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FACTORS INFLUENCING THE HABITAT VALUE OF TIDAL MARSHES FOR NEKTON IN THE WESTERSCHELDE ESTUARY

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An ecotone is a zone where two ecosystems overlap and which supports species from both ecosystems besides the species found only in that zone. Ecotones may have a higher diversity than the surrounding ecosystems since species may invade this area from both sides. However, lower species diversity may also be characteristic to ecotones since, due to the transitional position and unfavourable environmental conditions only a few generalist species may be adapted to cope with such an environment.

Intertidal saltmarshes are considered ecotones due to their positions between the terrestrial and marine or estuarine ecosystems. In the saltmarshes the environmental conditions (e.g. tide, exposure time, temperature, salinity) are constantly changing. Due to the constantly changing environment several factors may influence the habitat value of saltmarshes for nekton species. This study focuses on three aspects that affect the habitat value of the intertidal marshes in the Westerschelde Estuary: short-term temporal changes, small and large-scale spatial variation and marsh age.

Influence of short term temporal changes on the marsh habitat value

The aim of Chapter 2 was to investigate the effect of short-term temporal variation on the marsh faunal assemblages. The objectives included the description of the change of species densities and community structure during tidal, diel and semi-lunar cycle. Three null-hypotheses were formed as follow: 1- Number of migrating individuals does not differ between the different hours of the tidal cycle. 2- There is no difference in density of the main marsh visiting species during day and night. 3- There is no difference in nekton species densities and community structure between spring and neap tide. Samples were collected during seven tidal cycles from spring tide till neap tide to cover the period of a semi-lunar cycle in August 1994. On consecutive days, day and night samples were taken at spring and at neap tide. Similar to other investigations this study showed the existence of a strong tidal influence on the migration of nekton in and out of the marsh habitat. During the tidal cycles two different tidal-migration modes were observed. The mysid shrimp, *Mesopodopsis slabberi* showed a maximum abundance around high tide. For the remaining common species, the mysid *Neomysis integer*, the shrimp *Palaemonetes varians*, the crab *Carcinus maenas*, the common goby *Pomatoschistus microps* and the amphipod *Corophium volutator* highest numbers were recorded during lower water heights. These species migrate at the edge of the tides maximizing the utilization of the marsh creek habitat. This indicates the importance of tidal creeks for several species. A diel variation of the faunal assemblages was also observed. The total density of nekton and the densities of *Crangon crangon*, *P. microps*,

C. volutator, *P. varians*, and *C. maenas* were higher during the night hours both at spring and at neap tide. In other studies, *Crangon crangon* and *Corophium volutator* were reported to be more active during night hours, which may explain the higher abundance in the marsh creek. During spring tide a difference in community composition was noticed between the night and the day samples. At neap tide, day and night differences were less clear. The effect of the semi-lunar cycle on the nekton assemblages was also observed. Recorded total densities were generally higher during spring tide and lower during neap tide although at maximum water levels, a decrease in total density was observed. A multivariate analysis indicated a change in community composition between spring and neap tides. The first null-hypothesis was rejected since strong tidal influence was observed leading the activity of several species in the studied intertidal creek. Observations showed that most of the main species migrate in the first and the last hours of the tidal cycle while others like *Mesopodopsis slabberi* occurred in maximum numbers at high water. The second null-hypothesis was not proved because several species showed density differences during day and night. Diel changes influenced the density of some species however the few sampling occasions do not allow further conclusions. The third null-hypothesis was rejected due to the observation that most of the species had different densities at spring and at neap tide and the community structure also differed between the lunar phases. However explanation of this finding is still lacking therefore there is a need for more occasions with given sets of conditions in order to reach firm conclusions and to show robust patterns.

In Chapter 3 changes in the diet of the common goby over a complete semi-lunar cycle were investigated to obtain a better understanding of the influence of tidal, diel and semi-lunar cycles on marsh habitat usage. The study aimed to describe the feeding habit of juvenile *Pomatoschistus microps* during the semi-lunar period, to investigate the separate and combined effect of the tidal, diel and semi-lunar cycle on the feeding behaviour of juvenile gobies and to quantify the change in tidal food consumption. Null hypotheses were set as follows: 1- There is no difference in feeding habit between flood and ebb period. 2- Gobies feed similar during day and night. 3- No difference of the feeding habit of *P. microps* exists between spring and neap tide period. 4- There is no combined effect of the different short term cycles on the foraging habit of the common gobies. *Pomatoschistus microps* was chosen because this is a typical intertidal species that uses the marshes as a nursery and a foraging ground. Individuals enter the marsh creek at the beginning of the tidal cycle with a relatively empty stomach and leave the marsh with a higher stomach content. This indicates the strong dependence of the feeding habit on the tidal cycle and the intense utilisation of the area as a foraging ground. A diel effect on the feeding habit of *P. microps* was present. In marsh creeks common gobies generally foraged more intensively during day than during night. The influence of the diel cycle was inferior in comparison with the tidal influence. This seems obvious as the tides form the main environmental influence on the habitat and the ecology of marsh species. A significant difference in foraging activity occurred also between spring and neap tide. The common goby migrated in lower abundances into the creek during spring tide but foraged more intensively. Both at spring and neap tide, a significant difference was found in the fullness index between day and night. At spring tide, gobies fed more during day while at neap tide they foraged more intensively at night. No clear explanation could be given for the combined effect of the diel and the semi-lunar cycle.

