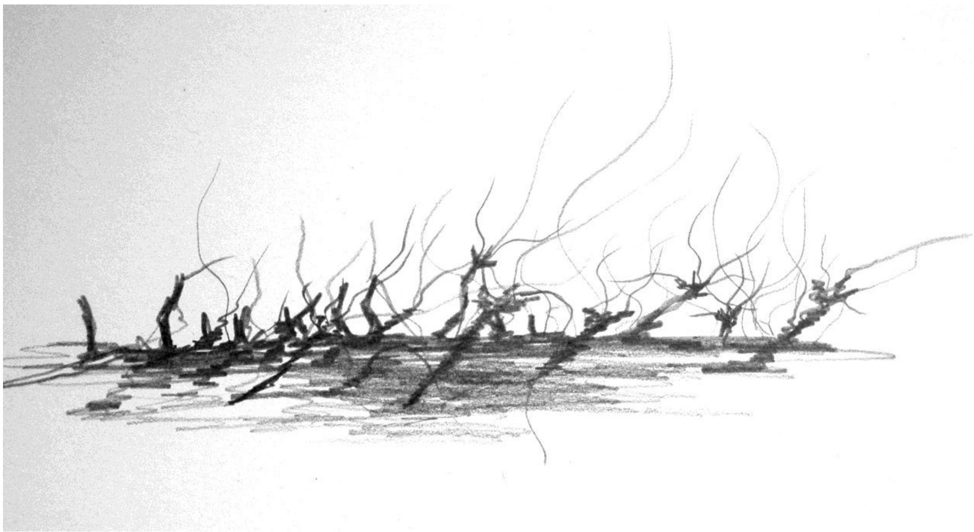
CHAPTER 6

Biogenic reefs as structuring factor in *Pleuronectes platessa* nursery



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Abstract

The structural distribution of juvenile flatfish in nursery areas is generally studied on a larger scale on which the effects of abiotic factors such as sediment characteristics, beach profile, tides, and turbidity dominate. The biotic structuring factor has never before been investigated from a very small scale-perspective. The latter is the subject of the present study. In an *in situ* experimental sampling design, the structuring effect of biogenic reefs on the distribution of *Pleuronectes platessa* (Plaice) in an intertidal nursery area is investigated. The density distribution of this flatfish species is significantly ($p < 0.0001$) explained by the presence of reefs built up by the polychaete *Lanice conchilega*. The importance of this reef builder has been highlighted before in other studies but present study demonstrates that not only the benthic biodiversity is affected by *L. conchilega* reefs, but that the distribution pattern of *P. platessa* is structured by them as well. This structuring impact of small-scale benthic reefs creating a patchy environment in nursery areas potentially plays an important role in other marine environments and indicates the need for further research on the ecological function of benthic reef environments for several flatfish species. Further modification of these biogenic habitats may lead to a loss of one or more ecosystem functions which flatfish species depend on.

Key words

Polychaete reefs, *Lanice conchilega*, *Pleuronectes platessa*, flatfish nursery, marine conservation

Introduction

The surf zone of Belgian sandy beaches is intensively used by a number of epibenthic macro-crustaceans and flatfish species (Beyst *et al.*, 2001). Despite the structurally homogeneous environment, several authors suggest that fluctuations in physical variables (e.g. wave exposure, sediment particle size and turbidity) have a strong influence on the relative abundance of certain species and may alter the composition and species richness (Blaber and Blaber, 1980, Clark *et al.*, 1996, Pihl, 1986, Pihl and Vanderveer, 1992, Romer, 1990). However, local biological characteristics of the beaches might be of major importance (Nicolas *et al.*, 2007) and the need to estimate the quality (biologically) of habitats that are potentially important for juvenile flatfish has already been emphasized (Le Pape *et al.*, 2003b). The Belgian coastal waters have been acknowledged as nursery area which is explained by abiotic variables on the one hand and food availability on the other hand (Dewicke *et al.*, 1998). It is known that the mobile and relatively homogenous nature of the substratum on sandy shores implies that few refuges are available. However, habitat structuring organisms possibly signify another important small scale variable to explain the relative abundance of several species. Habitat structuring organisms are known to add or alter physical, chemical and biological factors and are therefore often referred to as ecosystem engineers (Jones *et al.*, 1994). These structures represent important habitats for a variety of marine organisms. In most habitats, regardless of environmental stress, ecosystem engineers provide the template for all other ecosystem processes, making these engineers essential to conservation. This engineering template has received relatively less ecological attention than the processes generating spatial and temporal patterns of organisms within engineered landscapes (Crain and Bertness, 2006).

