Chemical Parameters of Northern Alaska Coastal Lagoons

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Introduction

The shallow estuaries of the Beaufort Sea are highly productive and support a diverse biological community of organisms ranging from microbes to economically important metazoans. However, the flux of nutrients and carbon into these waters is dependent on riverine flow. Peak river discharge occurs during a three week period in the spring, called the spring freshet. During this time, the coastal waters are still covered with sea-ice, which prevents river flow from exchanging with the ocean, therefore trapping terrestrial organic matter (tOM) in the near shore environment. We propose that this flux of tOM is a significant food source for microbial and metazoan communities.

Although seasonal changes from winter to summer causes these freeze/thaw events to occur, the timing and magnitude of discharge varies greatly (Carmack et al., 2006, McClelland et al., 2012). In light of recent climate changes, Arctic river discharge has been increasing and summer sea-ice cover has been decreasing (McClelland et al., 2006). These climate changes have

implications for the cycling and storage of carbon, greenhouse gas exchange, ocean productivity, and shifts in ecological food webs (McClelland et al, 2004).

The goal of the project is to compare how chemical parameters change in lagoon waters across three distinct seasons. Results from this study will compliment biological data in order to answer the question, "How do seasonally distinct terrestrial inputs of water and organic matter influence microbial and metazoan communities in coastal waters of the Alaskan Beaufort Sea?"

Study Site

The study is based out of Kaktovik, AK on the North Slope (Fig. 1). The ten chosen study sites are within 30 nautical miles of Barter Island. Figure 2 illustrates the location of each site with its respective acronym, (i.e. KA is for Kaktovik Lagoon, etc.) These shallow lagoons differ by their freshwater input from rivers and streams, as well as differ by their exchange characteristics with ocean shelf waters. For example, Kaktovik Lagoon (KA) receives freshwater from small streams fed by runoff from the surrounding Tundra. The lagoon itself is semi-enclosed, limiting water exchange with the Beaufort Sea to very shallow, small areas. Jago Lagoon (JA) receives large amounts of freshwater from the Jago River, but like KA, exchange with the sea is limited. More shallow lagoons like these extend eastward towards Demarcation Bay.

Sample Collection and Data Analyses

Water samples were collected during three distinct months, April (2012), June (2012), and August (2011, 2012), in order to assess how water quality changes throughout the seasons. April was chosen to reflect the end of the ice-covered winter period. June was chosen to capture

the onset of the spring freshet, a time when freshwater discharge is the highest. August was chosen to reflect the conditions when freshwater inputs are low, long after the spring freshet.

A Sonde YSI was used at each site to measure chemical parameters *in situ*, as well as record the GPS coordinates. Additional water samples were collected at these sites and later analyzed for optical properties. This study in particular focuses on samples from 2 and 3 meters and observations of salinity, dissolved oxygen (DO), and optical properties of chromophoric dissolved organic matter (CDOM). The specific optical measurements represented in this study include: a250, SUVA, and a250:365, which will be described further in the discussion.

GIS Data Processing and Map Production

The first step in map creation was to compile sample data in Excel and by matching data points to the corresponding station coordinates. The Excel file was then converted to .csv to be uploaded into ArcGIS 10.1. The base map chosen for the projections was the National Geographic map using the WGS 1984 Web Mercator Auxiliary Sphere projection. The X, Y coordinates from the .csv file were displayed using the geographic coordinate system NAD 1983. The displayed points were then exported to a shape file, and data values were displayed using graduated color symbology.

Results and Discussion

All three seasons exhibited distinct differences in salinity. April waters ranged from normal sea water to hypersaline conditions (31-44ppt), with little change from the 2 and 3 meter waters (Fig. 3). In June, conditions were very fresh at 2 meters with salinities between 1.2 to 3.9 ppt. However, in more than half the sites, the waters just below that at 3 meters were hypersaline (Fig. 4). In April, the surface waters are covered with thick winter ice. Below the ice a dense and

salty brine layer forms. In June, the lagoons are flooded by river inflow and ice melt, creating strong stratification with the dense brine waters below. August conditions are completely ice free, with mid-range brackish salinities that no longer maintain the previous stratification (Fig. 5). This evolution of salinity regimes over a nine month period highlights the importance of seasonal variability.

Dissolved oxygen concentrations at 2 meters remained relatively constant throughout the three seasons (Fig.6, 7, 8). Below that at 3 meters, slightly higher levels were observed at some sites in June and August, with the maximum value at 29 mg/L (Fig. 7).

The CDOM absorbance data measured at 250 nm was well correlated (R^2=0.65) with dissolved organic carbon (DOC) (Fig. 9). April waters exhibited the lowest a250 overall, with a slight increase in 3 meter samples (Fig. 10). June waters had the highest a250, with a maximum absorbance of 36.7 m^{-1} (Fig.11). These high absorbance signals indicate a higher amount of DOC in the water column. In August, a250 values were relatively moderate, with the highest amount in KA (Fig. 12).

The specific UV absorbance (SUVA) is the absorption at 254 nm normalized to DOC, and can reflect compounds with a high aromaticity (Potter and Wimsatt 2003). Observations of SUVA showed similar values between April and June, with a range of 4.8 to 14 (Fig. 13, 14). Unfortunately, SUVA data for August was not readily available while the maps were being made in ArcGIS.

The absorbance ratio of 250:365 nm (E_2:E_3) is used an indicator of molecular weight (MW) in dissolved organic matter. Due to stronger light absorption by CDOM at longer

wavelengths, a low ratio indicates a high MW compound (De Haan and De Boer, 1987; Peuravouri and Pihlaja 1997). April and August ratios appeared to be quite similar with ranges between 1.3 and 2.4 (Fig.15, 17). June waters all exhibited higher ratios with most samples being greater than 2.4 (Fig.16).

Conclusions and Future Work

Near the end of the ice-covered winter in April, lagoon waters are hypersaline, with low CDOM absorbance values. At the onset of the spring freshet in June, surface waters receive a pulse of fresh water, increasing stratification with the salty brine layer below. With this comes and increase in CDOM, and DO. Well beyond the spring freshet, August waters are ice free with a brackish mixture of low to mid range salinities. CDOM values in August are much than lower than June, as organic matter is consumed and conditions retreat back to the depleted winter state. Furthermore, the flux of tOM to the lagoons is highly influenced by seasonality. Future climate changes have the potential to shift the timing and magnitude of these freeze/thaw events, ultimately affecting the entire ecosystem structure.

Future work will include a comparison of biogeochemical data with biological community assemblages, to further understand the linkage between tOM and productivity. Additional data is currently being collected *in situ* via CTD data loggers deployed at six sites in August 2011, and will be retrieved in August 2013. These sensors continuously measure salinity and temperature, and will provide a unique opportunity to study changes during the winter period.

Figures

Figure 1. Location of study site using the Alaska Albers Conic projection.

