

EPI- AND HYPERBENTHIC COMMUNITIES OF BELGIAN SANDY BEACHES

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This is the first study on the epi- and hyperbenthic fauna of the surf zone of sandy beaches of the Belgian coast. Therefore, as a first objective of this thesis, a lot of attention has been paid to the inventarisation (species composition), and to the investigation of the temporal and spatial distribution patterns of both communities. A temporal and a spatial campaign were performed during which the hyper- and epibenthos was sampled. During the temporal campaign monthly samples were taken at 4 selected stations and the spatial campaign involved sampling of 12 stations along the Belgian coast. All in all, the surf zone of the Belgian coast is a habitat for a considerable number of species. The surf zone harbours a rich hyperbenthic fauna and also the epibenthic assemblage is diverse. Total hyper- and epibenthic densities were comparable or even higher than those of the adjacent, subtidal regions. It seems that the Belgian surf zone can be seen as an extension of the rich shallow sand bank system in front of the coast. Differences in total hyperbenthic densities with other European sandy beaches might be linked to the degree of exposure.

An attempt was made to elucidate the major environmental variables structuring the communities. Therefore several environmental variables were measured at the moments of sampling. Different uni- and multivariate statistical techniques were used for the analyses of the data. Although clear temperature-related seasonal distribution patterns were observed, the hyper- and epibenthic communities of the surf zone can also be influenced severely by hydrodynamic factors and this both by short-term events (e.g. storm) and long-term effects (influence on morphodynamics of the beach). Spatial differences were found both in species richness and in density. In general, highest hyper- and epibenthic densities were found on flat, wide beaches, but also intermediate sites and sites with a high turbidity were characterised with high densities and a high number of species. Although clear distribution patterns could be observed, the much lower densities of the epibenthos compared to the hyperbenthos, might require a higher sampling effort with replicate sampling in future research. Furthermore, this study indicates that both intertidal and subtidal characteristics should be considered if the (mobile) surf zone fauna is investigated.

Stomach/gut content analyses were performed on five common flatfish fish species from epibenthic samples taken during the temporal campaign in order to unravel part of the surf zone food web. Additional fish were obtained from commercial fishermen. Prey items of all species included hyperbenthic (e.g. mysids), endobenthic (e.g. polychaetes) and epibenthic (e.g. shrimps) species. Little dietary overlap was observed. If diet overlap did occur, it mainly involved prey species that are dominant in the surf zone of the studied beaches, such as shrimps and mysids. These results confirm the opportunistic utilisation by flatfish of the available food resources in surf zone ecosystems. Such opportunistic utilisation of food resources can be important for teleosts frequenting physically stressed environments such as surf-exposed beaches. The diets of turbot *Scophthalmus maximus* and brill *Scophthalmus rhombus* reveal part of the main interactions between the hyper- and epibenthos, whereas those

of plaice *Pleuronectes platessa*, dab *Limanda limanda* and sole *Solea solea* reveal important links between the epibenthos and the macro-endobenthos within the local surf zone food web. Three 24-hours sampling cycles were performed to study short term migration patterns. Again the hyper- and epibenthos was sampled alternately each hour. Stomach content analyses were performed on juvenile plaice *Pleuronectes platessa* of the first 24h-cycle (spring tide). Possible interactions between the epi- and hyperbenthic organisms are discussed. Despite the turbulent conditions of the studied sites, clear tidal (e.g. I-group plaice *Pleuronectes platessa*, the brown shrimp *Crangon crangon*) and diurnal (e.g. juvenile sole *Solea solea*) periodicities were observed in many macrocrustacean and demersal fish species. An opportunistic utilisation of available food resources is again suggested as I-group plaice clearly migrate high up the beach during flood to disperse in order to profit from the rich macrobenthic area (mainly the polychaete *Scolecopsis squamata* and ends of *Arenicola* species), while the 0-group feeds mainly on the most abundant hyper- and macrobenthic organisms from somewhat deeper water (mainly palps of the polychaete *Magelona papillicornis* and cyprid larvae). Finally, it can be concluded that the Belgian surf zone functions as a nursery and/or transient area for hyper- as well as epibenthic stages of several species.