Influence of spatial variation on the marsh habitat value

Hydrology strongly influences the formation of the typical physiographic features in the marsh (creeks, ponds, pans and vegetated marsh flat) creating small-scale habitats. These marsh features can have distinct environmental parameters and represent different habitats for species utilizing the marsh. In estuaries, another physical factor besides hydrology is the large-scale salinity change, which is considered to strongly influence the faunal assemblages. In Chapter 4 the aim of the study was to investigate the effect of salinity changes combined with the small-scale spatial variation on the marsh habitat value. The first objective of this study was to examine how the fish and macrocrustacean marsh fauna within one estuary differ between salinity regions including the fresh water area. The second objective was to determine the differences in the utilization of three marsh habitats (large and small creek and the marsh pond) by nektonic species. The following null-hypotheses were set: 1- There is no difference in epibenthic species composition between the marshes with different salinity. 2- Same species utilize the three marsh habitats like large and small channel and marsh pond. Samples were taken between spring and autumn 2000 in five marshes along the salinity gradient of the Schelde River. The euhaline Zwin, the polyhaline Zuidgors, the mesohaline Waarde and Saeftinghe and the freshwater Grembergen were chosen. In each marsh different habitats (large creek, small creek and marsh pond) were sampled. Similar environmental conditions may have resulted that the main species (*Platichthys flesus*, *Dicentrarchus labrax*, *Pomatoschistus microps*, *Carcinus maenas*, *Palaemonetes varians*) migrating in the marsh utilised both large and small creeks. Only *Anguilla anguilla* was not captured in the small creek habitat although this species has a wide environmental tolerance. In accordance with other investigations only few species utilised the marsh ponds. In the tidal pools, only *Palaemonetes varians* appeared in high numbers. Among fish species the common goby *Pomatoschistus microps* and *Gasterosteus aculeatus* were present although the latter one was captured only a few times. The tidal freshwater marsh had a species poor fauna and only low numbers of fish were caught. Besides some freshwater species, *Anguilla anguilla* was still an important fish. Amongst the poly- and mesohaline marshes no differences could be detected in nekton species composition. The dominant species were the flounder *Platichthys flesus* and the seabass *Dicentrarchus labrax*. In the euhaline marsh, *P. flesus* was not captured and numbers of *D. labrax* were low. This pattern could be the result of the salinity preference of flounder. The utilisation of the marsh creek by seabass may be less intense in the euhaline area although the lower catching efficiency of the fyke nets seems to have biased this result. Species are able to adapt and invade marsh areas where environmental variables constantly change and are probably also capable of using different marsh habitats under a wide range of salinity.

Food availability will also strongly influence the utilisation of an area by fish and macrocrustaceans. Macrobenthos is an important food source for nekton species. To better understand the potential of the marsh as feeding grounds Chapter 5 focuses on the main macrobenthic prey species. The objective of this chapter was to investigate temporal and spatial variation of macrobenthos. The study also aimed to compare the macrobenthic density and biomass between the marsh and the intertidal flat especially focused on a few taxa, which are an important food source for the marsh visiting fish species. Null-hypotheses were: 1- Macrobenthos exhibit similar seasonal pattern in

every marsh. 2- There is no change in the density, biomass and diversity of macrobenthos in the marshes with different salinity. 3- There is no difference in density and biomass of *Nereis diversicolor, Corophium volutator, Macoma baltica* and Oligochaeta between the intertidal flat and the marsh creeks. Samples were taken in the five marshes along the salinity gradient of the Schelde River every six weeks from May till October 2000. Macrobenthic total and species densities and the biomass of the four dominant taxa (the amphipod *Corophium volutator*, the polychaete *Nereis diversicolor*, the mollusc *Macoma baltica* and Oligochaeta) were measured and diversity indices were calculated. In Saeftinghe and Waarde the macrobenthic density peak occurred during summer while in Zuidgors and Zwin densities declined towards autumn. Higher macrobenthic biomass was measured during the second part of the sampling period due to abundance of *Nereis diversicolor* and *Macoma baltica*. The biomass of the four taxa was highest in August in every marsh except in Saeftinghe where the biomass peaked in October. The abundance of macrofauna fluctuated along the salinity gradient without any spatial trend due to the dominance of oligochaetes. In contrast, the diversity and the total biomass increased towards the euhaline area. Among the main taxa the density and biomass of *N. diversicolor* and *M. baltica* showed a significant positive correlation with salinity. The sampled marshes supported higher densities and biomass of these two species and a lower density and biomass of *C. volutator* than the intertidal flat of the Westerschelde Estuary during early autumn 2000.