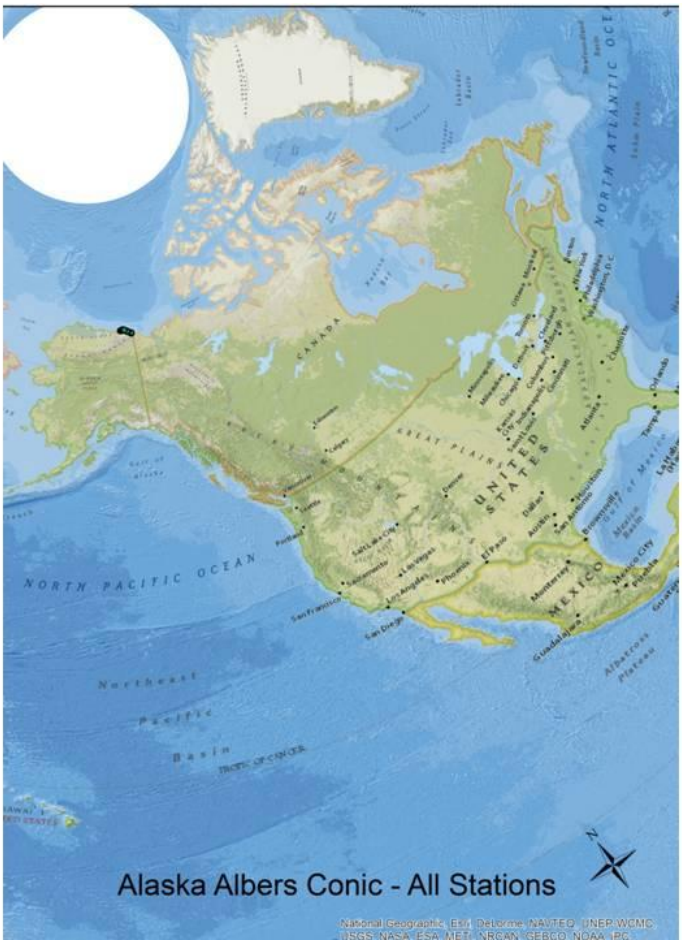


Figure 2. Spatial distribution of specific stations.

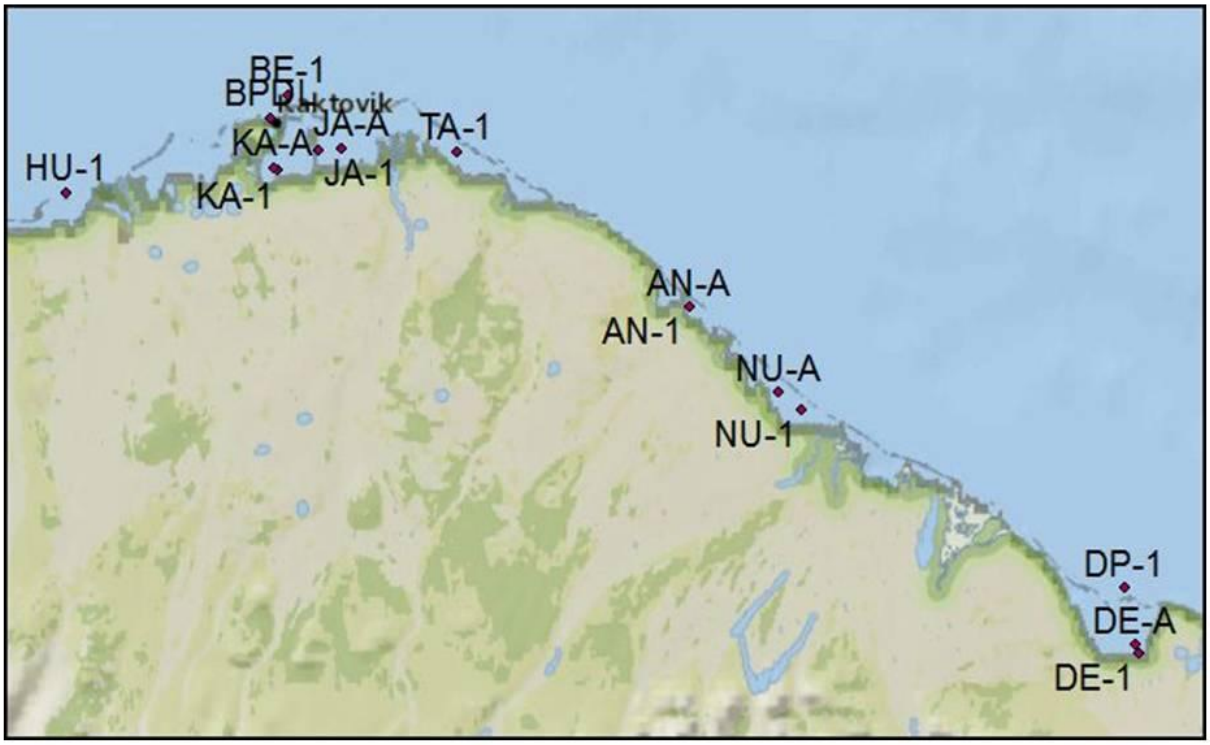
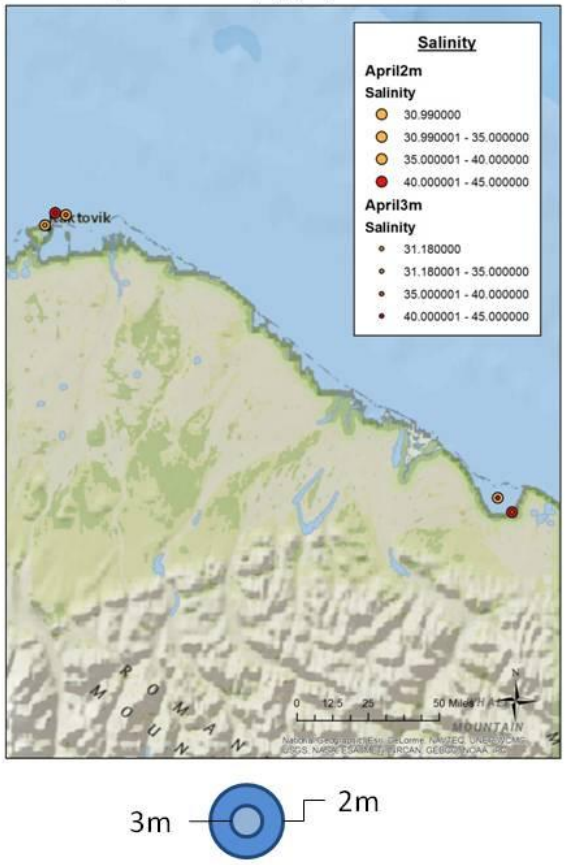
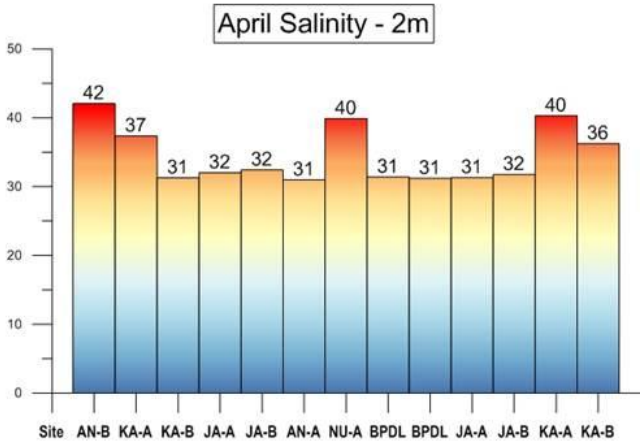


Figure 3. April Salinity (ppt)





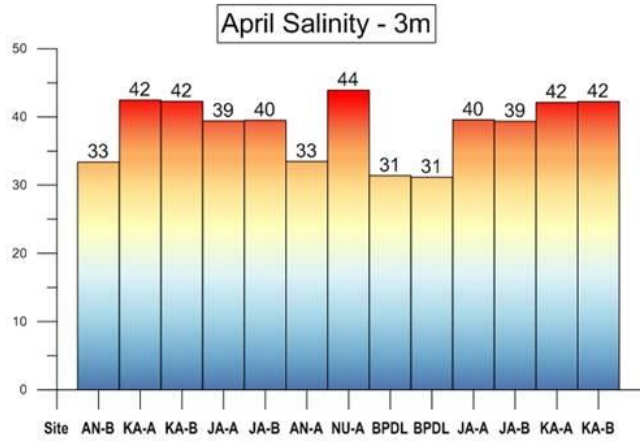
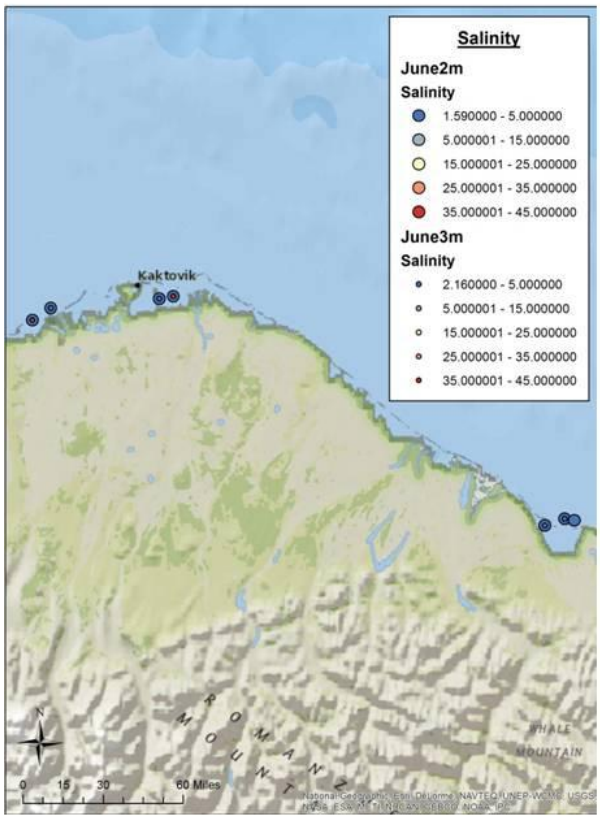


Figure 4. June Salinity (ppt)



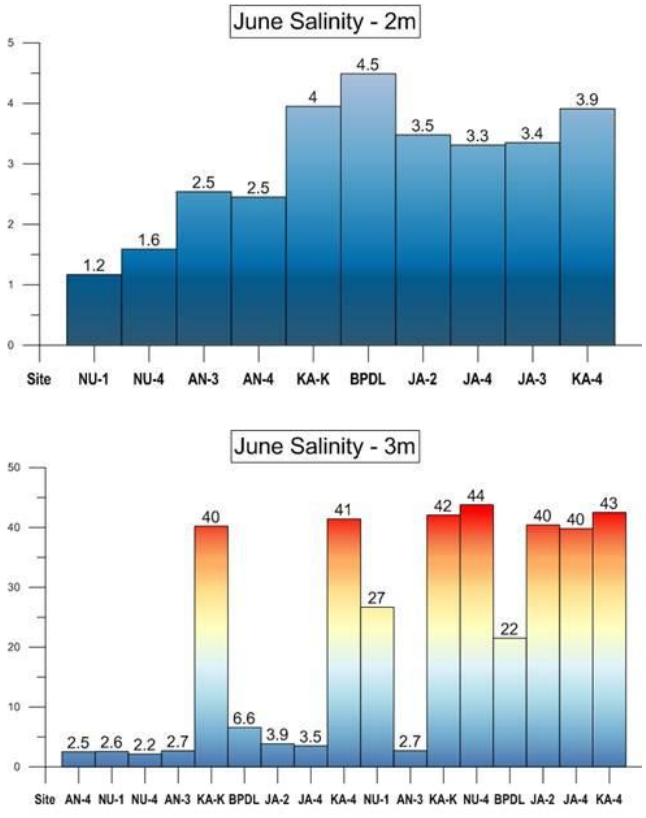


Figure 5. August Salinity (ppt)

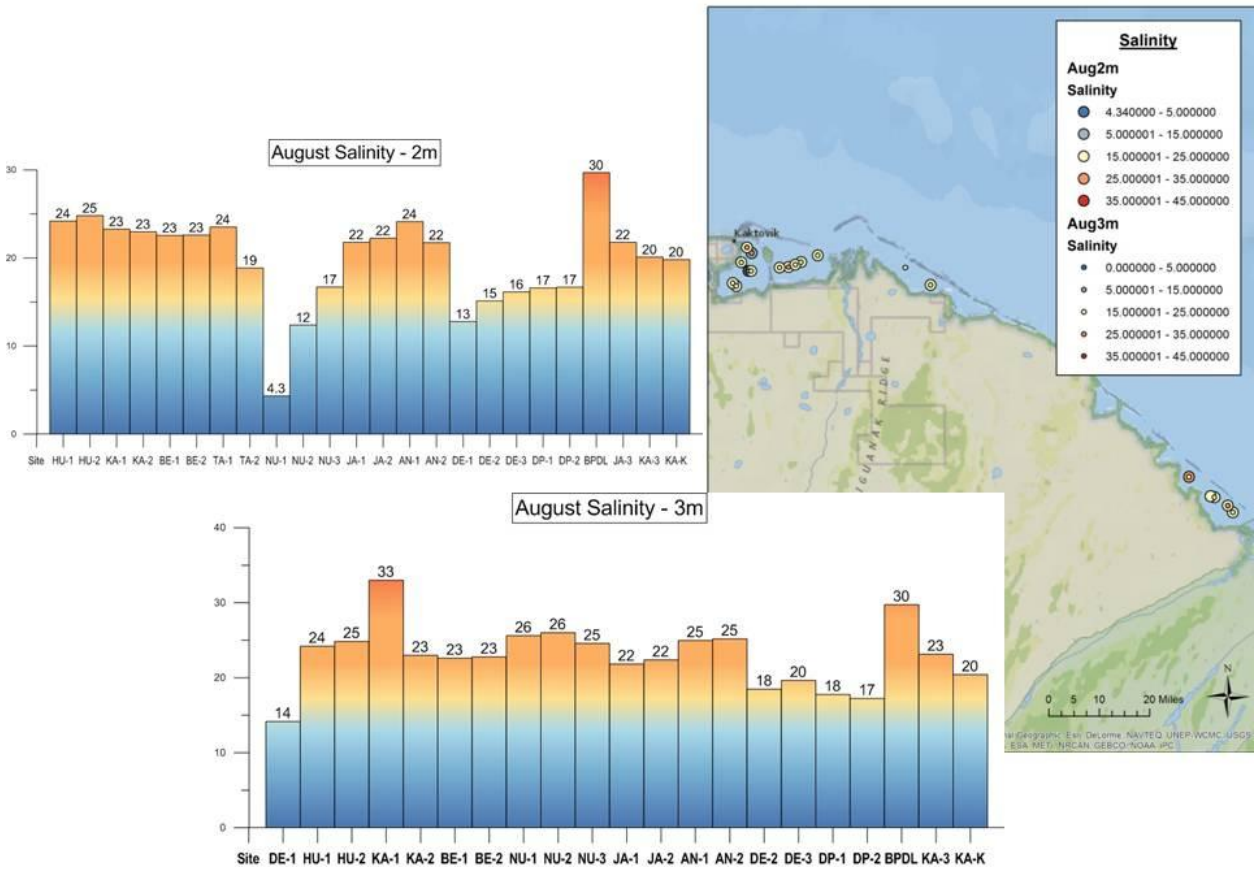


Figure 6. April Dissolved Oxygen (DO mg/L)

