Final Report of SIMBA's SIMCO's (by C. Fritsen)

General Objective:

To assess sea ice microalgal biomass, community composition and pack ice biogeochemistry in context of the seasonal progression and succession of the sea ice cover.

Transit work:

On transit into the ice pack along ~90W, the observations of sea ice conditions showed a relatively rapid transition from marginal ice edge conditions to inner pack ice conditions. Small pancakes (up to ~ 30cm in diameter and frazil ice did not appear to have visible accumulations of microalgal biomass, yet pancakes in excess of ca. 30 cm often were visibly colored. Observations of larger pancakes and first year ice in transit to the pack ice interior suggested that the range of microhabitats (surface, interior and bottom) have produced accumulations of biota to the degree that the biomass is readily evident with the unaided eyes. Three stations were undertaken where ice cores were taken from ice floes that were prevalent in the ice observations.

Chlorophyll *a* profiles show that interior assemblages were prevalent in the cores obtained by JLTison 's group and confirmed that which could be seen in cores taken for integrated biomass measures. Flat ice of ca. 60 cm in thickness had high chlorophyll a at the ice water interface. Viewing of biota from thick first year ice cores showed the prevalence of *Corethron* and *Rhizosolena*, *Thalassiosira* (Figure 1) with lesser abundances of *Chaeotoceros* sp., *Fragilariopsis* sp. and *Syndera* throughout the ice interiors. The thinner (60 cm) undeformed first year ice had a thin algal band at the bottom of the ice that was dominated by *Fragilariopsis curta.*

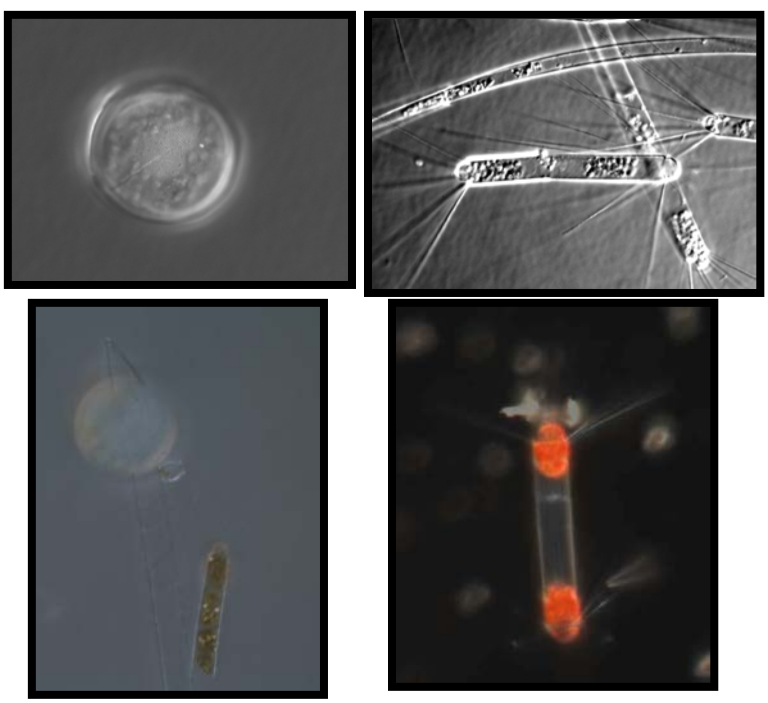


Figure 1: Upper Left *Thalassiosira* sp. : Upper right-*Corethron* sp. Lower Left *Rhizosolina*, *Corethron* and *Thalassiosira* sp. Lower right-*Corethron* sp. showing fluorescence of chloroplasts.

Ice station work:

Sampling ensued at the ice station to characterize the range of physical-chemical and biological conditions in the microhabitats of the sea ice floe. The floe was generally characterized by a predominant surface topography with 0.5 to 1.5 meter ridges and thick snow cover. The snow cover within these areas was commonly flooded with seawater thus creating a slush zone at the snow/sea ice interface that typically ranged from 2 to 30 cm thick (see the sea ice geophysics report from more precise details). The floe also contained a few areas where deformation was not prevalent and ice thicknesses were on the order of 60-100 cm (e.g. site Brussels and Liege) with relatively little snow cover (5-20 cm at the start of the ice station work). Samples from within the slush areas were taken to gather statistics regarding biomass and potential productivity in this prevalent habitat in addition to the consolidated sea ice habitats. Preliminary statistics show chla concentrations in the slush ranging between 0.3 to 16.6 ug chla l^{-1} and averaging ca. 6 ug l^{-1} (as of this writing some chlorophyll a data is still forthcoming and these values may change). These concentrations are slightly lower than the peak values that were found in a variety of cores obtained from different ice types embedded within the ISB ice floe (Figure 2) and peak values were 10 to 100-fold lower than those that have been reported in summer (Fritsen et al. 2000).

