CASES2003, Leg 3 (0305)

CCGS *Amundsen*

Cruise & Preliminary Data Report

26 November 2003 to 06 January 2004

Edited by Chrsitian Nozais

We, the scientific crew, wish to thank the Captain Julien, the entire crew, and John Kudlak for their perseverance and imagination in helping us completing our scientific activities, as well as for their and friendly companionship during this Christmas cruise.

Specific Science Activities

1. Atmospheric and sea ice forcing of coastal circulation on the Mackenzie shelf

Principal investigators: Eddy Carmack (Instute of Ocean Sciences, DFO) and Grant Ingram (Mc Gill University)

Cruise participant: Marie-Emmanuelle Ray

1.1. Rosette and CTD activities (Marie-Emmanuelle Ray)

The Rosette was deployed 61 times between December 12, 2003 and January 7, 2004. It was usually deployed twice a day at 6h30 and 18h30 local time (13h30 and 01h30 UTC). From cast 010 to the end, the ship was stationary, at 70 02.73°N et 126 12.07°W . As the water column was 232 meters deep, every cast went down to about 219m. Once every six days, the primary production team, zoologists and chemists sampled water (see table below). Each time, the Zoology and chemistry rosette occurred 2 hours after the primary production rosette. Zoologists also took samples on 5 others casts. From time to time other people asked for water, usually for animal maintenance. All Rosette Sheets, CTD logs, screen shots and bottle data are available on the network.

type	# cast	date (UTC)	sampling team
Total: CTD + Rosette	001 to 061	09-dec-2003 to 07 janv 2004	
primary production	004-016-029-041-053	10-16-22-28 dec 2003 03 janv 2004	Spain, Warwick Vincent teams and Christian Nozais
zoology and chemistry	005-017-030-042-054	10-16-22-28 dec 2003 03 janv 2004	Don Diebel, Louis Fortier, Lisa Miller teams and Makoto Sampei
zoology	009-021-022-051-052	12-18-19 dec 2003 02-03 janv 2004	Makoto Sampei, Sohei Matsuda
O-18 and salinity	005-018-031-043	10-17-23-29 dec 2003	CTD team

CTD data

For most casts, the parameters recorded were: pressure, temperature, salinity, fluorometer, oxygen, transmissometer, pH, nitrates, latitude and longitude. Unfortunately some problems occured around cast #020 with the nitrate sensor and no more data from this sensor were recorded after cast #024. Some problems occured with the transmissometer and oxygen sensors as well, but we don't know yet how it affected the data.

Preliminary results

The temperature inversion and halocline depths changed a lot during the leg. Essentially, they go from 40m on cast no.1 up to 10m on cast no.28. After a while, it disappeared and came back on cast no.36 at 10 m and fell to 30 m where it stayed to the end of the leg.

No chlorophyll maximum was seen during the whole leg.

All data still need to be calibrated.

2. Ice-atmosphere interactions and biological linkages

Principal investigator: Dave Barber, University of Manitoba

Cruise participants: Alexandre Langlois, Owen Owens and An Vinh Tat

2.1. Cloud Physics and Synoptic Climatology (An Vinh Tat)

Objective:

- To characterize atmospheric conditions associated with Arctic stratus
- To improve stratus cloud prediction in the Arctic
- To produce a climatology of stratus cloud over the CASES area for the various seasons and was this more or less than "normal"
- To assess the ability of the Canadian GEM/MM5 model(s) in reproducing stratus cloud occurrence
- To determine what the surface conditions were like (e.g. open water sources) when stratus cloud existed and what were the vertical wind shears like to suggest advective processes and air-mass mixing processes.

Rationale:

In order to quantify the relationship between atmosphere, snow, sea ice, and open water, hourly surface meteorological observations, continuous cloud base height, atmospheric sounding, horizontal visibility, precipitation (type and amount), as well as all-sky data (total fractional cloud cover) need to be collected. These data include measurements (visual and electronic) of hourly surface meteorological observations using the Automatic Voluntary Observing Ship (AVOS) system (provided by the Meteorological Society of Canada, MSC) and the human eye, cloud base height using the Vaisala CT25K laser ceilometer, atmospheric sounding using the Vaisala DigiCORA III MW21 radiosonde, horizontal visibility using the MAR II system (provided by MSC), precipitation type and amount by means of visual observations and a nipher snow gauge, respectively, and a specially built all-sky camera system that takes time-lapsed photos of atmospheric cloud state.

Sampling Program

Hourly surface meteorological (Met.) observations (Obs.)

Surface Met. Obs. are conducted on-the-hour plus or minus five minutes except when the weather conditions change dramatically. Only under these circumstances is a "special" observation made. When a special observation is made, the exact time and date of the observations should be indicated and only the weather element (s) that have changed dramatically. The recorded observations are then entered into a binder manually and the hourly observations will also be entered into the AVOS which serves as a means to transmit the data in real-time for all the manned Met. Obs. Observations are conducted at 1200Z UTC to 0600Z UTC ; that is, from 0500 am local time to 1100 pm local time. An example meteorological observation data entry table is shown in Table 1.

Table 1: Elements that should be observed.

Year Day (UTC)	Time (UTC)	Cloud Types	Total Cloud Amount	Opacity	Solar Disk	Vis (n. miles)	Present Weather	Wind Dir	Precip. Amount (mm)	Remarks

- The **Date and Time** should be entered according to Universal Time (UTC).
- **Cloud Types** are specified according to Table 2. There may be various cloud types occurring at the same time in which all should be mentioned in the Cloud Type column.

- **Total Cloud Amount** signifies the total amount of sky that is entirely and/or partially obscured by clouds and is measures in octas. For example, a totally overcast sky would be given a total cloud amount of 8/8. A clear sky would have 0/8 total cloud amount.
- **Opacity** signifies the amount of sky that cannot be seen through the clouds. Thus Opacity equals the total cloud amount minus that cloud fraction that can be seen through. For example, a total overcast sky (8/8 total cloud amount) where some blue sky can be seen through the clouds (say 1/8), the Opacity would be 7/8 (=8/8-1/8).
- **Solar Disk** signifies the degree to which the sun is obscured by cloud or weather. In a clear sky, the degree of obscuration = 0.0. In a thick overcast sky where the sun in not visible, the degree of obscuration = 1.0. Everything in between has a degree of obscuration = 0.5.
- **Visibility** is measured in nautical miles with the aid of the MARS II visibility sensor.
- **Present Weather** conditions signify the weather type that may obscure visibilities (other than clouds that are above ground level). This includes Fog, Snow, Rain, Drizzle, Freezing Rain/Drizzle, Blowing Snow and Ice Crystals. Some of these may occur simultaneously in which case all of those that are occurring should be indicated in the Present Weather column.
- **Wind Direction** (Wind Dir.) at the time of the observation should be indicated in this column. Wind directions should be entered as: N, NE, E, SE, S, SW, W, NW.
- **Precipitation Amount** (Precip. Amount) is the total water equivalent of melted snow (that is measured in mm using the graduated cylinder) accumulated in the Nipher snow gauge at 6-hour intervals. The precipitation measurements are conducted at 0000Z, 0600Z, 1200Z, and 1800Z UTC (plus or minus one half hour).
- **Remarks** should be used for special observations or further explanations of the previous columns. Also cloud ceiling height read from the ceilometer should also be enter here.

Table 2: Cloud Observations Symbol Key

Cloud Height	Cloud Type	Symbol
High (>13000 ft.)	Cirrus	Ci
	Cirrocumulus	Cc
	Cirrostratus	Cs
Middle (3000 ft.–13000 ft.)	Altostratus	As
	Altocumulus	Ac
Low (<3000 ft.)	Stratus	St
	Stratocumulus	Sc
	Stratus Fractus	Sf
	Cumulus	Cu

Automated Voluntary Observing Ship (AVOS) system

The AVOS system automatically collects temperature, sea surface temperature, relative humidity, wind speed, wind direction, and barometric pressure and transmits these data every five minutes past the hour to a weather station on land through the Inmarsat-C transceiver. Unfortunately, the AVOS system was not transmitting since LEG 2.

Ceilometer

Clouds are an integral part of global climate and Arctic thermodynamics and dynamics. Clouds block out incoming short-wave radiation while outgoing long-wave radiation is trapped beneath cloud base height. Cloud base height and cloud type is a major determinant in whether clouds warm or cool the planet. Cloud base height is measured using the Vaisala CT25K laser ceilometer. With the height determined, this information can be use to infer what cloud type is present. Clouds are generally expected to be found at specific heights in the atmosphere. Refer to Table 2 for the cloud types and the expected height where they are found. The only time that the ceilometer is stopped from collecting a continuous record of cloud base height is when the data is being saved onto a zip disk.

Radiosonde

Atmospheric thermodynamics and dynamics data are collected with the release of radiosondes. The Vaisala DigiCORA III MW21 radiosonde sounding system is used to collect pressure, temperature, relative humidity, wind speed and wind direction data as the radiosonde ascends through the atmosphere. Radiosonde release is weather dependent. I'm more interested in cases where there is no other cloud above the stratus; that is, want more scenarios where the only cloud above is stratus. However, I also want to compare cases where stratus cloud does not produce precipitation to cases where stratus does produce precipitation. In cases where stratus produces precipitation, this may require that radiosondes are launched with some mid level cloud above the stratus, as the mid level cloud can seed the stratus to generate the precipitation. There may also be situations where there is mid level cloud above the stratus but yet no precipition will occur. I'm also interested in these cases as well. When radiosondes are released, they are released at a frequency of three-hour intervals with three radiosondes being released a day except during severe weather where more radiosondes will be released.

Horizontal Visibility

Horizontal visibility is measured by the MARS II system. Measurements are taken from 1200Z UTC to 0600Z UTC. The visibility sensor utilizes a laser and measures the backscattered radiation to determine the visibility. Visibility is measured in nautical miles.

Precipitation

The type and amount of precipitation is determine visually and collected by a Nipher snow gauge, respectively. Precipitation type is determined during Met. Obs. Precipitation amount is measured at 0000Z, 0600Z, 1200Z, and 1800Z UTC by bringing in the Nipher snow gauge and measured the total water equivalent of melted snow in a graduated cylinder. Units of measurements are in milliliters.

All-Sky Camera

All-Sky data (total fractional cloud cover) is collected by a specially built all-sky camera system that takes time-elapsed photos of atmospheric cloud state. Data is collected continuously until the 8-mm tape is full (usually about 4 weeks) then a new tape is use.

2.2. Physical and electromagnetric properties of snow over sea ice (Alexandre Langlois)

Objective:

- Create spatial and temporal dataset of snow electromagnetic properties
- Characterize the physical properties of snow cover over first-year sea ice
- Infer the state of metamorphosis (SWE) of snow cover as winter progresses
- Link electromagnetic variation of snow as a function of metamorphosis
- Determine the ice porosity through electromagnetic measurements

Rationale

The spatial/temporal variations of snow cover over sea ice a key parameter for climate change investigations. Better understanding of snow related dynamic and thermodynamic processes within the snow/sea ice system suffer from a sparse observational record and lack of understanding of the salient processes. The microwave satellite data record appears as a very useful tool for estimating characteristics of this system, which will help to redress some of the limitations we have regarding snow on sea ice.

Understanding the physics of snow cover over sea ice is essential to the comprehension of the Arctic climate dynamics and aspects of surface-atmosphere coupling for mass, gas, and energy transfer. We expect some of the largest changes at high latitudes to be associated with the hydrological cycle (IPCC, 2003). In the case of the Arctic this means changes associated primarily with snow. Because of the low thermal diffusivity and shallow optical depth, snow dominates most processes associated with many physical and biological processes operating across the ocean-sea ice-atmosphere (OSA) interface. Both measurement and modeling of snow on sea ice is really in its infancy.

Microwave radiometry can be used to measure various characteristics of snow on sea ice (Barber et. al, 1998, Matzler, 1987). By combining in-situ measurements of snow and ice properties with estimates of the snow/ice interface temperature researchers have shown that a reasonable estimate can be made of snow water equivalent (SWE) over sea ice (Barber et al. 2003). Although many SWE algorithms for snow over land already exist, a precise approach to calculate SWE over sea ice has not yet been developed (Barber et al., 2003). Modeling of snow on sea ice is equally underrepresented in the literature. One of the major limitations is the inherent variability in both snow amount and spatial distribution at a full range of space and time scales.

Sampling Program

Electromagnetic Snow Measurements

The scatterometer will be mounted on a sled pulled by a snowmobile. It will be movable around the 6 stations (snow fences) located 1-2 km from the ship (Figures 4 and 6). The radiometer will be based on the ship, taking fixed and multi-angular measurements as snow accumulates on the ground toward the winter season. These EM measurements will provide information about the influence of the metamorphic state of snow on microwave scattering. With this information, we will be able to validate and develop snow related algorithms such as snow water equivalent (SWE). The EM measurements with the scatterometer (c-Band, 5.3GHz) will be made around 6 snow fences (3 fences * 2 orientations), the 2 other fences (1 fence * 2 orientations) are for the snow pits measurements (destructive).

Radiometer (passive microwave)

Fixed and multi-angular measurements will occur from the ship. A radiative pattern should be used by taking 50 seconds (10 points ➔ 1 point/5 seconds) measurements on the fixed points. Multi-angular measurements will be taken between 20° and 70° in which the predictive capabilities of polarization and frequency combination changes (Drobot and Barber, 1998). The solar angle will be considered in the analysis for surface energy balance purposes. Because the sled is not always leveled on the trail, a digital level will be required to fix the right angle.

1. Calibration (section 4.2.1.). Take pictures of the site.
2. Fixed measurements
   Take measurements from the ship. The acquisition time should be around 50 seconds (10 points). The fixed measurements should be marked on the field to take the data at the same place every day. These fixed measurements will be taken at different angles: 20°, 30°, 40°, 53°, 60° and 70°.
   AM, NOON, PM: 20°, 30°, 40°, 53°, 60° and 70° from the ship

Measurement of the ice/snow contact layer will be also done to consider the ice contribution on the radiation at the 3 frequencies (passive microwave only). This require the snow to be remove and consequently, these measurements of bare ice will be done at the destructive site.

Scatterometer (active microwave)

Active microwave measurements will also be taken along the fences. Measure the height when measuring from the ship. Take pictures of the site.

1. Fixed measurements
   The scatterometer will only take fixed measurements (scans). We will scan a region of a couple square meters (complete scan). These measurements will occur from the ship and at the fencing stations.

Bare ice measurements will also be taken in active microwave. According to Barber and Nghiem (1999) the penetration depth of the C-band into the ice is about 20 cm. We can then extract information about temperature, brine volume changes. During the fast ice program, these variables will be quite stable.

Snow Physical Properties Measurements (snow pits)

All the snow pits will be made along the destructive snow fence (Figure 4). The fence should have 120m long (i.e. 2 fences of 200' each and 5' height). The snow accumulation (deposition or interception) is decreasing while moving away from the fence. Thus, we will be able to measure snow in 2 different depths (deep and shallow snow). The snow pits will be carefully excavated to be refill for minimum disturbance. Data from snow pits measurements provide the best information of the snow cover characteristics. Snow pits will occur at the destructive sites, coordinating with the EM measurements as well as the SBR station before to leave with the EM equipment and after when we bring back the equipment. The stratigraphic method is the most common and accurate method:

<u>On the field:</u>

1. First, a snow pit needs to be dug (~0.5-1.0 m^2) and the snow wall needs to be perpendicular to solar illumination. Take pictures of the site.

2. After the snow pit is dug, note the thickness of the snowpack, as well as the thickness of the hoar layer. Also, note the air temperature, local time, wind direction, GPS position and fence number.
3. For each layer, samples will be taken in order to take pictures of the snow grains. The samples will be then melted to extract the salinity. A sample of the ice surface will also be collected in order to measure the ice surface salinity. For each layer, we should measure the following:

    a. Temperatures will be measured every 2 cm which is the spacing of the thermocouples. Thermocouples are high conductivity thermo epoxy that measures the voltage between two dissimilar metals, which is function of the temperature. Then, the data are downloaded from the logger.

    b. Snow wetness is measured with a capacitance plate (dielectric device). You first measure the air capacitance in the shade and on the top of the snowpack. Then, for every layer, starting at the top, you insert the capacitance plate and note the reading after having bring the dial as close to 0 as possible .

    c. Take a sample with density cutter every 2 cm. Two density cutters will be available, one have a width of X and the second one 2 X. The 2 X cutter will be only used in the basal layer in order to have a wider sample due to the snow properties heterogeneity near the sea ice. These samples will be marked in separated bas, and brought back to the ship for laboratory analysis (salinity and pictures.

    d. Measure the snow water equivalent (SWE) with the sampling tube. This tube is pushed in the snowpack until it hits the ice. The tube and the snow are pulled out and weighted on balance that gives the equivalent column of water we would have with a complete melt.

Note the snow water equivalent (SWE) with a SWE tube near the snowpit. SWE can also be calculated for each layer with the density ρ_n and the thickness d_n:

$$SWE_{layer\ n} = \rho_n * d_n$$

The SWE of each layer can be then cumulated and compared to the data obtained from the tube.

<u>On the ship</u>

    e. Density is measured with a scale (Denver Instrument) in the cold room using the samples taken on the field. This scale allows us to know the exact density of the layer sampled usually in g/cm^3 or kg/m^3. The density is calculated by subtracting the dry bags weight average (20 bags average for both small and big bags) from the total weight, then dividing by the sample volume (volume of the density cutters). Small and big bags weights are 3.6897g and 5.4901g respectively.

f. Snow grain/structure pictures are done in the cold room as well. The main purpose of these pictures is to be able to measure the grain size and quantify its structure that is function of the state of metamorphosis of the snowpack as winter progresses. A digital camera with snow grain plate will be used to do so. Oil is used to keep the grains shapes (stop sublimation and evaporation) while the pictures are taken. Picture of individual grain will be also taken with oil and dish.

*** *Snow grains pictures and sea ice salinity (scratching ice surface) will be taken for the Fences Snow Pits only (2 / day), AM and PM (biggest contrast).*

g. Conductivity is measured and converted into salinity from the melted sample (with salinometer).

For each of these snow cover physical properties measurements, we will have an EM signature associated. The combination of these dataset in order to extract SWE is the main objective of the project.

Encountered objectives

A constant dataset of snow physical and electromagnetic properties is in progress since the second week of the leg, week where the ship found the over wintering location. A field set-up has as well been started for further research on legs 4-5-6. The snow fences, gas chambers, temperature dowels, meteorological tower are part of this set-up that is nearly completed as planned for the beginning of leg 4.

References

Barber et. al., 2003, Hydrological Processes, vol. 17
Barber et. al., 1998, IEEE Transactions on geoscience and remote sensing, vol.36, no.5
Matzler, 1987, Remote sensing reviews, vol. 2

2.3. Gas Fluxes (Owen Owens)

Rationale

To measure surface trace gas exchange in a polar marine environment over, through and under the sea ice in the Canadian Arctic. CO_2 gas dissolved in seawater and sea ice brine will be measured, along with bulk air in the atmosphere and sea ice. This will be done with the use of water samplers (typically surface water), ice cores for brine collection, pCO_2 dowels for bulk gas within the sea ice, and surface chambers for measurement at the sea ice surface.

Instruments

- Surface gas chambers
  - Syringes
  - Exetainers
  - Limited sampling possible
  - Samples collected and brought back to ship GC for analysis

        - IR Gas Analyzer
        - Thermocouples
        - Data Logger
    - Gas flux ice dowel (modified from soils department)
        - Syringes
        - Exetainers
        - Limited sampling possible
        - Samples collected and sent south to a GC for analysis
    - Temperature probes
        - Part of surface chambers and gas flux dowels
    - Under sea ice water sampler
        - Small salt water aquarium pump

Time

- During frozen sea surface season
- CASES legs 3 and 4

Goals

- Sea water
    - Rough sampling of surface water by Rosette. This device is suited for depth sampling as it takes 12L per sample over a range of about 60 cm. This data can be used to determine fluxes with depth within the water strata and direction of movement, for surface flux data a finer water sampler is needed to get surface water, and the closer to the surface the smaller the fetch.
    - Fine sampling at surface of the sea under the ice will be done through core holes with a small aquarium pump.
- Sea Ice
    - To collect brine from ice cores and determine pCO_2 within, along with supporting data. Multiple ice cores will be collected a cut into pieces of matching depths and brine collection will occur from there.
    - Also to take gas samples at depth within the sea ice matrix with dowels. In situ samples at pre-specified depths will be taken remotely and analyzed by GC onboard the ship. This will be used to measure flux within the sea ice, may determine the limiting depth.
- Surface atmosphere
    - Sampling will occur in two types of surface chambers, steady state and non-steady state. A closed path gas analyzer will be hooked up to gather timescales. Others will use point sampling technique by using a syringe to collect coarse samples to be analyzed in the GC onboard the ship.

Support data

- Instruments
    - Anemometers
        - 2-Directional and speed
    - Barometric Pressure Monitor

- Campbell loggers
- Extension arms
- Gyro, for ship only
- High bandwidth cable
- Infra-red Gas Analysers
- Power source, for ice camp only
- Relative Humidity monitors
- Radiation Sensors
  - Upwelling
  - Downwelling
  - Under snow downwelling
- Sonic Anemometers
- Temperature probes
  - Multiple heights on tower
  - Snow combs
  - Ice dowels
- Tower

Time

- Will be based out of Met tower during camp and frozen in time. Before freeze up and after melt starts, when it is no longer safe to work on the ice the tower will be based on the ship.
- Water sampling during open water time will be from the ship. During frozen season it will occur from both the ship and ice camp.

Flux measurement equipment left in Inuvik airport not allowing gas analysis. Samplers placed in ice but removal was necessary for repair due to damage by foxes. A surface water sampler was developed onboard to acquire water samples.

3. Light, nutrients, primary and export production in ice-free waters

Principal investigator: Serge Demers, University of Québec at Rimouski

Cruise participants: Magdalena Bayer and Christian Nozais

3.1. Nutrients and phytoplankton dynamics in Franklin bay (Christian Nozais)

Rationale and objectives

This part of the CASES project is based more specifically on understanding the dynamics of the development of planktonic and benthic algal communities in polar ecosystems and the role of these biological components in biogeochemical processes. Planktonic and benthic microalgae production estimates for the arctic continental shelves are scarce (Grebmeier *et al.* 1995; Horner & Schrader 1982; Legendre *et al.* 1992; Macdonald *et al.* 1998), due to the difficulties associated with access to these areas. Furthermore, the mechanisms related to the inter-annual variability of primary production with regard to natural

physical and/or biological forcing are not well known. Finally, the level of contribution of phytoplanktonic cells to the vertical biogenic carbon flux and the present and future role of the biological pump in the arctic waters in response to the variability of ice cover are not well documented. Therefore, the main objectives of our group during this leg were:

- To assess the biomass and the production of pico-, nano- and microphytoplanktonic cells at the winter sites of the CASES project
- To determine species composition and pigment composition of phytoplankton in the upper part of the water column
- To define the bio-optic characteristics of the assemblages of pico- and nanophytoplanktonic cells by flow cytometry
- To determine nutrient levels in the water column

Methods

Study site

This study was undertaken at the CASES over-wintering site in Franklin Bay from 10 December 2003 to 03 January 2004.

Water column sampling and analyses

Water samples were collected using the rosette and a go-flow bottle. Water from 8 depths (10, 15, 25, 50, 75, 100, 150, near bottom) was collected every 6 days from the moonpool for the determination of chlorophyll *a* (chl *a*), phaeopigments, pigment composition, particulate organic carbon and nitrogen (POC and PON, respectively), BioSi, and species composition. Samples were also taken for further analysis on flow cytometry to determine the population composition of the small size class of phytoplankton and cells flurorescence. Additional surface water was collected once at the Titicaca site. Nutrient samples were collected using the rosette at 12 depths from the moonpool. The concentrations of nitrate, orthophosphate and orthosilicic acid will be further determined on board by Neil Price's team using an ALPKEM autoanalyzer with routine colorimetric methods (Grasshof 1999).

Water column sampling. Nut: nutrients; Chl a: Biomass of phytoplankton (size fractionated); CHN: POC, PON; Cells: taxonomy; PP: primary production; PI: photosynthesis-irradiance relationships.

Station	Date	Nut	Chl *a*	CHN	Cells	Cytometry
Winter	10/12	**X**	**X**	**X**	**X**	**X**
Winter	16/12	**X**	X	X	X	X
Winter	22/12	**X**	X	X	X	X
Winter	29/12	**X**	X	X	X	X
Winter	03/01	**X**	**X**	X	X	**X**

References

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Horner R, Schrader GC (1982) Relative contributions of ice algae, phytoplankton and benthic microalgae to primary production in nearshore regions of the Beaufort sea. Arctic 35:485-503
Iseki K, Macdonald R.W, Carmack E (1987) Distribution of particulate matter in the southeastern Beaufort Sea in late summer. Proc. NIPR Symp. Polar Biol.1:35-46
Legendre L, Ackley SF, Dieckmann GS, Gulliksen B, Horner R, Hoshiai T, Melnikov IA, Reeburg WS, Spindler M, Sullivan CW (1992) Ecology of sea ice biota. 2 Global significance. Polar Biol. 12:429-444
Macdonald RW, Solomon SM, Cranston RE, Welch HE, Yunker MB, Gobeil C (1998) A sediment and organic carbon budget for the Canadian Beaufort shelf. Mar. Geol. 144:255-273

3.2. Microcosms studies on phytoplankton growth during winter in Franklin bay (Magdalena Bayer)

Methods

Sampling

Samples were taken from the rosette in the moon pool starting from a depth of 20 m to avoid the contamination effects given by the ship. Sampling depths were 20 or 30 m (depending on the temperature profile), 50 m, 150 m and the bottom (220 m). Surface water was collected at ca. 500 m from the ship in NE direction (Titicaca station). It was always taken from a depth of 3 m from the ice surface. Ice thickness varied from 50 m (9 Dec 03) to 84 cm (3 Jan 04).

Microcosm experiment:

A microcosm experiment was carried out in order to measure the POC, PON and POP content of the microplankton fraction and its dependence on light availability. The experiment should be repeated during leg 9. It started on the 26th of December 2003 and lasted 10 days. Surface water (2 m depth) was filtered through a 200 µm-mesh net and incubated at 0.5^{o}C (nearly in situ temperature). It was distributed into 6 10-L transparent Nalgene bottles and exposed to 2 different light conditions: 3 bottles were exposed to a light irradiance of 70 µEm^{-2}sec^{-1} (photoperiod: 4.30am-11.30pm) and 3 to an irradiance of 3 µEm^{-2} sec^{-1} (photoperiod: 11.30am-3pm). At each light condition, nutrients were added to 2 of the containers, one was left unmodified as a control. The nutrients were added at the following concentrations: nitrate 16 µM, phosphate 1 µM, silicate 32 µM. A solution of minerals was added at the same ratio of nitrate to minerals as in the f/2 medium.

The containers were sampled daily for chlorophyll a, every other day for bacteria (flow cytometry), nanoflagellates (epifluorescence microscopy) and phytoplankton (light microscopy).

The concentration of POC, PON and POP were measured at the beginning and at the end of the experiment. Samples to measure the inorganic nutrients as well as total nitrogen and total phosphorus content were taken only at the beginning.

	Cast	Chl a	FCM	EMF	Macrom	Ciliates abundance	BIOLOG	FISH	DNA	Bactivory	Inorg. nutrients	BP	DMSP DMSO
10 Dec 03	004	X-5	X-5	X-5	X-1		X-5	X-5	X-5		X-1		X-1
16 Dec 03	016	X-5	X-5	X-5	X-1		X-5	X-5	X-5		X-1		X-1
22 Dec 03	029	X-5	X-5	X-5	X-1	X-5	X-3	X-5	X-5	X-1	X-1	X-5	X-1
28 Dec 03	041	X-4	X-4	X-4			X-2	X-4	X-4		X-1		X-1
3 Jan 04	053	X-3	X-3	X-3	X-1		X-3	X-3	X-3		X-1		

Samples taken by ICM Leg 3, X followed by number of depths sampled. Chl a: <50 and<3µm chlorophyll, at surface also total Chlorophyll; FCM: flow cytometry (for bacteria and picoeukaryotes); EMF: epifluorescence microscopy, slides for bacteria (0.22µmfilter) and small eukaryotes (0.8µm filter), Macrom.: ratio of DNA, RNA, Proteins, POC, PON, POP; BIOLOG: bacterial metabolic diversity; DNA: <50 and <3 µm; BP: bacterial production; DMSP and DMSO: both particulate and dissolved fractions.

4. Microbial communities and heterotrophy

Principal investigator: Warwick F. Vincent, Laval University

Cruise participants: Christine Martineau and Sébastien Roy

4.1. Microbial production and community structure (Christine Martineau and Sébastien Roy)

Rationale

The central hypothesis in CASES concerns the processing of organic matter in the Mackenzie delta versus offshore waters and its relationships with sea ice conditions. Micro-organisms are likely to contribute substantially to the biological carbon stocks across this region, and to play a leading role in the biogeochemical fluxes of organic matter. The microbial ecology subprogram was therefore formulated to measure microbial community structure and production dynamics throughout the CASES study region, including comparative measurements in the inshore delta and Mackenzie River source waters.

Very little is known about microbial production and community structure in Arctic water during the winter season. Sampling was undertaken during Leg #3 to determine a time serie of abundance and biodiversity of the following microbial communities within the water column in the Franklin Bay: viruses, heterotrophic Eubacteria, picocyanobacteria, picoeukaryotes, and pigmented and non-pigmented protists. Assays were conducted to quantify rates of bacterial heterotrophy. Experiences with nutrients (carbon, nitrogen and phosphorus)

were initiated to understand the state of the microbial community in winter. Grazing experiments were conducted to know the impact of the nanoplankton on the picoplancton community.

Objectives

Key objectives of this section of the microbial subprogram were to measure bacterial production in the water column, and the distribution and abundance of microbial taxa throughout the CASES study region. Several microbial groups were targeted for microscopic and molecular analysis. Protist communities were sampled as a guide to the balance of phototrophy versus heterotrophy. Picoeukaryotes and picocyanobacteria were sampled to evaluate whether there is a gradual seasonal change in Franklin Bay towards dominance by eukaryotic taxa, and a selective loss of prokaryotic phototrophs. A further objective was to apply molecular protocols that are being used elsewhere in the Arctic and Antarctic Oceans to assess the biodiversity of pico-autotrophs. Additional samples were obtained to determine the characteristics, sources and photoreactivity of coloured dissolved organic matter (CDOM) and disolved lignin, and the influence of CDOM and other optically active constituents on the underwater attenuation of UV and PAR.

The main objective for the leg #3 was to understand the dynamics of the microbial community in winter. We look closer to the change in the bacterial activity and the water column structure of this community in a time series sampling.

Methodology

Bacterial Production

Samples were obtained from 6 regulars dephts (bottom, 150m, 100m, 50m, 20m and temperature inversion when no overlaping with other depths) from the rosette and 2 dephts (10m; surface water 3m from the snow cover) from ice raid. This protocol was processed at every basic sampling and through some supplementary experiment (see below). Replicates from each depth were then incubated for 4 h with ^{3}H-thymidine to measure bacterial DNA synthesis and ^{3}H-leucine to measure bacterial protein synthesis, according to JGOFS protocols and was refine by Josep M. Gasol (ICM, Barcelona, Spain). The incubations were made in microtubes (2 mL) and were terminated by addition of trichloroacetic acid (50%), and then centrifuged for 10 minutes at 12 000 rpm. The surfactant was removed by suction and these were rinsed with ice-cold TCA (5%), before a second centrifugation (10 minutes at 12 000 rpm). The surfactant was removed a second time and scintillation cocktail was added to microtubes. The samples were counted after 24 to 48 of rest in the dark with a TriCarb 2900 (Packard).

Extra samples of surface water were taken to proceed time series experiments, Thymidine-Leucine saturation curve and conversion factor (twice).

Summary of Samples

Basic sampling at station WINTER 1

Date		**Sampled Depths**
10-12-2003	Rosette Cast 004	20m, 50m, 100m, 150m, Bottom (213m), temperature inversion

11-12-2003	Ice Raid	Surface (3m from snow cover), 10m
16-12-2003	Rosette Cast 016	20m, 50m, 100m, 150m, Bottom (219m), temperature inversion
17-12-2003	Ice Raid	Surface (3m from snow cover), 10m
22-12-2003	Rosette Cast 029	20m, 50m, 100m, 150m, Bottom (220m)
23-12-2003	Ice Raid	Surface (3m from snow cover), 10m
28-12-2003	Rosette Cast 041	20m, 50m, 100m, 150m, Bottom (219m), temperature inversion
29-12-2003	Ice Raid	Surface (3m from snow cover), 10m
03-01-2004	Rosette Cast 053	20m, 50m, 100m, 150m, Bottom (219m), temperature inversion (35m)
04-01-2004	Ice Raid	Surface (3m from snow cover), 10m

Microbial community structure

At each of the basic sampling (rosette and ice raid) the following samples were taken from all described depths above (water column profiles): picocyanobacteria (Anodisc filters on slides with Aquapolymount); heterotrophic bacteria (fixed then black Nuclepore filters on slides with Aquapolymount); and size-fractionated Chl *a* samples (3 μm to separate *Micromonas* and other picophytoplankton). Water samples were prepared for eukaryotic DNA analysis (clone libraries of greater than and less than 3 μm fractions); picocyanobacterial DNA and cultures of picocyanobacteria. Water column profiles were obtained at each full station for the following variables: picocyanobacteria (slides); heterotrophic bacteria (DAPI-slides and CTC slides); protists (preserved for fluorescence-Nomarski-Utermöhl microscopy); size-fractionated Chlorophyll *a* (total and 3 μm filtration).

On every basic sampling, surface, temperature inversion and bottom water were processed for FISH analysis (fluorescence *in situ* hybridisation) of picoeukaryotes; and FISH analysis of bacteria. These depths were chosen to do size-fractionated (total and less than 3 μm) HPLC analysis of pigments. The picoeukaryote DNA and FISH analyses will be conducted by Dr. Connie Lovejoy and other members of the laboratory of Dr. Carlos Pedros-Alió, Institut Ciènces del Mar, Barcelona, Spain.

Nutrients and grazing experiments

Nutrients and grazing experiments were conducted on surface water from independent ice raid during this leg. Nutrients were added to filtered (0.8 μm) and non filtered seawater. Different mixtures of nutrients were used: carbon (5 uM), nitrogen (10 uM) and phosphorus (5 uM). These results will lead to know the state of bacteria and the influence of nutrients on bacterial winter production. Grazing experiments were conducted on FLB (fluorescent labelled bacteria), FLA (fluorescent labelled algae; picocyanobacteria isolated from the mission CASES 2002) and fluorescent beads to understand the importance of nanoplancton in the microbial winter food web.

Summary of Samples from nutrients and grazing experiments
(WINTER 1 station, independent of basic sampling)

Enrichment experiments table (two replicates)

	C	CN	CNP	Control
total	**Sampling days (0, 2, 5, 7, 9, 13, 18)** a. Bacterial production (10 ml) b. Concentration of bacteria(4 ml) **Samples days 0 and 18** a. Nanoflagellate b. Picoplankton (15 ml) c. FISH (250 ml) **Respiration experiments** 2 BOD collected on day 0 2,5, 9	idem	idem	idem
Filtered on 0,8 um	idem	idem	idem	idem

Unfiltered seawater experiments (there was two replicates)

C	**CN**	**CNP**	**Control**
Sampling hours (0, 24, 36, 48 and 72h): a. Bacterial production (10 ml) b. Bacterial concentration (4 ml) **Unité d'échantillonnage (0,48 h):** a. Nanoflagellates (50ml) b. Picoplankton (50 ml) c. FISH (250 ml)	idem	idem	idem

Grazing experiments

	FLB	**FLA**	**Fluorescent beads** (0,5 and 1 um)
Replicates	2	2	2
Control	1	1	1
Sampling hours	**0, 24, 36, 48 and 72h** a. Bacterial production b. Bacterial concentration **0,48 h** a. Nanoflagellates (50ml) b. Picoplankton (50 ml) c. FISH (250 ml)	idem	idem

Complementary samples

From every depths at each basic sampling, FCDOM (for synchronous fluorescence characterization and sourcing of the dissolved organic matter), CDOM spectral absorption, and DOC samples were collected.

Twice during this leg, further surface samples (5L filtered through 0.22 um membranes) were obtained for photochemical action spectra of CDOM photodegradation and hydrogen peroxide formation. In parallel, 35 L of acidified water (pH ~2) were treated for lignin

extraction on sorbent C_{18}. This work will be conducted by Dr. Chris Osburn, at the Marine Biogeochemistry Section of US Naval Research Laboratory, Washington, DC.