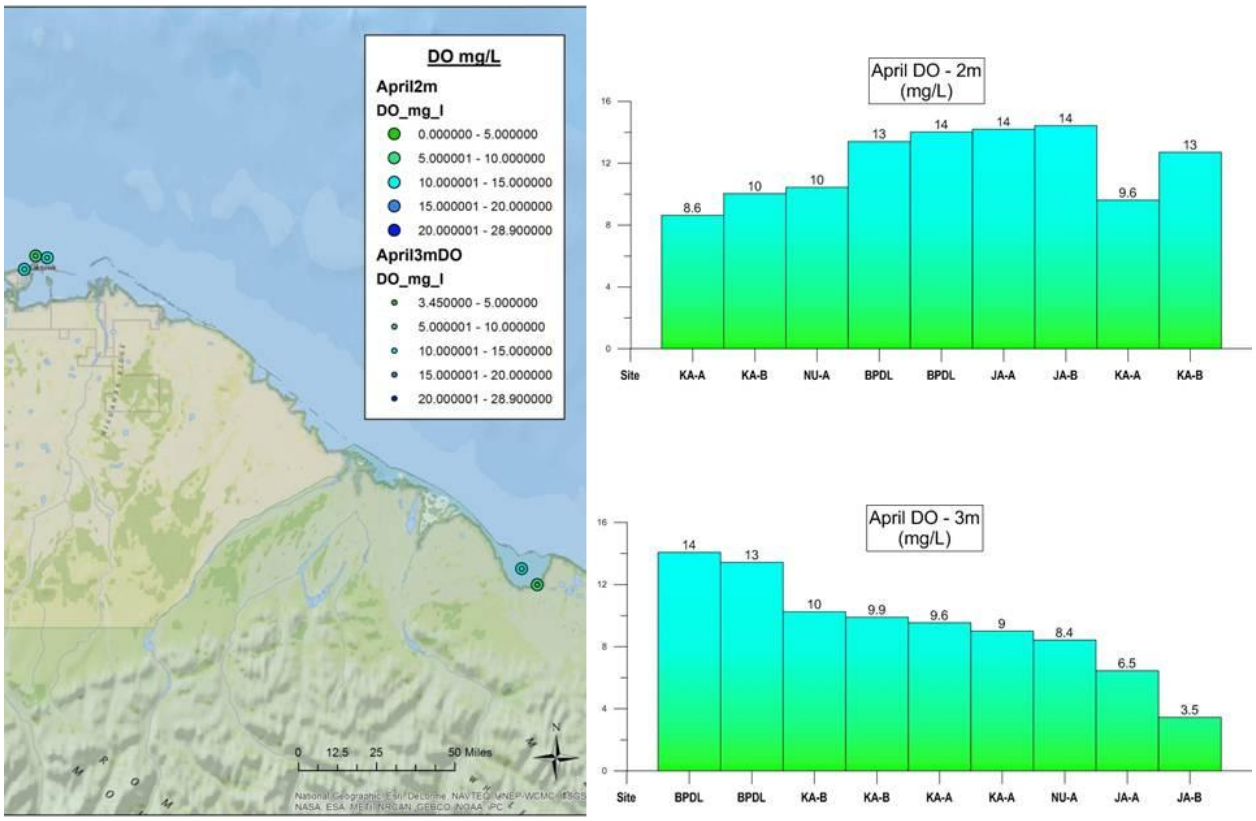


Figure 7. June Dissolved Oxygen (DO mg/L)

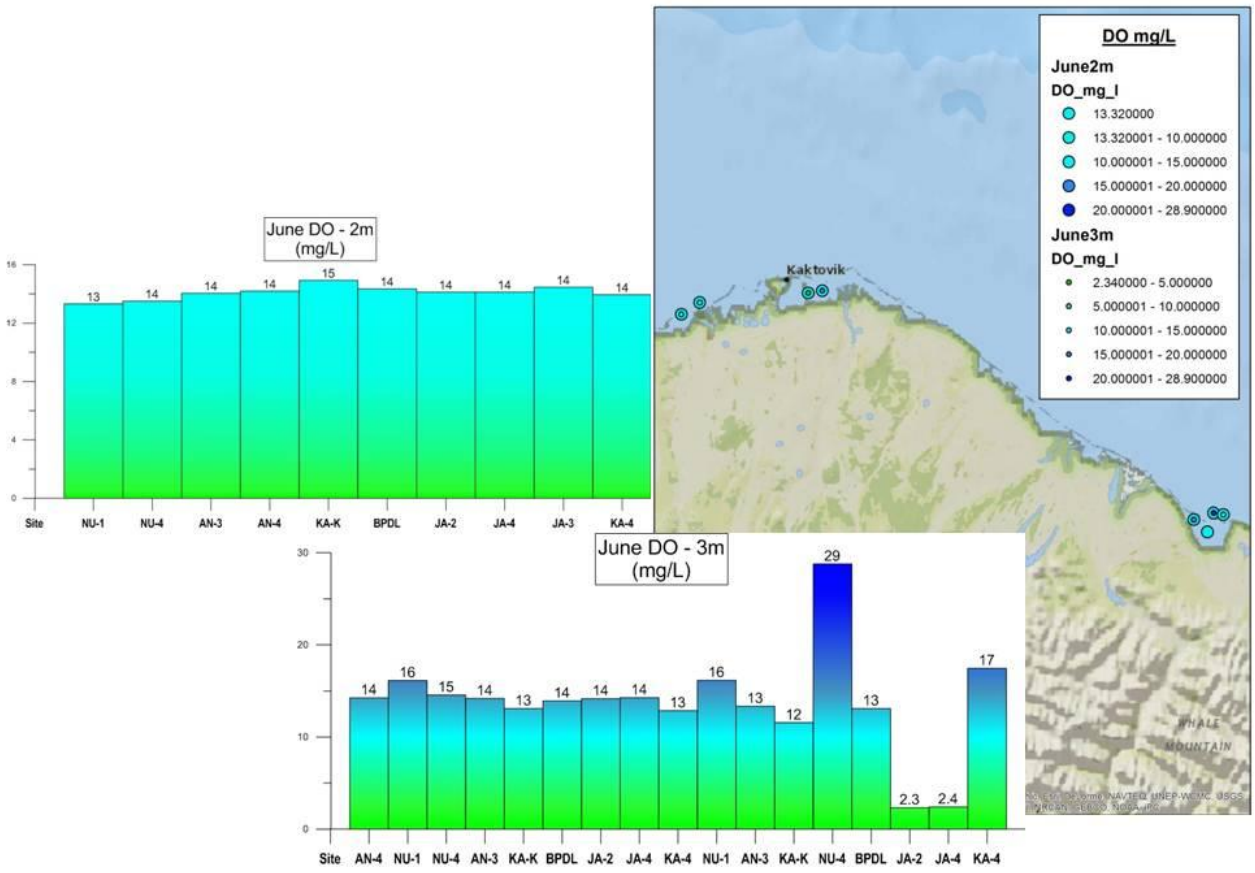


Figure 8. August Dissolved Oxygen (DO mg/L)