Chapter 6 presents the feeding habit of the main predator fish species through qualitative stomach analysis in different salt marshes situated along the salinity gradient of the Westerschelde Estuary. The objectives of the study were to assess the importance of marsh creeks as feeding grounds for larger seabass and flounder and to define the relative importance and impact of *Platichthys flesus* and *Dicentrarchus labrax* as predators on the infauna and the nursery/refuge function of the creeks for juvenile fish and crustaceans. The following null-hypotheses were set: 1- There is no difference in niche breadth of *P. flesus* and *D. labrax* in the marshes with different salinity. 2- There is no difference in fullness index of the two fish species between the marshes. 3- Predation of flounder and seabass does not affect significantly the macrobenthic stock in the intertidal creeks. 4- Due to the presence of the predatory fish marsh creek does not represent a good nursery area for other species. The study focused on flounder and seabass because these species occur in higher abundances and their postlarvae use marshes as nurseries. Qualitative stomach analyses showed that the two most important benthic prey items for flounder were *Corophium volutator* and *Nereis diversicolor*. *D. labrax* preyed upon a wider range of species and the main prey items were *C. volutator*, *N. diversicolor*, *Crangon crangon*, *Carcinus maenas* and *Orchestia* species. In the diet of *Anguilla anguilla* oligochaetes, *C. maenas*, *N. diversicolor* and *Orchestia* spp. were important. Both the stomach content diversity of *D. labrax* and *P. flesus* showed differences between the five marshes. The stomach content diversity indices of flounder in Waarde were generally lower and differed significantly from Saeftinghe and Zuidgors, which had similar indices. *D. labrax* had significantly different diet diversity indices between Waarde and Zuidgors although no typical species change could be attributed to the observed patterns. The fullness indices of the stomachs of the flounder and seabass in the marshes along the salinity gradient did not show significant differences indicating that these two species find similar foraging opportunities in all areas. The similar high macrobenthic stock in all five marshes also supports this conclusion. The

minimum consumption of flounder, seabass and European eel from the macrobenthic stock showed that these predators do not control the marsh infauna. The food was abundant and the availability of the potential prey did not restrict the utilization of the marsh creeks by fish. No correlations were found between the abundances of macrobenthos and fish. The very high abundances of the benthic food items might contribute to the fact that the typical nursery species like *C. crangon*, *C. maenas*, postlarvae of *P. flesus* and *D. labrax* and *Pomatochistus microps* were not preyed upon significantly. The spatial or temporal segregation of these species from the predator fish increases the survival of the former and support the hypothesis that marsh creeks offer good refuge opportunities.

Marsh age as an influencing factor on marsh habitat value

During the maturation process, the physical and chemical characteristics of a marsh system change constantly and consequently influence the potential of an area as a habitat for fish and macrocrustaceans. Chapter 7 aimed to compare a mature and developing marsh creek as a habitat for nekton species. The objective of the study was to investigate whether there are differences in utilisation of a mature and a developing marsh creek. The null-hypotheses were as follow: 1- There is no difference in total and species densities between the two areas. 2- Biomass of nekton species did not differ in the mature and developing marsh creek. 3- Common gobies exhibit similar growth during the sampling period in the two areas. To investigate the effect of marsh age on the nursery function, a mature (Saeftinghe) and a developing marsh (Sieperda) of the Westerschelde Estuary were sampled between April and October 1999. Density and biomass of nekton species and the length-frequency distribution of the most common marsh fish, *Pomatoschistus microps* were recorded. The densities of the main nursery species (*P. microps, Dicentrarchus labrax, Crangon crangon, Carcinus maenas*) and the total nekton density were higher in the mature marsh although no significant difference was found. In Saeftinghe, a density peak was mainly due to large numbers of the mysid, *Neomysis integer*. In Sieperda, maximum abundance of the mysid, *Mesopodopsis slabberi* caused the peak density. This difference in species dominance was observed in all samples. Total and most species biomasses were significantly higher in the mature marsh. Mysid shrimp (*N. integer*) and fish (mainly *P. microps*) were the main contributors to the biomass in the mature marsh. Herring, sprat (Clupeidae) and shore crab, *Carcinus maenas* were more important in Sieperda. In the mature marsh the observed length of the juvenile common goby increased during the sampling period while in the developing marsh the length of the gobies remained small. These observations indicate that fish and macrocrustaceans do migrate in the developing marsh but the utilisation of the marsh creek is still less intense compared to the mature marsh.