Changes in the reproduction success of the Gulf of Riga herring

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Abstract

Gulf of Riga herring is a small stock of spring-spawning Baltic herring inhabiting the Gulf of Riga in the eastern Baltic Sea. It differs substantially by size-at-age from the neighbouring herring stock in the Central Baltic, as well as in stock dynamics and year-class strength. Gulf of Riga herring spawns in April-July in the shallow coastal zone of the gulf. Since the 1950s, rich year-classes of Gulf of Riga herring appeared after mild winters, whereas severe winters caused the formation of poor year-classes. A series of mild winters starting in the 1980s contributed to the emergence of rich year-classes and a fast increase in stock size. The successful reproduction conditions allowed intensive exploitation of the stock. Significant relationships were found between year-class strength, water temperature and zooplankton abundance in spring. Investigations on the spawning grounds revealed that spawning is longer, all spawning grounds are used and the eggs are distributed more evenly when the water temperature is higher during the spawning season. Zooplankton abundance determines the feeding conditions and survival of larvae. In the 1990s, water temperature and zooplankton abundance were successfully used to predict Gulf of Riga herring recruitment. However, after the emergence of several (2000, 2002, 2005) very rich year-classes, this relationship has weakened. The paper analyses what other factors, in particular feeding conditions during summer, contribute to the reproduction success of the Gulf of Riga herring.

Keywords: Baltic Sea, Gulf of Riga herring, reproduction

Introduction

Gulf of Riga herring is a stock of Baltic herring inhabiting the Gulf of Riga in the eastern part of the Baltic Sea. It is a slow-growing herring with one of the smallest length and weight at age in the Baltic and significantly differs from the neighbouring herring stocks in the Baltic Proper (ICES 2010). The Gulf of Riga is a semi-enclosed basin of the Baltic Sea characterized by low salinity (about 5 PSU) that restricts the occurrence of marine species. Unlike the Baltic Proper, herring is the dominant fish species. It has been noticed already in the 1960s that after mild winters rich year-classes appear (Rannak 1971). After mild winters spawning starts earlier and the spawning activity is more evenly distributed over the spawning
season. This results in a more even distribution and lower mortality of eggs on the spawning grounds. Additionally, after mild winters the zooplankton is more abundant, providing better feeding conditions for herring larvae. After a series of mild winters which started in 1989, Gulf of Riga herring stock biomass significantly increased and still stays relatively high in comparison with the 1970s and 1980s. Until 2006, the Baltic Fisheries Assessment Working Group used relationships with average water temperature in April – before spawning, and the abundance of Copepoda (Eurytemora affinis + Acartia spp.) in May, when the hatching of larvae begins, to predict Gulf of Riga herring recruitment. However, after the appearance of two very rich year-classes in 2000 and 2002 these relationships became significantly weaker, especially for the abundance of Copepoda. Zooplankton abundance in May in those years was only slightly above average and thus these years stand out of line in the relationship between Copepoda abundance and year-class strength. Therefore during the ICES Workshop of Recruitment Processes of Herring in the Baltic Sea (ICES 2007) other factors explaining the year-class strength were analysed. In particular the average water temperature of the 0-20 m layer in May and the biomass of Eurytemora affinis had a stronger relationship with year-class strength of Gulf of Riga herring. Therefore since 2007 these predictors were used to forecast year-class strength. This increased the weight of the environmental data in the prediction, although the prediction of very rich year-classes still remained a problem (two more very rich year-classes appeared in 2005 and 2007). This paper examines which other factors could have favoured the appearance of very rich year-classes in this millennium.

Material and methods

The year-class strength of Gulf of Riga herring was estimated as the abundance of 1 year old herring in the beginning of the year and was obtained from the assessment performed for the Gulf of Riga herring in Baltic Fisheries Assessment Working Group (ICES 2010).

To describe the feeding conditions of herring the Fulton condition factor (F=weight/length$^3$*100) was calculated for herring age groups 2-5 from August – October, when the main feeding season of herring is terminated. The herring samples were collected from the commercial trawl fishery.