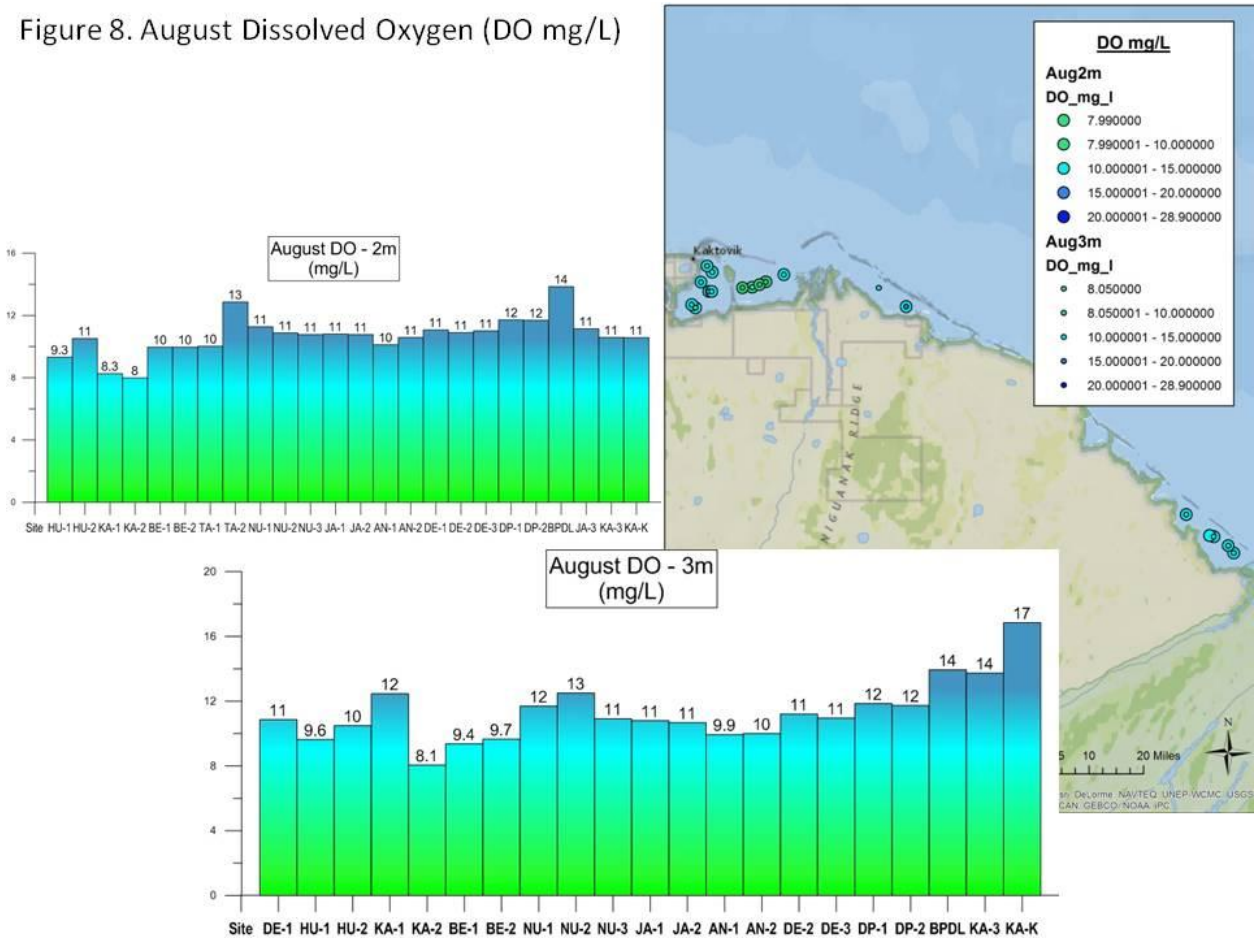


Figure 9. Relationship between CDOM absorption and Dissolved Organic Carbon (DOC) for all samples.

