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RNA:DNA ratios of Baltic Sea herring larvae and copepods in embayment and open sea habitats

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Abstract

Elucidation of important nursery habitats for young fish can aid in the management and assessment of fish stocks. Herring (*Clupea harengus*) in the Baltic Sea primarily spawn in coastal areas, but larvae are also present in off-shore, open sea areas. To investigate if sheltered coastal habitats provide a better growth environment for larval herring, we compared short-term growth (as indexed by whole body RNA:DNA ratios) of larval herring from three habitat types of the northwest Baltic proper (sheltered inner bay, exposed outer bay, and open sea). In addition, we compared individual RNA content of adult female *Eurytemora affinis* (a common Baltic copepod) among these different habitats. High RNA levels in these copepods indicate high production of nauplii, which are important food for larval herring. Both RNA:DNA ratios of larval herring and RNA content of *E. affinis* were significantly greater in embayment habitats, suggesting that the sheltered coastal areas are high quality nursery habitats for young Baltic herring.

Keywords: Baltic Sea; herring; nursery habitat; recruitment

1. Introduction

The identification of critical fish rearing habitats (i.e. those areas or volumes of water supporting significant fish production) can greatly aid fisheries management. By limiting anthropogenic stressors in such habitats, managers can increase the sustainability of fish populations and their associated fisheries. In addition, by focusing pre-recruit monitoring to such critical habitats, managers can more effectively and efficiently gauge pre-recruit year–class strength. Future fishable stock sizes can then be predicted well in advance of a year–class's recruitment to a fishery, thereby allowing for implementation of multi-annual management plans (as called for by the EU Common Fisheries Policy).

The Baltic Sea herring (*Clupea harengus*) population supports an economically and culturally important fishery, and is a critical component of the Baltic Sea ecosystem. It is capable of restructuring lower trophic levels (Hansson et al., 1990; Arrhenius and Hansson, 1993), influencing nutrient dynamics (Hjerne and Hansson, 2002), and is closely linked with cod (*Gadus morhau*) and sprat (*Sprattus sprattus*) dynamics, the other two historically abundant Baltic Sea fish populations (Sparholt, 1994; Köster and Möllmann, 2000; Harvey et al., 2003). Due to the economic, cultural, and ecological significances of Baltic Sea herring, it is important to identify herring nursery habitats in order to protect such habitats and more effectively gauge pre-recruit year–class strength.

Baltic Sea herring primarily spawn in shallow, coastal areas during March–June (Aneer and Nellbring, 1982; Aneer, 1989; Urho, 1992; Rajasilta et al., 1993; Arrhenius and Hansson, 1996; Fey, 2001). Not surprisingly, densities of both larval (Urho and Hildén, 1990; Hakala et al., 2003) and late summer

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young-of-year (YOY) herring (Rudstam et al., 1992; Axenrot and Hansson, 2004) are relatively high in sheltered in-shore areas. In addition, growth rates of young Baltic herring are linked with ambient temperature and prey availability (Arrhenius and Hansson, 1999; Fey, 2001), and Urho (1999) suggested that since sheltered, in-shore habitats warm quicker, such habitats should support higher larval growth rates. Further, since such areas likely contain higher densities of zooplankton prey, these habitats may also provide superior feeding conditions for young herring. Hakala et al. (2003) compared larval herring growth rates among habitats in the Archipelago Sea region of the Baltic, and documented highest growth rates in the inner, most sheltered regions of the Archipelago Sea. Since mortality rates of young fish tend to be negatively related to size (e.g., Miller et al., 1988), variation in growth rates among habitats may lead to differences in mortality rates, and thus one can speculate that sheltered coastal areas are more important for herring recruitment than open sea areas.

Herein, we present a study to compare short-term growth of Baltic herring larvae collected in various habitats in the northwest region of the Baltic proper. To quantify short-term growth potential, we rely on whole body ratios of RNA to DNA. Nucleic acid ratios have been used as indices of feeding condition, growth, and survival of various fish populations (Buckley et al., 1999; Pepin et al., 1999; Chicharo et al., 2003; Gwak et al., 2003; Smith and Buckley, 2003; Voss et al., 2006), including Baltic herring (Clemmesen, 1994). This technique has, however, not been used to compare the growth of herring among Baltic habitats.

