Primary productivity patterns in the Arctic: The 10 year SeaWiFs record.

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Abstract

Our aim was to study patterns of primary productivity in the Arctic Ocean using the 10 year satellite record available from SeaWiFs. A model based on biomass was applied to average monthly chlorophyll retrieved from satellite imagery. The annual productivity calculated in this way, in the surface layer of the ocean, ranged from 90 to 110 Tg C yr-1. Considerable interannual variation was observed, but there was no significant trend over the 10 year period. Open water area was the primary driver of variability in productivity. Analysis of functional regions reveals the Chukchi Sea to be the only region with a significant increasing trend in primary productivity over time. Future increases in open water area will impact the central basin, resulting in amplified productivity. However, productivity in shelf regions is currently nutrient, not light limited and therefore, is not expected to experience any further increases.

Productivity Model

Vertical distribution of productivity

➢**During the spring bloom, productivity was highest within the first optical depth, and homogenous throughout the rest of the water column (Figure 1a). After the bloom, nutrients were limiting at the surface and highest production was observed at approximately 3 optical depths.**

➢**Approximately 60% of total euphotic zone integrated productivity occurs within the first 2 optical depths in the spring, in comparison to 40% in the summer (Figure 1b).**

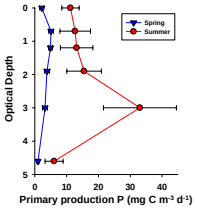


Figure 1a. Mean vertical distribution of productivity during the spring and summer, in the Chukchi Sea. 1 standard error bars plotted.

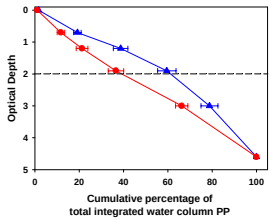


Figure 1b. Cumulative percentage of productivity with depth in the spring and summer. Data from figure 1a..

Limitations on remote sensing

➢**90% of the water leaving radiance signal that is measured by the ocean color satellite originates from the first two optical depths.** ***Any biomass below this depth is invisible.***

➢**Remotely sensed productivity estimates are limited to the surface layer.**

Biomass based productivity model

➢**Phytoplankton biomass in the form of chlorophyll concentration can explain 60% of the variation in carbon uptake across the whole Arctic (Figure 2). This forms the basis of the model, as seen below.**

$$PP = (m \times Chl + c) \times Z_{eu}$$

These variables are estimated from ocean color remote sensing.

These variables are estimated from figure 2.

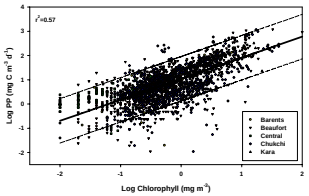
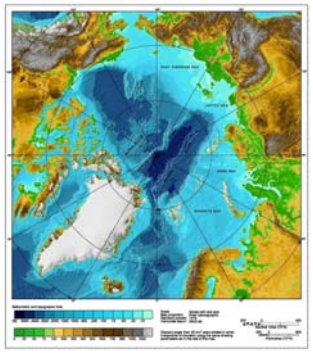


Figure 2. Chlorophyll biomass to carbon uptake relationship From Pan-Arctic dataset..



Pan Arctic Annual PP

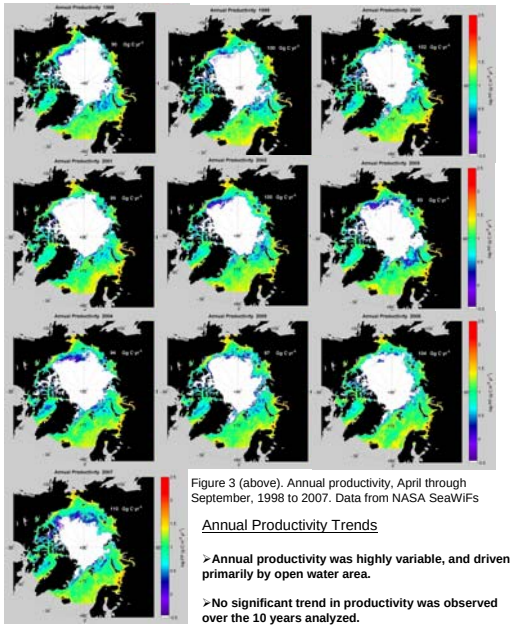


Figure 3 (above). Annual productivity, April through September, 1998 to 2007. Data from NASA SeaWiFs

