THE UNIVERSITY OF RHODE ISLAND
GRADUATE SCHOOL OF OCEANOGRAPHY

Plankton population dynamics and food web structure on the Northeast US Shelf (NES-LTER): Early indication of seasonal shifts in production regimes

NORTHEAST U.S. SHELF
Long-Term Ecological Research

Pierre Marrec, Heather McNair, Gayantonia Franzè, Françoise Morison, Jacob Strock and Susanne Menden-Deuer

Graduate School of Oceanography, University of Rhode Island, Narragansett RI

NATIONAL SCIENCE FOUNDATION LTER NETWORK LONG TERM ECOLOGICAL RESEARCH

Northeast US Shelf Long-Term Ecological Research (NES-LTER) Program

Motivation

- The highly productive NES ecosystems encompass essential economically and ecologically services.
- Strong seasonality along with high spatial (coast to shelf break)variability.
- We investigated planktonic food web changes through space and time in response to changes in the physical environment.
- To understand and predict the impact of these changes on ecosystem productivity.

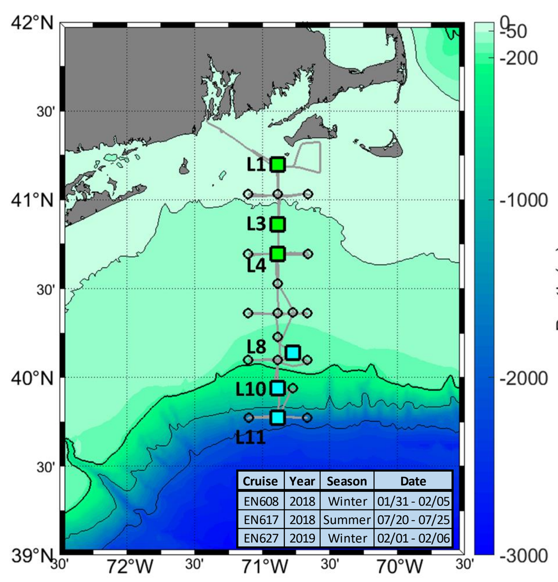

Figure 1: NES-LTER transect (winter 2018) and stations where incubation experiments were performed. 50m, 200m, 1000m and 2000m Isobaths are represented.

Methods

- Biannual transects from Martha's Vineyard to the shelf break onboard the R/V Endeavor.
- 24h on-deck incubation experiments.
- 2-points dilution method (Morison and Menden-Deuer, 2017).
- Phytoplankton growth and protist grazing rates based on Chl-*a* and flow cytometry abundances.

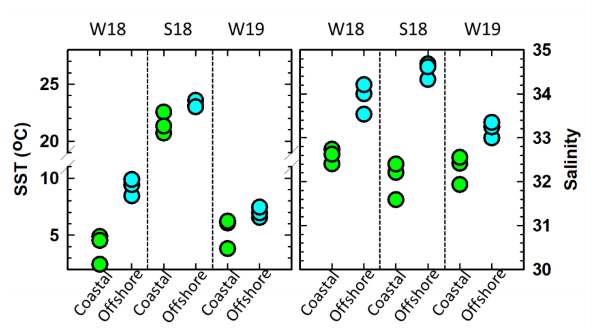

Figure 2: Sea surface temperature (SST, °C) and salinity at stations L1, L3, L4 (coastal, green) and at stations L8, L10 and L11 (offshore, cyan) during winter 2018 (W18), summer 2018 (S18) and winter 2019 (W19).

Phytoplankton Community Structure: Large cells (>20 µm) dominate in winter, small (<5 µm) in summer