The applicability of nucleic acid ratios is based on the notion that DNA concentrations within individual cells remain fairly constant while RNA concentrations increase as protein synthesis increases (Buckley et al., 1999). Thus, a well-fed, active, growing individual should have a relatively high RNA to DNA ratio compared to a starving, inactive individual. The primary objective of our study was to compare RNA:DNA ratios of larval herring from three habitats: sheltered inner bay, exposed outer bay, and off-shore open sea. Our secondary objective was to evaluate possible differences among habitats in the growth of zooplankton. To accomplish this objective, we used the same approach and quantified total RNA content of adult female *Eurytemora affinis* (a dominant Baltic copepod) collected at the same locations as larval herring. There is a strong positive relationship between copepod RNA content and egg production rates (Saiz et al., 1998; Gorokhova, 2003). In turn, high egg production should lead to high abundance of *E. affinis* nauplii. Since such nauplii are important food for larval fish and since feeding conditions partially regulate year–class strength of Baltic herring (Rannak, 1974), it follows that the RNA content of adult female *E. affinis* should be an indicator of habitat-specific rearing conditions for young herring.

2. Methods

During 2005, we collected larval herring and zooplankton on three occasions (3, 9, and 19 June) in three habitats (inner bay, outer bay, and open sea; see Fig. 1). Long-term environmental monitoring in this region of the Baltic (data from Larsson, 2007; stations H4 and BY31) demonstrates that salinity is low, stable and rather uniform: average salinity is 6.0 in the upper 10 m in the open sea habitat and 5.5 in the inner bay.

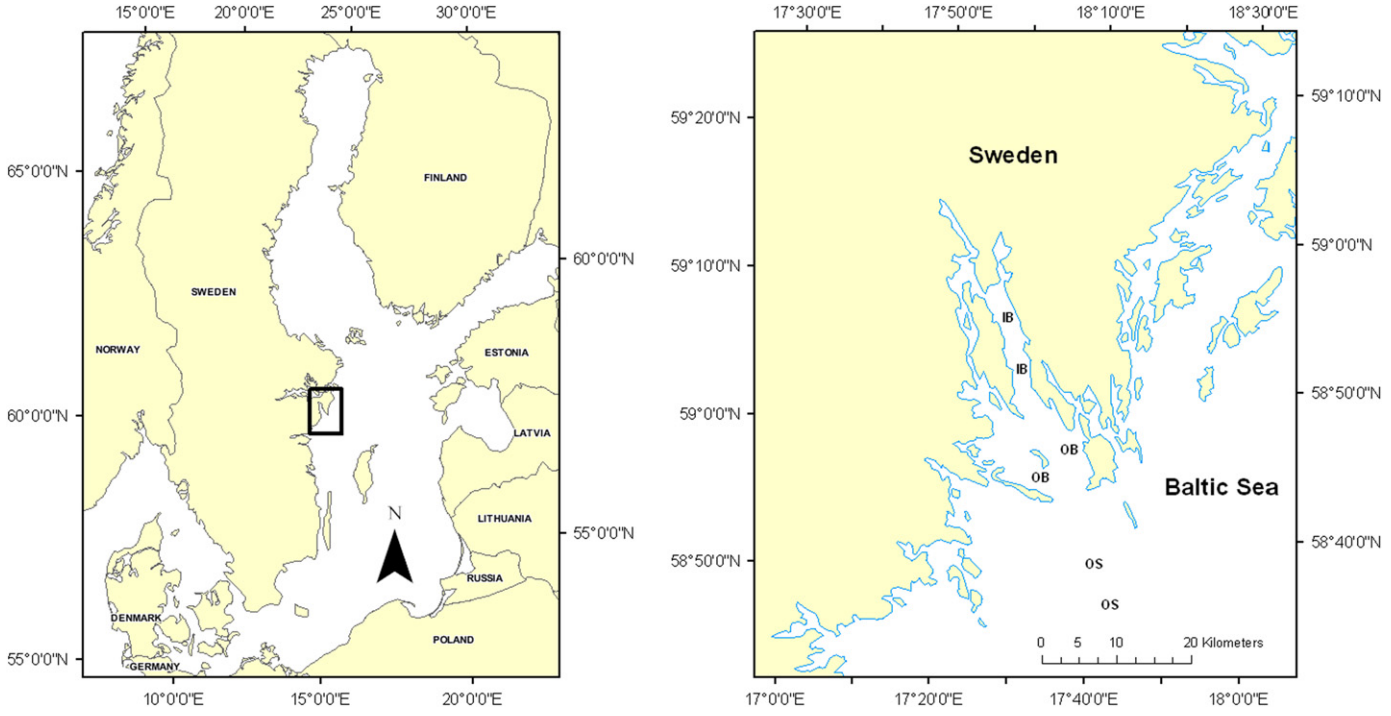

Fig. 1. The left panel depicts the Baltic Sea and our study area (black square). The right panel depicts our study area with inner bay (IB), outer bay (OB), and open sea (OS) collection sites.