Summary

In this summary, each chapter of the thesis is briefly discussed and some general conclusions are formulated. The main results will be illustrated by the results on the flatfish species plaice *Pleuronectes platessa*. This species is one of the dominant components of both the hyperbenthic (as postlarvae) and epibenthic (as 0- and I-group juveniles) communities. The species has already been recognised as a common resident in the surf zone of sandy beaches by other authors (see Wennhage & Pihl (1994) and references herein, Gibson et al. 1993, 1996) and it feeds to a large extent on hyperbenthic species (see below).

Chapter I deals with the inventory and description of distribution patterns of the hyperbenthos of the surf zone of Belgian sandy beaches and is divided into two parts.

A first part gives a detailed inventory of the surf-zone hyperbenthos and discusses the seasonal patterns of the hyperbenthic species (Chapter I, Part A). Monthly samples were taken in the surf zone of 4 sandy beaches along the Belgian coast from May 1996 until July 1997. A distinction was made between temporary hyperbenthic organisms (merohyperbenthos, e.g. early life stages of fish and macrocrustaceans), and permanent members of the hyperbenthos (holohyperbenthos, e.g. mysids and amphipods). In total, 172 functional species were recorded. More than 75% of the average total sample composition consisted of mysids, mainly *Mesopodopsis slabberi*, *Schistomysis spiritus* and *Schistomysis kervillei*. Within the merohyperbenthos, postlarval decapods and fish were the dominant organisms (e.g. plaice). Average densities per month exceeded 1500 individuals per 100m². Yearly biomass averages ranged from 300 to over 3000 mg ashfree dry weight per 100m². The number of species occurring in the surf zone was comparable to that of the adjacent, subtidal areas and recorded total hyperbenthic densities were slightly higher. If species were classified according to their occurrence, 15 residents and 10 migrants could be distinguished. Other species did occur irregularly or only sporadically. Most of the residents have a true hyperbenthic life style (e.g. most mysids, the amphipod *Atylus swammerdami*), some are known to inhabit the underlying sand and make vertical excursions into the water column (e.g. the isopod *Eurydice pulchra*, the amphipod species of the genus *Bathyporeia*) and some are known to be associated with drifting detritus (e.g. the amphipod *Gammarus crinicornis*). Almost all 'migrants' have a planktonic (e.g. jellyfish, copepods) or endobenthic (e.g. burrowing

amphipods, polychaetes) life style. Planktonic organisms are most likely passively transported towards the coast and their presence is mainly related to their seasonal patterns of occurrence. During the year, three recruitment peaks (mainly of postlarval fish and decapods) were observed: in winter, spring and summer. Winter was characterised by very low total density and diversity, and by the presence of fish eggs. In spring, total merohyperbenthic densities were highest and postlarvae of the shore crab *Carcinus maenas* dominated, while in summer the merohyperbenthos was dominated by postlarvae of gobies *Pomatoschistus* species. Postlarval plaice was caught from February to May. Next to water temperature as a major structuring force, the occurrence of most of the organisms was influenced by hydrodynamic factors such as wave height and turbidity.

The factors influencing the spatial occurrence of surf zone hyperbenthos is discussed in the second part of Chapter I (Chapter I, Part B). The hyperbenthos of the surf zone of 12 sandy beaches along the Belgian coast was sampled in spring of 1996. In order to assess the major influencing factors on the spatial occurrence of hyperbenthic assemblages of the surf zones, a wide variety of environmental variables were measured simultaneously. Multivariate statistical techniques were used to analyse the hyperbenthic distribution patterns and to evaluate the environmental variables measured. Small morphodynamical differences between the beaches still seem to be large enough to have an influence on hyperbenthic community structure. Next to 'external' (temporal) variables such as water temperature and extreme hydrodynamic forces, local morphological beach characteristics, and especially their intertidal and subtidal slope, are suggested to be important structuring variables. Holohyperbenthic as well as merohyperbenthic organisms both seem to respond, although in different ways, to these variables. The effect of the intertidal slope (and correlated variables) on hyperbenthic density is mainly reflected in the holohyperbenthos, and especially the mysids. These actively migrating organisms were found along the whole coast, but highest densities were reported from with flat and wide beaches. Less-mobile and more sediment-associated animals such as cumaceans and several amphipod species were rather restricted to certain types of beaches. Merohyperbenthic organisms were mainly found on beaches characterised by intermediate subtidal slopes and high turbidity, and this both in terms of density and number of species. It is suggested that protection from visual predators may be important in providing refuges in the turbulent and relatively homogeneous surf zone of these sandy beaches.