The complex biogenic benthic habitats formed by sessile emergent tube dwelling polychaetes are of potential ecological importance. In some cases they act as refuges for juveniles of some commercial species (Auster *et al.*, 1997, Walters and Juanes, 1993) and are associated with a diverse assemblage of fauna that may be important prey (Kaiser *et al.*, 1999a, Peattie and Hoare, 1981). The common tube dwelling polychaete *Lanice conchilega* (Terrebellidae) is the target ecosystem engineer in present study. The physiology, tube structure (Jones and Jago, 1993, Ziegelmeier, 1952), hydrodynamic influence (Dittmann, 1999, Eckman, 1983, Heuers *et* *al.*, 1998), as well as the occurrence of *L. conchilega* patches (Hartmann-Schröder, 1996) has already been described extensively. The influence on faunal abundance, species richness and species composition has been proved based on a long-term dataset (Rabaut *et al.*, 2007), which shows that the species can be classified as an important ecosystem engineer. Recently, scientific evidence showed that *L. conchilega* qualifies as reef builder under the definition of the Habitats Directive (Rabaut *et al.*, 2009b). Moreover, it has been suggested that flatfish species actively select for a tube mat biotope build up by *Chaetopterus sp.* and *L. conchilega* (Rees *et al.*, 2005). In present study we hypothesize that post-larval flatfish (*incasu Pleuronectes platessa*) selects for small spatial scale variations in a reef environment within one beach.

Material and Methods

Study area

The investigated sandy beach is situated along the eastern part of the Belgian coast in the Flemish nature reserve "Bay of Heist" (51°20'N; 3°14'E) (Figure 1). The beach has an intertidal zone of c. 500 m with a tidal range of 5 m. According to the slope and fine median grain size, the beach classifies as a dissipative beach (Wright *et al.*, 1979). However, this particular beach is protected from strong hydrodynamic impacts by the harbour wall of Zeebrugge, built into the sea; therefore, the typically heavy wave action dissipated in a wide surf zone (McLachlan, 1990) is reduced in present study area. According to Short (1996), the study area rates as a 'low -energy, dissipative beach'. The sheltered condition of the beach in the lee of the harbour wall together with the high turbidity makes the area favourable for the development of *L. conchilega* reefs. These reefs can be found below the mid-tidal level, with a maximum near lowest water level. As such, relatively small reefs (surface of c. 1-12 m^2) occur in an area with several other reefs, generating a 'reef zone' consisting of gentle mounds and shallow depressions, with about 20% coverage by reefs (Degraer *et al.*, 2008a, Rabaut *et al.*, 2009b). The location of the reef zones (*i.e.* zone consisting of patches of several reefs interspersed with small patches of bare sediment) could be marked during low tide. These reef areas were considered as treatment zone.

*Figure 1. Sampling area. Position of Belgian part of the North Sea (top left); Sampling zone in the Bay of Heist, protected by the harbour wall of Zeebrugge (top right and bottom left); Position of treatment (*i.e. *reef) and control (*i.e. *bare sand) zones (bottom right).*

Sampling design

The beach, in which the *L. conchilega* reefs were present, was divided into two different zones. One zone was classified as reef area (treatment zone; *i.e.* zone consisting of several reefs), whereas the other zone besides, at the same height on the beach with similar characteristics did not have the tube building polychaete (control zone; *i.e.* bare sediments without any reef). Within each zone, 2 to 4 samples were taken at each sampling event with the hyperbenthic sledge. This sledge samples the hyperbenthos from 0.5 to 45 cm above the bottom. The hyperbenthic sledge consists of two nets placed one above the other (3 m long; mesh size 1 mm) (Beyst *et al.*, 2002b). The results are only based on the contents of the lower net as no flatfish is caught in the higher net. For each sample, the sledge was towed by two persons during 2.5 minutes. Samples were taken on five different days in spring around spring tide events of March-April 2008 (10/3, 28/3, 3/4, 17/4, 25/4) (replication over time). Sampling was performed during ebbing with a water column of 1 to 0.3 m. Replication was done over time. The relatively small sample size combined with the time interval between sampling events justify the assumption of independent sampling.