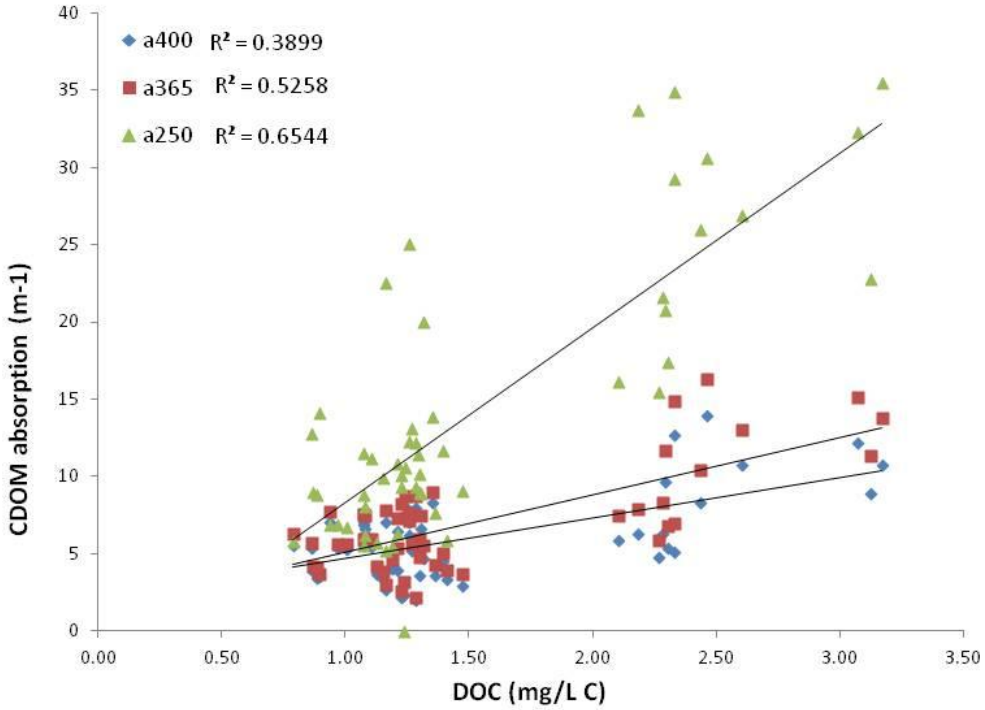


Figure 10. April a250

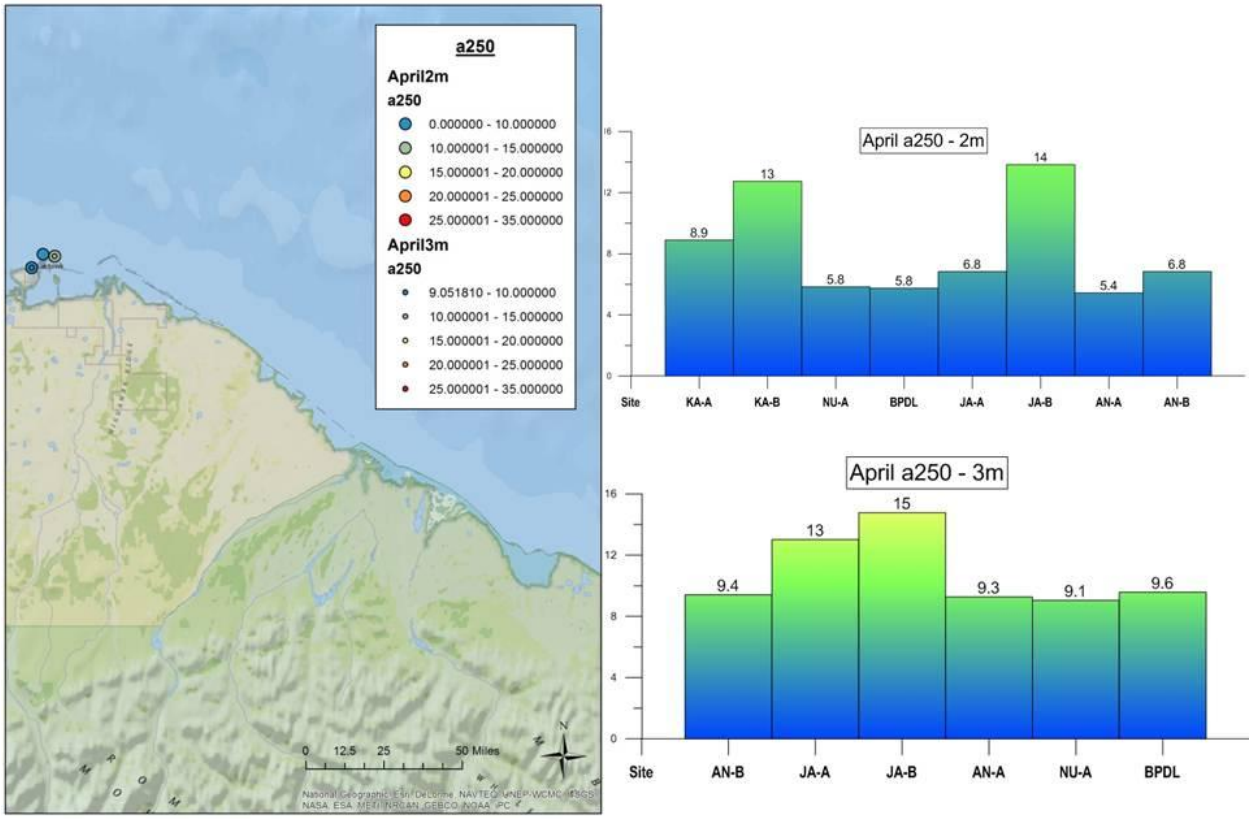


Figure 11. June a250

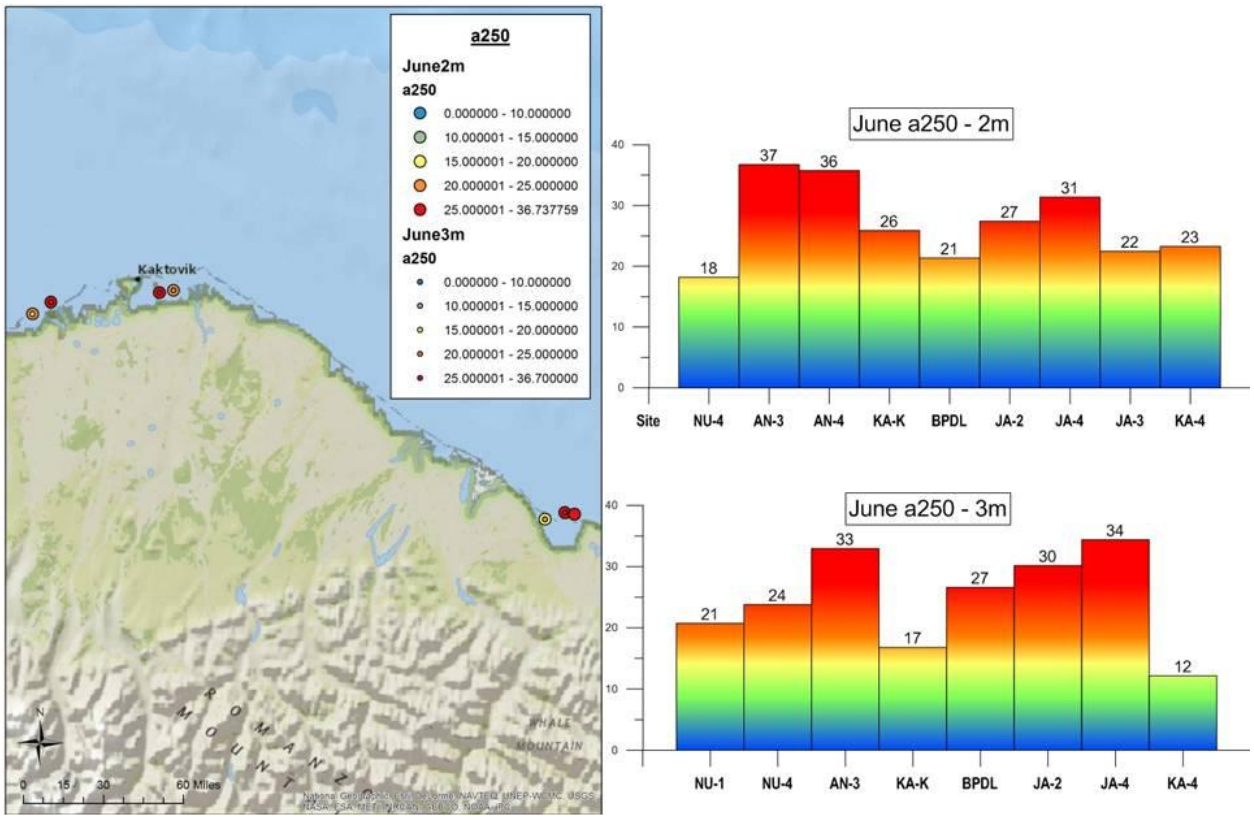


Figure 12. August a250

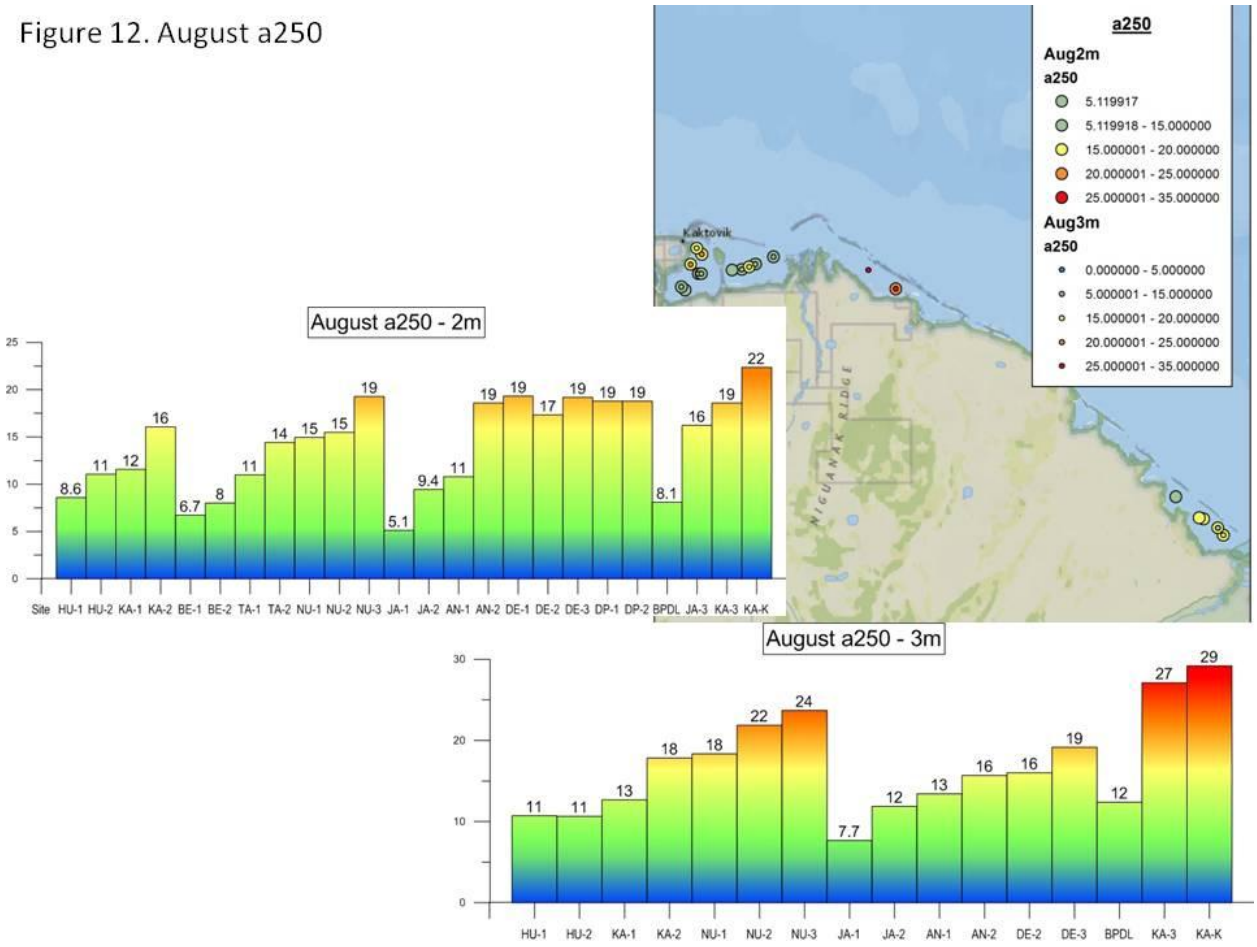


