Prey Selectivity of Juvenile Salmon on Neustonic Mesozooplankton in the Northern California Current

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Keywords: diet, prey availability, selection, neuston, Chinook salmon, coho salmon, chum salmon, steelhead

Various factors could play a role in influencing early marine survival of juvenile salmon. One factor is availability of prey that salmon consume. Off the coast of Washington and Oregon, juvenile salmon tends to reside in the upper 20 m of the water column (Emmett et al. 2004) and previous studies have indicated that juvenile coho salmon (*Oncorhynchus kisutch*) and Chinook salmon (*O. tshawytscha*) may be feeding in the neustonic layer (Brodeur et al. 1987, Brodeur 1989). In this study, we examined prey selectivity for four species of salmon (Chinook salmon (both subyearling and yearling), coho salmon, chum salmon (*O. keta*) and steelhead (*O. mykiss*)) by comparing stomach contents to concurrently sampled neustonic prey.

We collected juvenile salmon and neuston samples during four cruises off southern Oregon and northern California. The cruises were conducted in June and August of 2000 and 2002 as part of a GLOBEC salmon distribution study (Pool et al. 2012). To capture juvenile salmon, a Nordic 264 rope trawl constructed by Nor'Eastern Trawl Systems, Inc. was towed at the surface at 1.5 m/s for 30 min. Stomach contents were removed and then identified, measured, and enumerated to the lowest possible taxon (Baldwin et al. 2008). At stations where more than 30 individuals of a salmon species and age class were captured, at least 30 stomachs were processed. To collect potential prey of salmon, a neuston net was towed out of the ship's wake for 5 min at approximately 1.0 m/s. The neuston net had a 1-m wide x 0.3-m high mouth opening and contained 333-µm mesh (see Pool and Brodeur 2006).

The Johnson Selectivity Index was chosen to examine prey selectivity of juvenile salmon (Johnson 1980). This index has the capability of using numeric proportion (%N), samples with zero counts, and exclusion of certain taxa such as digested fish tissue. The proportions were calculated from counts in stomach samples and concentrations in neuston samples. Next, prey in each stomach (i.e., usage) was ranked according to their %N and ranks were also assigned to prey in each neuston sample (i.e., availability). The index number ranges from negative for the most preferred prey to positive for the least preferred prey. For the purpose of our analysis, only those stations with at least one salmonid stomach and a neuston net tow were examined. The indices were examined with all cruises combined and then calculated for each cruise for temporal trends.

