Zooplankton species and trait diversity in the Gulf of Alaska from the surface to the abyssopelagic

Caitlin A. Smoot*, Alexandra Poje, Jennifer M. Questel, Russell R. Hopcroft
University of Alaska Fairbanks
*casmoot@alaska.edu

Background

Two cruises conducted in July 2019 provided a unique opportunity to survey zooplankton communities of the Gulf of Alaska from nearshore to deep oceanic environments to a depth of 4,300 m. Here we report contributions to species inventories for the region and explore community structure and patterns of diversity across inshore-offshore and depth gradients.

Community & Faunal Groups

Methods: Stratified zooplankton samples were collected with fine (150-µm) and coarse (505-µm) mesh nets along the Seward Line during July 2019 (Fig. 1). Samples were analyzed to determine species composition and abundance. Community structure was explored with hierarchical clustering, non-metric multidimensional scaling (nMDS), and permutational multivariate analysis of variance (PERMANOVA) in Primer v7 software.

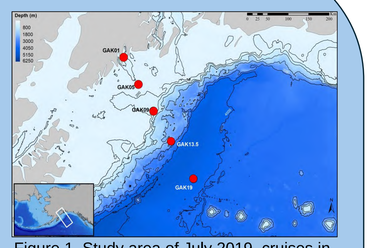

Figure 1. Study area of July 2019 cruises in the Gulf of Alaska.

Results:

- The 150-µm net was dominated numerically by copepods. Copepods were also a dominant component of the 505-µm net; however, other groups such as chaetognaths, mysids, and decapods were important contributors to the larger size spectra. We report new copepod species observations for the North East Pacific* such as *Cephalophanes* (Fig. 2), *Heteroptilus acutilobus*, *Mormonilla phasma,* and others.

Figure 2. Artistic rendition of *Cephalophanes.* Art by Nick Bezio.

- We observed faunal groupings along a depth gradient, with additional structure in epipelagic layers along an inshore-offshore axis (Fig. 3). Distinct zooplankton assemblages were observed in the Upper Epipelagic, Lower Epipelagic, Mesopelagic, and Bathypelagic domains (150-µm PERMANOVA; $p < 0.001$) (505-µm PERMANOVA; $p < 0.001$).

* North East Pacific (Gulf of Alaska, "P" station, British Columbia) Zone on the Biodiversity of Marine Planktonic Copepods webpage (Razouls et al.), accessed Dec 2023.

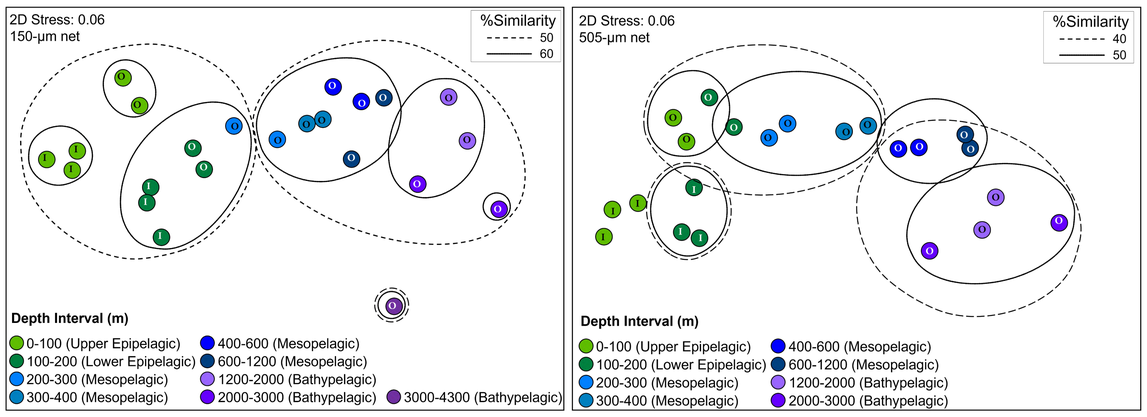

Figure 3. Non-metric multidimensional scaling (nMDS) of zooplankton community from the 150-µm net (left) and 505-µm net (right) overlain with clusters as determined by hierarchical clustering routine. Samples are symbolized by depth interval (m) with like colors representing major oceanic domains. Letters inside circles indicate Inshore (I) or Offshore (O).