Figure 13. April SUVA -- Specific UV Absorbance

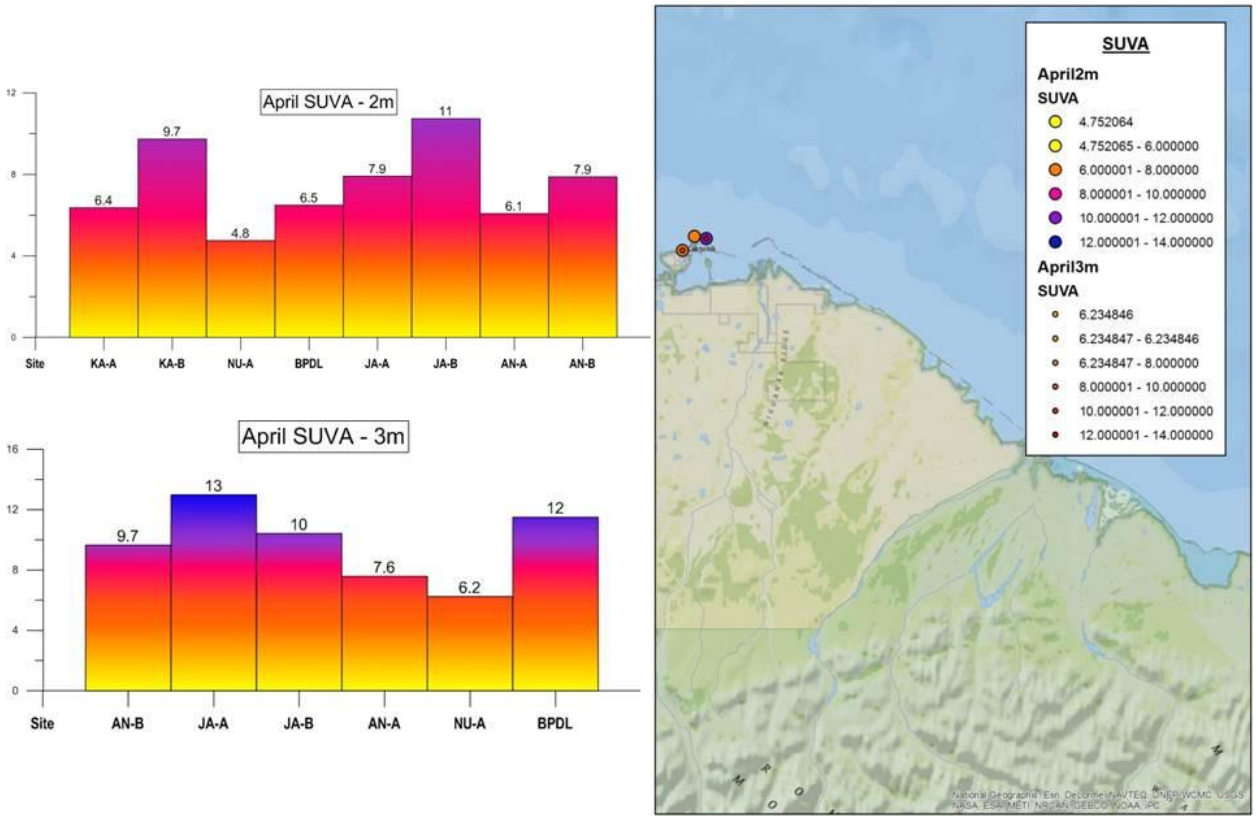


Figure 14. June SUVA – Specific UV Absorbance

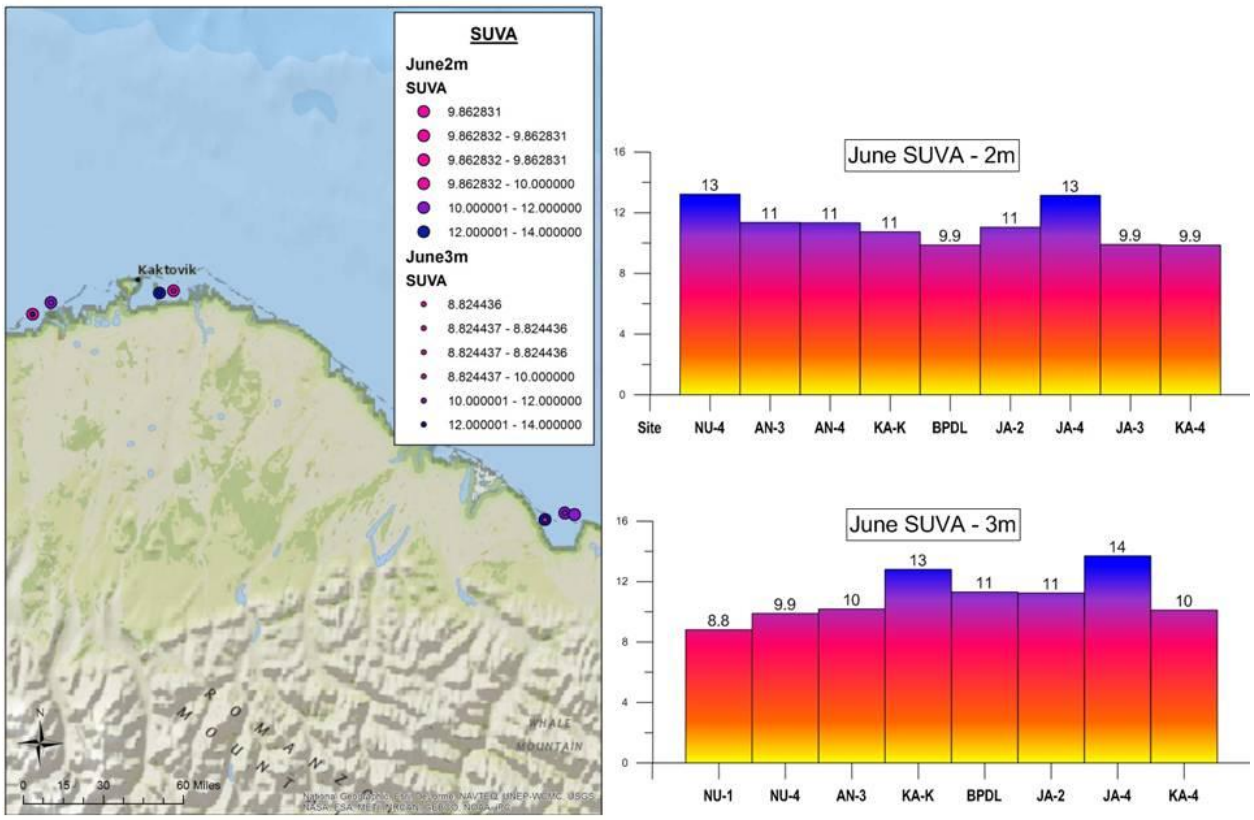
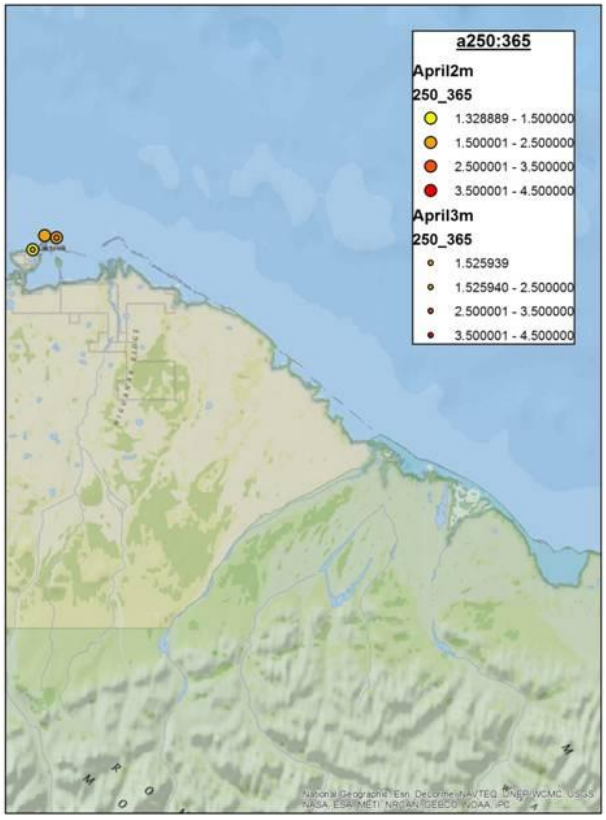
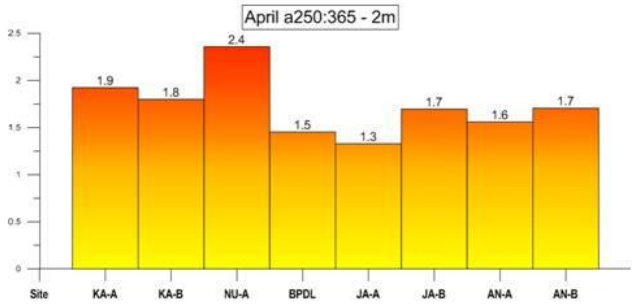