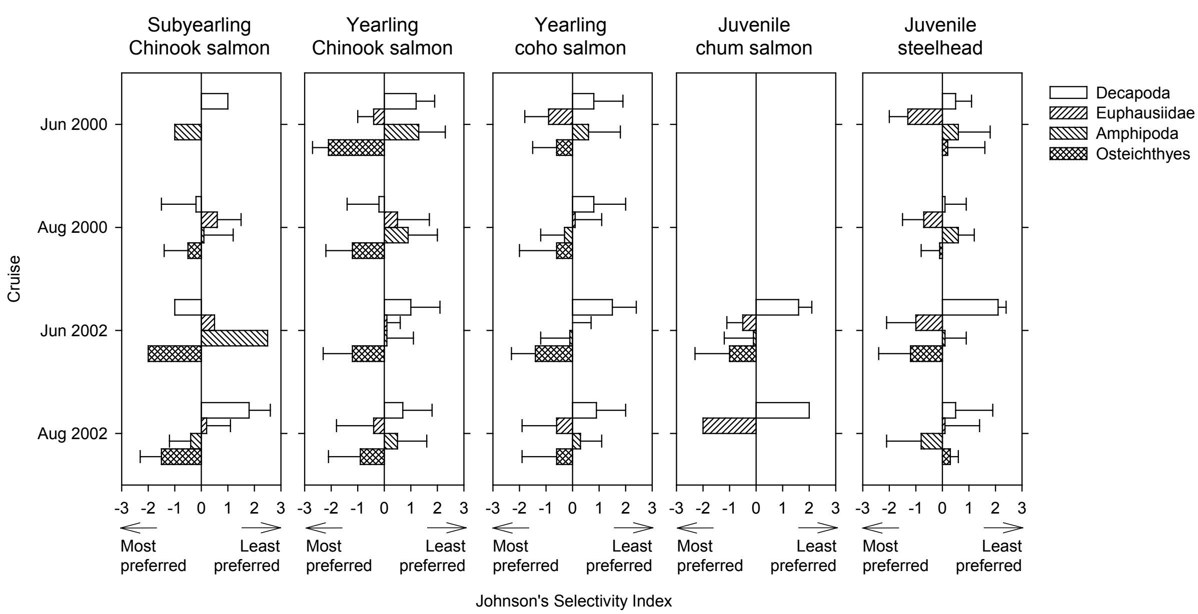

Fig. 1. Johnson's selectivity indices for contents of salmonid stomachs and neuston net tows by the major prey categories collected for each cruise in 2000 and 2002. Values shown are means (bars) and standard errors (error bars).

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To examine feeding selectivity, the twenty most dominant taxa by total %N were selected for each salmon species. Of the four major prey groups found in the diets, we found that euphausiids and fishes tended to be positively selected relative to their abundance in the neuston and decapods and amphipods were generally not consumed in the same proportions as their availability in the neuston (Fig. 1). Commonly preferred prey species included sculpins, rockfishes, sand lance, and offshore euphausiid species and the less preferred species included decapod larvae and hyperiid amphipods.

The dominant taxa consumed by subyearling Chinook salmon by %N were hyperiid amphipods, crangonids, fish, caprellids, mysids, insects, and euphausiids (Fig. 2). Subyearling Chinook salmon preferred *Hyperia medusarum* (hyperiid amphipod) and crangonids over *Thysanoessa spinifera* (euphausiid) and *Hyperoche medusarum* (hyperiid amphipod). Fish consumed included *Engraulis mordax* (northern anchovy), Cottidae, Osmeridae, and *Sebastes* spp. (rockfish).

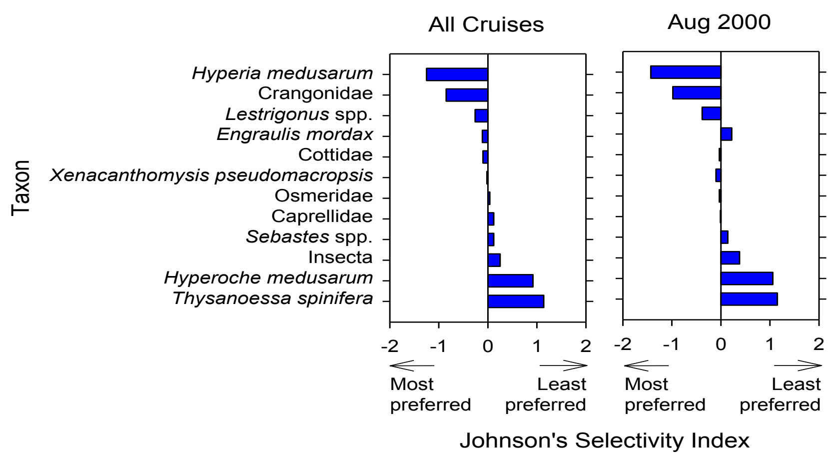

Fig. 2. Subyearling Chinook salmon selectivities for dominant prey and neuston taxa for the August 2000 cruise and all cruises combined. Taxa are ordered in terms of decreasing selectivity in the left panel.

For yearling Chinook salmon, the dominant prey taxa by %N included fish, decapods, hyperiid amphipods, and euphausiids. The first three taxa were fish, *Ammodytes hexapterus* (sand lance), *Hemilepidotus* spp. (Irish lords), and *E. mordax* (Fig. 3). *Cancer* spp. were least preferred. Other fish prey included *Sebastes* spp. and *Glyptocephalus zachirus* (rex sole). Trends in prey preference were somewhat similar in June 2000, August 2000, and June 2002. In August 2002, *G. zachirus, Euphausia pacifica* (euphausiid), and *Hyperia medusarum* were more preferred over other taxa.

