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Diet overlap between juvenile flatfish and the invasive round goby in the central Baltic Sea

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ABSTRACT

The present study offers a comprehensive analysis of changes in the abundance and diet composition of juvenile flounder (*Platichthys flesus*) and turbot (*Psetta maxima*), along with other dominant coastal fish species, before and after the establishment of the alien round goby off an exposed stretch of coast in the eastern Baltic Sea.
In the study area, the round goby (*Neogobius melanostomus*) was recorded for the first time in 2009. After a few years of low abundance, a sharp increase in the population occurred. After the round goby invasion, flatfish juveniles exhibited an increased diet overlap with other species and had a lower feeding success, reflecting an increase in resource competition. For juvenile turbot, the increase was mainly caused by the round goby, while for flounder it was due to both the round goby and the lesser sandeel (*Ammodytes tobianus*).
Juvenile turbot, whose dominant food item before the round goby establishment had been mysids, shifted their diet towards *Crangon crangon*, reflecting a decrease in mysid abundance by three orders of magnitude and a concurrent doubling in *C. crangon* abundance in the habitat. At the same time a significant decrease in turbot recruitment was observed.
Juvenile flounder had the widest food spectrum of the studied species. When the availability of the primary food item, *Bathyporeia pilosa*, decreased, flounder juveniles adapted by increasing the share of zooplankton in their diets. No changes in flounder feeding success and recruitment were observed. However, the recruitment estimates of flounder and turbot show an increasing co-variation after the round goby invasion, suggesting that recruitment of the species may currently be regulated by processes in the common nursery habitat.

1. Introduction

In the central part of the Baltic Sea two common, ecologically and economically important flatfish species are the flounder (*Platichthys flesus*) and the turbot (*Psetta maxima*). Juveniles of both species inhabit shallow, nearshore sandy bottoms in the Baltic Sea and have very specific habitat requirements during their early juvenile phase (Florin et al., 2009; Martinsson and Nissling, 2011; Ustups et al., 2007; Vitinsh, 1989). The juveniles of flatfish remain in these coastal nurseries from the post-metamorphosis stage until they reach maturity (Gibson, 1994; Vitinsh, 1989). During their first year, juvenile flounder and turbot inhabit waters up to one metre deep (Florin et al., 2009; Martinsson and Nissling, 2011), while older juveniles gradually move to deeper coastal waters. The shallow coastal waters warm up early in the season and provide favourable conditions for the feeding and growth of juvenile flatfish as well as other fish species, both as juveniles and as small adults (Florin and Lavados, 2010; Lappalainen and Urho, 2006; Martinsson and Nissling, 2011; Stankus, 2006). Previous investigations have identified several dietary guilds in these shallow waters (Ustups et al., 2007). Flounder juveniles are generalists with a wide food spectrum, while turbot juveniles are mainly mysid feeders (Aarnio et al., 1996; Florin and Lavados, 2010; Nissling et al., 2007, Ustups et al., 2007).

The round goby (*Neogobius melanostomus*) is a demersal benthivorous invasive fish species originating from the Ponto-Caspian region. In the Baltic Sea, this species was first reported in 1990 from the Gulf of Gdansk off the Polish coast in the southern part of the sea (Skora and Stolarski, 1993). Since its introduction, the round goby has successfully established itself in the coastal waters of the central Baltic Sea. The first records of round goby occurrence in Lithuania were reported in 2002 (Zolubas, 2003), in Estonia in 2002 (Ojaveer, 2006), and in Latvia in 2004 (Minde, 2007). Currently, one of the highest round goby concentrations and one of the biggest commercial landings in the central Baltic Sea are observed in the coastal area close to the Latvian–Lithuanian border (Knospina and Putnis, 2014).

Round gobies breed and feed in shallow water during summer (Kornis et al., 2012). At this time they have a very restricted home range with migrations mostly restricted to distances of a few hundred metres (Ray and Corkum, 2001). Longer migrations, probably up to

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several kilometres, take place to and from deeper waters in early spring and late autumn (Sapota, 2012). Round gobies prefer rocky bottom habitats, where blue mussels (*Mytilus trossulus*) are the main food item (Järv et al., 2011; Karlson et al., 2007; Strāķe et al., 2013). Although round gobies will probably colonize hard before soft bottoms, muddy and sandy habitats are not resistant to invasion (Kornis et al., 2012). In the Baltic Sea, these shallow areas, especially sandy bottoms, simultaneously constitute the main nursery areas for turbot and flounder.

