Spatial & Temporal Trends of Zooplankton Biomass along the Damariscotta River

Bigelow Semester, Fall 2022

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Introduction

Research Question

Is there an association between chlorophyll (CHL)/temperature with zooplankton biomass?

Background

- Zooplankton contribute to the transport of carbon & nitrogen to the deep sea by production of fecal pellets
  = active transport by daily vertical migration
  = a biological pump (Longhurst et al., 1990; Steinberg et al., 2002)
- Marine resources like fish undergo changes in stock size and productivity due to ecosystem processes and population dynamics of zooplankton (Alheit and Bakun, 2010).
- Zooplankton population size tracks closely to the seasonal-to-interannual changes to environmental conditions (Mackas and Beaugrand, 2010)

Motivation

- Zooplankton = source of information that captures the fluctuations of the local region's living conditions

∴ Zooplankton = proxy of the alterations in the local waters & its ecosystems → we can better predict, prepare, and manage ocean resources sustainably

Methods

Study Site:

The Bigelow Colby Sea Semester Program has conducted a time-series since 2012 at 4 stations along a transect starting in the Damariscotta River Estuary (See Figure 1).

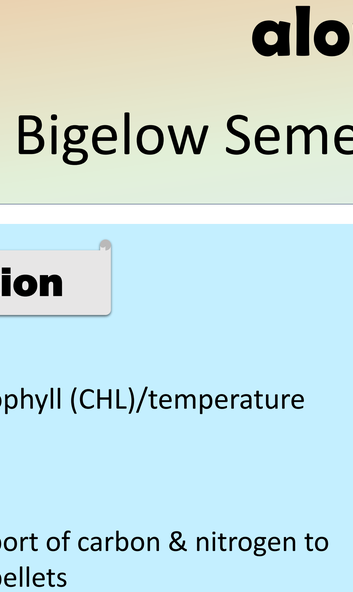


Figure 1. Aerial view of the Damariscotta River Estuary depicting Stations 1 (red), 2 (blue), 3 (green) and 4 (purple) on Google Maps.

Explanatory variables

- CHL/Fluorescence (in $mg\ CHL/m^3$): @2m, @10m
- Integrated CHL/Fluorescence (in $mg\ CHL/m^2$)
- Temperature (in C): @2m, @10m

Response variables

- Zooplankton Biomass (in mg/m^3)

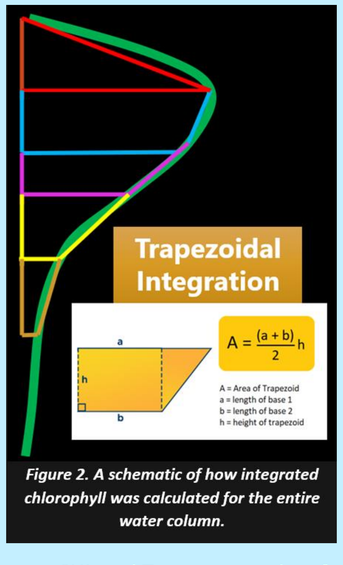


Figure 2. A schematic of how integrated chlorophyll was calculated for the entire water column.

Data:

- Two integrated samples of macro-zooplankton at each station were collected using a 0.75 m ring net with a 330µm mesh
  - One sample was used for biomass calculation
  - Other sample was used for community composition
- Zooplankton = Any organisms captured with 330µm mesh
- Temperature data were collected using a conductivity, temperature, and depth sensor (CTD)
- Fluorescence data were collected using an ECO-FL-RT G4 (CHL)(125ug/l) sensor
- CHL and Temperature data for each depth were average 0.5 meters above and below the desired depth
- Integrated chlorophyll was calculated using a trapezoidal integration (Figure 2)

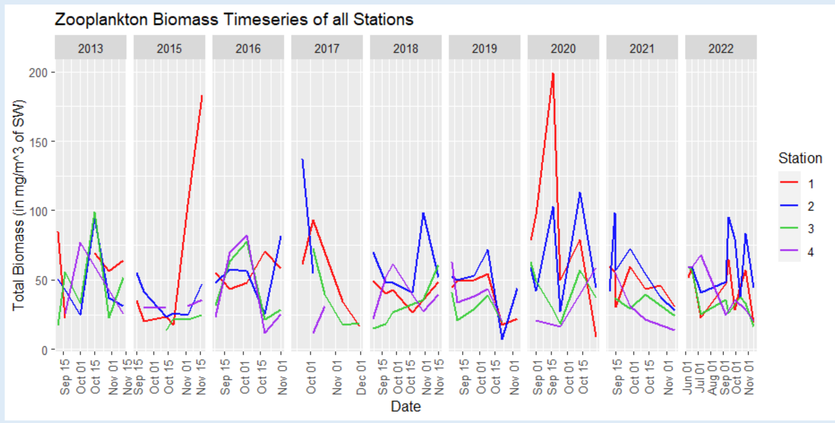


Figure 3. Zooplankton Biomass Timeseries for all 4 stations from year 2013 to 2022.