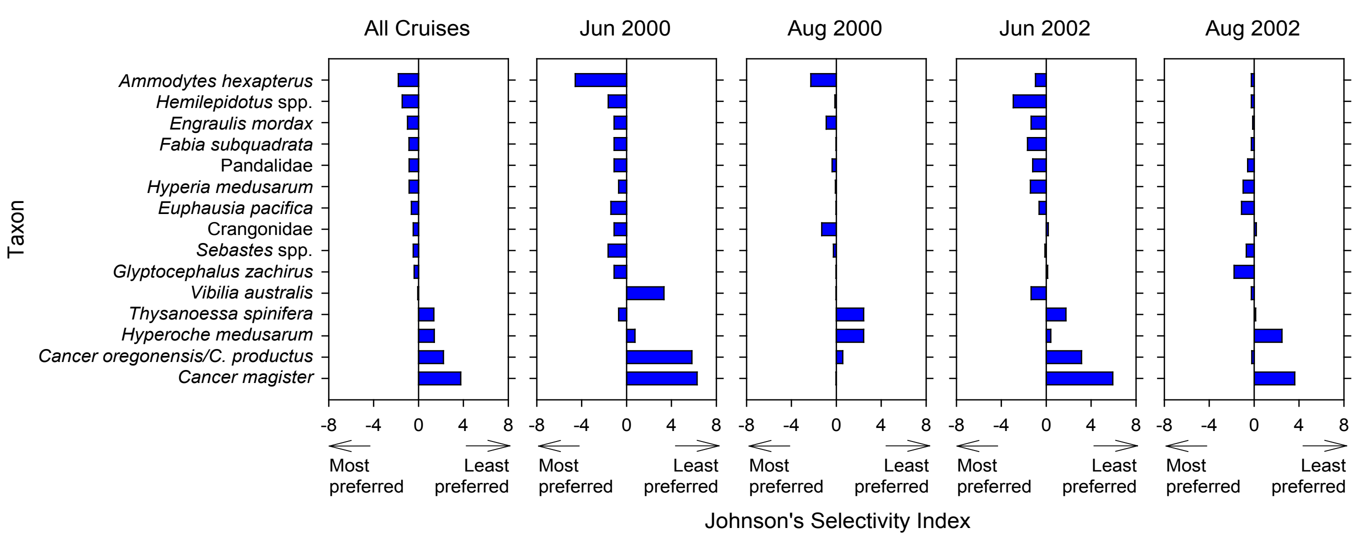

Fig. 3. Yearling Chinook salmon selectivities for dominant prey and neuston taxa by cruise and all cruises combined. Taxa are ordered in terms of decreasing selectivity in the left panel.

For juvenile coho salmon, the dominant taxa by %N included fish, decapods, amphipods, euphausiids, insects, and pteropods. It appears that yearling coho salmon preferred *Hemilepidotus* spp. and *Themisto pacifica* (hyperiid amphipod) over *Cancer* spp. (Fig. 4). Other dominant fish prey were *Sebastes* spp. and *A. hexapterus*. Trends in prey preference were somewhat similar in June 2000, August 2000, and June 2002. Though *T. spinifera* (euphausiid) was the most preferred prey in June 2000. This preference was repeated in August 2002 when *Cancer oregonensis/Cancer productus, Sebastes* spp., and *A. hexapterus* also were more preferred over other dominant prey taxa.

