

Impacts of Changing Oceanographic Conditions on Meroplanktonic Communities in the

Salish Sea

Kaper Greenfield

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1Friday Harbor Laboratories, University of Washington, Friday Harbor, WA 98250

Contact Information:

Kaper Greenfield

Biology: Ecology, Evolution, and Conservation, College of Arts and Sciences

University of Washington

Friday Harbor Laboratories

620 University Road

Friday Harbor, WA 98250

kaperg@uw.edu

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Abstract

Meroplankton are larval life stages of invertebrate animals that will eventually metamorphose into adult forms that live on the seafloor and comprise the majority of ecologically and economically important invertebrate animals in the Salish Sea (eg. barnacles, crabs, mussels, sea stars). Meroplanktonic larvae experience different habitats than their adult counterparts and are often more sensitive to environmental fluctuations. One such seasonal fluctuation is high temperature, low salinity pulses from the Fraser River into the Salish Sea due to snowmelt. While it is known that both high temperature and low salinity can affect larval performance in laboratory settings, little is known about how these stressors impact the abundance of meroplankton communities in nature.

Introduction

Many species with meroplanktonic life stages, (eg. mussels, oysters, crabs, sea stars) perform crucial ecosystem services and are commercially important. Meroplanktonic larvae experience different habitats than their adult counterparts and are often more sensitive to environmental fluctuations (Kimmel 2020). A variety of climate-related abiotic stressors, most notably high sea surface temperature (SST), and low salinity have been shown to impact a variety of important life processes in laboratory settings (Milione 2008). Understanding how climate-driven changes to the physical environment affect meroplankton and their development is critical to understanding how climate change will impact estuary systems.

The Salish Sea is a unique study site for observing the impacts of changing oceanographic conditions on planktonic communities. The species present are well adapted to survive in a dynamic environment more akin to coastal and oceanic regions than typical estuary systems, where salinity, temperature, pH, and dissolved oxygen fluctuate regularly. With highly variable freshwater input, and deep (>100 m) water columns, changes to planktonic community composition and abundance can be challenging to predict (Stepien 2023). The existence of strong vertical circulation cells could provide mitigation by acting as a physical buffer to prevent changes in temperature, dissolved oxygen, and acidity. However, in “near-shore intertidal areas”, or areas largely affected by riverine inflow, temperature, and salinity specifically are not buffered. (Khangaonkar 2019). Due to a lack of buffering, and variability from incoming freshwater sources, it is important to understand how river outwash can cause spikes in SST and drops in salinity during years of high runoff. More specifically the impacts of the Fraser River, as it contributes nearly half of the total freshwater discharged to the Salish Sea (Khangaonkar 2018).

To identify the oceanographic variables that primarily drive patterns of meroplankton abundance, we collected a two-year time series of oceanographic data (temperature, salinity, pH, dissolved oxygen, turbidity, current velocity) by utilizing data from the Friday Harbor Labs Ocean Observatory (FHLOO), the Salish Sea’s only multi-instrument remote sensing network. The FHLOO is positioned off a floating dock at Friday Harbor Labs (FHL), ~1-2 meters beneath the surface, and collects data from each sensor every hour.

A two-year time series of plankton abundance for 12 different taxa of meroplankton was collected by performing regular plankton tows at the site of the FHLOO approximately every week from March 2022 to September 2023. Tows were not performed in the winter due to logistical constraints, with this period generally being regarded as static in growth rate and reproduction (Dudeck 2021). This sampling extracts a snapshot of life in the water column,

which allows us to analyze both community composition and total meroplankton abundance. By subsampling this preserved plankton, identifying them, and recording species abundance for 12 taxa of meroplankton. We can then combine these two datasets to run regression analysis and determine relationships between SST/salinity and the biological survey.

Methods

Sample Collection:

The plankton samples were obtained with single net vertical plankton tows, utilizing a 153- μm -mesh ring net with a 0.3-meter diameter. The size of the mesh was selected to optimize zooplankton collection in an inland marine system, due to increased environmental variability in the region affecting size (Suthers 2019). All tows were performed from the floating dock at FHL, directly adjacent to the FHLOO (48°32'42.9"N, 123° 00' 43.6 "W). Samples were collected every 6 to 9 days from March to September.



Spring Marine Studies (SMS) students and Jack Litle conducting a plankton tow at the site of the FHLOO (UW Marine Biology)

Sample Processing:

After the tows were brought to the surface, the samples were preserved in a 5% plankton to 95% ethanol ratio and stored in a 50 ml falcon tube. The ethanol-plankton mixtures were uniformly mixed in the falcon tube by hand with a “swirling” method and subsampled using a 5 ml graduated plastic pipette (McCallum 1979). After mixing for 20 seconds, 5 ml of the normalized mixture was extracted from the center of the solution and placed in a small petri dish. Falcon tubes were designated for all major taxa, and abundance was assessed by removing individuals with a fine tip graduated plastic pipette into their respective containers until zooplankton were no longer present in the subsampled mixture.