The second chapter (Chapter II) deals with the utilisation of the surf zone by demersal fish and macrocrustaceans (epibenthos): temporal and spatial distribution patterns are described and discussed.

A first part on the temporal patterns of the epibenthos, starts with a detailed inventory (Chapter II, Part A). A time series of monthly samples, taken at the same 4 stations from May 1996 until July 1997, was analysed. In total, 34 species were recorded: 3 caridean shrimps, 5 anomuran and brachyuran crabs, 2 cephalopods and 24 teleost fish. The brown shrimp *Crangon crangon* dominated almost all samples (>80% of total density). on several occasions, total densities exceeded 400 individuals per 100m² (10 individuals per 100m² if *C. crangon* is excluded). Several fish species such as plaice *Pleuronectes platessa*, were exclusively caught as juveniles. Although juvenile plaice are less abundant on the Belgian coast as compared to the shallow bays of the UK and continental NW Europe (Rogers et al. 1998), catch densities are still higher in the surf zone of the sandy beaches as compared to the adjacent shallow subtidal habitats of the Belgian coast (see also Table 2 in Chapter V, Cattrijsse unpublished data). The surf zone of the Belgian sandy beaches may act as a nursery for longer (e.g. plaice *Pleuronectes platessa*) or shorter (e.g. brill *Scophthalmus rhombus*)

periods of time. The zone also seems to function as a transient area to other nurseries like estuaries (e.g. bass *Dicentrarchus labrax*) or between an estuarine nursery area and the fully marine environment (e.g. dab *Limanda limanda*). Seasonal patterns in the epibenthos were discussed after classifying each species according to their resident status. Seven resident (e.g. juvenile plaice) and 10 migrant species were identified. Temporal variation in community structure was greatly masked by spatial differences between sites. Although variables such as salinity and hydrodynamic characteristics may have influenced the data, clear temperature-related, seasonal patterns were detected. Most probably, low temperature conditions and subsequent migration of organisms to deeper waters caused a decline in both density and diversity in winter. The observed growth of 0-group plaice in the surf zone was compared to the optimal growth model of Fonds (1979). For this exercise, fish were obtained both from the by-catch of artisanal fishermen fishing with horses in the surf zone and from the own epibenthos samples described above (monthly samples from May 1996 to June 1997). Standard length was measured and stomach fullness indices (FIs), which can reveal temporal changes in feeding rhythm, were calculated per month. The observed growth rate was much lower than the growth expected under optimal circumstances. Although average FIs per month were rather low, food is unlikely to be limiting, since the surf zone of Belgian sandy beaches has been shown to be a very rich area with respect to macro-endobenthic (Degraer et al. 1999) and hyperbenthic (this study) organisms, the major prey items of 0-group plaice. Probably, young plaice spend much time and energy coping with the highly dynamic circumstances in the Belgian surf zone. Currents, general turbulence and wave action all have the potential to reduce growth rate by decreasing food intake below that possible in calm waters (Gibson 1994).

The second part of Chapter II (Chapter II, Part B) deals with the spatial variation in the epibenthos of the surf zone: what factors influence the fish and macrocrustacean communities? During the spatial campaign, epibenthic samples were taken at 12 stations along the coast. In total, 26 species were recorded: 4 caridean shrimps, 5 brachyuran crabs, 1 cephalopod and 16 teleost fish. Again, the brown shrimp *Crangon crangon* dominated almost all samples (>80% of total density). Total densities exceeded 250 individuals per 100m² on several occasions (10 per 100m² if *C. crangon* is excluded). A difference between the east and west coast of Belgium, as reported for other benthic components in deeper waters, was not found in this study. Spatial variation was mainly correlated with local conditions like turbidity of the water and the morphodynamic characteristics of the beach and the adjacent subtidal area. Few other studies to date have dealt with the effects of exposure on the surf zone fauna, and in general only the intertidal slope is considered when characterising the sampled beaches. High epibenthic densities and low diversities were observed on sites with long, flat slopes (when both the inter- and the shallow subtidal are considered). Highest diversity and densities were found at sites with intermediate profiles. The sites with highest turbidities were characterised by the highest number of species and high densities. Although turbulence and turbidity may have affected sampling efficiency, the mobile and relatively homogenous nature of the substratum on sandy beaches means that few refuges are available and that protection due to higher turbidity might be important. Also, the protection that is gained by occurring on flat, shallow beaches (less predation, less wave exposure) is probably outbalanced by increased fluctuations in environmental variables such as salinity and higher risks of retention on the beach at ebb-tide, resulting in a higher diversity at intermediate sites. Juvenile plaice could not directly be linked to these patterns, the species occurred in comparable densities at all sites investigated along the coast.

