New analyses of juvenile sprat growth and temporal origin in the German Bight (North Sea)

Hannes Baumann[1] and Arne M. Malzahn[2]

[1]Institute of Hydrobiology and Fisheries Sciences, Hamburg, Germany (hannes.baumann@uni-hamburg.de)
[2]Alfred Wegener Institute for Polar and Marine Research, Helgoland, Germany (Arne.Malzahn@awi.de)

The relatively shallow and highly productive German Bight in the south-eastern North Sea is recognised as an important retention (Bartsch and Knust, 1994) and nursery area for the larval and juvenile stages of many commercial fish species. The pre-recruit stages of sprat *Sprattus sprattus*, an ecologically and economically important clupeid, are particularly abundant in this area at most times of the year, which has made the species a preferred candidate in many larval growth and recruitment studies.

In the late 1980s and early 1990s, investigations conducted within the framework of the Sardine-Anchovy-Recruitment-Programme (SARP) compiled important information on seasonal and inter-annual spawning variability and larval abundance (e.g. Alheit *et al*., 1987) and tested, for example, the hypothesis that larval growth is promoted in the vicinity of tidal or river plume fronts (e.g. Munk, 1993; Valenzuela and Vargas, 2002). Other approaches focused on the juvenile stage of sprat, using otolith microstructure analysis to deduce the temporal origin of individuals and whether certain periods of the year are more conducive to larval survival than others (Alshut, 1988).

More than a decade later, the German GLOBEC project has followed up on these previous investigations with a new 3 year programme of multi-disciplinary field research in the German Bight. In a recent GLOBEC study, the growth histories and temporal origins of sprat juveniles sampled during three consecutive cruises in August, September, and October 2004 were studied by means of otolith microstructure analysis. A high month-to-month variability in sprat length distributions was encountered in the catches (Fig. 1), showing a continuous decline of the proportion of adult sprat (defined as > 90 mm TL) in the area, while the mean size of juveniles increased first from 71.1 mm TL in August to 76.4 mm TL in September, but decreased to 74.8 mm TL in October again. The majority of sprat juveniles, particularly in August and September 2004, were substantially larger than those caught during previous investigations, which may point to considerable interannual differences in the production and survival of sprat offspring from the German Bight and its adjacent spawning grounds. Uncertainties with regard to differences in gear selectivity and sampling locations, however, are known constraints to such comparisons across studies and decades.

