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## Secondary production at the Polar Front, Barents Sea, August 2007<sup>☆</sup>

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### ARTICLE INFO

#### Article history:

Received 4 October 2012

Received in revised form 17 June 2013

Accepted 15 July 2013

Available online 6 August 2013

#### Keywords:

Growth

mortality

Biomass spectrum theory

Laser Optical Plankton Counter

Zooplankton Production

Polar Front

### ABSTRACT

To investigate spatial patterns of secondary production we sampled four core hydrographical regions of the Polar Front in the Barents Sea (Arctic Water, ArW; Polar Front Water, PFW; Atlantic Water, AtW; and Melt Water, MW) by towing an undulating instrument platform along a transect crossing the front from August 8–9, 2007. Sensors mounted on the platform provided data on the hydrography (CTD), fluorescence (Fluorometer, F) and zooplankton abundance in the size range between 0.1 and 30 mm (Laser Optical Plankton Counter, LOPC). These continuous, biophysical data with high-spatial resolution were supplemented by discrete water and zooplankton net samples at stations for sensor calibrations. After in depth quality assessments of the biophysical data, estimates were made of the vital rates based on biovolume spectrum theory. Five size groups were distinguished from the LOPC data: small (S), mainly *Oithona* spp. and the appendicularian *Fritillaria* sp.; medium (M), mainly *Pseudocalanus* spp. and *Calanus* spp. CI–CIII; large (L), mainly *Calanus* spp. CIV–CV; and extra large (XL and 2XL), juvenile and adult euphausiids. Size groups were further divided based on transparency of organisms. Vital rates based on the biophysical in situ data in combination with biovolume spectrum theories agreed generally well with data from empirical and numerical models in the literature. ArW was characterised by subsurface maxima of chlorophyll *a* (chl *a*), and an estimated population growth of ca. 13 mg C m<sup>-3</sup> d<sup>-1</sup> for CI–CIII *Calanus* spp. and some older *Pseudocalanus* within the chl *a* maxima. Frontal waters were characterised by low chl *a* concentrations, but high abundances and production (around 1 g C m<sup>-3</sup> d<sup>-1</sup>) of small copepods (*Oithona* spp.) and appendicularians (*Fritillaria* sp.). The estimated production of small-size zooplankton was an order of magnitude higher than the production of all other size groups combined, including large copepods. The high loss rates (–166 to –271 mg C m<sup>-3</sup> d<sup>-1</sup>) of small zooplankton may contribute a substantial amount of carbon to the benthos and to pelagic predators such as young capelin. AtW was the most productive water mass, with surface chl *a* maxima and an estimated population growth of 134 mg C m<sup>-3</sup> d<sup>-1</sup> for small zooplankton, 3.6 mg C m<sup>-3</sup> d<sup>-1</sup> for medium-sized copepods and 0.9 mg C m<sup>-3</sup> d<sup>-1</sup> for CIV–CVI *Calanus*. For those *Calanus* spp. in the surface layer, the estimated specific mortality rates were up to –0.35 d<sup>-1</sup>, partly due to high predation pressure by hydrozoans and chaetognaths.

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### 1. Introduction

Secondary production in the pelagic zone, i.e. the increase in biomass of zooplankton over a period of time, constitutes the base for the largest fisheries in the world. It has therefore been a priority research question for biological oceanographers since the onset of marine research. Despite the major interest, spatio-temporal patterns of secondary production remain largely unresolved, due to a lack of adequate methods to estimate secondary production.

Among the approaches that have been tried for estimating secondary production in marine systems are the ecological method, the cohort

method, the physiological method, the egg production method, empirical models and more recently biochemical methods (see also Poulet et al., 1995; Runge and Roff, 2000). The ecological method is based on the trophodynamic concept (Lindemann, 1942), where the production of any trophic level is estimated based on primary production and transfer efficiencies between trophic levels (Lalli and Parsons, 1997). The cohort method has been very much in use in those situations where age or stage information of a population can be analysed with a minimum degree of uncertainty (Aksnes and Magnesen, 1988; Kimmerer, 1987; Kimmerer and McKinnon, 1987). Some decades ago the physiological method was extensively explored in experimental systems, using the energy budget of an individual to calculate growth and secondary production by taking into account all input to and output from the individual (Ikeda and Motoda, 1978; Le Borgne, 1982). In response to the high degree of uncertainty in many earlier methods (Miller, 2004), the egg production method was proposed as a means to obtain globally comparable production estimates by a simplified method (Poulet et al., 1995). Production estimates are limited to female copepods, allowing for

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