Microscale Abundance of Copepod Nauplii Prey of Larval Fishes in a Glaciated Fiord Measured with a 50-mL Sampler

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Microscale Abundance of Copepod Nauplii Prey of Larval Fishes in a Glaciated Fiord Measured with a 50-mL Sampler

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ABSTRACT: Copepod nauplii were collected with a 50-mL sampler in 1995 to examine the microscale spatial heterogeneity of copepod nauplii in the immediate hunting territory of larval fish. The study was done in a glaciated fiord during the spring hatching period for walleye pollock *Theragra chalcogramma*. From mid April through mid May 50-mL water samples taken at 5- and 10-m depths contained, on average, 0.2–1.0 copepod nauplii 150–350 μm long. By 15 May the average sample counts were typically 1.0–4.0 nauplii at 5 m and 0.4–2.0 at 10 m deep. Based on previous literature values, copepod nauplii in Resurrection Bay exhibited sufficient abundance in these microscale samples to support walleye pollock larvae.

INTRODUCTION

Along the northern Gulf of Alaska coast are numerous fiords and embayments where walleye pollock *Theragra chalcogramma* spawn. Growth rates of larval pollock are related to prey concentrations (Haldorson et al. 1989), and several studies have enumerated the availability of their copepod nauplii prey (Dagg et al. 1984; Haldorson et al. 1989; Nakatani 1991; Paul et al. 1991; Smith et al. 1991; Incze and Ainaire 1993). All of those studies used 10- to 30-L water bottles to collect the nauplii. Those samples estimated nauplii abundance but were not suitable for describing prey spatial heterogeneity in the immediate hunting territory of a 5- to 7-mm fish larva.

The objective of this study was to measure the number of copepod nauplii in a volume of water more equivalent to the hunting territory of a larval fish. Larval walleye pollock perceive prey at 0.5 to 0.7 body lengths (M. F. Canino, National Marine Fisheries Service, Seattle, personal communication), and first-feeding yolked larvae search 50 mL in feeding bouts of about 15 min (authors unpublished). In this initial experiment a 50-mL sampler was deployed to measure the microscale abundance of copepod nauplii during the period larval walleye pollock are traditionally present.

METHODS

Sampling of copepod nauplii was done at 1 location (Station 1 in Figure 1) in Resurrection Bay from 19 April to 24 May 1995 to encompass peak abundances of newly hatched pollock larvae, which in the northern Gulf of Alaska usually occurs between the third week of April and the first week of May (Muter and Norcross 1994). Copepod nauplii sampling was done with a messenger-operated 50-mL plastic syringe (Figure 2). The syringe had a 3-mm bore that was oriented toward the surface and was mounted on a wire clamp taken from a Niskin water bottle. The syringe's plunger base was connected to a vertical PVC pipe attached to a T-shaped PVC pipe fitting. The hydrographic wire ran through this T-fitting, which was situated above the syringe on the wire. Samples were taken almost instantaneously when the 0.5-kg messenger struck the T-fitting and drew out the syringe plunger.

Copepod nauplii samples were collected at 5- and 10-m depths during the daylight high tide because larval pollock are visual predators that are found near the surface during daylight hours (Paul 1983; Haldorson et al. 1993). Samples were collected every Monday, Wednesday, and Friday between 19 April and 24 May 1995. During this period National Marine Fisheries Service (NMFS) surveys in the nearby Gulf of Alaska