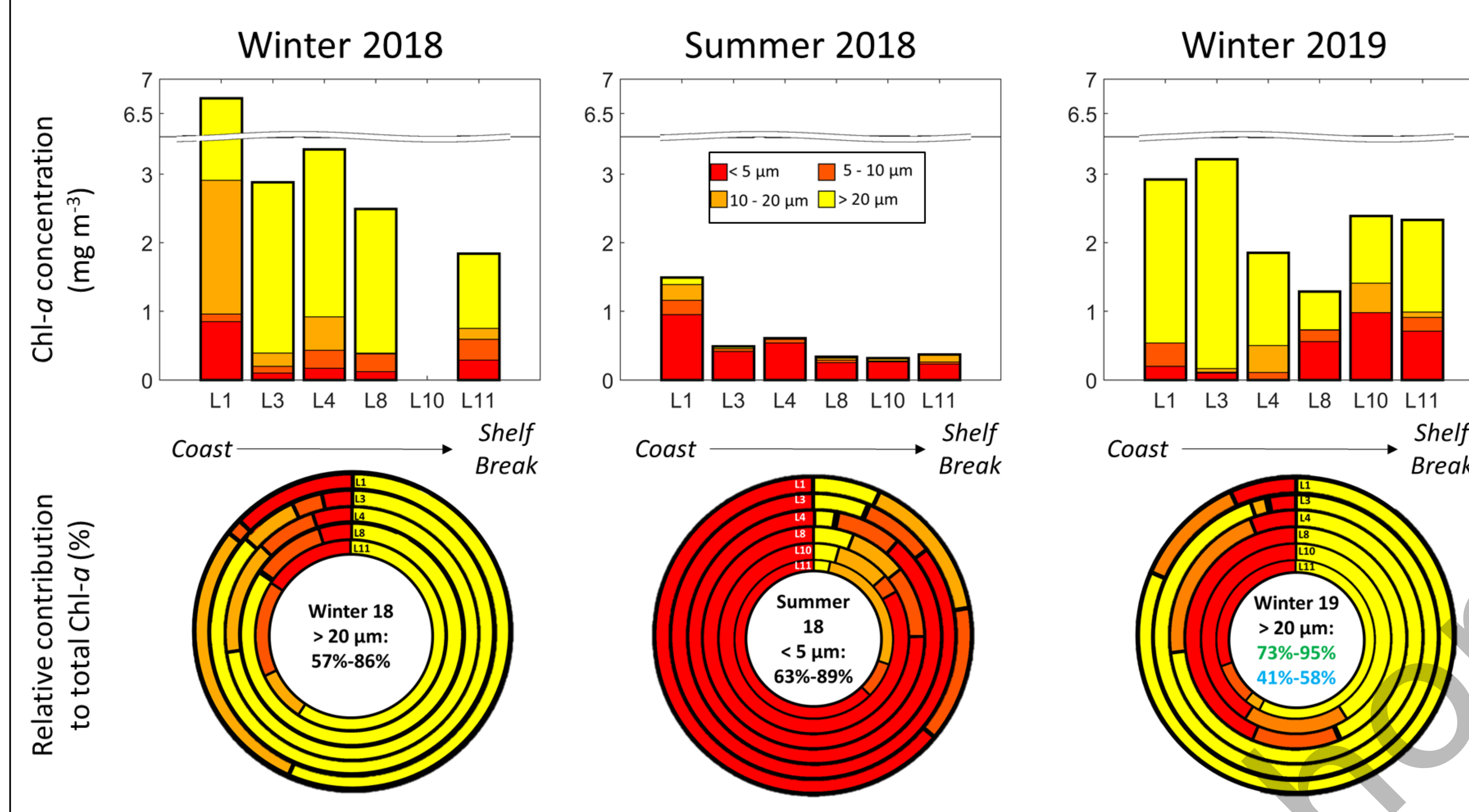

Figure 3: Top: Chl-a concentration (mg m^{-3}) and size fractionation (< 5 µm, 5 - 10 µm, 10 - 20 µm, > 20 µm) along a transect from the coast to shelf break in winter 2018, summer 2018 and winter 2019. Bottom: Relative contribution (in %) of each size fraction from the L1 coastal station (outer circle) to the L11 offshore station (inner circle) during each cruise. The relative contributions of the major size fraction are indicated in the center. For winter 2019, The contribution of the > 20 µm size fraction for coastal stations L1, L3 and L4 are in green and in cyan for offshore stations L8, L10 and L11.

Phytoplankton growth is temperature dependent, whereas grazing is not

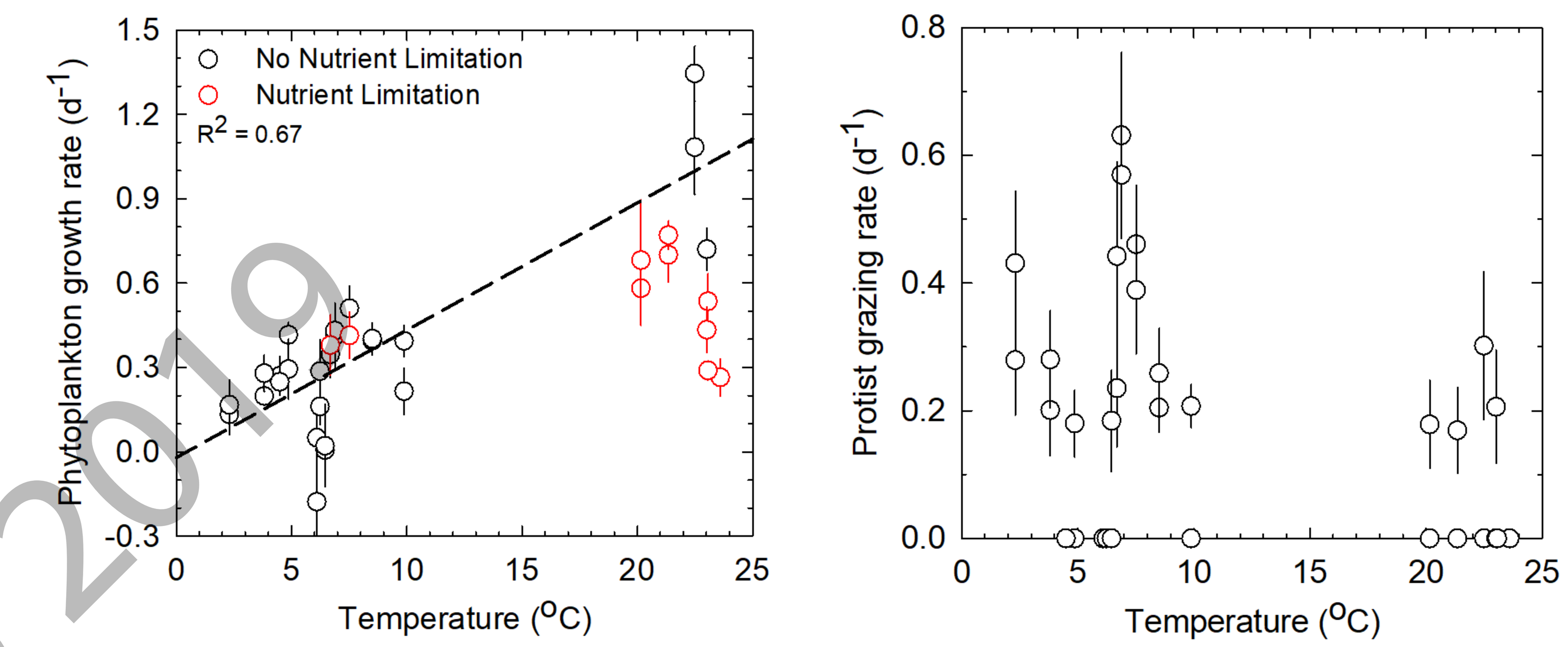

Figure 7: Phytoplankton in-situ growth (left panel) and protist grazing (right panel) rates (d^{-1}) obtained during winter 2018, summer 2018 and winter 2019 NES-LTER cruises vs. sea surface temperature (°C). Rates were estimated under 2 different light treatments (30-35% and 5-10% of light attenuation) but differed minimally, so averaged rates are presented. Maximum standard deviation among light treatments or replicates are shown. Red circles in left panel represents the incubation experiments where nutrient limitation was observed.

- Herbivory is expected to follow similar trends as phytoplankton growth.
- It appears that herbivory is less subject to temperature depression or seasonality (e.g. Morison & Menden-Deuer, 2017, Menden-Deuer et al., 2018) than the well-established relationship for phytoplankton (e.g. Eppley, 1972).

Seasonal, spatial and interannual variability of phytoplankton growth and protist grazing rates

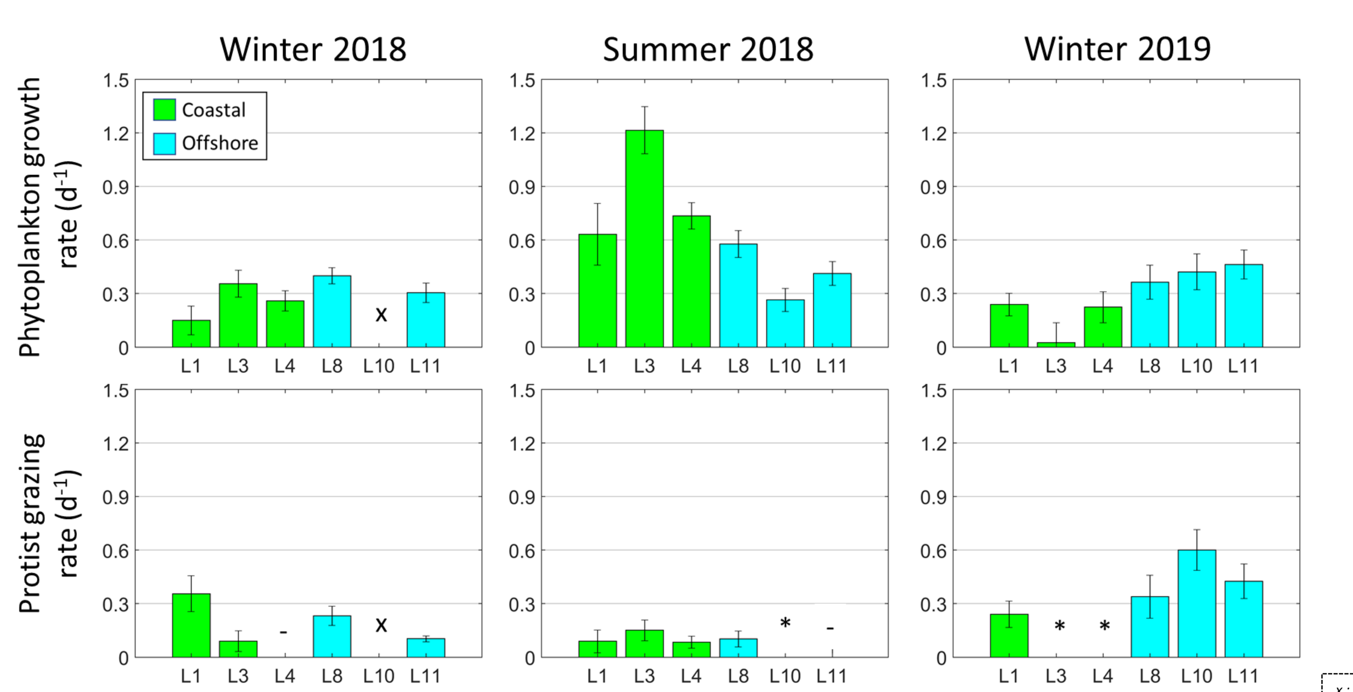

Figure 4: Phytoplankton growth and protist grazing rates (d^{-1}) obtained from incubation experiments along the NEST-LTER transects. Coastal stations L1, L3 and L4 are represented in green and offshore stations L8, L10 and L11 in cyan. Rates were estimated under 2 different light treatments (30-35% and 5-10% of light attenuation) but differed minimally, so averaged rates are presented. Maximum standard deviation among light treatments or replicates are shown.

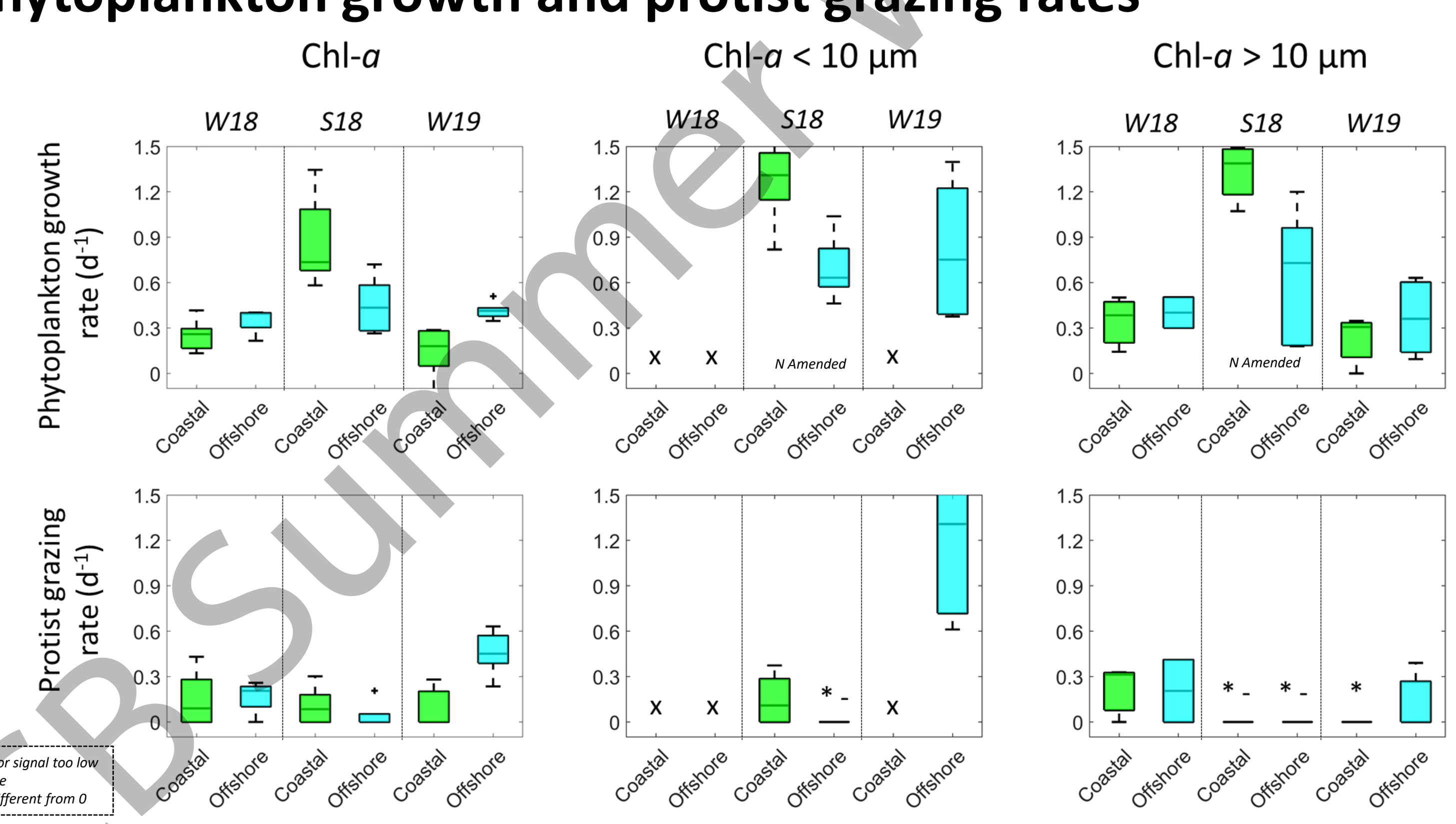

Figure 5: Top: Phytoplankton growth and protist grazing rates (d^{-1}) for coastal (green) and offshore (cyan) stations computed from Chl-a and for < 10 µm and > 10 µm size fractions. Growth rates of > and < 10 µm size fraction during summer 2018 were obtained from nutrient (N) amended samples only. On each box, the central mark indicates the median, and the bottom and top edges of the box indicate the 25th and 75th percentiles, respectively. The whiskers extend to the most extreme data points not considered outliers, and the outliers are plotted individually using the '+' symbol.

- **Seasonal variability:**

Phytoplankton growth rates < 0.5 d^{-1} in winter and up to 1.4 d^{-1} in summer. Relatively low (< 0.5 d^{-1}) protistan herbivory in winter and in summer.

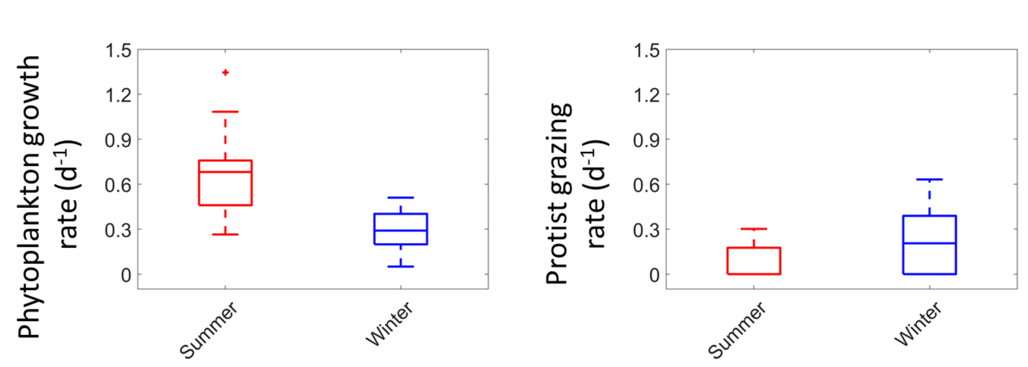

Figure 6: Phytoplankton growth and protist grazing rates (d^{-1}) obtained during summer (red) and winter (blue).

- **Spatial Variability:**

Summer 2018: Higher phytoplankton growth rates in coastal than in offshore region.
Winter 2019: Higher protistan herbivory in offshore waters, supported by phytoplankton cells < 10 µm.

- **Interannual variability:**

Winter: Importance of small phytoplankton cells in offshore waters in 2019, whereas this size fraction was poorly represented in 2018 in the same region.

Trophic transfer coupling during winter, decoupling during summer High-export vs. low-export potential ?

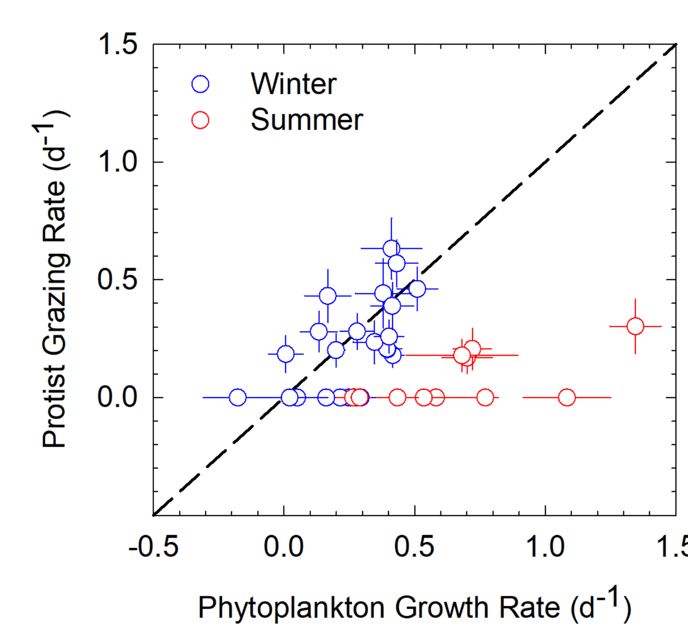

Figure 8: Protist grazing vs. phytoplankton growth rates (d^{-1}) obtained in winter (blue) and summer (red).

