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# Multidecadal dynamics of larval gobies *Pomatoschistus* spp. in response to environmental variability in a shallow temperate bay

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ABSTRACT

Compared to commercial fish, there is relatively limited information available about the dynamics of non-commercial fish that very often play important structural and functional roles in marine ecosystems. Long-term investigations that provide quantitative estimates of the population dynamics as a function of environmental variability are needed to understand the ecology and role of the non-commercial fish in the ecosystem, and assist the ecosystem management where relevant. Here we analyze the inter-annual variability and long-term trends of the abundance of the larval non-commercial gobies *Pomatoschistus* spp. in a shallow coastal bay (Pärnu Bay, northeastern Baltic Sea) in 1959–2010, in relation to climate and prey field related variables. The abundance of larval *Pomatoschistus* spp. decreased over the last 50 years along with the concomitant decrease in the water transparency. The first appearance of larvae has shifted for about two weeks earlier and is mostly related to the timing of ice cover breakdown. However, some of the effects of the environmental forcing on larval fish may be obscured by the uncertainty of species identification of individuals of the genus *Pomatoschistus* at larval stage, and the investigated population of *Pomatoschistus* spp. consists of at least two species with slightly different ecologies and also environmental preferences.



## 1. Introduction

In-depth knowledge of the abundance and distribution of early life-history stages provides important insights to the ecology of fish populations and communities. The most critical time in the life history of fish is the larval stage when the highest mortality occurs (Hjort, 1914; Cushing, 1975). The early life history stages of fish are particularly susceptible to the variability of the environment and are affected by both, the biological (e.g. abundance of food) as well as the physical factors such as water transparency, temperature and salinity (e.g. Fiedler, 1986; Somarakis et al., 2002; Genner et al., 2010). Temperature is an important factor controlling seasonal abundance pattern of larval fish through various mechanisms and processes (e.g. Marques et al., 2006; Genner et al., 2010). Abiotic factors, food limitation and starvation together can explain high mortality in the early larval stage, and the decline of abundance of fish larvae (e.g. Bochdansky et al., 2008), resulting either from declining abundance of prey or mismatch with prey due to earlier/later appearance.

Gobies *Pomatoschistus* spp. are small-sized short-living abundant fish (Fonds, 1973). They constitute a significant part of demersal fish communities form the Mediterranean up to Norway including the Baltic Sea (e.g., Hesthagen, 1977; Psuty-Lipska and Garbacik-Wesolowska, 1998). In the Baltic Sea, there are at least two *Pomatoschistus* species: sand goby *P. minutus* and common goby *P. microps*. They are well-adapted to the brackish conditions prevailing in the estuaries (e.g. Bouchereau and Guelorget, 1998). Temperature requirements differ between the adults as *P. microps* is more of a warm water species (Fonds, 1973). As a consequence of lower spawning temperature, *P. minutus* may reproduce earlier in the season and benefit from longer period of growth before the onset of winter (Wiederholm, 1987). In northern areas gobies are known to avoid low temperatures and migrate to deeper offshore areas in winter and return to shallower areas again in March when the water temperature increases (Fonds, 1973). *P. minutus* is probably the first to migrate back to shallower areas to spawn and *P. microps* dominates in summer when the water temperature is above 20 °C. *Pomatoschistus* spp. are batch spawners that develop and releases multiple batches of eggs within a spawning season

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(Waligóra-Borek and Sapota, 2005). Newly hatched larvae are approximately 2.5 mm long. They live pelagically for at least one month (Fonds, 1973) and change to a demersal way of life after metamorphosis (Guelinckx et al., 2008). In the Baltic Sea, *Pomatoschistus* spp. is shown to serve several important functions, such as being a prey for upper trophic levels (Uzars, 1994; Lundrstöm et al., 2010) and influence stock performance of commercially exploited predatory fish (Müller-Karulis et al., 2013).

The current study examines the multi-decadal dynamics of the larval *Pomatoschistus* spp. in a shallow bay in the northeastern Baltic Sea in order to 1) describe the long-term trends in the abundance of goby larvae, 2) analyze the impact of abiotic environment and prey density on their abundance.

## 2. Material and methods

### 2.1. Study area

Pärnu Bay in the northeastern Baltic Sea (Fig. 1) is a sheltered and shallow (maximum depth around 10 m) sea area covering 400 $km^2$ with a volume of 2 $km^3$. In most years the bay is ice-covered in winters. Sea surface temperature (SST) fluctuates seasonally from regular sub-zero °C with a closed ice sheet in winter to >20 °C during summer. In the warm season, the water is generally well mixed down to the bottom. The currents are weak (velocity below 10 cm $s^{-1}$) and mainly determined by wind, but modified by coastline and bottom topography. The salinity varies from nearly freshwater at the river mouth to 7.5 psu in more open areas. Because of the shallowness, changes in the air temperatures directly affect the water temperature. The hydrographic conditions are formed under the complex influence of ice conditions, freshwater inputs from the Pärnu River and the water exchange with the GoR (e.g. Kotta et al., 2009).