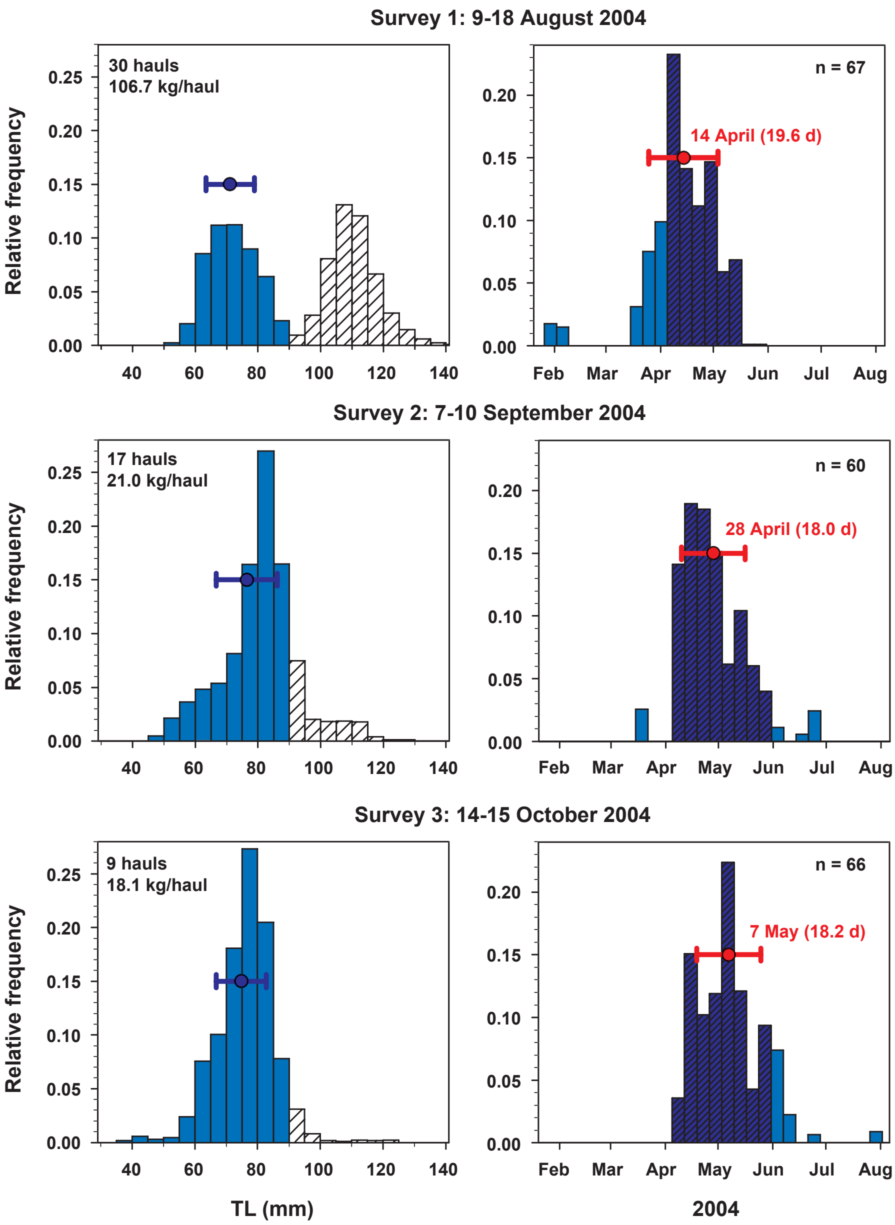

Figure 1. Left panels: Relative length frequency distributions of juvenile sprat (blue bars) sampled during 3 consecutive surveys 2004 in the German Bight (North Sea) with mean ± SD of total length (horizontal error bars). Hatched bars depict relative frequencies of sprat > 9 cm TL, which were assumed to be ≥ 1 year of age and not analysed. Number of hauls and mean CPUE are also given. Right panels: Relative frequencies of the day of first increment formation (dif). Hatched, dark blue bars indicate the period when distributions from all 3 surveys overlapped. Number of analysed otoliths per survey and mean ± SD dif (horizontal error bars) are also given.

Backcalculated days of first increment formation (dif), a proxy for hatch day, indicated that the majority of sprat juveniles in 2004 originated from the spring months April and May (Fig. 1). Although from one survey to the next, later born juveniles appeared in the sampled population, whilst the earliest born conspecifics continuously disappeared (Fig. 1). However, the main

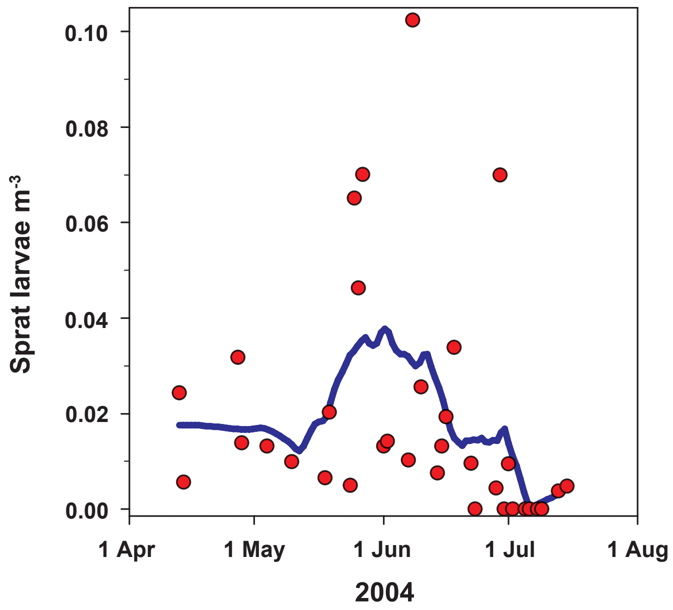

Figure 2. Seasonal abundance of small sprat larvae at the monitoring station 'Helgoland Roads' (54°11.18´N and 07°54´E), surveyed 3-5 times per week in 2004. Double oblique hauls were carried out using a CalCOFI ring trawl equipped with 500 µm mesh nets. A local smoothing function was used to estimate the seasonal trend in sprat larval sprat abundance (Loess, SigmaPlot 10.0®).

