Timing and Mesoscale Variability of Phytoplankton Blooms in the Northern Gulf of Alaska

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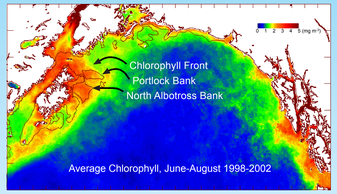


Abstract

Seasonal dynamics of primary production are strikingly different offshore of Kodiak Island compared to other regions of Gulf of Alaska (GOA). In general, high nutrient concentrations in early spring are observed over the entire shelf due to winter entrainment and onshore Ekman flow of nutrient rich water from the basin. The spring bloom persists until nutrient concentrations become limiting, and, thereafter, chlorophyll concentrations remain low. A dramatic exception is offshore of Kodiak Island where chlorophyll concentrations remain high all summer, suggesting additional mechanisms of nutrient supply. We compare mesoscale and interannual variability in sea-surface chlorophyll over the GLOBEC domain from 1998 to 2002 using in-situ data and time-series of SeaWiFS satellite imagery. To examine interannual variability of production from spring to fall, two week composites were examined from May to September in each year. These images also reveal the relevant extent to which eddies and filaments contribute to chlorophyll production. To better examine seasonal variability, two-week averages were generated using the five-years of available data. Sustained production over the shallow banks and troughs off Kodiak Island is a clear indication of a stable localized nutrient source. These results are compared to time series from moorings and other in situ data.

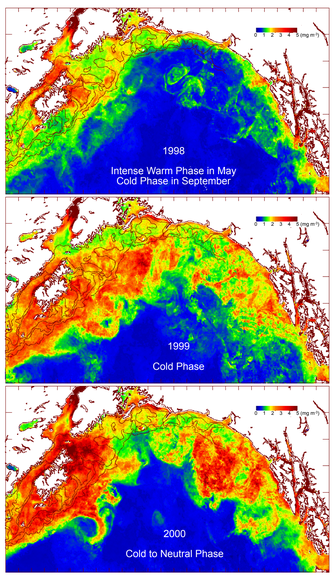
Imagery

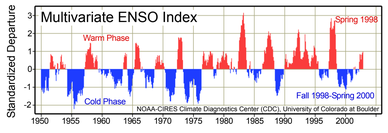
To create the chlorophyll images, we ordered level 1A files from SeaWiFS and processed them with SeaDAS to obtain mapped files with 1 km pixel size where land, clouds and areas of high sun glint are masked. The files included OC4 chlorophyll (in mg/m3), satellite zenith angle, and level 2 flags. We then averaged the mapped files with an IDL program which also imposed more restrictions on the data. Pixels at a zenith angle greater than 57^{o} were excluded, as well as pixels within 2 km of a masked pixel. The value at each pixel of the resulting image was the sum of all the "good" values of chlorophyll at that pixel divided by the number of good values. The region near Kodiak Island generally had more clear days than the eastern Gulf of Alaska. Two possible problems with the data were turbidity and negative water-leaving radiance. Turbidity was usually caused by sediment which can either hide or erroneously enhance chlorophyll values. Cook Inlet was always turbid, and SeaDAS also often flagged the nearshore region off Yakutat for turbidity.

Interannual Variability

- Imagery showed lower chlorophyll associated with the intense warm ENSO phase in spring 1998 and the moderate warm phase in 2002.
- Enhanced stratification associated with El Ninos reduced nutrient supply to the upper mixed layer and reduced biological production (see Whitney & Welch, 2002).
- In 1998, chlorophyll around Kodiak remained high despite enhanced stratification, suggesting that additional mechanisms of nutrient supply exist (see poster by N. Kachel et al.)
- We speculate that the lower chlorophyll abundance in 1998 and 2002 were typical for the frequent warm phases observed in the ENSO cycle, and may be indicative of conditions concomitant with future global warming.