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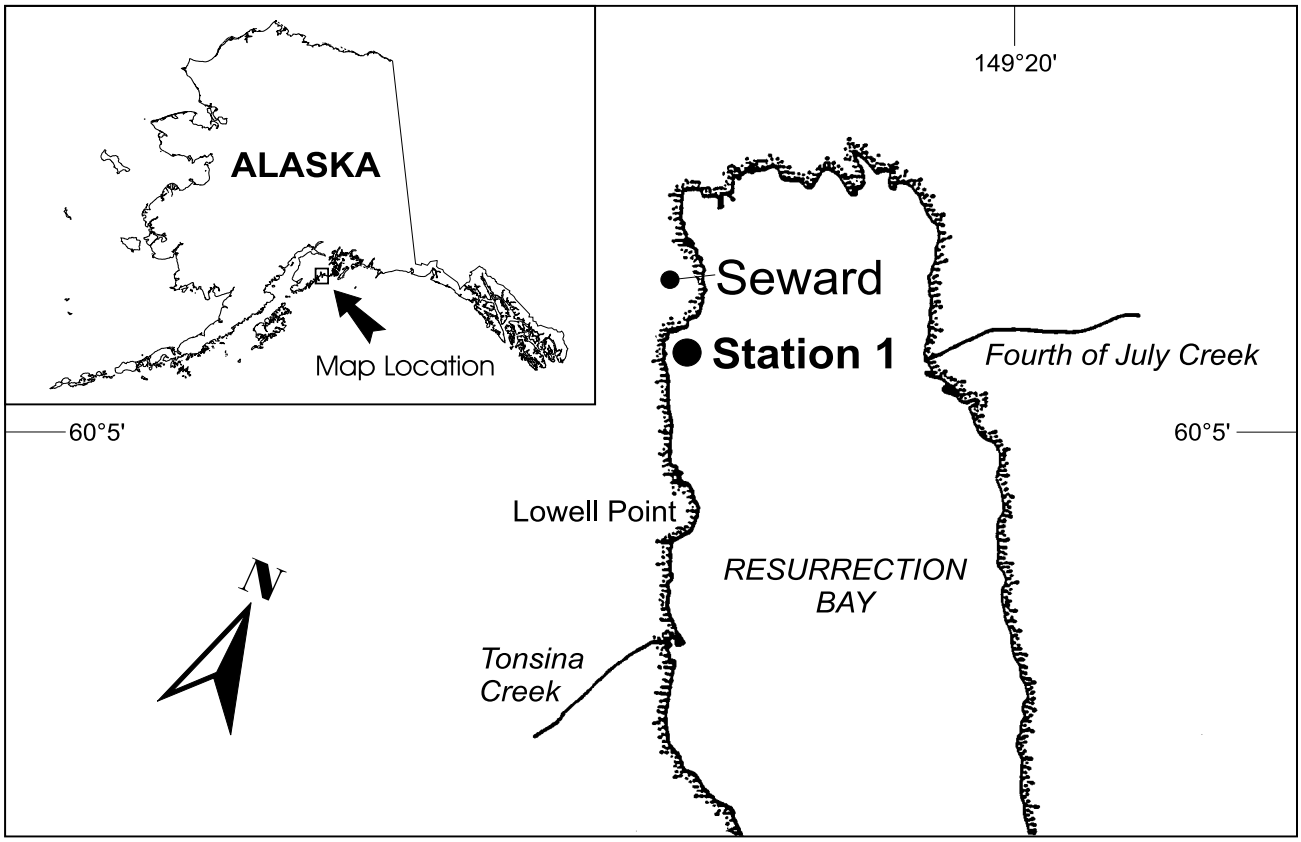

Figure 1. Resurrection Bay, Alaska, showing the location of Station 1 where microscale abundance of copepod nauplii was measured during the spring of 1995.

reported widespread spawning of pollock (A. Kendall, NMFS, Seattle, personal communication). On each of the 15 sampling days 5 replicate samples were taken at both depths; a total of 150 samples were collected.

Each sample was preserved in 50% isopropanol for subsequent microscopic analysis. Only the nauplii of copepods were enumerated; all other nauplii and zooplankters were ignored. Walleye pollock larvae typically select copepod nauplii with body lengths of 150–350 μm (Dagg et al. 1984; Hillgruber et al. 1995). We measured nauplii with an ocular micrometer and recorded the number with body lengths 150–350 μm and the total number (so the data would be comparable to previous studies).

RESULTS

The depth of visibility measured by a Secchi disk was initially 7 m and declined to 2 m by 8 May because of increased primary production and glacial silt. During the study, temperatures increased from 4.5° to 8.2°C at 5 m deep and from 4.4° to 7.0°C at 10 m. Corresponding salinity values were 31 to 27 ppt at 5 m and 32 to 29 ppt at 10 m. Wave height never exceeded 0.6 m.

At the 5-m depth 45% of the 50-mL samples contained no copepod nauplii 150–350 μm long, 26% had 1 nauplius, and 29% had 2 or more nauplii (Figure 3). The average number of nauplii 150–350 μm long in all of the 5-m-deep samples was 1.1 (n = 75, SD = 1.5). Samples containing >4 copepod nauplii were rare.

At the 10-m depth (Figure 4) copepod nauplii 150–350 μm long were less abundant than at 5 m, averaging 0.7 individuals per 50 mL (n = 75; SD = 0.7). However, only 37% of the samples at 10 m contained no nauplii, 50% of them had 1 nauplius, and 13% contained 2 or more. Only 1 sample contained >3 nauplii.

