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Variability in growth and nutritional condition of sprat larvae in the Baltic – a combined field and biophysical modelling study

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Sprat larvae (*Sprattus spratttus*) were sampled by Bongo net in the Bornholm basin area (Baltic Sea). The nutritional condition based on RNA/DNA ratios and age and growth estimates based on sagitta otolith increment numbers and width were determined on the same individual larva. An exercise combining 3-D hydrdynamic model simulations and field data on otolith growth characteristics of larval sprat was utilised to backcalculate their potential drift routes and hatching locations. In parallel the temperature history experienced along their tracks was extracted from the model output back to the site where larvae started first feeding. To identify spatial and temporal variability in growth potential and nutritional condition experienced by young larvae otolith increment widths have been normalised with respect to daily resolved ambient temperatures. Questions which will be addressed: Does the location of the spawning site effect the growth potential of the larvae? Is a drift from or a retention situation in the Bornholm Basin more favourable for growth? Can the increment width of the sagittal otoliths relate to differences in nutritional condition experienced by young larvae?

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Fine- to micro-scale distribution of plankton based on Video Plankton Recorder profiles from Georges Bank with implications for larval fish feeding

R. G. Lough and E. R. Broughton

Theoretical plankton modeling studies show that patch structure can greatly modify encounter rates of predators and prey. However, direct observations of micro-scale patchiness are limited so that the theoretical basis for these models is not well developed. During the U.S. GLOBEC Georges Bank Study, a self-contained, analog Video Plankton Recorder (VPR) mounted on a 1-m2 MOCNESS sampling system was used to obtain simultaneous data on the fine-scale (10's m) to micro-scale (<1 m) distribution of zooplankton as prey for larval cod and haddock.

Video plankton images were recorded at 60 frames per second and integrated with the MOCNESS CTD-data, fluorescence, and light attenuation while being towed at 1 ms-1. In May 1997, a single camera was used to image a view of 7 mm x 5 mm x 10 mm per frame. In 1999, on four cruises from March through June, a two-camera system was used for simultaneous imaging of both the general net-plankton and the micro-plankton. The low magnification camera imaged a view of 2.5 cm x 2.5 cm x 10 cm per frame to capture the adult zooplankton and larger phytoplankton, while the high magnification camera, 4 mm x 4 mm x 10 mm, viewed the smaller phytoplankton and juvenile stages of zooplankton, especially copepod nauplii which are an essential component of the prey for larval fish. Data-series analysis was used to describe plankton patchiness at fine- and micro-scale in mixed and stratified water in relation to temperature, salinity, density, turbulence, and fluorescence. The negative binomial frequency distribution was found to best describe the various plankton categories. The degree of water-column stratification was especially important in structuring micro-scale high-density layers of phytoplankton and copepods.

Encounter rates of larval fish and their prey are evaluated in relation to the initial micro-scale patchiness observed.

Keywords: Plankton, Patchiness, Larval Fish, Feeding.

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The three-dimensional prey field of *Meganyctiphanes norvegica* and the escape responses of their copepod prey

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In the North Atlantic, *Meganyctiphanes norvegica* feeds on Calanus spp. However, its prey perceptual field, and the sensory modalities underlying its detection of prey, are little known. Krill responses to free swimming copepods were observed using silhouette video photography, which allowed quantification of the interactions (in 3-D, and at 25 frames per second) between the predator and its prey. An attack attempt was characterised by a pronounced and directed movement of the krill's antennae, followed by a "grabbing" lunge and opening of the cephalothorax appendages (the "feeding basket"), in close spatiotemporal association with the swimming trajectory of a copepod prey. Prey detection distances differed significantly between experiments run in light vs. dark (25 * 9 and 22 * 10 mm respectively), but there were no differences in the position of the detected prey relative to the predator. Attack attempts were uniformly oriented laterally (in both light and dark), with 80 % of the detected prey located below the krill's body axis, i.e. presumably out of its visual field of view. This indicates that vision is not the main sensory modality involved in prey detection by M. norvegica, but more likely provides supplemental information to the mechanoreceptive sensors on the antennae. Avoidance responses of the copepods were nearly twice the velocity of their normal swimming speeds (153 * 48 and 85 * 75 mm s-1 respectively), on average taking them 43 * 16 mm away from the predator, which is far beyond the krill's perceptual range.

Keywords: Meganyctiphanes norvegica, Calanus spp., perceptive field, silhouette video photography, feeding behaviour, vision, mechanoreception, predator avoidance.

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Annual and interannual variability of body size and population development of 4 dominant copepod species at Helgoland Roads, southern North Sea

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A four-year time series of prosome measurements of the dominant calanoid copepods *Acartia clausi, Temora longicornis, Centropages hamatus* and *Pseudocalanus elongatus* at Helgoland Roads was used to determine the timing of the first appearance of the G1 generation, to describe interannual variability of body carbon from length-weight relationships, and to predict egg production rate from a weight-egg production relationship established in the field. Annual variability of female prosome length was clearly related to temperature, while egg production was best correlated with body size. While maximum and minimum prosome length varied interannually by ca. 10%, body carbon varied by up to 50%. Maximum egg production rate varied by a factor 1.5 to 2. The range in first appearance of the G1 generation between the 4 years was highest in Acartia clausi with 67 days, in the other species it varied from 30 to 50 days. This should have significant impact on the feeding condition of larval fish. Interannual size variability was not explained by temperature.

Keywords: copepods, interannual variability, North Sea.

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Storm impact on clupeid larvae, their condition and their planktonic prey

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Tidal mixing front systems with their array of diverse water bodies (mixed zone, transition zone, three different layers in the stratified zone) offer excellent test beds to study differential survival of fish larvae. Sardine (*Sardina pilchardus*) and sprat (*S. sprattus*) larvae were sampled together with their potential prey (micro- and meso-zooplankton) across a tidal mixing front system in the German Bight of the North Sea in June 2002. Spatial and temporal changes in their condition were determined using a suite of different methods: trypsin activity to determine short-term starvation and RNA/DNA ratio and growth ring increments on otoliths to measure longer-term starvation. A storm event during the study which disrupted the frontal system allowed to investigate changes in larval condition due to short-term changes in their environment. The dynamics of larval condition and starvation are discussed in relation to physical forcing and abundance and composition of accompanying phyto-, micro- and meso-zooplankton communities in contrasting sites of the frontal system.