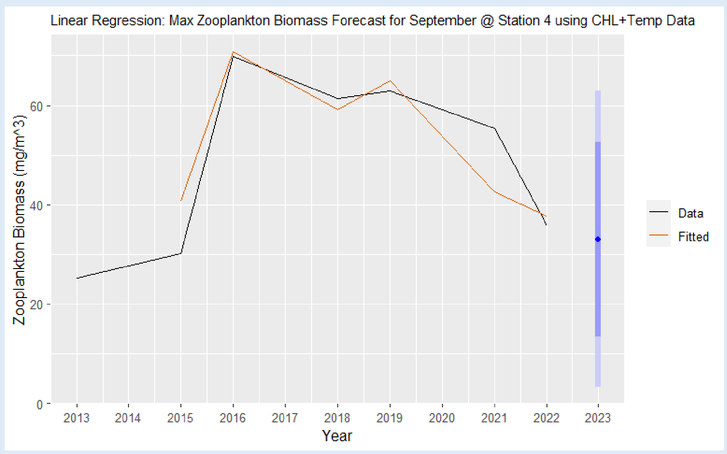
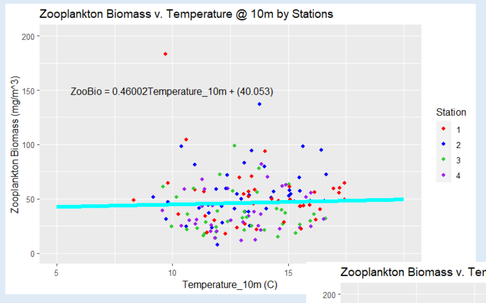


Figure 4. Model prediction (orange) of the maximum zooplankton biomass for the month of September 2023 at Station 4 using chlorophyll and temperature data. Model is calculated using the offset method based on actual data (black).



Zooplankton Biomass & Temperature

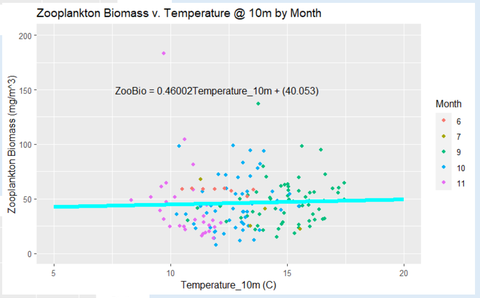


Figure 5. Zooplankton biomass as a function of Temperature at 10 meters from 2013 to 2022. Colors represent stations (5A) and months (5B).

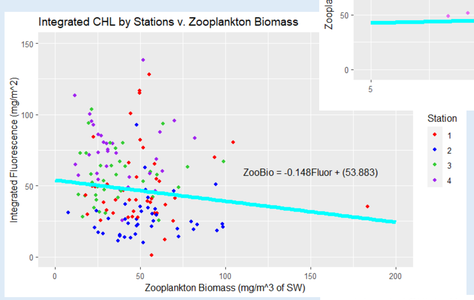
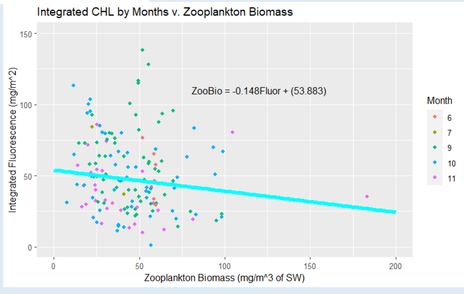


Figure 6. Zooplankton biomass as a function of Integrated Chlorophyll from 2013 to 2022. Colors represent stations (6A) and months (6B).

Zooplankton Biomass & Chlorophyll



Predictive Model

- A linear regression model is used to predict the maximum zooplankton biomass for September of 2023 at Station 4
- Forecast using an offset method
- Uses average CHL at 10 meter, average Temperature at 10 meter, & average integrated CHL CTD data from September 2022 to forecast zooplankton biomass

Results

Zooplankton Biomass and Temperature @ 10 meters

No correlation between zooplankton biomass and temperature at 10 meters (r = 0.0386, df = 153, p-value = 0.6337; Pearson's test) (Figure 5).

Zooplankton Biomass and Integrated CHL

There is a correlation between zooplankton biomass and integrated values of CHL/Fluorescence (r = -0.186, df = 153, p-value = 0.02039; Pearson's test) (Figure 6).

Predicting 2023 Zooplankton Biomass

Predicted zooplankton biomass: ≈ 33.015 $\frac{mg}{m^3 of\ SW}$ (Figure 4).

Discussion

Interpretation

- Zooplankton biomass is driven by consumers/zooplankton
- Why zooplankton biomass decrease with increasing CHL all year long (June to November)?
  - During the fall: Zooplankton are probably metabolizing more
  - Heading to winter: (1) Zooplankton are probably building up for the winter/getting bigger (2) Seeing a change in zooplankton species towards a winter fauna/different group of animals are present
- More stratification in the water column → Better correlation between zooplankton biomass and CHL data

Limitation

The predictive model is limited by 2022 data on CHL & temperature → may not be representative of the 2023 season.

There were gaps within the dataset:

- 2012: Zooplankton biomass data collected using a different method
- 2014: Only had summer REU CTD data and no zooplankton biomass data
- 2017: No zooplankton biomass data for September
- 2020: No CTD data for CHL and Temperature

Future Study

In future data analysis, if we were to collect data for all four seasons, we could better analyze the correlation with zooplankton biomass and temperature. There may be a shift in zooplankton biomass as it gets warmer in the spring and colder during the winter.

References

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