DISCUSSION

Haldorson et al. (1989) showed that walleye pollock larvae grow at near maximum rates when copepod nauplii concentrations are $\geq 20 \cdot L^{-1}$. Currently, we have no basis to confidently convert the number of

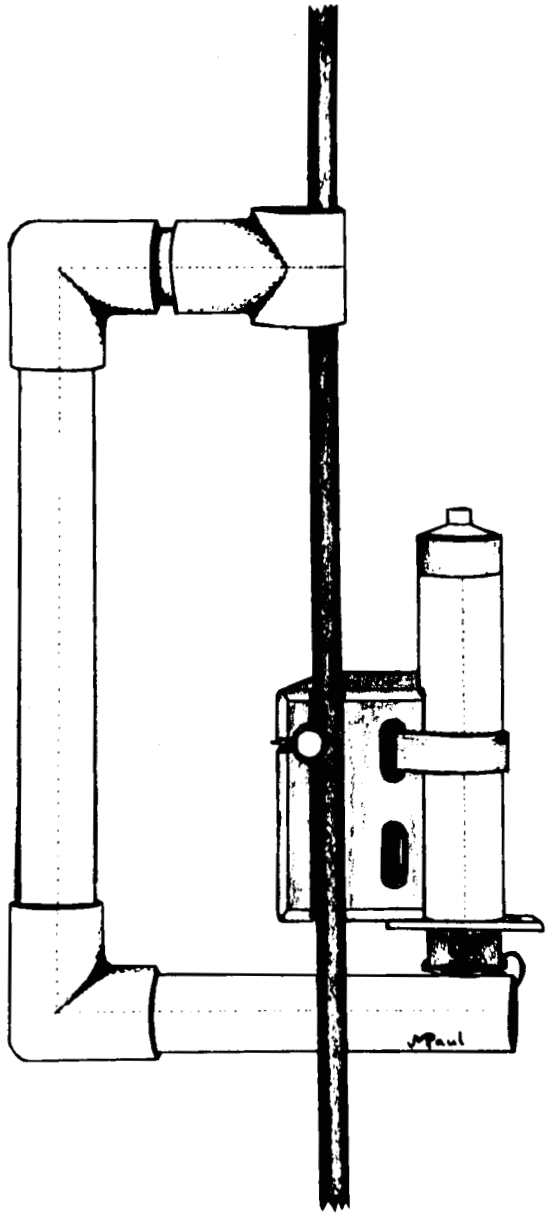

Figure 2. The 50-mL sampler used to measure copepod nauplii abundance in Resurrection Bay, Alaska, during the spring of 1995. The components are a plastic syringe attached to a Niskin bottle wire clamp and 21-mm PVC pipe fittings.

nauplii in 50-mL samples to number per liter because nauplii dispersion is poorly understood. If we assume there are no complications in this conversion, 1 nauplius in 50 mL would be the equivalent of $20 \cdot L^{-1}$. In 1995 at Station 1 vertically migrating pollock larvae were likely to encounter 1 or more nauplii in 50 mL (Figures 3, 4). Typically, the other most common larval fish coexisting with pollock in Resurrection Bay are flathead sole *Hippoglossides elassodon* and Pacific herring *Clupea pallasi* (Smith et al. 1991). Flathead sole appear to reach saturation feeding at nauplii densities below $15 \cdot L^{-1}$ (Haldorson et al. 1993), whereas herring larvae display good growth and survival at 5–12 nauplii$\cdot L^{-1}$ (Purcell and Grover 1990). Thus, prey availability in Resurrection Bay during 1995 should have been adequate for the most common larval fish taxa.

Copepod nauplii abundances in the fiord were similar to those reported for unglaciated pollock rearing grounds, although much larger-volume samplers were used for those studies (Dagg et al. 1984; Haldorson et al. 1989; Nakatani 1991; Paul et al. 1991; Incze and Ainaire 1994). The largest concentrations of spawning pollock occur in the southeastern Bering Sea, where 2–20 nauplii$\cdot L^{-1}$ of all sizes are typical (Clark 1984). During 1988, nauplii counts in 10-L bottles frequently exceeded $20 \cdot L^{-1}$ throughout Resurrection Bay (Smith et al. 1991). Another study showed that growth rates of pollock larvae in Resurrection Bay and unglaciated nursery areas were similar (Muter and Norcross 1994). In these 1995 samples *Pseudocalanus* was qualitatively the most common nauplii, and *Oithona* was the only other regularly observed genus. *Metridia, Calanus,* and *Neocalanus* nauplii were observed rarely. Nauplii of *Pseudocalanus, Oithona,* and *Metridia* are preyed on by walleye pollock larvae (Hillgruber et al. 1995). In terms of prey, the fiord appeared to be a suitable nursery area for larval pollock during 1995.

Processing 50-mL samples only required one-third the time needed to count 10-L volumes in our previous study (Smith et al. 1991) and eliminates errors associated with concentrating bottle samples with nets and splitting the larger samples for counting. Large volumes are concentrated with nets so they can be stored in small sample bottles. During the process nauplii can become stuck in the net and lost, or they may contaminate another sample. When splitting large-volume samples to reduce the time needed to count them, getting a truly representative split is problematic. With 50-mL samples no nets are involved and the whole sample is counted. It might be possible to automate processing 50-mL volumes with image analyzers (Incze and Ainaire 1994).