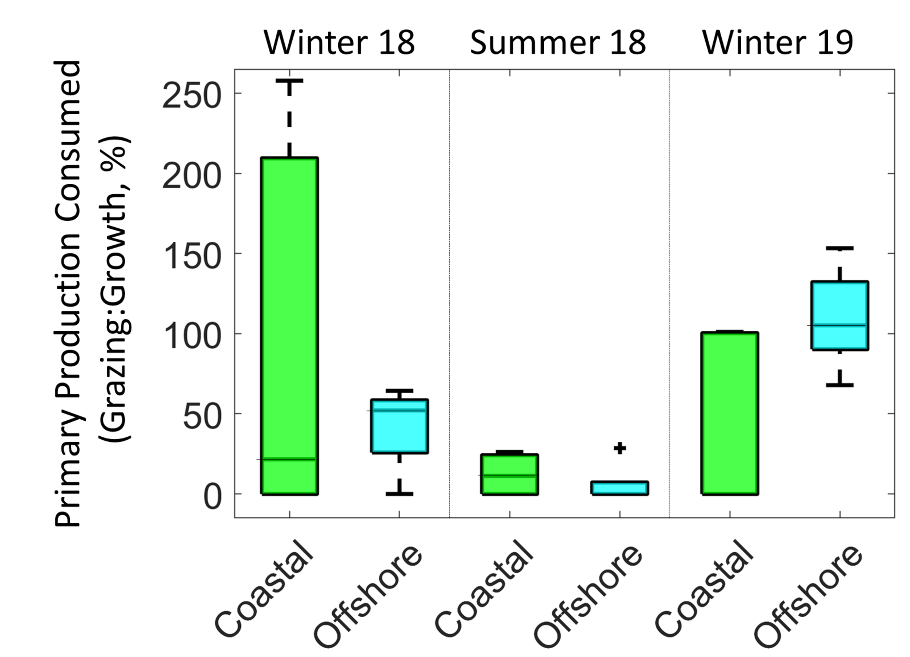

Figure 9: Primary production consumption (%) estimated as the protist grazing : phytoplankton growth ratio in winter 2018, summer 2018 and winter 2019 for coastal (green) and offshore (cyan) stations.

- Primary production was transferred more efficiently between first trophic levels during winter (%PP > 50%) than during summer (%PP < 20%).
- Early indication of our ability to quantify seasonal and inter-annual matter and energy flow from planktonic food webs

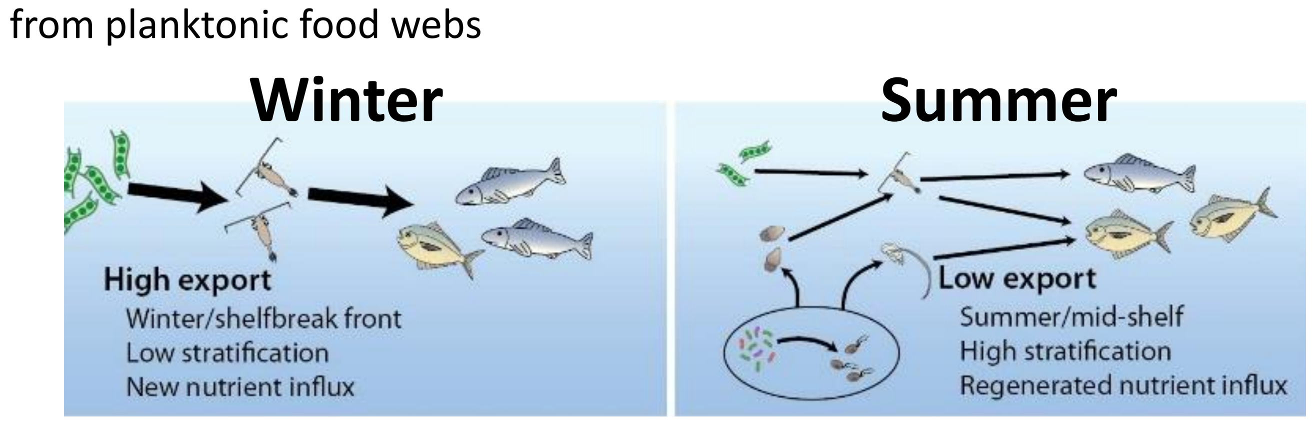

Figure 10: Representative, simplified food webs of high- and low-export conditions, contrasting the relatively simple food chain of high-export with the more complex microbial loop dominated food web of low-export (credit NES-LTER, WHOI Graphics).

References

Eppley et al. (1972), *Fish. bull*, *70*(4), *1063-1085*. Menden-Deuer et al. (2018), *PeerJ*, *6*, e5264. Morison and Menden-Deuer (2017), *Limnol. Oceanogr.: Methods 15(9), 794-809.*

Acknowledgements

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