Sampling treatment

Samples were stored in an 8% formaldehyde solution. Subsequently, all samples were sorted and juvenile flatfish specimens were identified to species level and counted. The length of all specimens was measured. Only individuals of age group 0 yr were used for further analysis as only two individuals of age group I yr were found.

Statistical analysis

To test for the effect of the presence of *L. conchilega* on the densities of juvenile flatfish, a generalized linear model was used in which the fixed factors treatment (*i.e.* presence/absence of *L. conchilega*), time and their interaction effect, were related to the densities of juvenile flatfish species. The SAS software package was used as modelling environment. As the response variables are count data, the residual error structure was tested against a Poisson distribution. When overdispersion became apparent in the model output, the model was rerun, taking the overdispersion into account in order to avoid underestimation of the standard errors. Because the predictor and the mean response are not linearly related to each other, the relationship was specified by a log link function. The fixed effects structure was reduced in a backward stepwise manner.

Results

Two flatfish species were found during this study: *Solea solea* (Sole) and *Pleuronectes platessa* (Plaice). We captured 269 *P. platessa*, ranging from 0.6 – 4.0 cm (average length 1.477, SD = 0.272) and 8 *S. solea* ranging from 0.9 – 1.4 cm (average length 1.250, SD = 0.151). Only for *P. platessa*, a representative amount of specimens was available to perform further analyses. Overall, there were no differences in *P. platessa* densities over time within the control zone, nor within the treatment zone ($p > 0.7$) (Figure 2). Comparison between control and treatment show significant differences in *P. platessa* densities ($p < 0.0001$) (Figure 2, inset). The mean abundance of *P. platessa* in *L. conchilega* free zones (control) was 4.70 (+/- 0.66 SE) individuals per sample, while the abundance in the *L. conchilega* zones (treatment) was 15.50 (+/- 3.63 SE) individuals per sample.

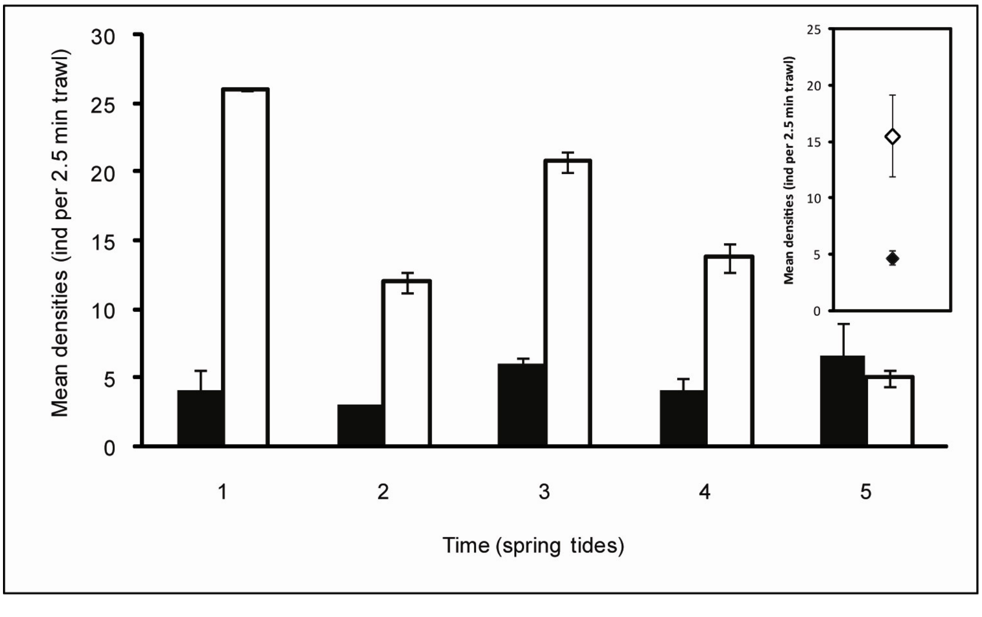

Figure 2. Density distribution of Pleuronectes platessa *(0-group); densities outside* Lanice conchilega *reefs (black) compared with densities inside* L. conchilega *reefs (white). Inset: Overall flatfish density differences between control zones without* L. conchilega *(black) and treatment zones with* L. conchilega *(white). These differences are significant ($p < 0.01$).*