Chapter III focusses on the interactions between the epi- and hyperbenthos. The feeding ecology of juvenile flatfish species in the surf zone was investigated. The diet of five 0- and I-group flatfish species of the surf zone was studied both numerically and gravimetrically by means of stomach and/or gut content analyses. Monthly samples were obtained from the by-catch of artisanal fishermen from May until December 1996. To assess the niche width of, and the niche segregation between, the different species, multivariate analyses were performed on the numerical data. The five flatfish species were plaice *Pleuronectes platessa*, sole *Solea solea*, brill *Scophthalmus rhombus*, turbot *Scophthalmus maximus* and dab *Limanda limanda*. Prey items of all flatfish species included hyperbenthic (e.g. mysids), endobenthic (e.g. polychaetes) and epibenthic (e.g. shrimps) species. Little dietary overlap was observed. If diet overlap did occur, it mainly involved prey species that are dominant in the surf zone of Belgian beaches such as shrimps and mysids. These results suggest an opportunistic utilisation of the available food resources in surf zone ecosystems.

Also, two strategically different feeding habits could be distinguished. Turbot and brill mainly fed on large, highly mobile prey (e.g. fish, mysids) and had a rather narrow prey-spectrum, whereas plaice, dab and sole ate more benthic prey (e.g. polychaetes) and had a broader prey-spectrum.

In Chapter IV, short term migration patterns of the epi- and hyperbenthic organisms are discussed. Three consecutive 24h-sampling-cycles were performed in spring of 1996, during which hyper- and epibenthic samples were taken on alternate hours. Multivariate statistical techniques and three-way ANOVAs were used to evaluate the effects of the environmental variables measured. In spite of the strong turbulent conditions of the studied site, clear tidal (e.g. the brown shrimp *Crangon crangon* and juvenile plaice *Pleuronectes platessa*) and diurnal (e.g. sole *Solea solea* and clupeids, respectively caught mainly during the night and during the day) periodicities of many macrocrustacean and demersal fish species were observed. Nevertheless, the extremely turbulent conditions of the surf zone possibly had their effect on the behaviour of many species (e.g. juvenile brown shrimp are not able to bury themselves as the water retreats). Within this chapter, special attention was given to juvenile plaice and the question is asked whether the high dynamics of the surf zone suppress the ability of young plaice to actively search for food. In order to answer this question, additional stomach content analyses were performed. Also, the interactions with potential prey species was investigated: the hyperbenthic fauna was sampled simultaneously and data on macrobenthos of an adjacent beach were obtained from literature. Clearly, the Belgian sandy beaches are used as a feeding ground by I-group plaice. An opportunistic utilisation of available food resources is suggested. I-group plaice clearly migrate high up the beach during flood tide, where they disperse to profit from the rich macrobenthic fauna. In contrast, the 0-group mainly feeds on the most abundant hyper- and macrobenthic organisms from somewhat deeper water.

Finally, in Chapter V, general conclusions, some remarks and recommendations for future research are given. One of the major conclusions is that the surf zone of the Belgian coast, despite its turbulence, is by no means a marine desert, but is used intensively by a number of hyper- as well as epibenthic species. Even more, it is used as a nursery and/or transient area for several early life stages of fish and macrocrustaceans. Although the strong hydrodynamic conditions of the Belgian surf zone are important in structuring hyper- as well as epibenthic communities, it is remarkable that several species seem to cope so well with this turbulence. Future research should include a thorough study of the feeding ecology and behaviour of the brown shrimp *Crangon crangon* as it is the dominant epibenthic species of the study area. Since the food web of surf zones of exposed sandy beaches is dominated by the phytoplankton-

zooplankton-fish pathway, additional information on the phytoplankton component is of major importance to understand the interactions. Also estimations of primary and secondary production are necessary to assess the relative importance of the faunistic groups studied here.

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