Figure 15. April a250:365





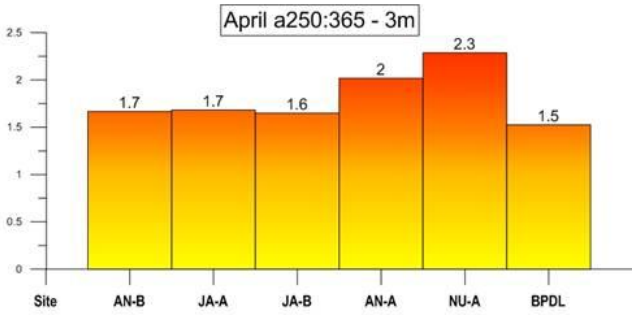
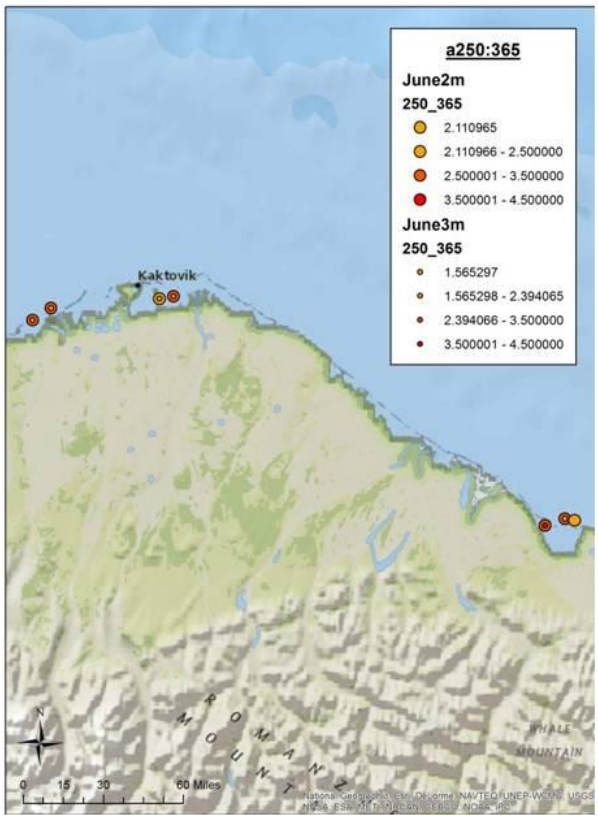
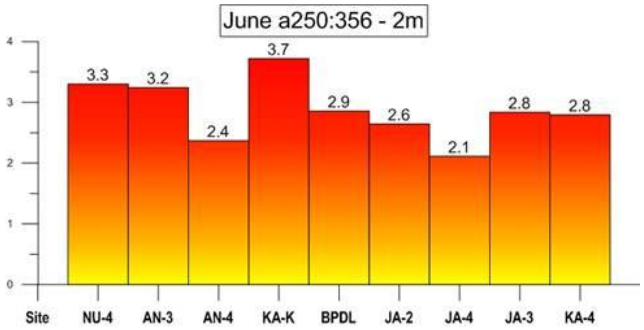


Figure 16. June a250:365





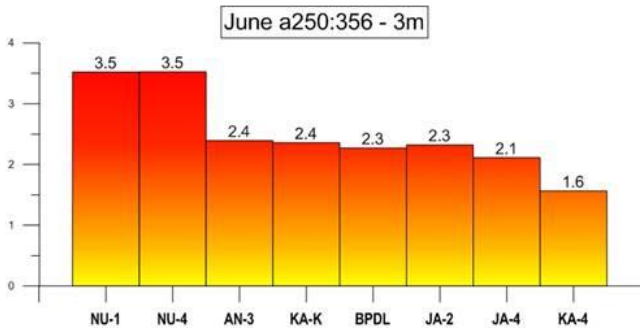
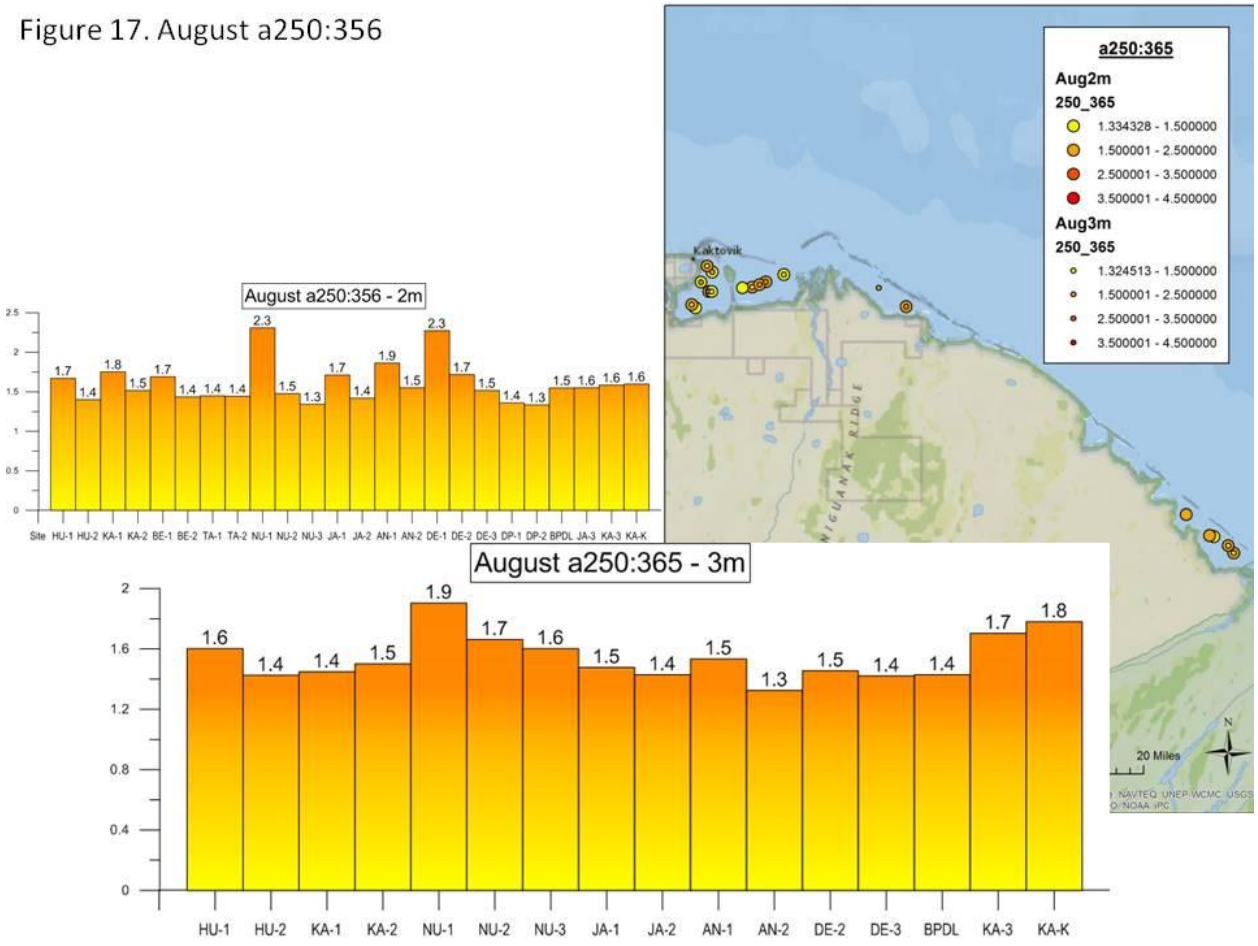


Figure 17. August a250:356



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