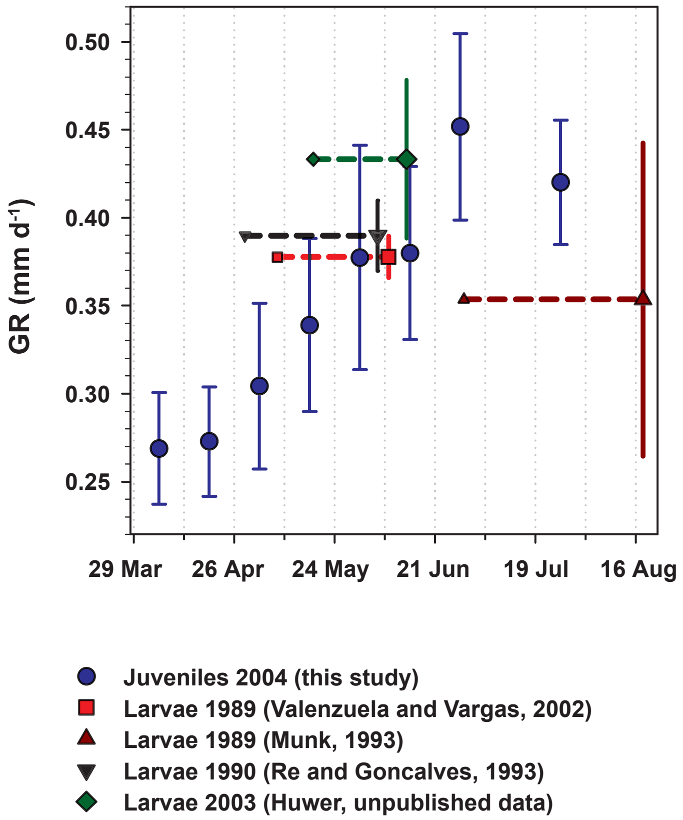

Figure 3. Published growth rates for sprat larvae from the German Bight compared to backcalculated larval growth rates of sprat juveniles sampled in 2004 (blue circles). Standard length growth rates (GR) were averaged (±SD) over the initial 50 days after first increment formation and for individuals with similar temporal origin (14 days intervals). Published larval growth rates are based on age-standard length relationships, error bars depict the range of reported growth rates. Dashed lines correspond to the encountered age range in each of the studies.

spawning season in the German Bight generally commences later, typically at the end of May (Munk, 1993), which is consistent with seasonal monitoring data obtained for 2004 at Helgoland Roads (Fig. 2). Thus, many of sprat juveniles encountered in late summer and autumn of 2004 in the German Bight may have been produced outside the study area, and either drifted and/or actively migrated subsequently into it (Alshut, 1988).

Otolith-based length and growth backcalculations suggested a second pattern in the seasonal dynamics of juvenile sprat in the German Bight. When backcalculated to a common date just prior to the beginning of the first survey (8 August), individuals present in the area in October were substantially smaller than those present in September, which in turn were smaller than those present in August. Similarly, a comparison of relative, i.e. 'age-independent' otolith growth rates clearly showed that sprat juveniles remaining in the area in October were those that grew slowest on average between the end of July and September 2004. In other words, the largest and fastest growing sprat juveniles seemed to have progressively disappeared from the study area, either as a consequence of selective migration and/or selective mortality. The latter would challenge a paradigm in larval fish ecology, being that larger and faster growing individuals generally have higher survival probabilities (Leggett and Deblois, 1994). Interestingly, however, average growth rates for sprat larvae in the German Bight – as compiled from the literature – were found to be consistently as high or even higher than backcalculated *larval* growth rates of juveniles with similar temporal origins (Fig. 3). To eliminate some of the many sources of uncertainty inherent to such comparisons (e.g. different methods to estimate growth rates from otoliths), further analyses are presently carried out with sprat larvae sampled during 2004 in the German Bight.

References

Alheit J., E. Wahl and B. Cihangir. 1987. Distribution, abundance, development rates, production and mortality of sprat eggs. ICES Council Meeting Papers CM 1987/H:45.

Alshut S. 1988. Bestimmung von Alter und Wachstumsraten bei Larven und Juvenilen der Sprotte, Sprattus sprattus L. PhD thesis. Alfred-Wegener-Institut für Polar- und Meeresforschung. University of Bremen. 191pp.

Bartsch J. and R. Knust. 1994. Simulating the dispersion of vertically migrating sprat larvae (*Sprattus sprattus* (L.)) in the German Bight with a circulation and transport model. Fisheries Oceanography 3: 92-105.

Leggett W.C. and E. Deblois. 1994. Recruitment in marine fishes: is it regulated by starvation and predation in the egg and larval stages? Netherlands Journal of Sea Research 32: 119-134.

Munk P. 1993. Differential growth of larval sprat (*Sprattus sprattus*) across a tidal front in the eastern North Sea. Marine Ecology Progress Series 99: 17-29.

Ré P. and E. Gonçalves. 1993. Growth of sprat *Sprattus sprattus* larvae in the German Bight (North Sea) as inferred by otolith microstructure analysis. Marine Ecology Progress Series 96: 139-145.

Valenzuela G.S. and C.A. Vargas. 2002. Comparative larval growth rate of *Sprattus sprattus* in relation to physical and biological oceanographic features in the North Sea. Archive of Fishery and Marine Research 49: 213-230.