Images of Averaged SeaWiFS Chlorophyll from May to Mid-September

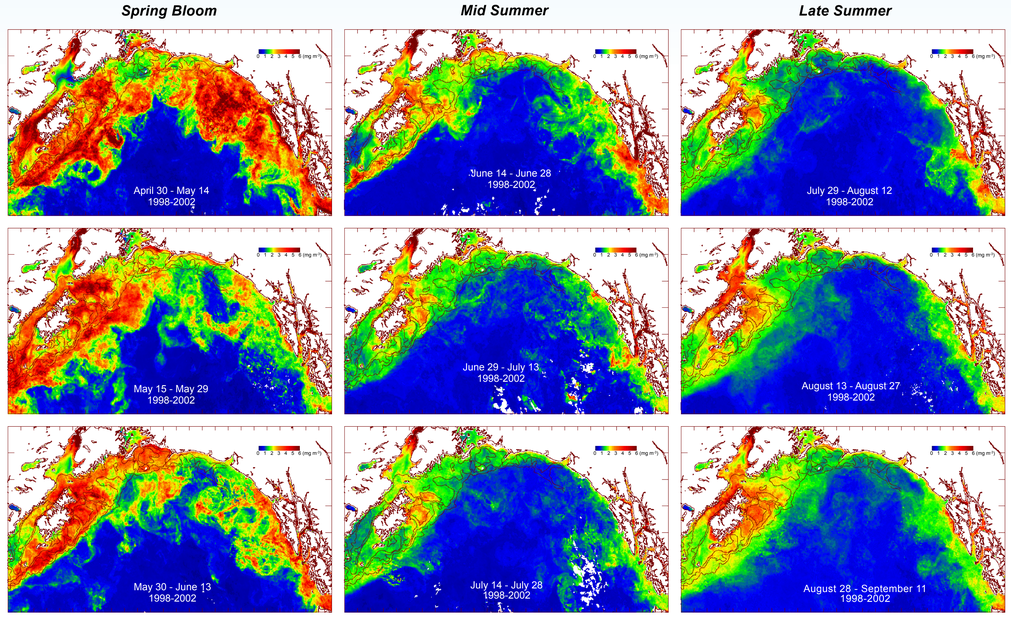




Interannual Variability

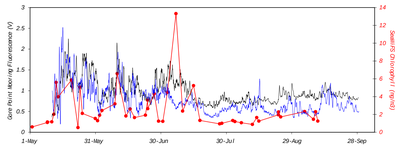
- Massive spring blooms are observed over the entire Gulf of Alaska shelf as a result of the winter supply of nutrients and the onset of adequate light.
- It has been hypothesized that chlorophyll concentrations over the basin remain low due to iron limitation (Martin et al.).
- Late in the spring, surface chlorophyll concentrations remain high over the broad shelves of the western GOA relative to the narrow shelves of the eastern GOA.
- In summer, surface chlorophyll concentrations are low due to depleted nutrients (not shown) in the photic zone. A strong subsurface chlorophyll maximum has been observed in summer.
- An exception is over shallow banks where chlorophyll concentrations remain high due to additional nutrient supply mechanisms.
- In late August and early September, surface chlorophyll increases in the vacinity of Kodiak Island, but nowhere else in the GOA .

Images of 15 Day Averaged SeaWiFS Chlorophyll from 1998-2002



In Situ Data

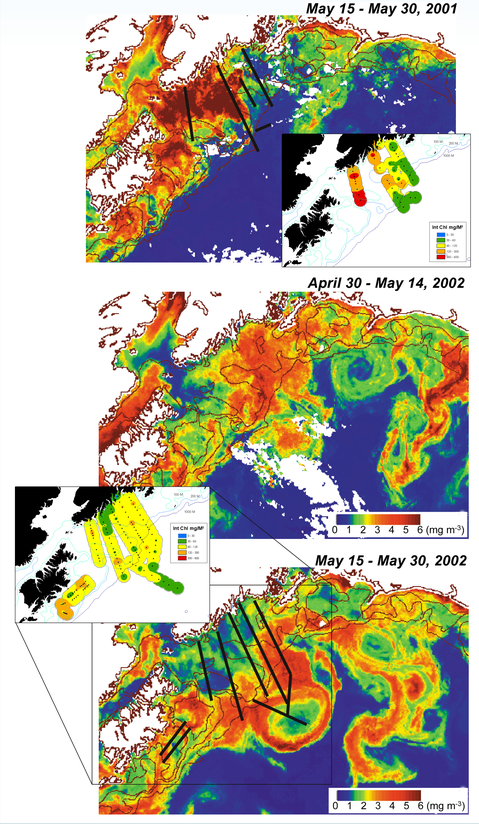
Fluorescence from the moorings are in general agreement with chlorophyll extracted from SeaWiFS imagery. Shown at right are two time series of fluorescence measured at 15m from moorings along the Kenai Peninsula at Gore Point. The spring bloom is evident in the time series with less production during occurring the summer mohths.



Mesoscale Variability

- Imagery shows numerous filaments and eddies which promote basin-shelf exchange.
- In 2001, both imagery and integrated chlorophyll show a strong front just southeast of the Seward Line.
- In 2002, a strong offshore chlorophyll front observed from space was not apparent in integrated chlorophyll.
- The bloom dynamics of an eddy off of Amatouli was evident with the core blooming prior to the edge.

Images of 15 day Averaged SeaWiFS Chlorophyll and Concurrent Integrated Chlorophyll



Acknowledgements

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