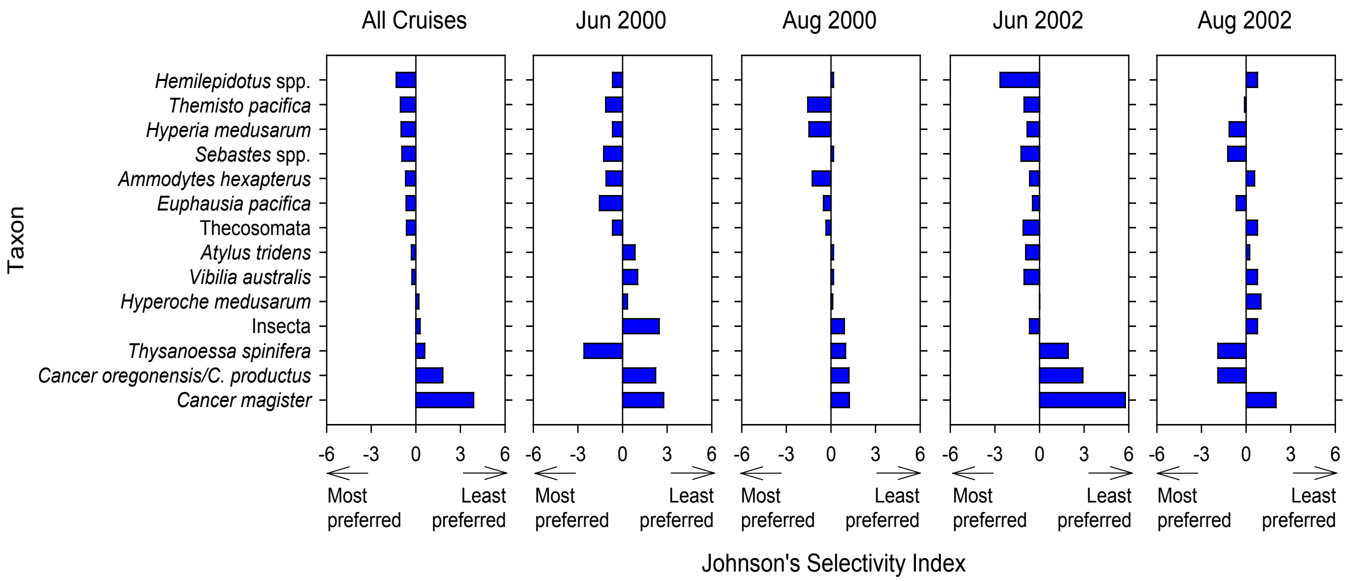

Fig. 4. Juvenile coho salmon selectivities for dominant prey and neuston taxa by cruise and all cruises combined. Taxa are ordered in terms of decreasing selectivity in the left panel.

Juvenile chum salmon were captured in June 2002 only. Dominant prey taxa included copepods, polychaetes, decapods, mysids, amphipods, euphausiids, and chaetognaths. *Epilabidocera* sp. (copepod), polychaetes, and *Fabia subquadrata* (crab) were more preferred than Chaetognatha, *T. spinifera*, and *Hyperoche medusarum* (Fig. 5). The dominant fish prey was *A. hexapterus*.

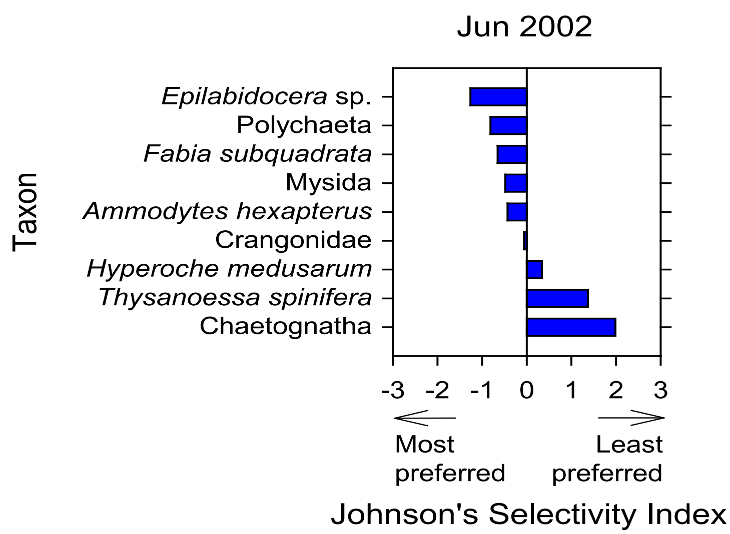

Fig. 5. Juvenile chum salmon selectivities for dominant prey and neuston taxa for the June 2002 cruise. Taxa are ordered in terms of decreasing selectivity in the left panel.