Data Analysis:

The FHLOO contains the Sea-Bird Electronics 37-SM/SMP conductivity and temperature recorder, which was used to record SST and salinity. A measurement for each oceanographic variable is recorded every hour and archived by the Biological and Chemical Oceanography Data Management Office. The data for salinity and temperature were averaged by 24-hour increments and plotted over a series of two years.

Results

Fraser Pulse Events:

We found multiple low salinity, and high-temperature events in the 2022 FHLOO data that correspond with seasonal snowmelt in the Fraser River. In 2023, Fraser River pulses were comparatively mild, with less intense and consistent pulse events (Fisheries and Oceans Canada 2023).

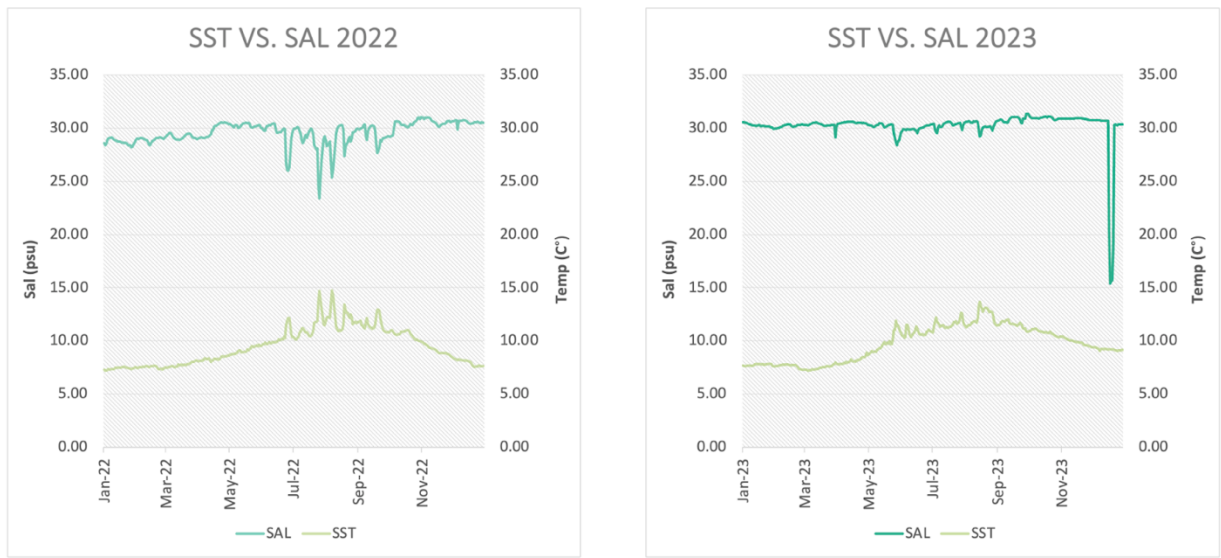


Figure 1A-B. Sea surface temperature (°C) (top) and salinity (PSU) (bottom) over two years at the FHLOO in A) 2022 and B) 2023. Significant pulse events from Fraser River were observed in 2022 while 2023 was relatively weak.

Plankton Survey:

Nauplii dominated in relative abundance, followed by ascidians and larval polychaetes. Out of the 12 major meroplankton taxa recorded, nauplii comprised 83% of the total zooplankton population. Spikes in the abundance of all three abundant taxa co-occur in 2022, while are spikes in abundance are not as consecutive in 2023.

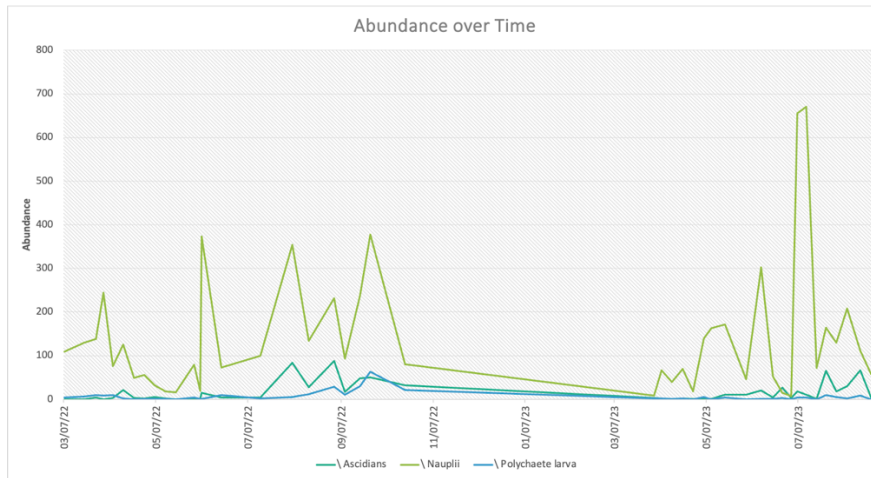


Figure 2. Abundances of the three most dominant meroplankton taxa (nauplii, ascidians, and polychaetes) from 2022-2023.

Impacts of Oceanographic Conditions:

The linear regression analysis was used to quantify the magnitude of the relationship between the total meroplankton abundance and SST and salinity. The R^2 of both the salinity and SST regressions were much higher in 2022 than in 2023. This difference was especially prominent between the 2022 and 2023 salinity regression models.