### 2.2. Data, sampling procedures and laboratory analysis

Sampling of fish larvae was performed weekly in six stations (Fig. 1) from May to July during daytime in 1959–2010. Locations of the stations, together with the sampling frequency, were historically placed with the intention to collect samples of ichthyoplankton representative of the study area (Pärnu Bay). These selected stations cover the study area evenly. In most cases all six stations were sampled every week (an average of 5 stations per week). Hensen larval trawl (approximately 920 mm in length) with mouth diameter of 800 mm and the mesh size 500 μm (170 μm in the cod-end sampler) was used for collecting ichthyoplankton. Sampling was performed with circular movement of the boat to keep the gear away from the disturbance caused by the boat at a speed of approx. 2 knots in the surface layer (0–1 m) by 10-min hauls. Surface sampling was adopted as the study area is very shallow with some stations characterized by depth around 3 m (Arula et al., 2012). As goby larvae are pelagic for at least one month and they adopt a demersal life style only after metamorphosis (Fonds, 1973; Guelinckx et al., 2008), it is therefore considered that the obtained data are representative to characterize dynamics of larval stages of the fish. The numbers were recalculated according

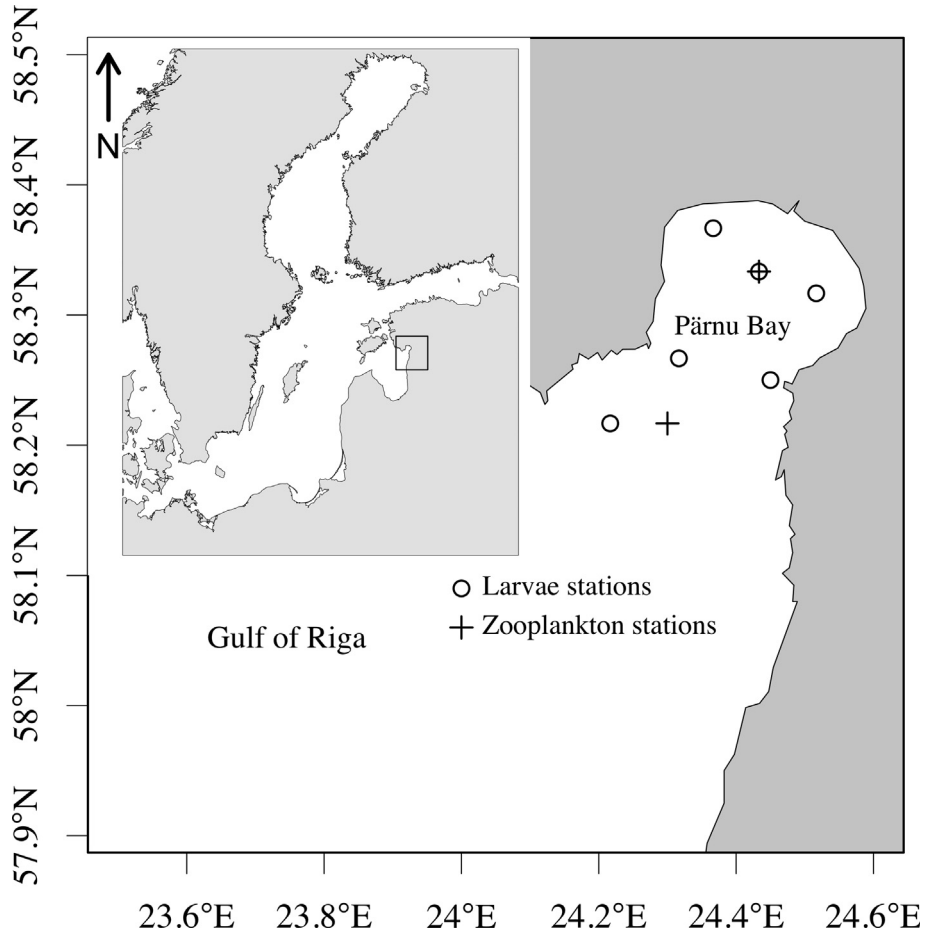


**Fig. 1.** Study area with six larval *Pomatoschistus* spp. (circles) and two zooplankton (crosses) sampling stations in Pärnu Bay (Gulf of Riga, Baltic Sea).