Mesozooplankton in the Gulf of Riga was sampled using a Judai net, with a mesh size of 160 µm and an opening diameter of 0.36 m. Sampling was performed in May (spring), August (summer) and October (autumn) from 1977 to 2010 on 10-13 stations from two depth layers (0-20 m, 20 m-bottom or 0 m–bottom).

Calanoid copepods Acartia spp. (including A. bifilosa and A. longiremis), Eurytemora affinis and Limnocalanus macrurus were identified to developmental stages (nauplii N, copepodites C1-5, as well as adult male and females). Cladocerans Evadne nordmanni, Podon spp. (including P. polyphemoides, P. leuckarti and P. intermedius), Bosminia longispina, as well as the rotatorians Synchaeta spp. (including S. baltica and S. monopus) and Keratella spp. (including K. quadrata and K. cochlearis) were identified to species level.

For each station the total abundance (n*m$^{-3}$) of individuals of each species/stage was calculated for the entire water column (0-bottom) and then averaged over all stations. Biomasses (mg*m$^{-3}$) were estimated from individual standard wet weights (Henroth 1985).

Winter air-temperature (°C) was measured by the Latvian Hydrometeorological Agency in Riga. Water temperatures (°C) were measured using a Deep Sea Reversing Thermometer in 5 or 10 m steps. Average temperature (0-20 m, 0-50 m) was used from various seasonal cruises in the period 1977 to 2010 in the Gulf of Riga.

The zooplankton, hydrology (water temperature) and herring biological data were collected by the Institute of Food Safety, Animal Health and Environment “BIOR” (Latvia).

The monthly river run-off to the Gulf of Riga was calculated using information from the hydro-electric plants on the Daugava River, the main river discharging into the gulf.
The data were analysed using multiple regression and linear correlation analysis. The prediction of herring recruitment was performed using RCT3 (Shepherd 1997).

Results and discussion

We analysed which factors could have favoured the appearance of several very rich herring year-classes in this millennium. The year-classes in 2000, 2002 and 2005 were almost twice as abundant as the rich year-classes in the 1990s, while the 2007 year-class was as abundant as the richest year-class in the 1990s. All these year-classes appeared after mild winters, but the conditions in spring (water temperature and zooplankton abundance) did not stand out from other years with mild winters. It was noticed that all these years were characterized by good feeding conditions of older herring (age 2+). The Fulton condition factor for 2-5 year old herring in these years was the highest in the period since 2000 and correlated well \((r=0.7)\) to recruitment. We interpret this relationship as an indicator of feeding competition between young-of-the-year and older herring. In years when the feeding conditions are good (high condition factor) this competition is weaker and more young-of-the-year survive. It was also noticed that this relationship persists only in the latest 10 years and could not be observed in the previous years.

In years with rich year-classes Fulton’s condition factor was also high, showing good feeding conditions, but zooplankton biomass in summer was on average or even lower level in comparison with other years. This indicates that herring grazing reduced zooplankton biomass. Accordingly, for all years characterized by rich herring year-classes, biomass of the zooplankton species *Eurytemora affinis* was below average level in August. Consequently, during 2000-2010 a strong negative correlation \((r=-0.63)\) was found between *E.affinis* biomass in August and herring recruitment.

Undulating year-class strength – a strong year-class followed by weak recruitment, became characteristic for the Gulf of Riga herring during the recent decade. At the same time RCT3 prediction tended to not only underestimate the year-class strength of the very rich year-classes but also slightly overestimate the recruitment in other years, especially those following very rich year-classes. Strong negative correlations between recruitment and the abundance of 1 year old herring \((r=-0.7)\), as well as the total number of herring older than age 1 \((r=-0.88)\), were found. In years following the rich year-classes of 2000, 2002 and 2005 one-year old herring comprised more than 50% of the total herring stock number (ages 1+). Gulf of Riga herring starts to spawn at age 2 and usually starts feeding close to the end of spawning season in the end of June. Unlike the spawning herring, the 1 year old herring start feeding in May. Therefore, at high abundance, 1 year old herring potentially influence the feeding conditions of herring larvae. This relationship emerged only during the recent decade, probably because this effect becomes apparent only for very rich year-classes.

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References