Thus, although it seems the biomass in these habitats was relatively enriched (e.g. hundred times higher than seawater) it is likely that the development and biomass

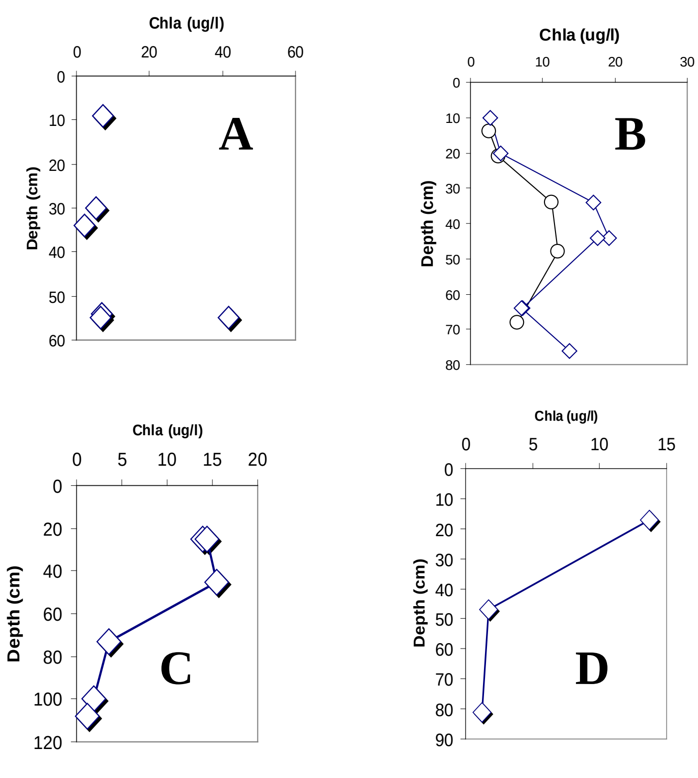


Figure 2. Examples of chlorophyll a profiles from cores collected at various sites on the ice floe A. near site Brussels- in flat FY ice. B. Flat FY ice near the ship. C. Ice near site Liege. Ice ca. 500 meters from ship near the geophysical thickness profile line.

accumulation in these communities was in progress during the ice station work. Preliminary nutrient data from only a few locations show some areas of nitrate depletion with relatively little drawdown of silica (Figure X). This could be indicative of microbial community development that is weighted toward non-silica requiring protists (e.g. dinoflagellates, prymnisophytes etc…) or enhance silica regeneration relative to nitrogen in these habitats. Whereas- these results are highly preliminary- microscopy, sampling and further experimentation may help in interpreting these remarkable geochemical signatures. Community composition analysis along with the more complete nutrient data set (that will be available in the days to weeks following the cruise end) will allow a better assessment of the degree to which the biotic communities had developed and whether or not they had depleted or enriched nutrient resources within the sea ice ans slush habitats.

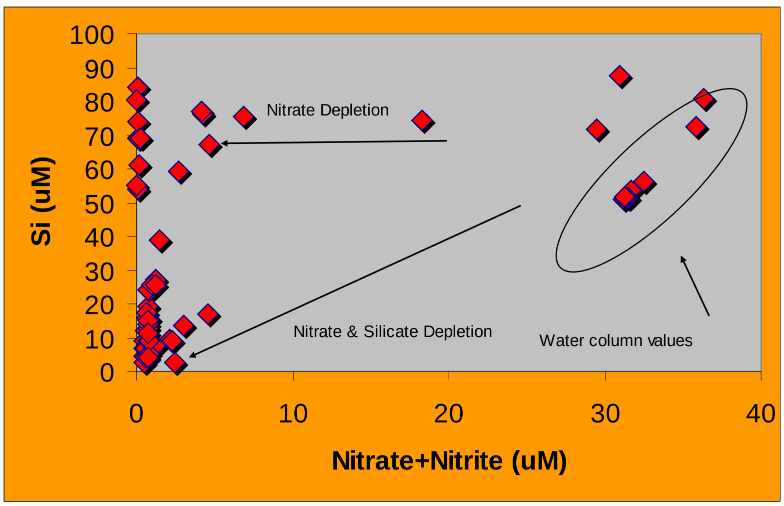


Figure 3: Preliminary results of nitrate and silica analysis showing apparent nitrate depletion with little Si depletion- relative to water column values.

