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Spatial and Temporal Variability of Abundance and Biomass of Microplankton in the Gulf of Alaska

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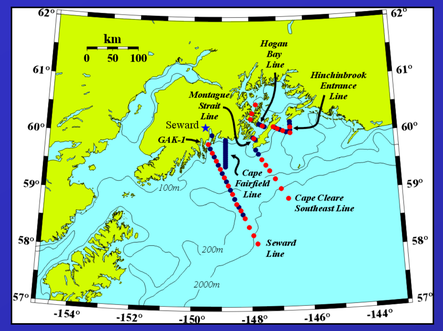
U.S. GLOBEC — GLOBAL OCEAN ECOSYSTEMS DYNAMICS

INTRODUCTION

The goal of this project is to describe the seasonal and spatial variability in abundance, biomass and size-structure of the microplankton (phytoplankton and microzooplankton <200 µm) and to interpret these distributions in the context of physical, chemical and biological data collected on the CGOA LTOP cruises. The size-structure, taxonomic composition and growth dynamics of the lower trophic food web can be highly responsive to physical forcing and, in turn, exert strong influences on zooplankton growth, fecundity, community composition and nutritional state.

The composition of phytoplankton and microzooplankton communities and their seasonal development in the coastal Gulf of Alaska are poorly known. Published reports are few and focus on subsets of the plankton (Larrance et al. 1977, Howell-Kübler et al. 1996 and Strom et al. 2001). This is the first study to use epifluorescence microscopy techniques to distinguish phototrophs and heterotrophs and to include all size ranges from picoplankton to microplankton. This study will provide critical data for extrapolating and interpreting phytoplankton and zooplankton rate information obtained on the Process cruises to the larger region and to construct realistic annual food web models. The data will also provide mechanistic insight and validation for coupled biological-physical models of the Gulf of Alaska shelf ecosystem, and vital information for comparison with the GLOBEC California Current System study.



METHODS

Samples for pico- , nano-, and microplankton (<200µm) identification and enumeration were taken on the April, May, June/July, July/August, and October 2001 LTOP cruises. We sampled all stations along the Seward Line (GAK 1-13), select stations along the Cape Cleare Southeast (CCSE), Cape Fairfield (CF) and Hinchenbrook Entrance (HE) Lines and select stations within Prince William Sound (PWS). At each station, either detailed vertical samples were taken (0, 20,30,40,50 & 100m) or samples from individual depths were taken and combined to form an upper (0, 10, 20, 30, 40, 50m) and lower water column (5 & 100m) integrated sample. Discrete vertical samples were taken at GAK 2,4,6,8,10,13 and PWS2 while integrated samples were taken at GAK 1,3,5,7,9,11 & 12, CCSE 2,5 & 8, CF 3 & 9, HE 2,7 & 10, Montague Straight 3, and Knight Island Pass 2.

At each of the above stations, subsamples were preserved with either 0.5% glutaraldehyde or 10% acid Lugols's iodine. The glutaraldehyde-fixed samples were used to enumerate, and distinguish between, heterotrophic and autotrophic organisms with epifluorescence microscopy. Settled Lugol's-fixed samples were used to enumerate and size ciliates and other rarer large microplankton with combined transmitted light and epifluorescence microscopy. Glutaraldehyde-fixed samples were filtered onto 0.2µm (for pico- and nanoplankton) and 0.8 µm (for microplankton) black polycarbonate membrane filters and stained with 4', 6-diamidino-2-phenylindole (DAPI) and proflavin. Organisms were counted and sized using a Zeiss Axiovert microscope and a computer-aided digitizing system (Roff & Hopcroft, 1986). Biovolumes were estimated using appropriate geometric shapes and converted to biomass using the equations in Menden-Deuer & Lessard (2000). In addition, samples were fixed and frozen for flow cytometry.