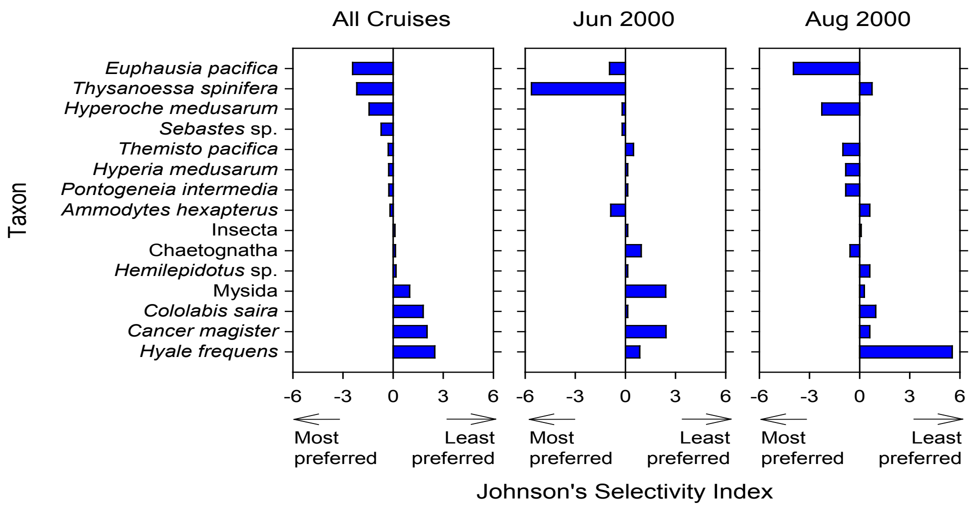

Fig. 6. Juvenile steelhead selectivities for dominant prey and neuston taxa by cruise and all cruises combined. Taxa are ordered in terms of decreasing selectivity in the left panel.

Juvenile steelhead were captured during all cruises but combined for both cruises in 2002 due to the small sample size. Dominant prey taxa included euphausiids, amphipods, fish, insects, mysids, chaetognaths, and decapods. *E. pacifica, T. spinifera*, and *Hyperoche medusarum* were more preferred than *Cololabis saira* (Pacific saury), *Cancer magister* (Dungeness crab), and *Hyale frequens* (gammarid amphipod) (Fig. 6). In June 2000*, T. spinifera* was strongly preferred over other prey. Dominant fish prey included *Sebastes* sp., *A. hexapterus, Hemilepidotus* sp., and *C. saira*.

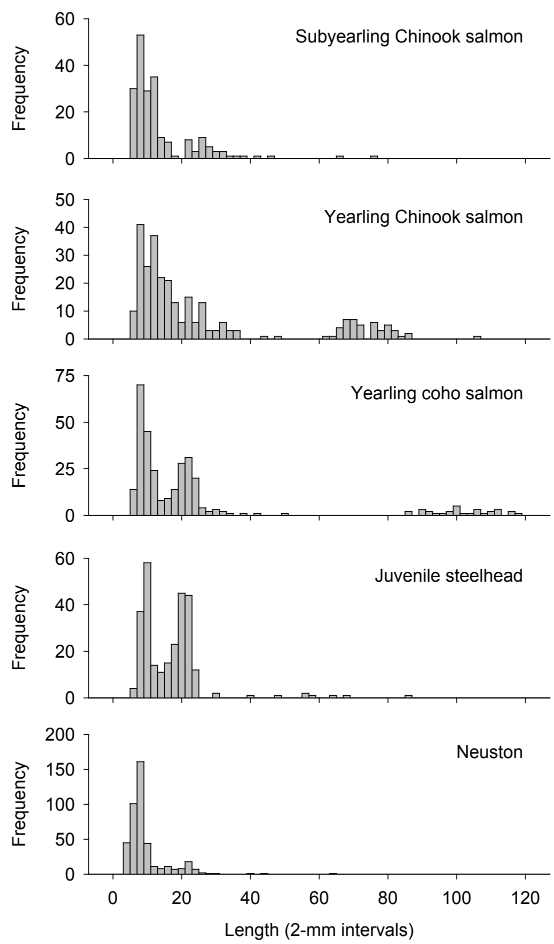

Fig. 7. Comparison of lengths of all prey consumed by juvenile salmon and available in the neuston.

We also compared lengths of prey in stomachs with those in the neuston to determine whether prey size selection was occurring. Most salmon showed a similar bimodal distribution of prey lengths as found in the neuston sampler but yearling Chinook and coho salmon also consumed a larger mode of mostly fish prey that were not sampled by the neuston net, possibly due to their avoidance of the small mouth opening of the net (Fig. 7).

Although the neuston samples do not represent the full range of prey resources available to juvenile salmon as some prey are found only in subsurface layers, there has been a better correspondence between the neuston taxa and diets, especially for juvenile coho and Chinook salmon and steelhead, than with integrated bongo tows (Brodeur 1989, unpublished data). Neuston prey biomass is as important a determinant of salmon habitat as any abiotic variable measured (Pool et al. 2012). Based on the results of our analysis, prey is consumed in the following preference order: Osteichthyes > Euphausiidae > Amphipoda > Decapoda for most species and life history types. Sand lance and sculpins appear to be particularly selected for and *Cance*r crab larvae selected against relative to their abundance in the neuston.

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