Diet analyses in previous studies suggest that the round goby is an opportunistic feeder and will feed on prey according to availability (Kornis et al., 2012; Skora and Rzeznik, 2001). Previous studies have shown negative interactions between the invasive round goby and native fish fauna due to resource and interference competition (Järv et al., 2011; Karlson et al., 2007; Kornis et al., 2012). Thus, there is a concern that the dispersal of the round goby, which is territorial and highly competitive, may have a vast impact on the resident fish communities via several channels: through interference competition, through resource competition via heavy predation on certain benthic prey species, and through direct predation on fish in the early life stages. Although knowledge is scarce, there are also indications that round gobies may predate on newly-settled flatfish (Institute of Food Safety, Animal Health and Environment (BIOR), Riga, Latvia, unpublished data). So far, knowledge on these interspecific interactions is limited in the Baltic Sea, especially concerning potential population-level effects. The objective of this study was to assess the diet overlap between the round goby and other common species of the nearshore fish community, focusing mainly on juvenile turbot and flounder. Previous studies have indicated that the feeding spectrum of turbot juveniles is relative narrow (Ustups et al., 2007), making it vulnerable to resource competition, while flounder juveniles are opportunistic feeding generalists (Nissling et al., 2007; Ustups et al., 2007). However, in the areas subject to round goby invasion, the flounder is a specialist feeder with a small niche width (Järv et al., 2011), which suggests that the presence of the round goby might influence the feeding strategy of the flounder. Utilizing time-series data on the nearshore fish community and the diets of different fish species, we identify changes in feeding conditions before and after the invasion of round gobies and discuss implications for the recruitment of turbot and flounder.

2. Materials and methods

2.1. Sampling

The study was conducted in the coastal zone of the eastern central Baltic Sea, at two locations off the Latvian coast, Pape (56.15° N latitude, 21.03° E longitude) and Jurmalciems (56.30° N latitude, 20.98° E longitude) (Fig. 1). In the study area, bottoms down to a depth of 7 m are mainly dominated by sandy substrates, while below 8 m bottom substrates are composed of boulder, cobble, and gravel (Strāķe et al., 2013).

A beach-seine study was conducted annually in the late spring or early summer (May or the beginning of June), to capture the period when the round goby is most abundant in shallow waters. The available information from the Latvian scientific gillnet survey clearly indicated a peak in the abundance of the round goby in shallow waters from April to June.

The seine data were collected annually from 1998 to 2014. On each sampling occasion, five hauls were made per location. The seine had a mesh size of 10 mm in the wings and 5 mm in the cod-end. The length of the wings was 12.5 m, and the vertical opening was 1.5 m. The hauls were carried out perpendicularly to the shoreline, starting at a distance of 130 m (up to 3 m deep) and hauling towards the shore. Each haul covered an area of approximately 0.4 ha (Vitinsh, 1989). All hauls were made during daytime under calm wind conditions (<5 m/s). Fish were sorted by species, counted, weighed (total weight per species) and immediately preserved in 80% ethanol. For all fish species that were included in the diet analyses, the weight and total length of each individual were determined later in the laboratory. In total, 143 hauls were made from 1998 through 2014.

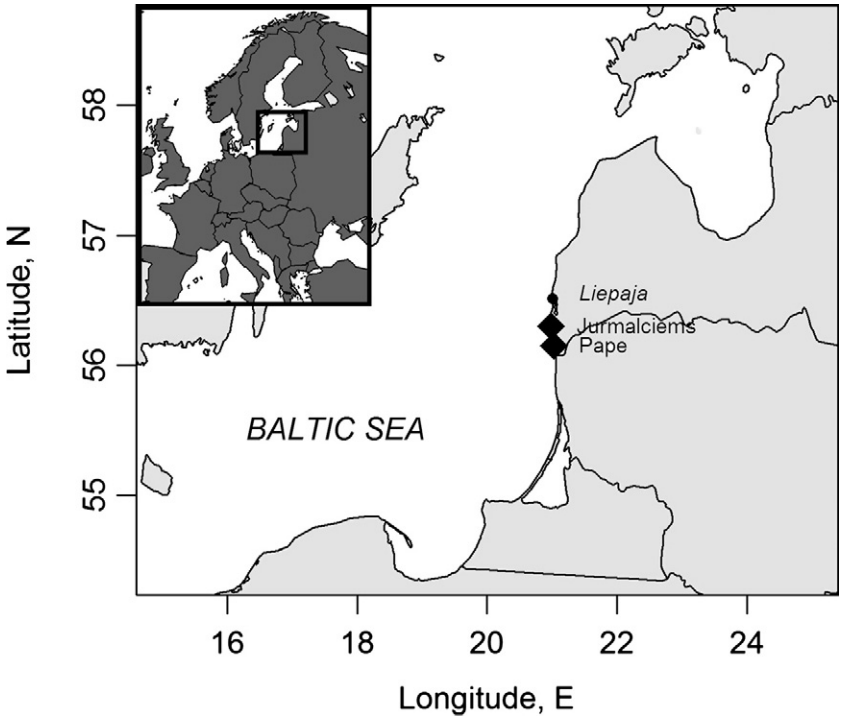

Fig. 1. Study area (black diamonds) off the Latvian coast of the central Baltic Sea. The black dot (Liepaja) indicates the first round goby finding in Latvian waters in 2004.