In addition to sampling ice cores and slush from the ISB ice floe under ice images were obtained at several locations to better characterize the general morphology of sampling locations and the general nature of the ice floe.

At sampling location “Brussels” the under ice images showed a scalloped ice water interface that was indicative of n ablating surface and small (~10 cm in diameter) plumes of brine that were draining from the underside of the ice. These observations coupled with the measured cold temperature at the surface of the ice indicated a cooling and

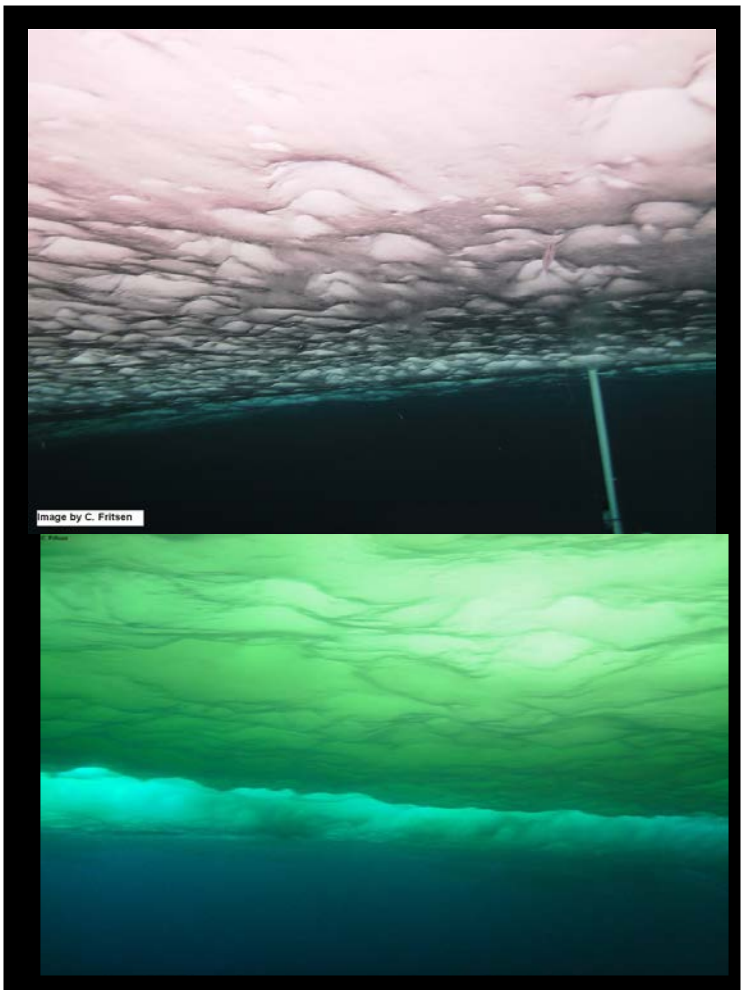


Figure 4. Top Image: The underside of the ice at Site Brussels (ice thickness sounder in background); Bottom Image: The underside of the ice at Site Liege (images by C. Fritsen).

freezing process in the upper ice column (which produces the brine drainage) yet melting at the ice water interface. Under ice images at site Liege also showed a scalloped morphology- again being indicative of an ablating surface- and more prevalent deformation features than at site Brussels. Under ice images from this location also were a noticeable shade of “green” that was likely due to the thicker snow cover, thicker ice and more algal biomass at this site.