Annual Productivity Trends

➢**Annual productivity was highly variable, and driven primarily by open water area.**

➢**No significant trend in productivity was observed over the 10 years analyzed.**

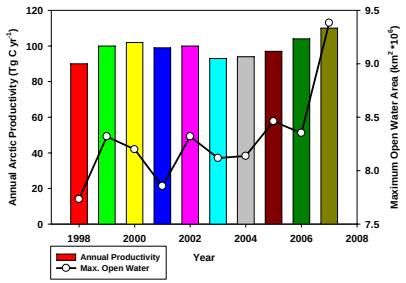
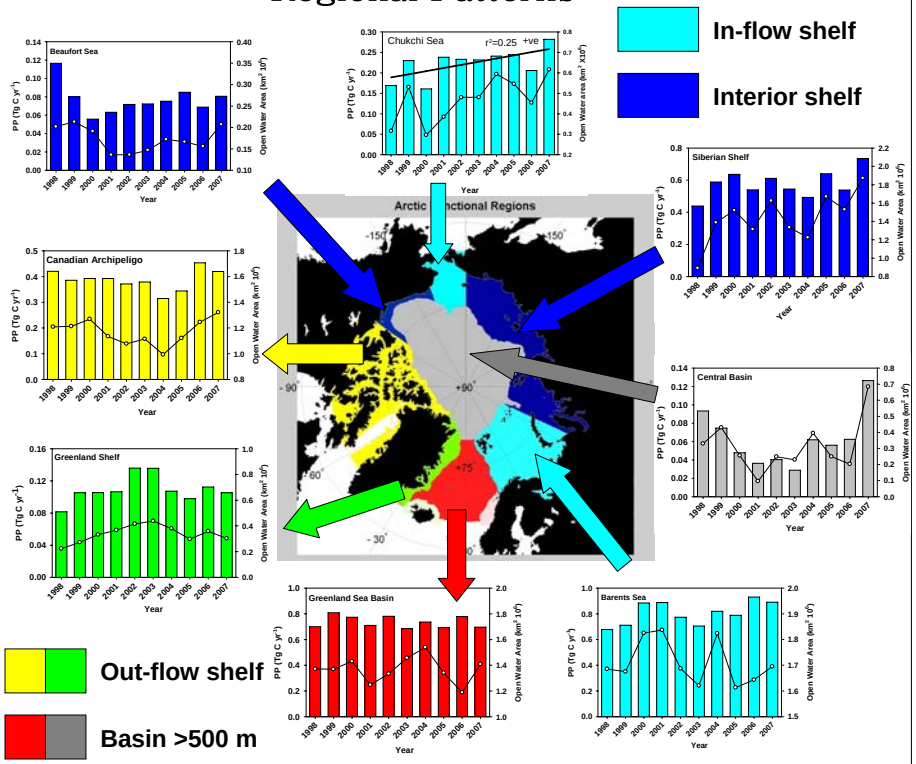


Figure 4 (right). Annual productivity, plotted with maximum open water area. Year 1998 to 2007.

Regional Patterns



Conclusions

➢**Longer period time series are needed to make conclusive determinations of the impact of climate change on water column productivity in the Arctic.**

➢**Productivity in regions which are currently ice free for the majority of the growing season (i.e shelves) is nutrient, not light limited and therefore, will not experience increased productivity if ice continues to decrease.**

➢**Basin regions are currently still light limited due to ice cover, these areas will continue to experience increases in annual productivity as ice retreats further.**

➢**Changes in both mixed layer depth due to increased water column mixing, and nutrient loading from terrestrial runoff , not ice cover are likely to be important factors in annual productivity in the future.**

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