Traditional Diversity Indices

Methods: The number of taxonomic categories (richness) and Gini-Simpson index (evenness) was calculated for each sample in Primer v7 software.

Results:

- In both the 150-µm and 505-µm nets the number of taxonomic categories peaked in mesopelagic layers (Fig. 4).
- Epipelagic layers in the 505-µm net had similar numbers of taxonomic categories; the number of taxonomic categories observed in the same layers in the 150-µm net was more varied.
- Evenness in the 150-µm net was relatively constant below 300 m.
- In the 505-µm net GAK05, a shelf station, had the lowest evenness - indicating the dominance of a few taxa.

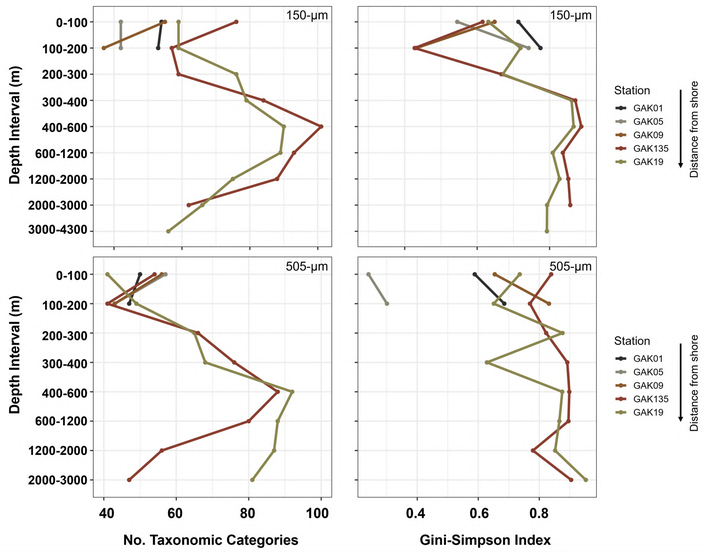

Figure 4. Number of taxonomic categories for the 150-µm (top left) and 505-µm (bottom left) nets. Gini-Simpson index for the 150-µm (top right) and 505-µm (bottom right) nets.

Vertical Partitioning of the Water Column

Methods: Abundance was overlain on nMDS plots to visualize distribution of taxa in nMDS space.

Results:

- Some copepod families, such as the Augaptilidae, exclusively occurred in the mesopelagic & bathypelagic domains (Fig. 5).
- These families exhibited vertical partitioning of the water column, with different genera occupying separate depth strata (Fig. 5).

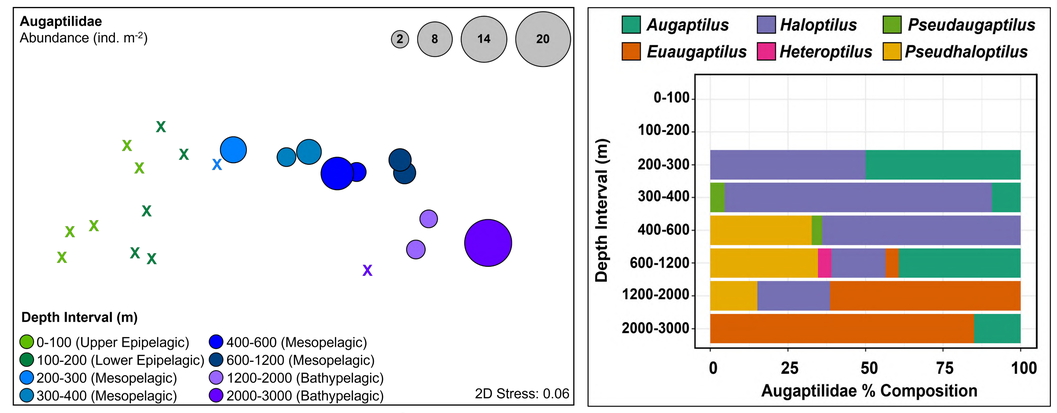

Figure 5. Augaptilidae abundance (ind. m^{-2}) overlain on nMDS plot (left) and percent composition of the family Augaptilidae by depth (right). Data from 505-µm net.