Optics:

Measurements of light transmission through the ice and snow were made in areas near the ice mass balance stations at sites Brussels and Liege. These measure of incident downwelling and under ice downwelling irradiances when coupled with the measures of ice and snow thicknesses allow the first-order calculation of bulk ice and snow attenuation coefficients (Figure 5). Overall, these attenuation spectra were similar at each site and the minor differences between the two spectra (e.g. magnitude and slight shift in minima of ca. 20 nm) may be due in part to differences in SIMCO biomass pigmentation or scattering characteristics of the snow and ice. Through further analysis of samples that

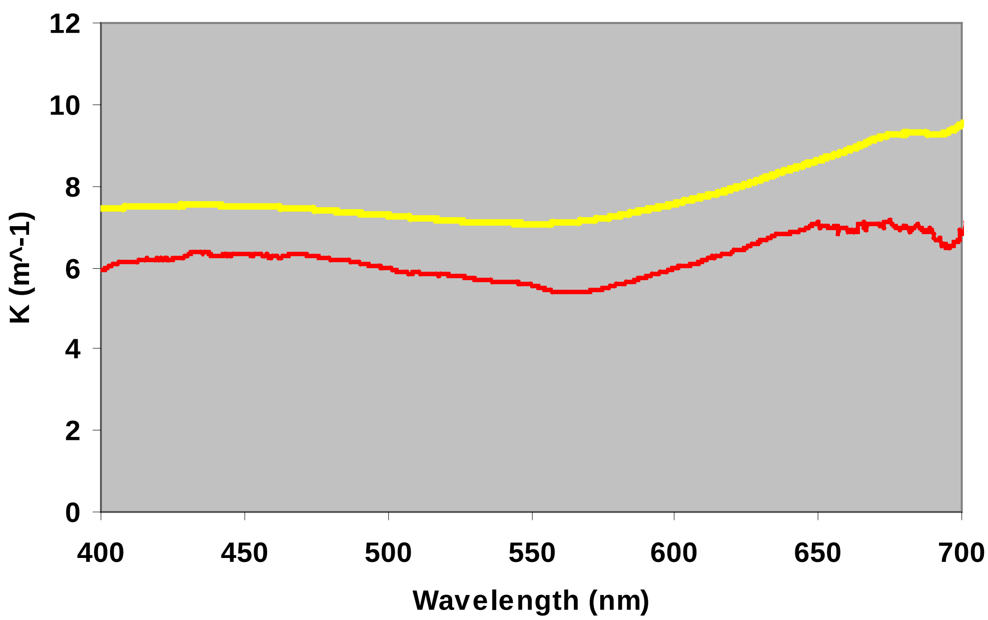


Figure 5. Attenuation coefficients for ice and snow at sites near Brussels (yellow line) and Liege (red).

