Andreas Dänhardt, Myron A. Peck, Catriona Clemmesen & Axel Temming

DEPTH-DEPENDENT NUTRITIONAL CONDITION OF SPRAT (*SPRATTUS SPRATTUS*) LARVAE IN THE CENTRAL BORNHOLM BASIN, BALTIC SEA

The growth and survival of larval and early juvenile stages can be positively correlated and have been identified to be the main determinants of recruitment variability in populations of sprat (*Sprattus sprattus*) and cod (*Gadus morhua*) inhabiting the Baltic Sea (Köster et al. 2003). Sprat plays a key trophodynamic role as a prey resource (Nissling 2004) for a number of species and as a predator on both zooplankton and fish eggs (Arrhenius & Hansson 1993, Köster & Möllmann 2000).

Bi-modal depth distribution patterns observed for sprat larvae in previous field studies conducted in the deep basins of the Baltic Sea have led researchers to hypothesize that larval sprat condition was depth-dependent. We examined this hypothesis by measuring morphological, biochemical and otolith-based proxies for nutritional condition in sprat larvae collected in discrete 5 m depth intervals from the surface to the bottom in the central Bornholm Basin by means of a BIOMOC vertically resolving sampling device (Wieland & Jarre-Teichmann 1991).

Similar to earlier studies, larval sprat were most abundant in two depth strata (0–10 m and 65–75 m). Depending on trawl time, specimen suffered substantial damage upon catch, which is discussed elsewhere (Dänhardt & Temming 2007, http://www.int-res.com/articles/ab2007/1/b001p135.pdf).

Larval sprat condition was not uniformly expressed by all measures that were applied to test the hypothesis that nutritional state was similar between shallow and deep waters of the central Bornholm Basin. Sprat larvae from 0–10 m could not be distinguished from conspecifics at 65–75 m using slow (otolith-based daily somatic growth rates) and intermediate responding

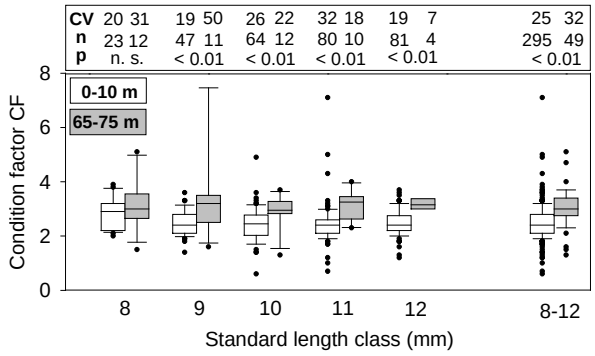

Figure 1. Condition factor (CF) of sprat larvae obtained from 0–10 m and 65–75 m. The median line, 10th, 25th, 75th and 90th percentiles are shown. Variability (CV), sample size (n) and significance levels (n. s. = not significant) are given above the respective plots.

proxies (*RNA:DNA*) (Belchier et al. 2004), whereas short-latency proxies (protein:*SL* and *DNA:DW*) (Ferron & Leggett 1994) indicated superior nutritional condition and better (recent) growth of larvae in surface waters. Assessments of a larva's nutritional state using only one proxy may thus lead to spurious conclusions. We therefore suggest a combination of relatively slow, medium and fast responding indicators be implemented, unless sampling periods longer than the response time of all condition proxies (i. e., several days) are utilized and data on cause (good or poor feeding conditions) and effect (fast growth or starvation) are available. In particular for sprat residing in the present habitat, the morphometric condition factor *CF* (Hempel & Blaxter 1963) and the daily protein growth rate *Gp* (Buckley 1984) should be applied with caution and only in addition to more unequivocal condition indices.

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andreas@daenhardt.com

It is still unknown if the nutritional condition of the larvae resulted *from* or *in* the observed bi-modal depth distribution. At the time of sampling, sprat larvae found at 65–75 m experienced low temperatures that reduced protein growth (*Gp*) that may have resulted in higher *DNA:DW* and the lower *SL* at weight (i. e., protein:*SL*). The depth-dependent differences in