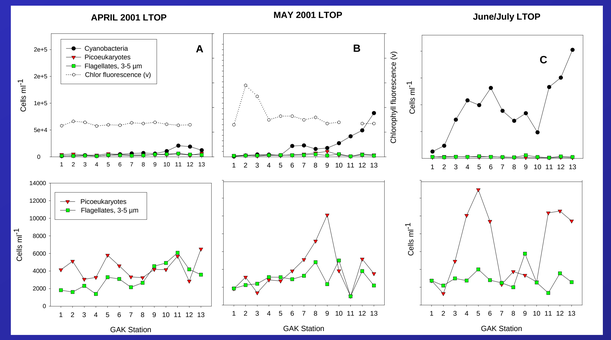


Figure 1. Average picoplankton abundances (cells ml^{-1}) in the upper 50 m and chlorophyll fluorescence (v) in the fluorescence maximum at stations (GAK 1-13) along the Seward Line during **A)** 3-13 April , **B)** 4-14 May, and **C)** June 29-July 8 2001 LTOP cruises. The lower plots show abundances of picoeukaryotes and an unidentified photosynthetic 3-5 µm flagellate on expanded scales to better show fluctuations.

• Picoplankton are present in significant numbers, increasing offshore and from April to May, even though water temperatures were <6ºC, and further increasing into early summer where surface temperatures were between 10-13ºC.

• During May, elevated chlorophyll was observed at stations in PWS and inshore along the Seward (GAK 2&3) and Cape Fairfield (CF3) Lines. The community was composed of large chain-forming *Thalassiosira* sp., other diatoms, cryptophytes and cyanobacteria. The *Thalassiosira* sp. was visibly healthier in PWS than at the GAK or CF stations, and was not found at any of the upstream stations. This supports the idea that an early bloom starts in PWS and is transported out on the shelf, but was not seeding the offshore blooms.

• Chlorophyll fluorescence alone gave little indication of underlying changes in phytoplankton biomass or composition. For example, there was an abrupt change in April at GAK 7 from mixed microdiatoms to almost exclusively nano-sized *Nitzschia* sp.(data not shown). The > 4X increase in cyanobacteria in May from GAK 9-11 was likewise not reflected in the fluorescence signal.

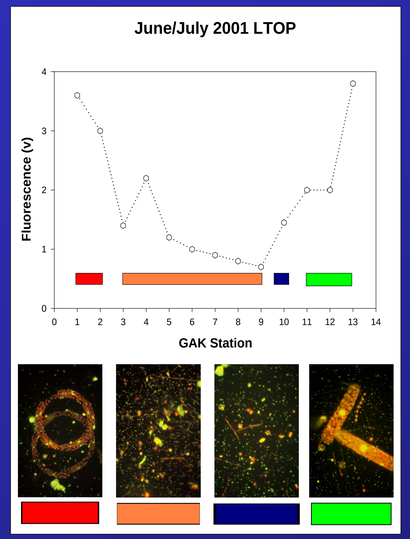


Figure 2. Chlorophyll fluorescence (v) at the fluorescence maximum at GAK Stations during 28 June - 8 July 2001 LTOP cruise. Colored bars represent different plankton assemblages. **Red** = large diatom-dominated, *Guinardia* and *Chaetoceros* spp.; **Orange** = cyanobacteria, cryptophyte, nano-diatoms; *Guinardia* absent; **Blue**: small *Nitzschia* spp.; **Green**: cyanobacteria, small *Nitzschia*, increasing domination ocean-ward by the large diatom, *Corethron.*