Discussion

Results show that 0-group *P. platessa* densities are described by the presence of *L. conchilega*. On a large scale (hundreds of meters), structuring abiotic factors as the beach profile and turbidity has been highlighted in earlier studies (Beyst *et al.*, 2001, 2002a). Data shown here indicate that on a small scale (meters) habitat structuring organisms such as tube building polychaetes are able to influence the distribution of *P. platessa*. These findings contradict another study in the English Channel where no clear association was found between flatfish abundance, structuring epifauna, and prey availability (Hinz *et al.*, 2006). Nevertheless, it has been suggested that emergent structures, in otherwise low-relief benthic habitats, may play an important role in the ecology of some juvenile flatfishes (Ryer *et al.*, 2004). This study confirms these findings and suggests that aggregations of *L. conchilega* provide shelter for *P. platessa*. As burying in sand is only a partial refuge for juvenile flatfishes (Ansell and Gibson, 1993), reefs may be a good alternative to hide in.

Besides, it has also been demonstrated that food availability can be an important factor (Beyst *et al.*, 1999). An opportunistic utilization by flatfish of the available food resources in surf zone ecosystems has been shown (Lockwood, 1984, Molinero and Flos, 1992, Wyche and Shackley, 1986). The composition and quantity of juvenile *P. platessa* gut contents varies over a small spatial scale (meters) (De Raedemaecker *et al.*, submitted), while food availability in the nursery areas was not found to be related to *P. platessa* density (Pihl and Vanderveer, 1992). This apparent contradiction might be attributed to the spatial variability in condition, growth and diet of juvenile plaice (Beyst *et al.*, 1999). The present study shows that small scale variability of *P. platessa* density can be induced by biological factors and plays a significant role indeed. For age class 0, individuals smaller than 5 cm mainly feed on meiobenthos, while larger individuals shift to macrobenthos (Aarnio *et al.*, 1996).

Furthermore, this study is of interest for the protection of the intertidal environments if the ecosystems approach is to be applied within the framework of integrated coastal zone management. Habitat modification through the removal of emergent structure by anthropogenic and/or natural disturbance may influence patterns of distribution on a very small scale (*i.e.* within one beach), knowing that redistribution to less preferred habitat may decrease survival rates through increased losses to predation (Ryer *et al.*, 2004). Moreover, given the important nursery function of estuaries (Dolbeth *et al.*, 2008, Hampel *et al.*, 2005), these emergent structures contribute probably to survival of flatfish species in estuarine environments. The important conservation stake of these reef systems in intertidal environments has recently been advocated because of their particular functional value (Godet *et al.*, 2008), while it has been suggested that protection is possible under the EU Habitats Directive as habitat type 'reef' (Rabaut *et al.*, 2009b). Furthermore, the patchy environment created by *L. conchilega* is of potential importance for *P. platessa* in subtidal areas as well (as feeding ground, shelter, etc.), where patchy distribution of *P. platessa* has been reported before (Poos and Rijnsdorp, 2005). It has been suggested that relatively sparse elements of habitat structure can have important implications for resource management and conservation (Thrush *et al.*, 2001). Moreover, in the subtidal, severe habitat modification such as bottom trawling affect these reefs (Rabaut *et al.*, 2008).

Conclusion

This spatially small-scale research highlights that biogenic emergent structures such as *L. conchilega* reefs provide a patchy environment which ameliorates the nursery function of highly dynamic shores. Not only do the *L. conchilega* reefs affect the benthic biodiversity and ecosystem functioning (Callaway, 2006, Rabaut *et al.*, 2007, Van Hoey *et al.*, 2008), but they also influence the distribution pattern of *P. platessa*. The present study indicates the need for further research on the ecological function of emergent benthic ecosystem-engineered environments for *P. platessa* and other flatfish species.

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