Sampling at just 5 and 10 m precluded identifying the whole range of nauplii concentrations coexisting with pollock larvae. Also, our methods may not have measured true prey abundance if the presence of the syringe, the orientation of its orifice, or the sucking action during sample collection stimulated escape or attraction reactions by nauplii near the opening. Regardless of factors possibly causing sampling bias, this

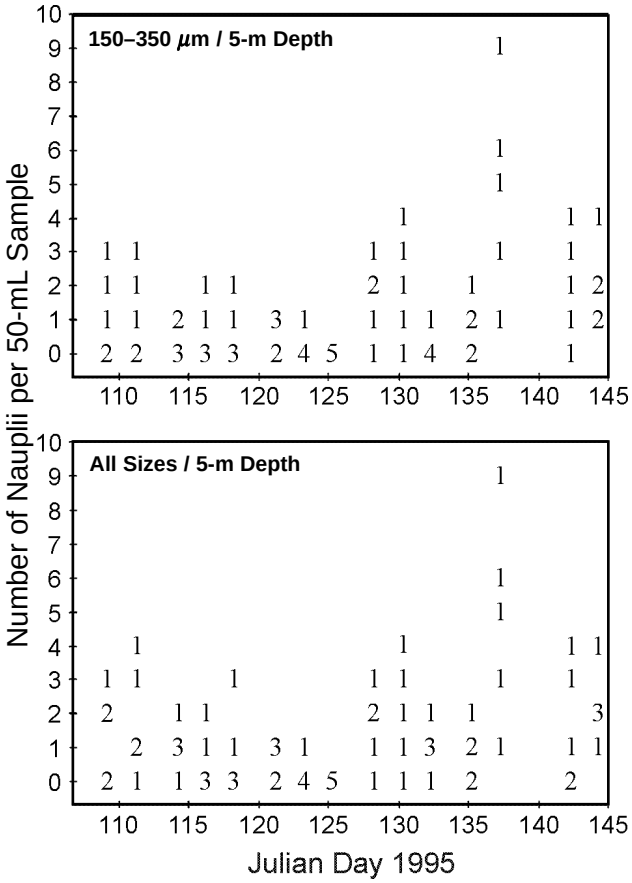

Figure 3. Number of 50-mL samples per Julian sample day containing from 0 to 10 copepod nauplii with body lengths of 50–350 μm (upper) and those of all sizes (lower). Samples collected at the 5-m depth from Station 1 in Resurrection Bay, Alaska, during 1995.

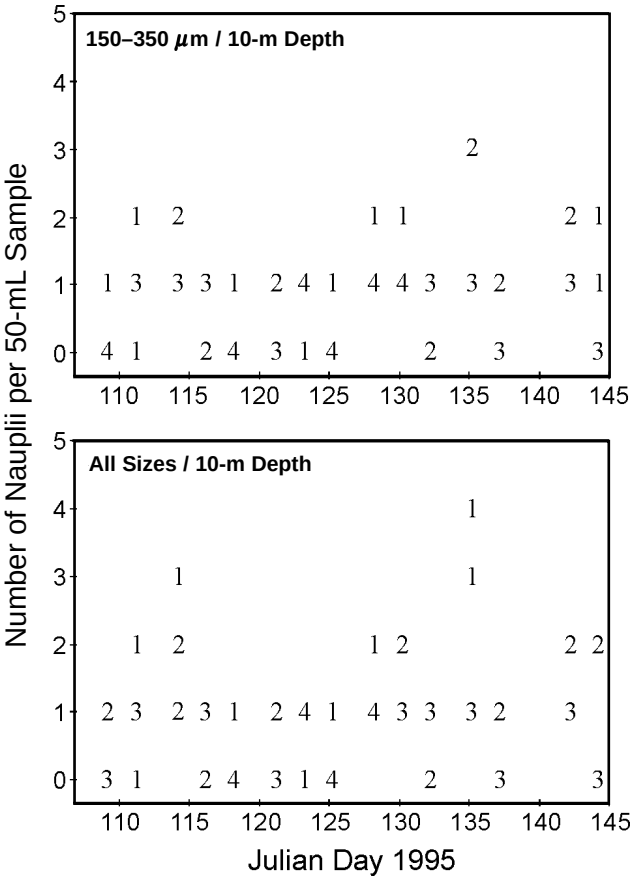

Figure 4. Number of 50-mL samples per Julian sample day containing from 0 to 10 copepod nauplii with body lengths of 50–350 μm (upper) and those of all sizes (lower). Samples collected at the 10-m depth from Station 1 in Resurrection Bay, Alaska, during 1995.

initial examination of microscale abundance of copepod nauplii indicates that 50-mL samples are adequate for measuring their relative abundance in Alaskan fiords. Additionally, these 50-mL samples can measure the dispersion of nauplii in the water column on a scale more relevant to foraging fish larvae.

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