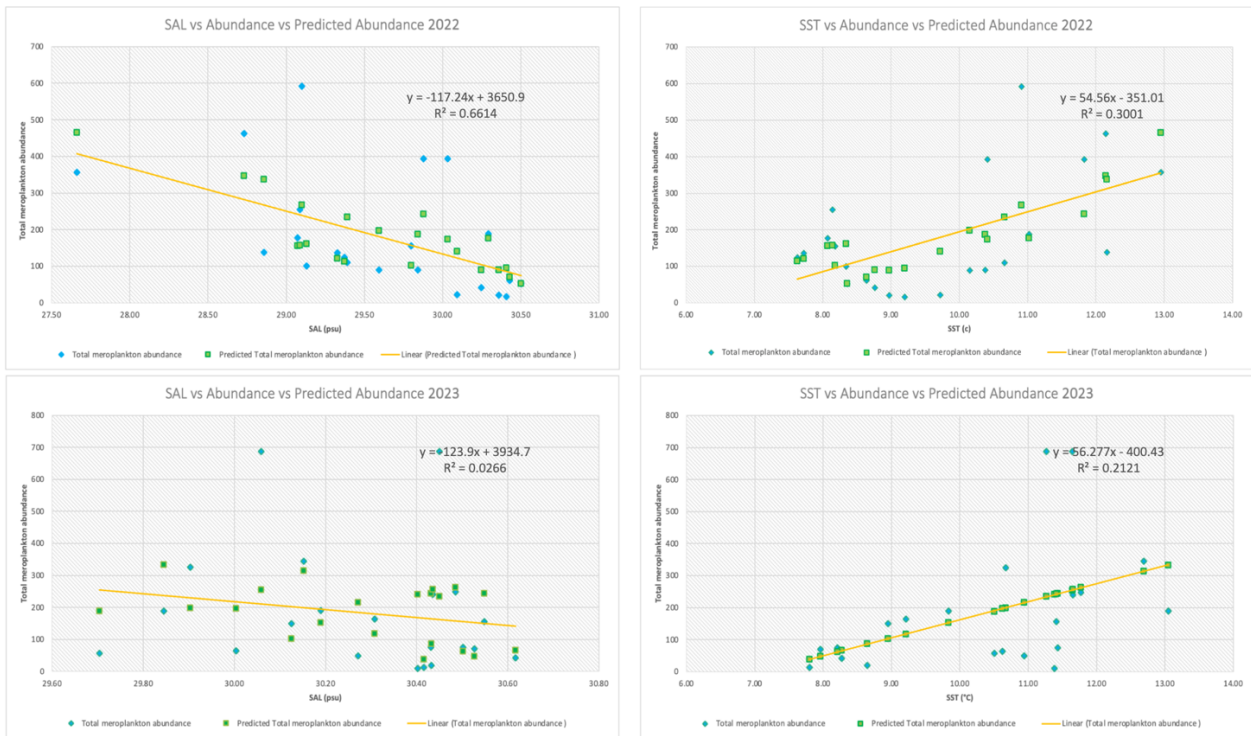


Figure 3. Regression analysis of SST/salinity with total meroplankton abundance in 2022 and 2023.

Discussion

Meroplankton community structure around the FHLOO was consistently dominated by nauplii. Due to their poor swimming ability, nauplii are often advected towards the areas of higher salinity as they are brought to the mouth of the estuary during periods of strong flow, or high outwash (Chinnery 2004). Due to their tolerance for dilution (Castro-Longoria 1999), nauplii development typically continues during this period of translocation, which could cause these plumes to be the primary driver for increased nauplii abundance at our study site (Chinnery 2004).

According to the regression models, salinity was found to be the most important environmental factor in shaping zooplankton abundance. In complex estuary systems similar to the San Juans, salinity has been shown to have a negative impact on the abundance of species such as rotifers, cladocerans, and other zooplankton, while nauplii were more tolerant of fluctuations (Yuan 2020).

Meroplankton abundance patterns did exhibit some correlation with salinity and SST, however the regression analysis did not provide strong relationships for all variables examined. SST had a much lower associated impact on meroplankton abundance and overall saw less variation. In 2023, Fraser River pulses were comparatively mild and did not correlate as strongly with spikes in nauplii and total meroplankton abundance. It is likely that in the absence of significant freshwater output a mass spawning event took place in July of 2023, causing a sudden spike in nauplii. Although further research is needed to confirm this relationship, this study suggests input from high river plumes could suppress mass spawning events of organisms with a nauplius life stage.

Conclusion and Future Research

Overall, this study found salinity be the primary driver of meroplankton abundance at our study site, in correlation with freshwater plumes from the Fraser River. This study also exhibits the complexities of the San Juans as a site to study the interactions of oceanographic conditions on meroplanktonic communities. Investigation into drivers outside of salinity and temperature, such as chlorophyll concentration impacting mass spawning events, would contribute to a more complete understanding of how changing environmental conditions affect meroplankton abundance in the Salish Sea.

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