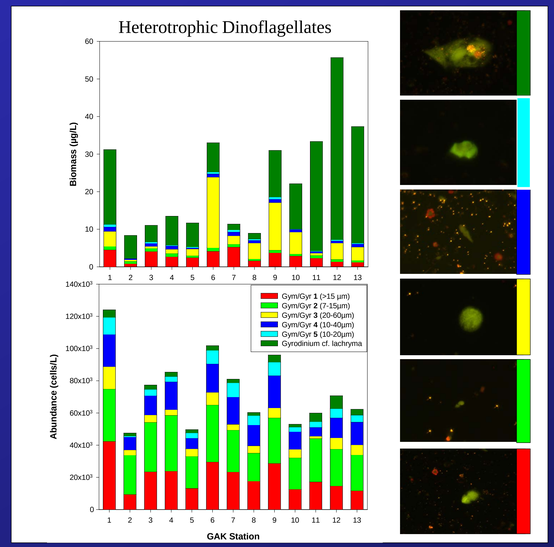


Figure 4. Abundance and biomass of athecate heterotrophic dinoflagellates in upper 50 m integrated samples along the Seward Line in June/July. (Herbivorous ciliates and heterotrophic dinoflagellates were present at all stations; ciliates and large thecate dinoflagellates not presented here as Lugol's counts not complete.). Athecate dinoflagellates were numerous (up to 125 ml^{-1}). Dinoflagellates were diverse with at least five different dinoflagellate taxa (probably more), ranging in size from 5 -150 µm in size (illustrated at right). All sizes were seen to ingest cyanobacteria, even the very large *Gyrodinium cf. Lachryma*, which is capable of ingesting much larger items.

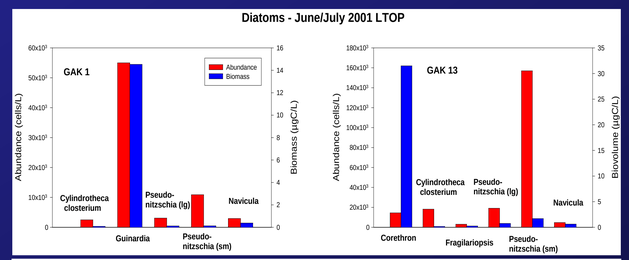


Figure 3. Major diatom species abundance and biomass at the fluorescence peaks at GAK1 and GAK13 of the Seward Line on the June/July cruise. Fluorescence maxima dominated by completely different assemblages in terms of species and size structure:

- GAK1 dominated by the diatom *Guinardia striata* which formed spiral chains of ca. 150 µm diameter.
- Oceanic GAK13 dominated by a mixture of cyanobacteria and diatom spp. with increasing dominance offshore by the large (122 X 25 µm) solitary diatom, *Corethron hystrix*.

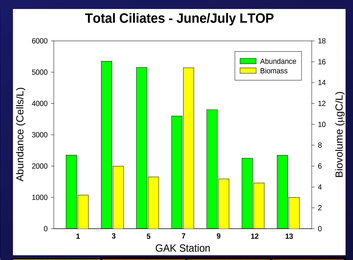


Figure 4. Total ciliate abundance and biomass at stations along the Seward Line on the June/July cruise. Examples of types of ciliates observed.

SUMMARY

1. Phytoplankton assemblages were very heterogeneous over short distances across the Seward Line in all months. Clearly, blooms do not start inshore and move offshore. Even in early summer (June/July) there was elevated chlorophyll at offshore stations due in part to large diatoms.

2. Picoplankton (cyanobacteria and picoeukaryotes) are significant members of phytoplankton communities all across the Gulf of Alaska shelf in early spring to early summer, reaching extremely high numbers (8x10^4 ml^{-1}) in May (<6ºC) and even higher numbers (2x10^{5}ml^{-1}) in June/July (12ºC). These values are considerably greater than those observed at similar temperatures and latitudes (eg. Baltic Sea, Kuylenstierna & Karlson, 1994). This is the first quantitative report of picoplankton in the northern coastal GOA. Picoplankton and their trophic interactions need to be considered in food web models of this region.

3. Chlorophyll fluorescence can be a misleading and inadequate indicator of phytoplankton biomass and/or species composition. This is not a new observation, but particularly true in this dynamic region.

4. Athecate heterotrophic dinoflagellates are ubiquitous and abundant and very diverse ranging from 5 to 150 µm in size. All sizes were frequently found with ingested cyanobacteria, suggesting a much wider size range of potential prey than is generally acknowledged.

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