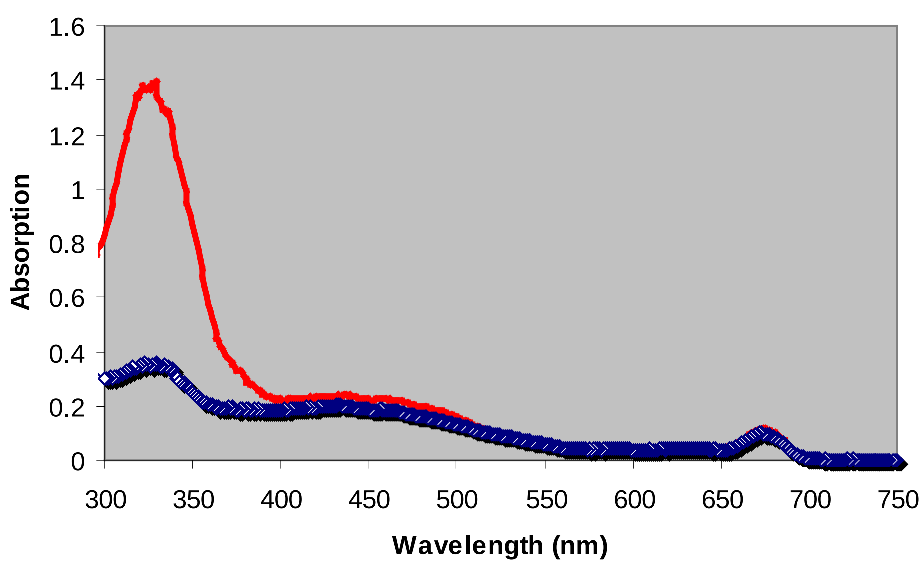


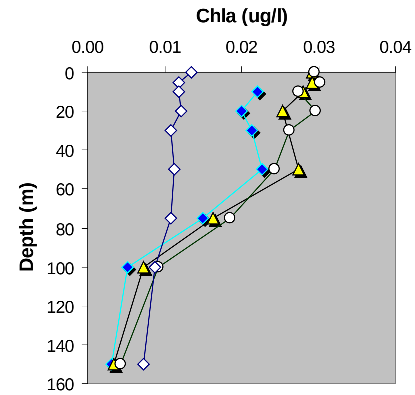
Figure 6. Absorption spectra from sea ice particulates collected from FY ice near site Brussels

were collected for measuring absorption properties of the sea ice particulates (i.e. algae, detritus, etc.., Figure 6) we aim to derive the disposition of radiant energy through the ice cover and will use this data to constrain estimates of primary production.   The preliminary assessment of these measures indicates the radiative transfer was weighted heavily by algal biomass and the overlying snow. Also of note is the relatively large absorption of ultraviolet radiation (UVR) by the ice algal/microbial communities in the upper layers of the ice (Figure 6). These spectra are strong indicators of in-situ photoprotective adaptations to UV by the resident biota.

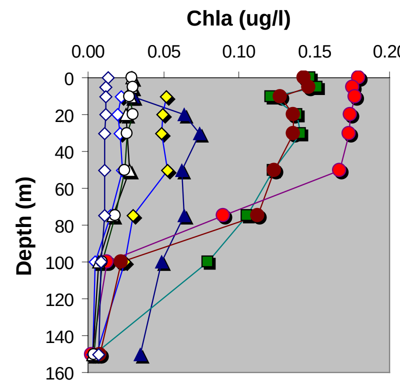
Water Column Chlorophyll a:

The first hydrocasts during transit into the ice station showed little vertical structure in regards to chlorophyll a concentrations with low values (less than 0.02 ug Chla l^{-1}) that are typical of winter conditions beneath pack ice. Vertical structure chla profiles in the upper 50 to 75 meters became apparent and upper mixed layer values increased by approximately an order of magnitude to values between ca. 0.15 to 0.2 ug chla per liter. Integrated over the upper 100 meters the biomass (as chlorophyll a) reached ca. 15.0 mg chl m^{-2} near its maximum values. Because the ice was drifting- this time series also has a spatial dimension and the profiles with the higher biomass were generally at or near the northern segments of the drift and near Peter I. Island.   The northern portion of the sampling area was not always ice covered during this austral spring.   Thus, the measured increases in the water column biomass may be to be due to the ice pack drifting over waters (northern) where biomass had previously accumulated during ice-free conditions and thus was relatively high. However, it is also just as plausible that some of the increase in water column biomass is due to the seeding of the water column from algae from within the pack ice habitats that was released during mechanical and thermodynamic ablation and melting processes that occurred during the study period (see reports on ice thickness changes from the geophysical group).   Further analysis of water column nutrients and biota from within the water column samples (e.g. water column samples from sites Brussels and Liege) may help in determining the processes that lead to the relatively large increases in water column biomass.

HC001, HC003, HC006, TMC 3



HC001, HC003, HC006, TMC 3,
then
HC 041, 042, 053, 067, 069



General Preliminary Conclusions:

The autotrophic biomass in the various sea ice habitats spanned several orders of magnitude with chla ranging from 0.05 to ~60 ug chla l^{-1}. The preliminary analysis of the biogeochemistry of the ice indicates these communities were affecting the nutrient status of the ice and the austral spring development of pack ice biomass was occurring during the program. Anecdotal observations of krill aggregates in association with the ice and findings of copepods in several slush samples collected on the surface of the ice suggests the energy derived by production within these habitats was being utilized by the local foodweb. Preliminary estimates of the biomass in the varied sea ice habitats has autotrophic biomass on the order of 10-20 mg chla m^{-2} . This value is close to that which was reached in the upper 100 meters of the water column at its highest point during the study. Thus, it appears as if the local austral spring processes produced biomass and energy within the snow, ice and water column. The coupling of these production processes to the sea ice geophysical dynamics will only be ascertained through further analysis of the program's combined efforts.

Figure 7:

Nutrients in Slush and Brine

Microscopy:

Ice Optics
--graphs

Primary Production: