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STUDIES OF SEDIMENT TRANSPORTED BY BEAUFORT GYRE PACK ICE, ARCTIC OCEAN, 1993: CONCENTRATIONS, TEXTURAL AND CARBON DATA

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Abstract

Two sampling expeditions to the coastal and offshore Beaufort Sea to study the sediment in the ice of the Beaufort Gyre encountered high sediment concentrations. Sediment concentrations in the sea-ice obtained during the Spring expedition averaged 49.5 mg/L, but ranged up to 821 mg/L. Concentrations measured during an offshore icebreaker cruise in August and September averaged 364 mg/L and ranged up to 10002.7 mg/L in part of a subsampled core. This average concentration is an order of magnitude greater than measured during similar field efforts in 1992. Spring studies indicated that sediment was prevalent in ice offshore of the stamukhi zone while ice inshore was relatively sediment-free. Studies at the end of summer found significant concentrations found as far as 79.5°N in the relatively sparse ice pack. Much of the sediment was found in pockets on the surface of first-year ice, although laterally discontinuous bands of sediment were seen within turbid ice in core sections suggesting entrainment by anchor ice. Most of the sediment consisted of clays and silts, although a 100km-wide belt of dirty ice off Point Barrow in the Fall included sands and gravels, as well as wood and leaves. Sediment was rare in samples from multi-year ice. Sediment concentrations in snow samples averaged 56.3 mg/L in the Spring and 2.4 mg/L in the Fall suggesting that aeolian processes are not major sediment contributors to offshore ice but may be an important local contributor to nearshore ice.

Introduction

As part of a continuing effort to discern climate change in geologic history, and to understand the relationship between climate change, and the Arctic Ocean ice pack, the U.S. Geological Survey undertook two expeditions to the Beaufort Gyre in 1993 (Figure 1). The first sampled ice in April and May and was incidental to a study of methane gas concentrations in Beaufort shelf water and ice (Kvenvolden et al., in press) (Figure 2). The second used the US Coast Guard Cutter *Polar Star* as a base for ice sampling during the fall of 1993 (Figure 3). Operations included geophysical transects, piston and box coring, water mass sampling and analyses, and the investigation of physical characteristics of the ice pack. This report presents data concerning the last of these emphases. Preliminary reports on other research can be found in Grantz et al. (1993).

Our study of the pack ice centered on three major research thrusts; First, the quantity and type of sediment contained in the Arctic ice pack and its method of entrainment. Second, the post-entrainment fate of the sediment in the Beaufort Gyre circulation patterns (Figure 1), and the metamorphosis of the ice/sediment mixture with age. Thirdly, the effect of the sediment on visible wavelength spectral signals and the ice albedo. The first two questions have been addressed recently by Barnes et al. (1982), Osterkamp and Gosink, (1984), Kempema et al. (1986; 1989; 1993), McCormick et al. (1993), Reimnitz et al. (1987; 1990; 1992; 1993a; 1993b; 1993c), Reimnitz and Kempema, (1987), and Clayton et al. (1990) primarily from studies of coastal areas. The effect of sediment on the albedo will be the subject of future publications.

Studies on the Beaufort Sea shelf indicate the inshore region (0-30 m; ranging down to 50 m) as the source for ice rafted sediment in the deep basin (Reimnitz et al. 1992; 1993a,c). However, only two major sediment entrainment events producing *turbid ice* occurred during 20 years of study (Kempema et al., 1989; Reimnitz et al., 1993c). The sediment load carried by the pack over the Canada Basin is highly variable (Reimnitz et al., 1993a, 1993c). The 1992 *Polar Star* cruise (McCormick et al., 1993) found little turbid ice. Considering the observed variability and the small portion of the polar ice pack that has been sampled, our knowledge is insufficient to permit generalizations about sea-ice sediment transport during interglacial times. This year's cruises were aimed at broadening that data base, determining the

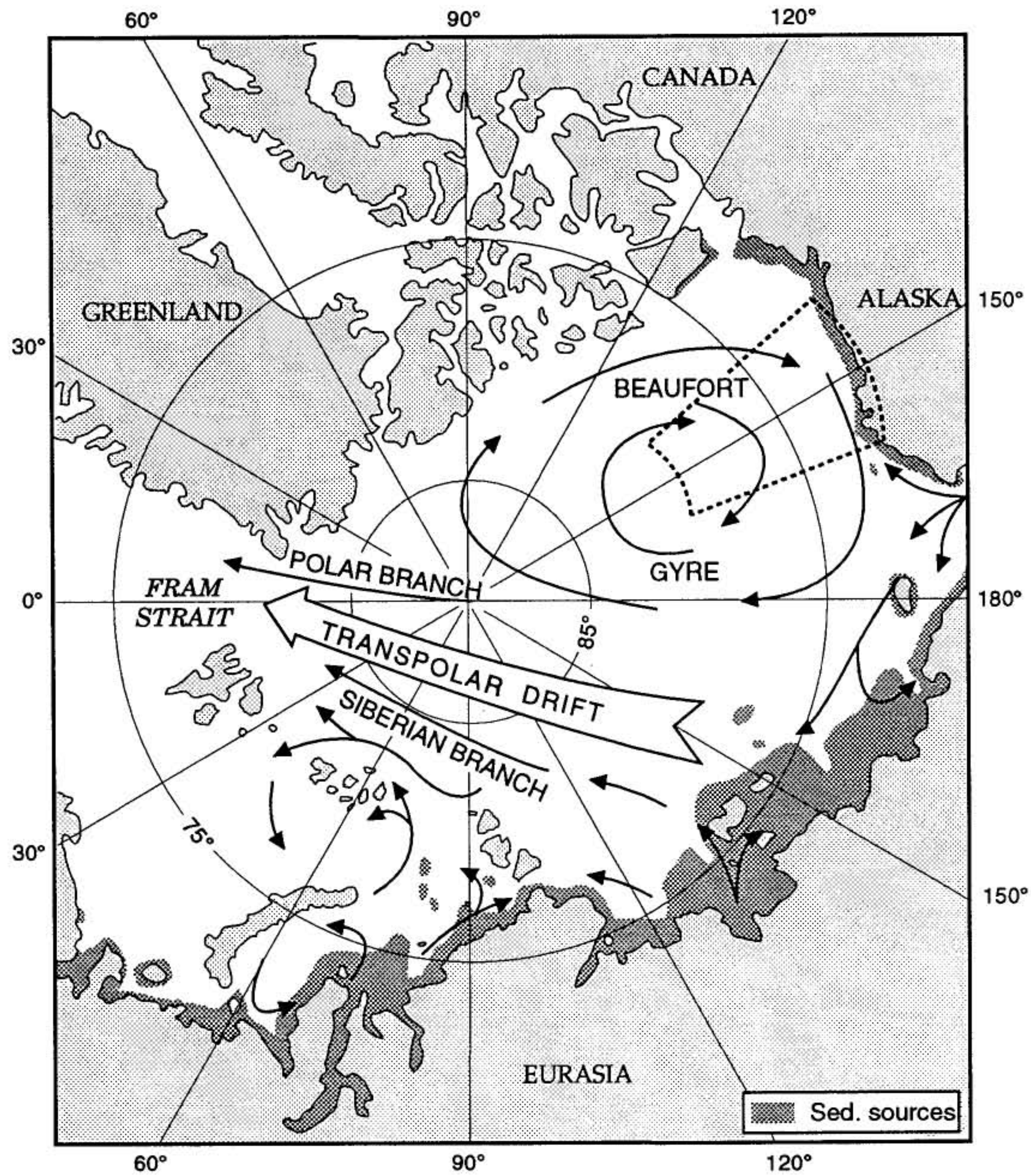

Figure 1 : Map of Arctic Ocean showing Beaufort Gyre and study area. Shelf areas shallower than 30m are stippled.

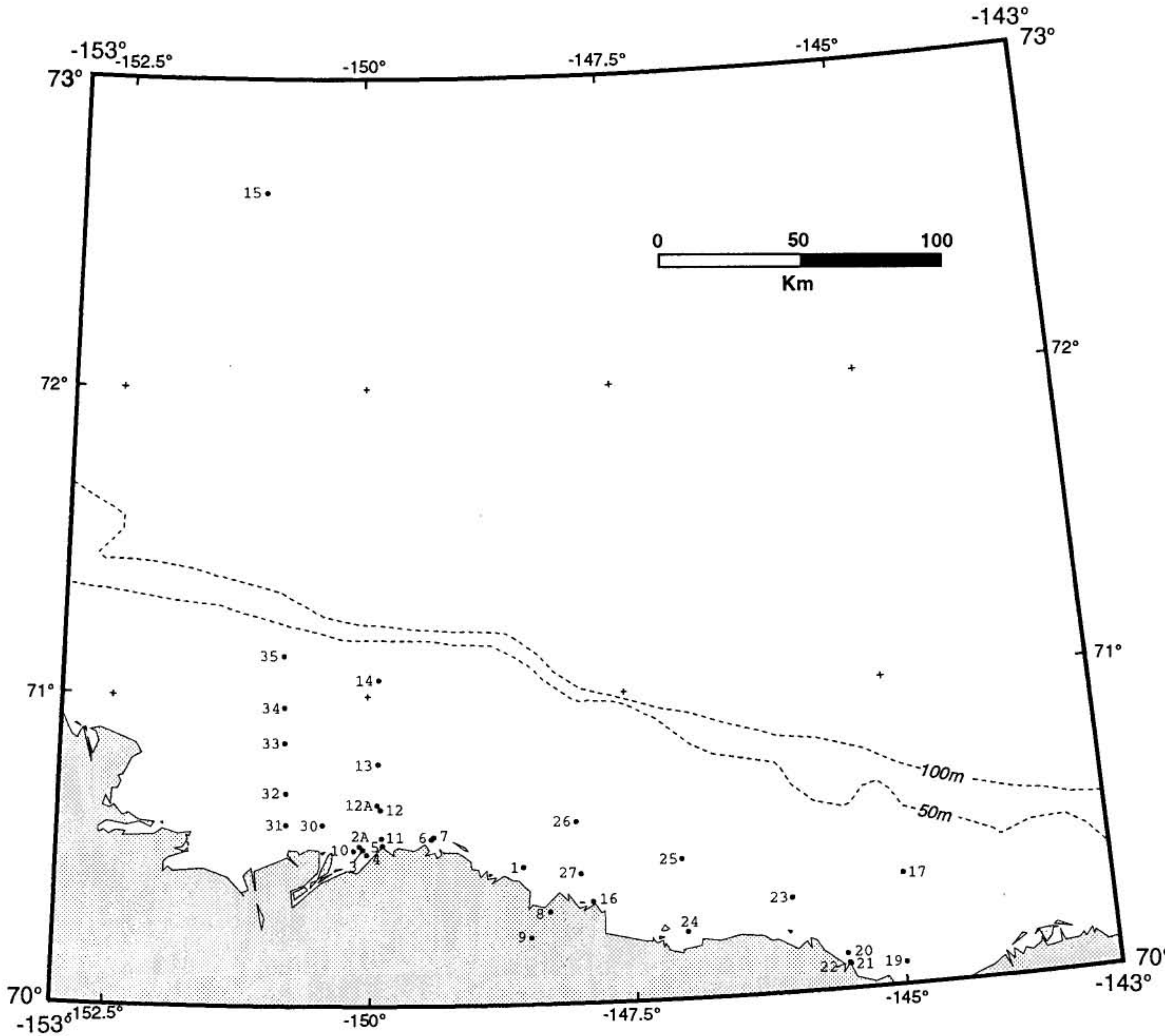

Figure 2: Alaksan Beaufort Sea 1993 station locations

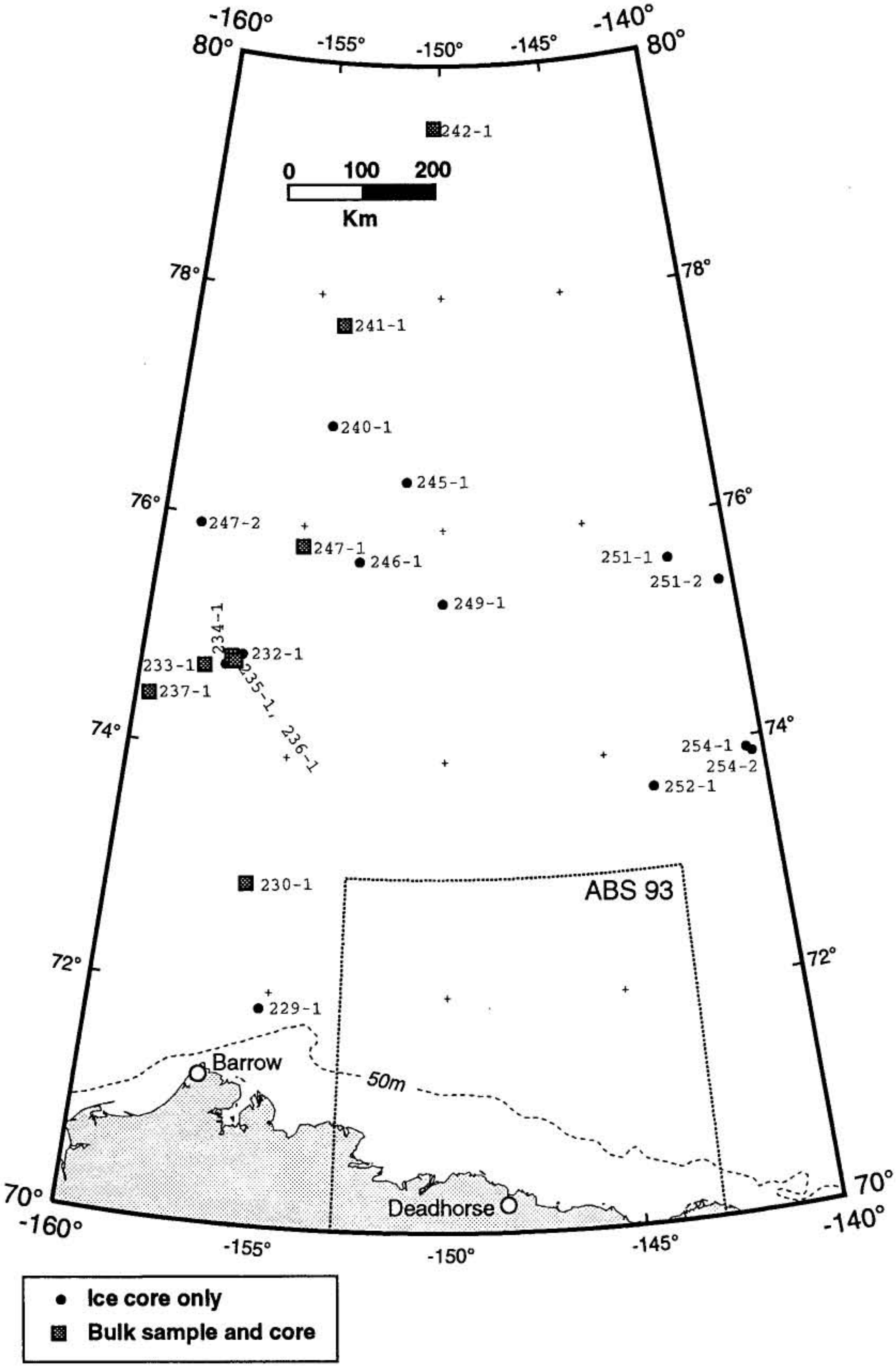

Figure 3: POLAR STAR 1993 Ice Stations

character of ice rafted sediment, and to compare ice-rafted sediment with that accumulating on the sea floor today.

Methods

We took ice samples, snow samples and water samples wherever opportunities were provided during the two 1993 expeditions (Figures 2, 3; Appendix A). Global Positioning Satellites (GPS) provided navigation control for all tracklines and sample sites. Sample logs are presented as Appendices B and C.

Ice samples were taken by a variety of methods. While cruising and breaking ice, small ice fragments were scooped out of the ocean using a dip net. When on the ice, ice cores were obtained. Some cores were split into sections to determine the variability of particle content down section. In some cases, fractures occurred in the cores at points of different physical properties in the ice such as slushy layers or granular ice. In such circumstances the splits were made at these fractures, and thus appear to have been made at random intervals. Melting of ice and snow samples was accomplished in a microwave oven. Water samples were filtered through pre-weighed 0.4 μm polycarbonate filters using a vacuum pump. The salt was removed by rinsing with distilled water. Filters were then re-weighed in the laboratory to determine particulate concentration in the ice in milligrams per liter of melt water (*SPM-suspended particulate matter*). Filters were also examined under a binocular microscope. The density of selected ice cores was determined by comparing the volume of ice with the volume of melt water. The snow was sampled to determine differences in particulate load between sea ice and snow. Care was taken during the snow collection to avoid particulate contamination from the ship or helicopter exhaust. These samples were treated identically to the ice samples.

Larger sediment samples were obtained by scraping sediment-rich ice, melting, and concentrating the sediment by flocculation using table salt. These samples were analyzed for textural characteristics by sieving and pipetting procedures described in Galehouse (1971) and for total carbon and inorganic carbon content using a CO_2 coulometer with an induction furnace and acid digester (Huffman, 1977). Statistical analyses for texture follow Folk and Ward (1957). Organic carbon was determined as the difference between total carbon and acid-digestible carbon. Carbonate percentage was derived by multiplying inorganic carbon by 8.33, a constant which assumes all carbonate is in $CaCO_3$.

Sea water sampling was abandoned shortly after the start of cruise PS93. Due to the sparse ice pack, the ship was able to maneuver around floes, therefore little sediment was released from the ice by the ship. Where sampled, water was obtained from a sea-water intake forward of the ship's discharge at about five meters depth. The water was pumped into a 20 L tank over periods of up to several hours where sediment was allowed to settle before being sampled, filtered and examined.

In order to facilitate a comparison between the sediment in the ice pack and that on the sea floor, we collected samples of the upper-most millimeter of certain box cores and of overlying water. These sediments are presumed to represent the most recent sedimentation and should contain any modern ice-rafted components.

The spring and fall expeditions use different conventions for station/sample numbers. The spring expedition's samples all have ABS93 (Alaska-Beaufort Sea 1993) as a preliminary modifier followed by a station number. The fall cruise's sample number's first modifier is PS93 representing *Polar Star* 1993. The second modifier is the Julian Day, followed by the station number for that day, and then the sample number. For example, sample 242-1-4 was taken on Julian Day 242, at station 1, and was the fourth sample at that station.

In addition visual observations were made of regional ice cover and types, percentages of discolored ice, thickness and extent throughout the cruises.

Results

The results of analyses are presented in Appendices D, E, and F, and are summarized in Tables 1 and 2.

Table 1. Summary of sediment concentrations of melt water and density of ice cores.

	SPM (mg/L)			Density		
	n	Avg.	Range	n	Avg.	Range
ABS93						
Ice	71	49.5	0.7 - 821.4	23	0.9	0.8 - 1.0
Snow	21	56.3	1.5 - 528.7	-	-	-
PS93						
Ice	61	364.7	2.7 - 10002.7	30	0.8	0.7 - 1.0
Water	2	4.2	0.9 - 7.4	-	-	-
Snow	2	2.4	1.1 - 3.8	-	-	-

Table 2: Summary of textural characteristics and carbon contents from 7 sea-ice samples collected on *Polar Star* 1993 cruise.

	Average	Range
Gravel (%)	9.1	0 - 64.0
Sand (%)	4.9	0.2 - 21.2
Silt (%)	43.7	11.1 - 55.1
Clay (%)	42.3	3.7 - 55.8
Mean Grain Size (μm)	347.2	2.3 - 2411.6
Sorting (phi)	3.0	2.7 - 3.9
Skewness	0.3	0.2 - 0.7
Total Carbon	1.61	1.09 - 2.18
Inorganic Carbon	0.06	0.01 - 0.27
Organic Carbon	1.55	0.93 - 2.15
$CaCO_3$	0.490	0.04 - 2.28

Eight broad categories of particulate matter were found on the filters. These are:

Algae : Seen as green silt-sized or finer particles, and as white powdery material.

Diatoms:

Foraminifera: Benthic or planktic foraminifera.

Metallic Spherules: Silt to sand-sized, metallic beads.

Red specks: Glassy red, silt-sized specks of unknown affinities, but probably resulting from contamination.

Sand: Sand-sized material.
Silt: Silt-sized mineral material was seen on all filters in varying amounts.
Wood: Woody material distinct from algae.
Larvae: Crustacean larvae.

ABS93

71 ice samples from 31 stations yielded sediment concentrations averaging 349.48 mg/L, ranging from 0.71-821.40 mg/L (Table 1). 21 snow samples from 19 stations had sediment concentrations averaging 56.3 mg/L which ranged from 1.5-528.7 mg/L,. 23 measurements of ice densities ranged from 0.8-1.0, and averaged 0.9. Many filters had large amounts of well-sorted silts, with occasional sand grains. Algae was abundant in the bottom of some cores as noted in Appendices B and D. The reader is referred to Appendix D for individual sediment concentrations, density results, and a listing of particle types on the filters.

Aerial and surface observations of the coastal and nearshore ice indicate two major zones of turbid ice concentration during our spring, 1993 observations. The ice inshore of the stamukhi zone (Reimnitz et al., 1977, 1978) was composed of first-year (FY) fast ice 130-180 cm thick, covered with 10-15 cm of snow. Occasional ridges and hummocks exposed clean-appearing ice as reflected in samples 1, 19, 27, & 30. Turbid ice was also seen in patches (less than 30% of the inshore ice cover) as represented by samples 3 & 5. When sediment was present, multiple cores at the same station indicated that the sediment was laterally discontinuous over distances of 5 or more meters. Algal discoloration was common in the bottom 5-10 cm of the ice cover.

Turbid ice was wide spread in the first-year ice offshore of the inner edge of the stamukhi zone (Samples 14, 25, & 17) where ridging exposed sea ice surfaces and edges through the snow cover. Aerial estimates of turbid ice ranged from 30-80% of the ice cover. The pervasive but muted occurrence of sediment was influenced by the snow cover. The particulate matter occurred as either disseminated 10-25 cm bands within ice blocks and ice cores, or as discrete horizontal, 1mm bands of sediment also within the ice. The latter are similar to surface ablation concentrations observed in summer. Their occurrence within the ice is unusual. The offshore extent of this turbid ice is unknown except that samples from a refrozen lead and adjacent ridge more than 200 km offshore (Sample 15) had very little particulate matter.

PS93

The 61 ice samples' sediment concentrations ranged from 12.7 to 10002.7 mg/L with an average of 364.7 mg/L. (Table 1). Ice densities in 30 measurements ranged from 0.7 to 1.0, averaging 0.8. Sediment concentrations in 2 water samples ranged from 0.9-7.4 mg/L, averaging 4.2 mg/L. Concentrations in snow ranged from 1.1-3.8 mg/L, averaging 2.4 mg/L (Appendix D).

Total carbon values averaged 1.6% of total weight, ranging from 1.1-2.2% (Table 2; Appendix E). Carbonate values averaged 0.49, ranging from 0.04 to 2.30%.

The mean grain size of ice-rafted material was 347 micrometers although this number is skewed due to the extreme coarseness of sample 230-1 which contained 64% gravel (Table 2; Appendix F). Most samples were primarily composed of muds. All samples were poorly sorted and positively skewed

Algae were found on many ice-sample filters. Quartz and other sand-sized fragments rarely occurred. Diatoms were rather common, while foraminifera and other biogenic components were found infrequently. Particulate matter on snow-sample filters was primarily algae, but other components were seen. Water-sample filters contained similar particulates. Core top slurries primarily contained silts and planktic foraminifera. Full results of the microscopic analyses can be found as Appendix D.

Shipboard and aerial observations showed large amounts of turbid ice throughout the first half of the cruise. A zone of extremely dirty, rotten first-year ice (represented by sample 230-1) was encountered north of Barrow to about 100km offshore. Dirty ice in this 1-4/10ths total ice cover was 8-9/10ths of the total. The sediment in this belt had concentrations of coarse grains in small patches, and commonly contained wood and leaves. Sediment was concentrated at the surface, but the ice was turbid to about 50 cm. Stations following 230-1 contained less sediment, most of which was finer grained. This sediment occurred as concentrations under a slightly frozen snow cover and was thus, commonly hidden from direct view from the passing ship. However, it was recognized that hummocks of snow covered FY ice were often slightly discolored. Close examination found sparsely separated sand grains on the surface of the frozen snow. When this was removed sediment was often found concentrated as a layer that was laterally discontinuous on the solid ice's upper surface. Occasionally sediment was seen in clumps down core. Sediment commonly occurred in cryoconite holes and on submerged ice rams. Sediment was found in this mode as far north as 79°29'N, although as we proceeded farther north, the amount of multi-year (MY) ice increased. This ice had less sediment. The ice encountered towards the end of the cruise over the Canada Basin was very dense, multi-year and clean.

In general, there was a very sparse ice cover during the cruise as far north as 79° enabling the ship to transit through large open leads most of the time.

A brown leafy algae was seen throughout the cruise. This often was observed growing on the underside of the ice and floated to the surface as the ice was broken.

Discussion

The average sediment concentrations of 1993 samples were unusually large being a magnitude greater than 1992 (McCormick et al., 1993). This may partially reflect the number of 1993 ice cores sub-sampled at small intervals which included dense sediment concentrations.

Sediment concentrations showed indications of having been entrained by anchor ice. These include the findings of sediment concentrated into clumps within turbid bands of ice and the occurrence of coarse material and wood. Future analysis of enclosed fauna will test this hypothesis.

Much of the sediment sampled in 1993 was hidden from view by a thin crusty semi-frozen snow layer. This indicates that sediment in the Beaufort Gyre is not easily delineated by aerial observations when snow is present. This observation also complicates tracking of sediment pulses using visible band remote sensing.

Sediment concentrations in snow samples averaged 56.3 mg/L in the Spring and 2.4 mg/L in the Fall suggesting that aeolian processes are not major sediment contributors to the offshore ice sampled from the *Polar Star* but may be an important local contributor to nearshore ice sampled in the Spring.

Almost all the sediment seen in 1992 (McCormick et al., 1993) occurred along the southern edge of the Gyre. The 1993 cruise showed substantial sediment-laden ice in the central-western portions as well as the southern fringe of the Gyre. Little sediment seems to be present in the central Gyre.

A further difference between PS92 and PS93 concerns the amount and type of algae seen. In 1992, there was an abundance of a fine filamentous algae seen growing within the ice, often forming melt voids within the ice. Little of this algae was seen in 1993 except on the underside of the ice during the spring observations, although as noted, there was an abundance of leafy algae growing on the underside of the ice.

In conclusion, the 1992 and 1993 observations from the *Polar Star* encountered different ice regimes in terms of total coverage and sediment concentrations. These observations suggest it is unwise to extrapolate ice conditions from one year to another.

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APPENDIX A - Station locations

Station	Latitude (N)	Longitude (W)	Bulk	Ice Core	Other	Box core slurry
ABS93						
ABS-93-1	70.4393°	148.5274°		3		
ABS-93-2(2A)	70.5162°	150.0986°		1(2)	snow	
ABS-93-3	70.4994°	150.0621°		2	snow	
ABS-93-4(4A)	70.4830°	150.0246°	1	1(1)	snow	
ABS-93-5	70.5122°	149.8627°	2	1	snow	
ABS-93-6	70.5329°	149.3982°		1	snow	
ABS-93-7	70.5416°	149.3727°		1	snow	
ABS-93-8	70.2932°	148.2923°	1		3 snow	
ABS-93-9	70.2154°	148.4845°			ice, 2 snow	
ABS-93-10	70.5026°	150.1473°		2		
ABS-93-11	70.5386°	149.8736°		2		
ABS-93-12	70.6342°	149.8814°		2		
ABS-93-12A	70.6493°	149.9212°	1		ice	
ABS-93-13	70.7805°	149.9013°		2	snow	
ABS-93-14	71.0527°	149.8899°		2	ice, snow	
ABS-93-15	72.6397°	151.0547°	2		3 ice	
ABS-93-16	70.3239°	147.8711°		1	snow	
ABS-93-17	70.3531°	144.9489°		1	snow	
ABS-93-19	70.0692°	144.9983°		2	snow	
ABS-93-20	70.1125°	145.5263°	1	2	snow	
ABS-93-21	70.0792°	145.5145°			ice	
ABS-93-22	70.0850°	145.5074°		1	snow	
ABS-93-23	70.3089°	146.0128°	1	2	ice	
ABS-93-24	70.2192°	147.0092°		2	snow	
ABS-93-25	70.4527°	147.0136°	1	2	ice	
ABS-93-26	70.5856°	148.0121°	1	2		
ABS-93-27	70.4128°	147.9959°	1	2		
ABS-93-30	70.5868°	150.4555°		2	snow	
ABS-93-31	70.5848°	150.8078°	1	2		
ABS-93-32	70.6847°	150.7991°		2	snow	
ABS-93-33	70.8485°	150.8104°		2		
ABS-93-34	70.9640°	150.8091°		2	snow	
ABS-93-35	71.1324°	150.8235°	2	2		
POLAR STAR 1993						
PS93-229-1	71°50.24	155°13.46			ice	
PS93-230-1	72°52.73	155°46.15	1	2		BC1
PS93-232-1	74°48.08	157°09.46	1		snow	
PS93-233-1	74°42.69	157°58.61	1	2		
PS93-234-1	74°44.46	157°13.47		3		
PS93-234-2	74°44 59	157°13 47	1			
PS93-235-1	74°50.69	156°47.89	1	2		
PS93-236-1	74°49.40	156°44.58	1	2		
PS93-237-1	74°24.27	159°39.54	1	2		
PS93-240-1	76°51.80	154°12.86	1	3		
PS93-241-1	77°44.02	153°58.37	1	3		
PS93-242-1	79°27.42	150°22.27	1	2		
PS93-245-1	76°24.40	151°20.18		2		
PS93-246-1	75°42.26	153°09.87		2	snow	

PS93-247-1	75°49.14	155°00.27	1	4		
PS93-247-2	75°56.39	158°44.76		2		
PS93-249-1	75°20.62	150°02.44		2		
PS93-251-1	75°35.92	142°05.07		1		
PS93-251-2	75°21.0	140°31.1		2		
PS93-252-1	73°41.42	143°34.64		2		
PS93-254-1	73°53.21	140°29.67			ice	
PS93-254-2	73°51.33	140°22.47		1		
PS93-254-3	73°52.43	140°36.47				BC17

APPENDIX B - Alaska-Beaufort Sea 93 sample notes

Sample #	Vol. filtered (ml)	Filter #	Sample type
ABS-93-1-1	850	426	Ice core
Segments 20-30 and 55-65cm in ice core.			
ABS-93-1-2	870	427	Ice core
Segments 105-115 and 150-160 in ice core - can be used for density			
ABS-93-1-3	765	428	Ice core
0-10cm segment of ice core.			
ABS-93-2-1	505	434	Snow
Snow sample at core site 1 mile southeast of Thetis ice island and north of the ice road from pad 3M to the SE tip of the island.			
ABS-93-2-2	530	433	Ice core
0-13cm in ice core.			
ABS-93-2-3	795	432	Ice core
30-41cm plus 67 -71cm in ice core.			
ABS-93-3-1	195	440	Ice core
460ml remainder decanted into vial for bulk sample (103-2-1). Thus total melt from 0-15cm section of ice core was 655ml.			
(103-2-1)			Bulk sample
Decanted sediment from ABS93-3-1.			
ABS-93-3-2	790	437	Ice core
55-75cm section of ice core.			
ABS-93-3-3	193	441	Ice core
Total melt from 0-20cm section of core was 793ml. Core hole adjacent to 93-3-2.			
ABS-93-3-4	490	431	Snow
Upper 10cm of snow.			
ABS-93-4-1	294	443	Ice core
0-20cm section of ice core. Total melt from section was 784ml.			
ABS-93-4-2	780	435	Ice core
50-70cm section of ice core.			
ABS-93-4-3	425	430	Snow
Snow sample of upper 10cm of snow.			
ABS-93-5-1	101	444	Ice core
0-20cm of turbid ice core. Total melt volume of core section was 751ml.			
ABS-93-5-2	98 99	438 439	Ice core
45-55cm of turbid ice core. Total melt from section was 437ml.			

ABS-93-5-3 400 436 Snow
Snow sample from upper 10cm northeast of Oliktok seawater plant.

ABS-93-5-4 725 442 Ice core
Core sample of congelation ice.

ABS-93-4A-1 810 445 Ice core
0-20cm of 155cm ice core taken on Thetis ice road nearest mainland coast. Turbid ice at 8-12cm.

ABS-93-4A-2 925 446 Ice core
110-122 and 135-145cm of 155cm core.

ABS-93-2A-1 750 447 Ice core
Clean ice. Can not see granularity seen at surface of Station 93-2. Taken 1mile from Thetis Island.

ABS-93-2A-2 750 448 & 449 Ice core
152-172 segment of ice core that had algal discoloration at 165-172cm.

Blank filter 100 450

ABS-93-6-1 800 451 Ice core
0-20cm segment of 164cm ice core with discoloration at 8-12 cm.

ABS-93-6-2 705 452 Ice core
142-162cm of core with algal discoloration in bottom 10cm. Algae stuck to the side of the filter funnel.

ABS-93-6-3 470 453 Snow
Snow sample -- Drill rig NE of this location. Contains noticeable sand particles.

ABS-93-7-1 820 454 Ice core
0-20cm of clean core offshore?? of small island where we ran into bed at base of core at 164cm. May contain sand particles.

ABS-93-7-2 840 455 Ice core
110-130cm of 164cm long core. Some slight discoloration. May contain sand particles.

ABS-93-7-3 365 456 Snow
Snow sample - drill rig to the ENE about 1km.

ABS-93-8-1 370 457 Snow
Dirty surface snow at Dunes site on East Dock Road 30m south of road.

ABS-93-8-2 470 458 Snow
Clean snow between surface discoloration and dirty snow below.

ABS-93-8-3 100 459 Snow
Dirty granular snow above the tundra surface at Dunes site.

ABS-93-9-1 925 460 Ice
Representative clear clean ice from Lake Colleen.

ABS-93-9-2 220 461 Snow
Surface discolored snow from upper 1-2cm on Lake Colleen.

ABS-93-9-3 385 462 Snow
Underlying cleaner snow above lake ice on Lake Colleen.

ABS-93-10-1 815 466 & 467 Ice core
0-20cm of 85cm-long ice core
0-10cm is clean. 10-35cm has dirty bands which are dirtiest between 15 and 25cm. 35-85cm consists of clean ice.

ABS-93-10-2 815 468 Ice core
65-85cm section was same core as 10-1.

ABS-93-10-3 675 469 Ice core
Representative cuts of 80cm-long core taken 25m away from 10-1 and 10-2. Less turbid than those previous core. 0-3cm clean, 3-14cm turbid, 14 to base is clean.

Blank filter 100 470

ABS-93-11-1 800 471 & 472 Ice core
0-10cm plus 70-80cm of clean ice core. 2.8m water depth Filtered very slowly.

ABS-93-11-2 785 473 Ice core
0-10cm plus 75 to 85cm of clean ice core.

ABS-93-11-3 100 481 Algae from ice core
Algae from 160-165cm at base of core.

ABS-93-12-1 780 464 Ice core
Representative sample of 85cm ice core. Turbid band at 30-35cm, clean above and below. 14.3m water depth.

ABS-93-12-2 765 474 Ice core
Representative sample of ice core taken 25m away from 12-1.

ABS-93-12-3 75 483 Algae from ice core
Algae from base of core.

ABS-93-12A-1 200 482 Ice
Sample of turbid ice (50+% of ice) from 50x100mx10m high ice ridge between stations 12 and 13. Also took bulk sample in vial.

ABS-93-13-1 445 475 Snow
Snow sample at 20m water depth station.

ABS-93-13-2 815 478 Ice core
Clean ice core representative sample.

ABS-93-13-3 820 480 Ice core
Ridge ice core 100m to south of 13-2. Has 10% turbid ice +/- 20%.

ABS-93-14-1 815 465 Ice core

Representative sample of ice core. 0-14cm is clear, 14-18cm has slight discoloration, 18-79cm is clear, 79-85cm is turbid, 85-110cm is clear.

ABS-93-14-2 775 479 Ice core
Representative sample of ice core taken 25m east with slight discoloration at 10cm. Sampled 0-20cm.

ABS-93-14-3 360 476 Snow
Snow sample.

ABS-93-14-4 100 477 Ice
Selected turbid ice from shear ridge rubble within 50m of sta. 14. Most of sample in vail.

ABS-93-15-1 630 463 Ice
Ice cuttings from 40cm-thick refrozen lead offshore.

ABS-93-15-2 not filtered Ice
Sample of discolored cuttings.

ABS-93-15-3 not filtered Ice
Sample of multiyear ice ridge. Looks clean.

ABS-93-16-1 905 484 Ice core
0-22cm clear ice core from east end of Endicott Causeway.

ABS-93-16-2 475 485 Snow
Snow sample.

ABS-93-17-1 605 486 Ice core
Representative vertical cut of upper 60 cm of clear ice core.

ABS-93-17-2 420 487 Snow
Snow sample.

ABS-93-17-3 100appox. 488 Algae from ice core
Algal layer from 175-178cm in ice core.

ABS-93-19-1 885 500 Ice core
Representative cut of clean 135cm ice core from Camden Bay.

ABS-93-19-2 890 551 Ice core
Representative cut of second ice core from Camden Bay.

ABS-93-19-3 340 499 Snow
Snow sample.

ABS-93-19-4 497 Algae from ice core
Algal stain at bottom of core (130-135cm).

ABS-93-20-1 905 552 Ice core
Representative cut of clean 135cm ice core from Camden Bay.

ABS-93-20-2 865 566 Ice core

Representative cut of clean ice core 25m west of 20-1.

ABS-93-20-3 390 498 Snow
Snow sample.

ABS-93-20-4 553 Ice
Non-representataiave dirty ice sample from ridges. Also took sample in vial.

ABS-93-20-5 496 Algae from ice core
Algae from 130-135cm in ice core

ABS-93-21-1 775 555 Ice
Clean looking ice from Canning Delta. Layers of sediment near base.

ABS-93-22-1 740 556 Ice core
Clean ice core in shallow water off Canning Delta.

ABS-93-22-1 310 557 Snow
Snow sample.

ABS-93-23-1 820 558 Ice core
Representative sample of ice core with turbid ice from stamukhi zone.

Blank Filter 100 560

ABS-93-23-2 895 561 Ice core
Representative sample of ice core taken 25m away from 23-1.

ABS-93-23-3 not filtered vial Ice
Sediment sample from the ridges.

ABS-93-24-1 815 562 Ice core
Representative sample of ice core from 1.6m of ice from Leffingwell Lagoon.

ABS-93-24-2 820 564 Ice core
Representative sample of ice core taken 25m west of 24-2.

ABS-93-24-3 395 565 Snow
Snow sample.

ABS-93-25-1 860 489 Ice core
Representative sample of ice core from stamukhi zone.

Blank filter 100 490

ABS-93-25-2 795 493 Ice core
Representative sample of ice core taken 25m away from 25-1.

ABS-93-25-3 not filtered 563 Ice
Non-representative sample of dirty ice. Also took sample in vial.

ABS-93-26-1 775 491 Ice core
Representative sample of 130cm clean ice core from stamukhi zone north of Cross Island.

ABS-93-26-2 800 492 Ice core
Representative sample of ice core taken 25m northeast from 26-1.

ABS-93-26-3 559 Algae from ice core
Algal layer from base of core.

ABS-93-27-1 875 494 Ice core
Representative sample of 160cm clean ice core taken south of Cross Island.

ABS-93-27-2 860 495 Ice core
Representative sample of clean ice core taken 25m north of 27-1.

ABS-93-27-3 not filtered 554 Algae from ice core
Algal material from base of core.

ABS-93-30-1 785 581 Ice core
Harrison Bay core taken in 10m water. "Thinly" turbid; upper 15cm granular.

ABS-93-30-2 875 582 Ice core
Representative ice core 5m from 30-1. Similar appearance.

ABS-93-30-3 325 583 Snow
Snow sample.

ABS-93-31-1 770 584 Ice core
180cm long ice core. Taken in Harrison Bay. Discoloration at 25-50cm.

ABS-93-31-2 840 585 Ice core
Ice core taken 5m from 31-1.

ABS-93-31-3 not filtered 586 Algae from ice core
Algal discoloration at base of core.

ABS-93-32-1 810 587 Ice core
Representative sample of ice core from 16m of water in Harrison Bay. Very dirty cores which are variable from site to site.

ABS-93-32-2 825 589 Ice core
Ice core representative sample taken 5m from 32-1 Similar to 32-1.

Blank filter 100 590

ABS-93-32-3 435 588 Snow
Snow sample.

ABS-93-32-4 591 Ice core
Non-representative 13cm section of ice core with sediments.

ABS-93-33-1 780 592 Ice core
Clean ice core although slight and random sediments can be seen in surrounding ridges when examined very carefully.

ABS-93-33-2 840 593 Ice core

Representative core taken 5m away from 33-1.

ABS-93-34-1	805	594	Ice core

Clean ice core taken at this site in 14m of water.

ABS-93-34-2	805	595	Ice core

Clean ice core duplicate from this site.

ABS-93-34-3	410	596	Snow

Snow sample.

ABS-93-35-1	825	597	Ice core

Very dirty ice began between last station and this one. This core is representative of one end of the variability of turbidity.

ABS-93-35-2	825	598	Ice core

Representative cut of second core at this site. Includes some layering.

ABS-93-35-3		599	Ice core

4cm of core with a lot of dirt that occurred as a nearly discrete layer. Also took bulk sample in vial.

ABS-93-35-4	not filtered		Ice sample

Selected chips and scrapes of ridge 50m south of site collected for bulk sediment sample analysis. This is in first-year ice and has not been concentrated as much as it will later this year. However there were abundant bands running at angles, presumably rafted.

APPENDIX C - *Polar Star* 93 sample notes

All Filter Numbers have the prefix 93- (i.e. 93-1). All sample numbers have the prefix PS93-. Italicized notes are notes made after visual analysis of sand fraction from grain size residue.

AUGUST 17, JD 229

Sample #	Vol. filtered (ml)	Filter #	Sample type
229-1-1	150	1	Ice

Ice sample taken from dip net while underway. Mostly algae.

229-2-1	960	2	Water

Water sample taken while steaming from 1700-2000hrs.

AUGUST 18, JD 230

230-1-1	None		Bulk

Bulk sample from very dirty floe. Abundant pebbles. Common leaves, twigs and algae fronds. Rare shell debris.
Abundant large graywacke pebbles. Predominantly clear and opaque quartz. Abundant chert. Grains very angular to rounded. Poorly sorted. common plant material. Very rare foraminifera. Rare large black clasts.

230-1-2(0-15cm)	270	3	Ice core
(15-30)	350	4	
(30-48)	423	6	

48 cm core from same station as above. Top 2 cm is dirty. The rest appears clean.

230-1-3(0-91)	420	5	Ice core

representative sample of a whole core taken at same station. Took 1/4 section lengthwise of core using circular saw. Filter may contain some rust flakes from saw blade. Top 5 cm is turbid. There are occasional mottled turbid layers below: especially from 58cm-75 cm.

230-1-4	None		BC slurry

Box core slurry from top of Box Core 1.

AUGUST 20, JD 232

232-1-1	645	7	Snow sample

Snow sample

232-1-2(0-90)	490	8	Ice core

Melt water from 90cm core of clean looking FY ice from area of minor ridging.

AUGUST 21, JD 233

233-1-1(0-10cm)	150	9	Ice core
(10-27)	535	10	
(27-42)	545	12	
(42-52)	405	11	
(52-83)	325	13	

83cm ice core taken from small floe with some ridging that showed discoloration in cross-section. Surface was covered with algae balls. 0-10 cm was slushy with algae balls; 10-27cm was clean granular ice; 27-42 cm was solid clean, clear ice; 42-52cm was clear ice-mostly clean except for a 1/2 cm laminae at 48cm; 52-83cm composed of clean granular ice.

233-1-2 None Bulk
Surface ice scraped off. Included many algae balls.

233-1-3 463 15 Ice core
A second core which was taken for archiving but spilled out of tube onto ice. Thus all was melted for SPM value comparison to 233-1-1.

Blank Filter 16 Blank Filter

SUNDAY, AUGUST 22, JD234

234-1-1(0-77) Archive core
77 cm archive core taken from top of small pressure ridge - appears clean.

234-1-2(0-10cm)	175	14	Ice core
(10-38)	204	17	
(38-80)	450	18	
(80-90)	100	19	

90 cm core taken from area of small ridging. Appears clean throughout. Top 10 cm is slightly slushy, and did not hold together well. The rest of the core was hard, clean, clear and granular.

234-1-3(0-~50cm) 420 20 Ice core
Ice core taken. Entire core melted to give representative SPM. Total length unknown due to fractured nature of core but is estimated to be about 50 cm long.

234-2-1 405 21 Surface ice
Surface scrapings from a small ridged ice block (2 x 2 x 2m) that appeared dirty. Taken 30 m from station 234-1. This location could not be cored because of the unstable nature of the floe.

MONDAY, AUGUST 23, JD 235

235-1-1(0-12cm)	200	22	Ice core
(12-30)	270	23	
(30-42)	225	24	
(42-60)	235	25	
(60-80)	165	26	

80 cm granular core taken of small pressure ridge of FY ice. Sediment was concentrated on ice's surface, under 12 cm of old snow (0-12cm). The core reveled sediment in clumps at 35 and 46 cm, with small speckled inclusions throughout except for the snow on top.

235-1-2 Bulk sample
Bulk sample scraped off exposed areas on pressure ridge. Appears to be all fine.
Mud in mud chips and pellets. Abundant muscovite, clear angular quartz. Rare black lithoclasts, angular ?limestone, coal, and metamorphics.

235-1-3 Archive core
Archive core taken adjacent to 235-1-1. Similar in every respect.

TUESDAY, AUGUST 24, JD 236

236-1-1(0-19cm) 315 27 Ice core

(19-30)	407	28	
(30-54)	330	29	
(54-91)	350	30	

91 cm core taken from area of low ridging in discolored ice. Much of the area was covered with sediment in cryoconites but neither core taken here had concentrations of sediment - rather it was speckled throughout.

236-1-2 Bulk

Bulk sample scraped off snow and scooped from cryoconite holes.
Abundant clear angular quartz. Common angular black grains.

236-1-3(0-89cm) Archive core

Archive core similar to 236-1-1

WEDNESDAY, AUGUST 25, JD 237

237-1-1(0-90cm) 490 31 Ice core

Ice core with minor amounts of sediment distributed throughout. Melted whole sample to get a representative SPM.

237-1-2 Bulk sample

Bulk sample from cryoconite hole. Originally in pellets which broke apart during sampling.
Abundant clear and white quartz grains. Common micas. Possible cherts

237-2-1 950 32 Water sample

Water sample taken from 237/2045 - 238/0945 hrs.

SATURDAY, AUGUST 28, JD 240

240-1-1(0-77cm) 295 33 Ice core

77 cm core from low relief area of MY floe. Appears clean throughout but there were a few speckles of sand/silt on the top. 1/4 section melted for representative sample.

240-1-2(0-88cm) 408 34 Ice core

88 cm core from low ridge of MY floe. Appears clean throughout but there were a few speckles of sand/silt on the top. 1/4 section melted for representative sample.

240-1-3(0-91cm) 350* 35 Ice core

91 cm core from 2 m high ridge of MY floe. Appears clean throughout but there were a few speckles of sand/silt on the top. 1/4 section melted for representative sample. (* amount approx.)

240-1-4 3300 Bulk sample

Surface ice scraped off ridges. Has rare sand particles.

SUNDAY, AUGUST 26 JD 241

241-1-1(0-13cm)	107	36	Core
(13-35)	225	37	
(35-55)	298	38	
(55-79)	250	39	

79 cm core from the top of small hummocks of old? FY ice. The top 1cm was clean but underlying it was 1/2 cm layer of sediment. Sand was speckled on top, and randomly throughout. The total core was probably about 10 cm longer - some of the core was

slushy and did not core (around 20 cm deep). A few sediment concentrations were seen in the 13-35 cm section.

241-1-2			Archive core

As above but with less sediment at the surface.

241-1-3(0-52cm)	380	40	Core

As above - some slush missing. Not as much sediment on surface.

241-1-4			Bulk sample

Frozen sediment scraped off of small ridges. Looks fine grained. Resembles previous sediment scraped off ridges and scooped from cryoconites but this was frozen solid. The fresh snow on the surface had melted faster than surrounding areas. *Composed of mud in gray pellets. Rare black and sandstone lithofragments.*

MONDAY AUGUST 30, JD 242

242-1-1(0-18cm)	235	41	Ice core
(18-40)	340	42	
(40-62)	230	43	

Ice core from top of small hummock. Top 5 cm has sand and silt discoloring it. Sediment sprinkled throughout with a few large clumps at 25 cm that look like pellets. Appears clean below.

242-1-2(0-5cm)	225	44	
(5-89)	300	45	

Same as 242-1-1 but without clumps of sediment below surface layer.

242-1-3			Bulk sample

Bulk sediment sample scraped off ice hummocks and out of frozen cryoconite holes. Much of the sediment looks to be in pellets.
Mud in pellets. Angular coal fragment and clear quartz sand. Abundant biotite. Rare rounded clear quartz.

THURSDAY, SEPTEMBER 2, JD 245

245-1-1	453	46	Ice core
245-2-2	472	47	Ice core

Two cores of clean ice from 3 m thick MY floe. Both cores were entirely melted and a representative sample of melt water filtered.

FRIDAY, SEPT. 3, JD 246

246-1-1	230	48	Ice core
246-1-2	415	49	Ice core

Representative samples of two cores of clean FY ice. Taken 10 m away from each other. No apparent sediment anywhere on floe.

246-1-3	243	50	Snow sample

Fresh snow sample from same site.

SATURDAY, SEPT. 4, JD 247

247-1-1(0-14cm)	160	51	Ice core
(14-38)	268	52	
(38-70)	225	53	

Core taken from base of ridge where melting had shearing/melted away half of it. Sediment could be seen in the cross section, and was concentrated at the base of the cut where sediment had presumably washed down off the face and accumulated in melt puddles. The ice at the base was clear indicating that this was a melt pool. The sediment was seen in clumps - perhaps old cryoconite holes or anchor ice concentrations. There was a band of clumps from 14-38 cm and at 44-50cm. The ice was turbid from 44-50cm.

247-1-2(0-37cm) 328 54 Ice core
Core taken 4 meters away from 247-1-1. Sediment was seen on the ice's surface but no concentrations were seen. The core had sediment sprinkled throughout this upper section. The core was taken to see how localized the sediment concentrations in the previous core were.

247-1-3(0-85cm) 240 55 Ice core
Core taken 30 cm away from 247-1-1. A representative portion of melt water was filtered for SPM. Overall, the core was not as turbid nor did it have as many sediment clumps as sample 1. One turbid clump at 25-27 cm.

247-1-4(0-22cm) 295 56 Ice core
Top 22cm of a core taken 30 cm away from sample 1 in the opposite direction to sample 3 for comparison of SPM values.

247-1-5 Bulk sample
Bulk sample from the above location. Scraped off ice and out of frozen pockets in the ice. Some turbid slush/water from the core hole was added.
Predominantly algae. Rare angular quartz, chert, ?coal. Possible highly dissolved foraminifera.

247-2-1 295 57 Ice core
247-2-2 325 58 Ice core
2 cores of clean MY ice taken from snow covered floe with minor ridging.

MONDAY SEPT. 6, JD 249
249-1-1(0-73cm) 370 59 Ice core
Clean core of MY ice. Top 10 cm slushy, then crystalline.

249-1-2((0-89cm) 345 60 Ice core
Same as sample 249-1-1

Blank filter 200 61 Blank filter

WEDNESDAY SEPT. 8, JD 251
251-1-1(0-90cm) 355 62 Ice core
Clean ice core from MY floe. Top 10cm granular, but could have been recrystallized windblown snow.

251-2-1(0-70cm) 270 63 Ice core
Clean MY core from small hummock.

251-2-2(0-70) 475 64
Clean core from small hummock of MY floe. Taken 30m from sample 1.

THURSDAY SEPT. 9, JD 252
252-1-1(0-86) 410 65 Ice core
252-1-2(0-92) Archive core

2 clean cores from MY floe with low hummocks. Cores taken from top of hummocks.

SATURDAY, SEPT. 11, JD 254

254-1-1	325	66	Frazil Ice

New frazil ice scooped with dip net.

254-2-1	280	67	Ice core

Core of very old MY ice. Very hard and clean. Comes from a floe 3 m thick but with only 30 cm of freeboard.

254-3-1			Box core slurry

Box core slurry from Box core 17.
Abundant planktic foraminifera.

APPENDIX D - Filter summary and density results

Sample #	SPM (mg/L)	Density	Notes
ABS-93			
ABS-93-1-1 (20-30,55-65cm)	2.62	0.96	silt, wood, algae
ABS-93-1-2 (105-115,150-160)	3.09	0.98	silt, wood, algae
ABS-93-1-3 (0-10)	4.63	0.8	silt, wood, plastic contamination
ABS-93-2-2 (0-13)	7.21	0.92	silt, wood, algae
ABS-93-2-3 (30-41,67-71)	5.08		silt, sand
ABS-93-2A-1	7.31		silt, algae
ABS-93-2A-2 (152-172)	5.43	0.85	sand, algae, metallic sphere, sand
ABS-93-3-1 (0-15)	128.10		silt, sand
ABS-93-3-2 (55-75)	2.37	0.89	silt, sand
ABS-93-3-3 (0-20)	90.52		silt, sand
ABS-93-4-1 (0-20)	34.42	0.89	silt, sand
ABS-93-4-2 (50-70)	3.15	0.88	silt, plastic contamination
ABS-93-4A-1 (0-20)	35.81	0.92	silt
ABS-93-4A-2 (110-122,135-145)	3.25	0.95	silt, sand, algae
ABS-93-5-1 (0-20)	808.12	0.85	silt, sand, wood
ABS-93-5-2 (45-55)	181.21	0.99	silt, sand
ABS-93-5-2 (45-55) duplicate	164.59		silt, sand
ABS-93-5-4	9.23		silt, sand
ABS-93-6-1 (0-20)	27.04	0.91	silt, sand
ABS-93-6-2 (142-162)	2.21	0.8	silt, algae
ABS-93-7-1 (0-20)	40.30	0.93	sand, silt
ABS-93-7-2 (110-130)	30.75	0.95	sand, silt
ABS-93-9-1	4.35		silt, algae
ABS-93-10-1 (0-20)	156.42	0.92	silt, sand
ABS-93-10-1			silt
ABS-93-10-2 (65-85)	2.15	0.92	silt, algae, plastic contamination
ABS-93-10-3 (0-80)	78.81		silt, sand
ABS-93-11-1 (0-10,70-80)	8.10	0.91	algae, plastic contamination
ABS-93-11-1			silt, algae, wood
ABS-93-11-2 (0-10,75-85)	3.30	0.89	silt, sand
ABS-93-11-3 (160-165)	24.90		algae, wood
ABS-93-12-1 (0-85)	38.10		silt
ABS-93-12-2	19.49		silt, algae
ABS-93-12-3	11.60		algae
ABS-93-12A-1	156.85		silt
ABS-93-13-2	2.63		algae, silt
ABS-93-13-3	77.00		sand, silt
ABS-93-14-1 (0-110)	36.65		silt, algae
ABS-93-14-2 (0-20)	9.08		silt, algae
ABS-93-14-4	821.40		silt, larvae

ABS-93-15-1	6.97		silt, algae
ABS-93-16-1 (0-22)	8.23	0.93	algae, silt
ABS-93-17-1 (0-60)	7.19		silt, algae
ABS-93-17-3 (175-178)	20.60	0.75	algae, larvae
ABS-93-19-1 (0-135)	1.81		algae
ABS-93-19-2	3.83		silt, algae
ABS-93-19-4 (130-135)			algae
ABS-93-20-1 (0-135)	3.72		silt, algae
ABS-93-20-2	3.04		algae, silt
ABS-93-20-4			silt, wood
ABS-93-20-5 (130-135)			algae
ABS-93-21-1	41.42		silt, sand, wood
ABS-93-22-1	2.54		silt, sand
ABS-93-23-1	10.65		silt
ABS-93-23-2	2.39		silt
ABS-93-24-1	29.08		silt
ABS-93-24-2	3.62		algae, silt, sand
ABS-93-24-3	2.51		silt
ABS-93-25-1	5.36		algae
ABS-93-25-2	27.43		silt, algae
ABS-93-25-3			silt
ABS-93-26-1 (0-130)	2.32		algae, silt
ABS-93-26-2	3.41		algae
ABS-93-26-3			algae
ABS-93-27-1 (0-160)	1.14		silt, algae
ABS-93-27-2	2.79		algae, sand
ABS-93-27-3			algae
ABS-93-30-1	5.46		silt, algae
ABS-93-30-2	31.67		silt
ABS-93-31-1 (25-50)	20.22		silt, wood, diatom
ABS-93-31-2	10.14		silt, algae, wood
ABS-93-31-3			algae
ABS-93-32-1	1.06		algae
ABS-93-32-2	99.02		algae, wood
ABS-93-32-4			silt, algae, wood
ABS-93-33-1	3.90		silt, algae, diatoms,
ABS-93-33-2	1.75		silt, algae, diatoms
ABS-93-34-1	1.81		algae, silt, diatoms
ABS-93-34-2	1.83		algae, silt, diatoms
ABS-93-35-1	66.87		silt
ABS-93-35-2	31.79		silt, algae
ABS-93-35-3			silt
BLANK	1.20		algae
BLANK	0.70		algae
BLANK	1.10		silt
BLANK	0.50		
BLANK	1.70		algae
ABS-93-2-1 (snow)	8.30		silt
ABS-93-3-4 (snow)	6.53		silt, algae

ABS-93-4-3 (snow)	3.58		silt
ABS-93-5-3 (snow)	6.38		silt, sand
ABS-93-6-3 (snow)	18.47		sand
ABS-93-7-3 (snow)	32.66		silt
ABS-93-8-1 (snow)	528.65		sand
ABS-93-8-2 (snow)	54.28		silt, sand
ABS-93-8-3 (snow)	231.60		silt, sand, wood
ABS-93-9-2 (snow)	167.32		silt
ABS-93-9-3 (snow)	54.47		silt, algae
ABS-93-13-1 (snow)	2.83		silt, algae
ABS-93-14-3 (snow)	2.03		algae
ABS-93-16-2 (snow)	15.75		algae, silt
ABS-93-17-2 (snow)	7.40		silt, algae
ABS-93-19-3 (snow)	14.18		silt, sand
ABS-93-20-3 (snow)	3.54		silt, sand
ABS-93-22-2 (snow)	9.94		silt, algae
ABS-93-30-3 (snow)	10.77		algae
ABS-93-32-3 (snow)	1.59		silt, algae, wood
ABS-93-34-3 (snow)	1.49		algae
POLAR STAR 1993			
PS93-229-1-1	4227.00		silt, diatoms
PS93-229-2-1 (water)	7.38		silt, diatoms
PS93-230-1-2 (0-15cm)	1039.30	0.88	silt, diatoms, sand, wood
PS93-230-1-2 (15-30)	151.43	0.83	silt, algae, wood
PS93-230-1-3 (0-91)	225.33		diatoms, wood, algae
PS93-230-1-2 (30-48)	91.56	0.93	sand, diatoms, wood
PS93-232-1-1 (snow)	6.09		silt
PS93-232-1-2 (0-90)	7.69		wood, silt
PS93-233-1-1 (0-10)	377.27		pellets, silt, metallic sphere, algae
PS93-233-1-1 (10-27)	26.69		algae, wood, sand
PS93-233-1-1 (42-52)	14.20		algae, diatom, silt
PS93-233-1-1 (27-42)	13.63		silt, algae, planktic foram.
PS93-233-1-1 (52-83)	33.48		algae, silt
PS93-234-1-2 (0-10)	32.06		algae, silt
PS93-233-1-3	47.99		pellets
BLANK	3.75		algae, diatoms
PS93-234-1-2 (10-38)	9.12		silt
PS93-234-1-2 (38-80)	8.71		silt, wood
PS93-234-1-2 (80-90)	15.70		silt, sand, algae
PS93-234-1-3	6.98		silt, sand, algae
PS93-234-2-1	94.62		pellets, algae, silt
PS93-235-1-1 (0-12)	17.35		sand, silt, wood
PS93-235-1-1 (12-30)	22.48	0.65	silt, sand, forams.
PS93-235-1-1 (30-42)	1778.00	0.84	silt
PS93-235-1-1 (42-60)	196.81	0.80	silt
PS93-235-1-1 (60-80)	19.82		diatoms, silt, algae, pellets
PS93-236-1-1 (0-19)	12.83	0.87	algae, pellets
PS93-236-1-1 (19-30)	12.60	0.84	silt, algae

PS93-236-1-1 (30-54)	7.64	0.88	silt
PS93-236-1-1 (54-91)	3.83	0.83	silt
PS93-237-1-1 (0-90)	23.47	0.82	silt, algae, pellets
PS93-237-2-1 (water)	0.92		silt, diatoms
PS93-240-1-1 (0-77)	13.36		silt, sand
PS93-240-1-2 (0-88)	7.11		sand, algae
PS93-240-1-3 (0-91)	6.20		sand, algae
PS93-241-1-1 (0-13)	10002.71	0.77	silt, pellets
PS93-241-1-1 (13-35)	102.98	0.82	silt
PS93-241-1-1 (35-55)	41.17	0.97	silt
PS93-241-1-1 (55-79)	12.20	0.82	sand, silt
PS93-241-1-3 (0-52)	106.05	0.87	sand, silt, pellets, algae
PS93-242-1-1 (0-18)	528.38	0.80	silt, pellets
PS93-242-1-1 (18-40)	925.74	0.95	silt, pellets
PS93-242-1-1 (40-62)	4.17	0.85	pellets, silt
PS93-242-1-2 (0-5)	78.22		silt
PS93-242-1-2 (5-89)	6.47		silt, pellets
PS93-245-1-1	12.08		silt
PS93-245-1-2	4.32		silt, wood
PS93-246-1-1	6.96		silt, red specks
PS93-246-1-2	4.94		sand, red specks
PS93-246-1-3 (snow)	3.29		silt, pellets
PS93-247-1-1 (0-14)	44.63	0.96	pellets, silt
PS93-247-1-1 (14-38)	288.36	0.84	pellets, silt
PS93-247-1-1 (38-70)	900.36	0.95	pellets, silt
PS93-247-1-2 (0-37)	50.67	0.69	pellets, silt
PS93-247-1-3 (0-85)	415.63		silt
PS93-247-1-4 (0-22)	121.63	0.91	silt
PS93-247-2-1	6.95		silt, red specks
PS93-247-2-2	3.51		algae, diatoms
PS93-249-1-1 (0-73)	3.05	0.65	silt
PS93-249-1-2 (0-89)	5.77	0.84	silt, wood, contamination
BLANK	1.10		silt, wood
PS93-251-1-1 (0-90)	4.70	0.87	sand, silt, wood
PS93-251-2-1 (0-70)	3.63	0.79	silt
PS93-251-2-2 (0-70)	2.65	0.83	silt
PS93-252-1-1 (0-86)	4.00	0.86	silt
PS93-254-1-1	3.35		
PS93-254-2-1	4.04		

APPENDIX E - *Polar Star* 1993 carbon results

Sample	Total C (%)	Inorgan. C (%)	Organic C (%)	$CaCO_3$ (%)	Notes
PS93-230-1-1	1.201	0.274	0.928	2.280	
PS93-230-1-4	1.552	0.133	1.418	1.111	Box Core 1
PS93-233-1-2	6.439	0.016	6.423	0.133	Algae
PS93-235-1-2	1.086	0.005	1.081	0.042	
PS93-236-1-2	1.578	0.008	1.569	0.068	
PS93-237-1-2	1.642	0.014	1.628	0.120	
PS93-240-1-4	13.808	0.153	13.655	1.275	Algae
PS93-241-1-4	2.178	0.033	2.146	0.273	
PS93-242-1-3	1.876	0.061	1.815	0.509	
PS93-247-1-5	1.725	0.016	1.709	0.137	
PS93-254-3-1	1.234	0.337	0.897	2.810	Box core 17

APPENDIX F - *Polar Star* 1993 grain size results

Sample	%gravel	% sand	% silt	%clay	mean sz. (μm)	sorting (phi)	skew.
PS93-230-1-1	63.95	21.19	11.13	3.74	2411.62	3.90	0.67
PS93-230-1-4*	0.00	3.16	28.76	68.73	1.84	2.40	0.05
PS93-233-1-2**	0.00	0.51	36.18	63.31	1.63	2.11	0.23
PS93-235-1-2	0.00	0.32	51.56	48.13	2.73	2.78	0.31
PS93-236-1-2	0.00	9.77	46.77	43.46	4.52	3.19	0.18
PS93-237-1-2	0.00	1.66	48.68	49.66	2.94	3.10	0.19
PS93-241-1-4	0.00	1.05	43.16	55.79	2.34	2.67	0.20
PS93-242-1-3	0.00	0.17	49.31	50.52	2.73	2.65	0.25
PS93-247-1-5	0.00	0.38	55.13	44.50	3.56	2.80	0.29
PS93-254-3-1*	0.00	0.17	28.94	70.89	2.47	3.11	-0.11

* Box core top slurries.

** Algae from ice.