Taxonomic Diversity

Methods: Average Taxonomic Distance (AvTD) indicates the taxonomic breadth of a sample. It offers a different facet of diversity than richness; it can capture differences in communities that would be considered equivalent in terms of richness alone: five species in one family vs. five species in five different families. AvTD was calculated for the copepod community at offshore stations from the 150-µm net in Primer v7.

Results:

- AvTD exhibited different trends within oceanic domains: it increased with depth within the epipelagic domain and decreased with depth within the mesopelagic and bathypelagic domains (Fig. 6).
- AvTD increased at transition zones between major oceanic domains; e.g. from epipelagic to mesopelagic and from mesopelagic to bathypelagic.

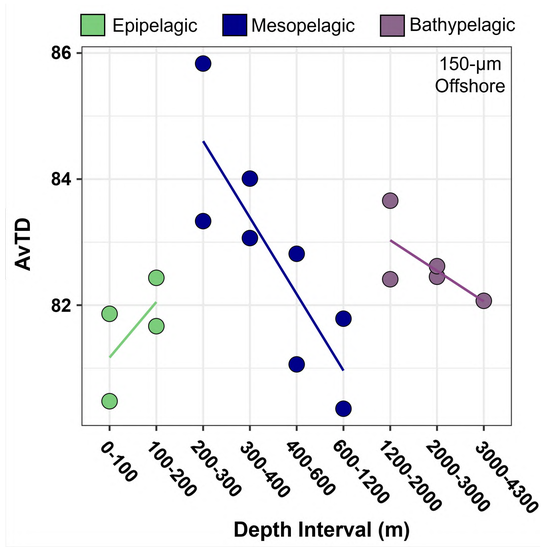

Figure 6. AvTD by depth interval with trend line for each major oceanic domain.

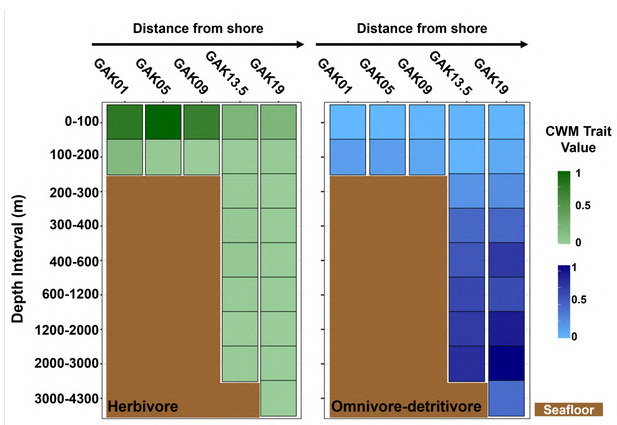

Figure 7. CWM value for herbivore (left) and omnivore-detritivore (right) traits plotted along the Seward Line.

Trait Diversity

Methods: We assigned trophic traits (herbivore, omnivore, carnivore, omnivore-detritivore) to copepod taxa using published literature and trait databases. Using copepod abundance data from the 150-µm net and the trait matrix, we calculated Community Weighted Mean (CWM) value of each trait using the FD package in R. CWM of trait values are an index of functional composition. CWM of trait values were plotted to explore spatial patterns.

Results:

- Communities in the upper epipelagic (0-100 m) on the shelf were dominated by herbivorous copepods (Fig. 7).
- Communities at depth past the shelf break were dominated by omnivore-detritovores (Fig. 7).

Conclusion and Discussion

- These efforts contribute to zooplankton biodiversity estimates in the North Pacific; however additional study of the deep sea is needed to more completely characterize diversity → more samples to be processed from 2019 cruises; another deep-sea cruise is planned for 2024.
- Zooplankton communities observed during these surveys were highly structured with depth. A second layer of separation was observed within the epipelagic domain along an inshore-offshore axis.
- It is valuable to consider both traditional diversity indices and measures of taxonomic diversity. Mesopelagic communities exhibit the highest richness, but taxonomic breadth of the copepod community decreases with depth within the mesopelagic domain, indicating the dominance of a few specialist copepod groups that are highly speciose.
- These results suggest that the taxonomic breadth of the copepod community increases at transition zones between major oceanic domains, perhaps due to overlap of species from each domain. Consideration of functional traits, such as trophic group, can give insight to community structure and function but is limited by the availability of data regarding these traits. Future work will aim to expand the traits and taxa considered while adding additional samples.

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