Interannual drivers of planktonic food web dynamics in the Northwestern Gulf of Alaska

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Background and Objectives

- The northwestern Gulf of Alaska (NGA) was recently designated as a Long-Term Ecological Research site to investigate the impact of climate change on ecosystem dynamics.

- However, it is challenging to understand the long-term effects of climate change when organisms are naturally exposed to strong environmental variability on seasonal, interannual and decadal time scales (ex: basin variability, downwelling, light, rivers, eddies).

- As part of the NGA-LTER project we developed a coupled physical-biogeochemical model to explore the main biotic and abiotic drivers of the seasonal and interannual variability of the coastal NGA planktonic food web.

- Here, we ran a 27-year-long simulation in order to better understand:
  1. The interannual variability in the yearly cumulative biomasses
  2. How variability in biomasses relate to the variability in the environment
  3. How energy transfers in the food web change for: 
     - years with lower/higher NO3 concentrations
     - years with lower/higher temperatures
     - 2015-2016 Large Marine Heat Wave (The Blob)

NEMUGA model and Evaluation

- 2 phytoplankton - 2 microzooc. and 3 mesozooplankton - euphausiids - 4 nutrients
- Includes a variable C/Chla ratio and an Iron module with a formulation of luxury uptake
- Zooplankton grazings vary in response to prey availability

Grazing and mortality rates of microzooc., copepods and euphausiids are affected by temperature, and mortality of copepods and euphausiids are affected by salinity <16

NEMUGA is coupled to ROMS model with an horizontal resolution of 4.5km and 50 vertical terrain-following levels

Open boundary conditions: 7-day averages from GLORYS global ocean physics reanalysis for abiotic variables and global ocean biogeochemistry hindcast for biotic variables

Surface atmospheric forcing: 3-hourly fields from ERA5 global reanalysis

Daily river discharge from the hydrological model of Hill et al. (2015)

- Includes tidal forcings
- Climatological and interannual NEMUGA outputs have been evaluated against in situ and satellite data

Trophic Relationships and Biomass Fluxes

We performed pairwise linear correlations between the biological variables:

- Strong correlations between diatoms variability and copepods
- Strong correlations between nanophyto. and microzooc.: 
  - Large microzoo, regulated by nanophyto.
  - Small microzoo, variability anti-correlated to nanophyto. due to top-down effect of large microzoo. on small microzoo.
- Anti-correlations between diatoms and large microzoo. and between large microzoo. and copepods/euphausiids but no top-down effects identified

Diatoms control large zooplankton dynamic

Nanophytoplankton controls small zooplankton dynamic

Responses to perturbations and Large MHW

Years with lower NO3

- Correspond to 15% less NO3 than the mean conditions
- Diatoms respond with the same order of magnitude of change, as well as the grazing fluxes towards Copepods and Euphausiids
- Changes of about 1 to 5% of the groups related to nanophytoplankton variability
- Despite the increase in large microzoo., copepods and euphasiids decrease : they are not able to fully compensate the loss of diatoms by increased grazing on large microzoo.

Years with higher temperatures

- The signs of the responses are similar to low NO3 years
- Changes are more important for large microzoo. :
  - It is very sensitive to changes in the DIN/DN ratio
  - Its grazing efficiency relative to mortality may be increased with temperature

- Despite a higher increase on large microzoo. grazing compared to years with lower NO3, copepods and euphasiids are still not able to compensate the loss of their main prey (diatoms)

Large MHW (2015-2016)

- Responses are an amplification of the lower NO3 and higher temperature years