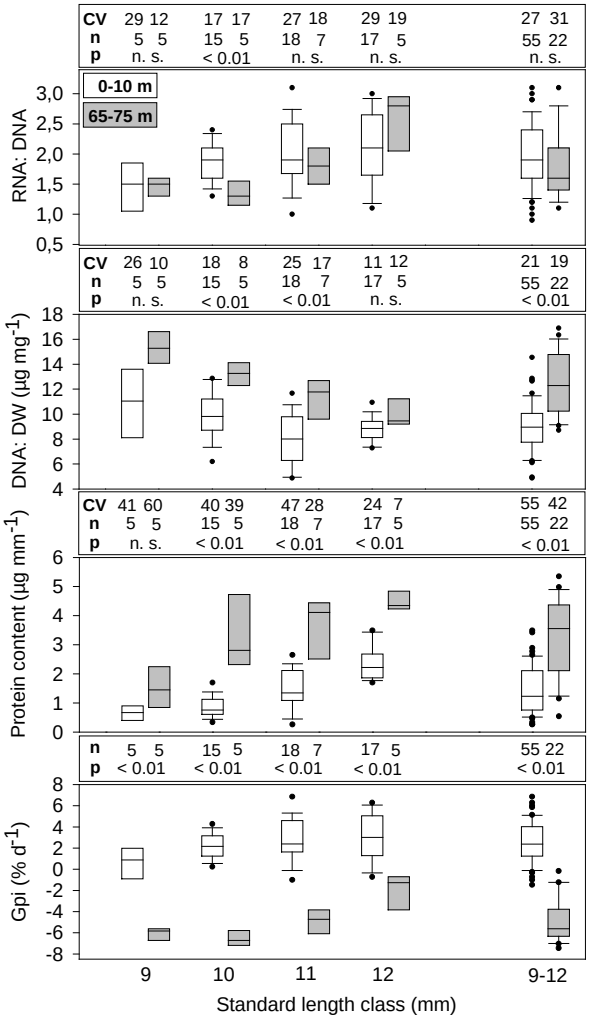

Figure 2. Biochemical condition proxies: RNA:DNA, DNA:DW, protein content: SL and daily protein growth rate (Gp) of larval length classes 9, 10, 11 and 12 mm caught at 0–10 m and 65–75 m depth. The median line, 10th, 25th, 75th and 90th percentiles are shown. Variability (CV), sample size (n) and significance levels (n. s. = not significant) are given above the respective plots. CV of Gp is not provided.

these short-latency proxies suggested that the observed depth distribution could have been a recent phenomenon. At 65–75 m, low water temperatures and a concomitant reduction in metabolic rates and other physiological processes would be expected to retain individuals in poor condition.

Successful ascent to the surface would be required for sprat larvae at 65–75 m to return to water layers characterized by warm temperatures, sufficient light, high food and low predator concentrations - conditions favouring growth and survival even in larvae with less than optimal nutritional condition. Larval ascents from 65–75 m were not observed in our study. Moreover, directed movements towards deep waters would be highly maladaptive since these environments render fast growth and survival unlikely. The larvae we observed in the Bornholm Basin's deep strata may be interpreted as a result of a selection against individuals in a poor nutritional state at these depths (Grønkjær et al. 1997, Voss et al. 2005).

Cited literature

Arrhenius F, Hansson S (1993) Food consumption of larval, young and adult herring and sprat in the Baltic Sea. Mar Ecol Prog Ser 96:125–137

Belchier M, Clemmesen C, Cortes L, Doan T, Folkvord A, Garcia A, Geffen A, Hoie H, Johannessen A, Moksness E, de Pontual H, Ramirez T, Schnack D, Sveinsbo B (2004) Recruitment studies: manual on precision and accuracy of tools. ICES Tech mar environ Sci 33, 35 pp

Buckley L (1984) RNA-DNA ratio: an index of larval fish growth in the sea. Mar Biol 80:291–298

Dänhardt A, Temming A (2007) Effects of haul duration on the physical condition of sprat larvae. Aquat Biol 1: 135–139

Ferron A, Leggett WC (1994) An appraisal of condition for marine fish larvae. Adv Mar Biol 30:217–303

Grønkjær P, Clemmesen C, St. John MA (1997) Nutritional condition and vertical distribution of Baltic cod larvae. J Fish Biol 51 (Suppl A):352–369

Hempel G, Blaxter JHS (1963) On the condition of herring larvae. Rapports et Procès-verbaux des Reùnions. Cons int Explor Mer 154:35–40

Köster FW, Möllmann C (2000) Egg cannibalism in Baltic sprat *Sprattus sprattus*. Mar Ecol Prog Ser 196:269–277

Köster FW, Hinrichsen, H-H, Schnack D, St. John MA, Mackenzie BR, Tomkiewicz J, Möllmann C, Kraus G, Plikshs M, Makarchouk A, Aro E (2003) Recruitment of Baltic cod and sprat stocks: identification of critical life

andreas@daenhardt.com

stages and incorporation of of environmental variability into stock-recruitment relationships. Sci Mar 67 (Suppl 1):129–154

Nissling A (2004) Effects of temperature on egg and larval survival of cod (*Gadus morhua*) and sprat (*Sprattus sprattus*) in the Baltic Sea – implications for stock development. Hydrobiologia 514:115–123

Voss R, Clemmesen C, Baumann H, Hinrichsen HH (2005) Baltic sprat larvae: Coupling food availability, larval condition and survival. Mar Ecol Prog Ser 308: 243–254

Wieland K, Jarre-Teichmann A (1997) Prediction of vertical distribution and ambient development temperature of Baltic cod, *Gadus morhua* L., eggs. Fish Oceanogr 6:172–187