Size-fractionated (total and less than 3 μm) seston samples for dry weight measurements were taken from 3 depths (surface, bottom and 20m or temperature inversion when present) at each basic sampling. Twice during this leg, seston samples were obtained on precombusted GF/F filter for stable isotope analysis ($\delta^{13}C$ and $\delta^{15}N$) from the water surface as a further guide to the source of POM.

Summary of Complementary Samples

Type of analysis	**Sampling**	**Sampled depths**
POM Dry Weight	Basics	3 depths (Surface, Bottom and temperature inversion or 20m)
CDOM / DOC	Basics	Every depths
Lignin extraction	Ice raid (2)	Surface
Stable isotopes	Ice raid (2)	Surface

Considerations for Leg #4 to Leg #6

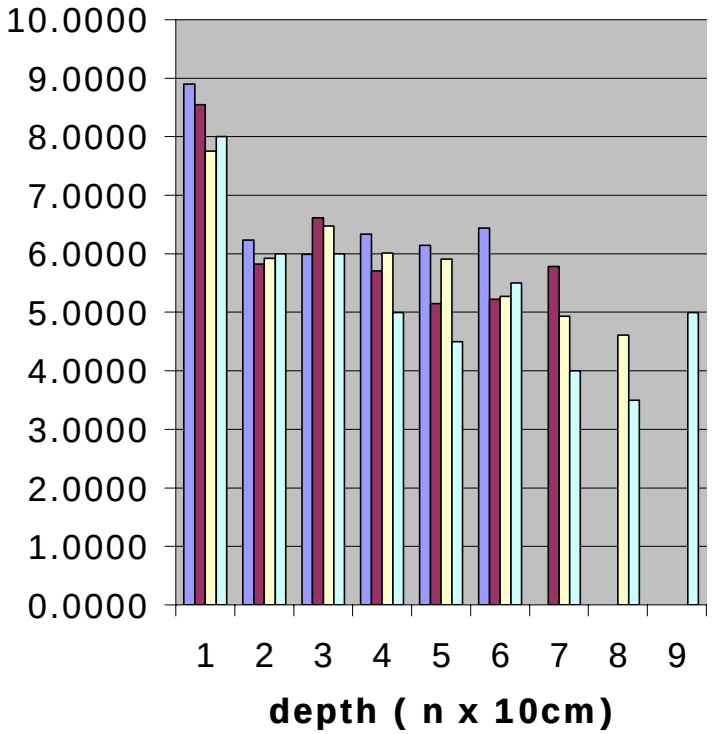
Within the winter legs where the ship will stay in the Franklin Bay, a transect should be sampled between the ship and the Horton River for at least 2 stations (one as near as possible from the River and one between the vessel and the River). This should give insight of the influence of this river on our samples and the processing of organic matter in Horton River versus offshore waters and its relationships with sea ice conditions (one of the main objectives of CASES mission). This would give a similar gradient than what we can expect between Mackenzie delta and offshore water at this period of the year but at a lesser scale.

Steve Vance – Jody Deming, University of Washington, Seattle, Ice Microbes Group

While the ship spent the first two weeks looking for a suitable overwintering spot, I located all inventoried items brought by me as well as those left on board in August. I set up a countertop space in the Hobby Room for preparing brine solutions and a space in the Cold Room for sample processing. During this time, the planned first seawater sample was not processed, mainly due to uncertainty about the how to proceed.

In the weeks that followed, samples were collected every Saturday, thanks largely to the help of Owen Owens, who will also be present during Leg 4. Core depth and average salinity are shown in the chart below. After collection, the first two sets of samples were put into brine solutions to melt immediately. This meant processing occurred late Sunday night, and early into Monday morning. EPS I samples may have been compromised for these, since filters and filtrate were frozen together rather than separately. Further problems were encountered due to a recurring difficulty reaching the desired 250 ppt concentration of brine solution (225 was the highest attained). To achieve desired salinities, I used the fully concentrated brine as solution for melting of some samples. This was thought to be the cause of the build-up of precipitates on their DNA filters, but the most recent set of 20-30cm samples processed with an appropriately concentrated solution, also had precipitates. It seems more likely that precipitation is occurring because the brine solutions were exposed to relatively high temperature (-5 to +1 ^{o}C as opposed to the –12 native temperature). DNA filtration was done

for an average of about 1300 ml of solution per sample. Problems were encountered with FISH protocol when the week's samples were not transferred to their freezer vials for a week rather than the prescribed 24 hours. No other major mishaps occurred, aside from difficulties keeping the pump trap from overflowing while managing other tasks. Sampling and processing details are summarized in the documents "SampleLog-CASES03.doc" and "TempsLog-CASES03.doc". Physics data were taken in part by Alex Langlois, who will also be present during Leg 4.



Time constraints limited some core sampling efforts, as fieldwork was not allowed outside "daylight" hours. A course-toothed, or wood, saw worked best for cutting samples. Motorized assistance was not required for core collection, though ease of hand drilling was not assured if one paused during drilling, during which time ice could form inside the barrel. To avoid seawater contamination of deep core sections, samples were only taken from cores that were successfully removed from 5-10cm above the ice/water interface before seawater seeped into the hole. This process required quickly breaking off the core section from the ice to which it inevitably remained attached. Retrieving the section by hand proved very difficult for cores 84cm long, and may be impossible for longer cores unless a means for gripping them are devised.

5. Pelagic Food Web: Structure, Function and Contaminants

Principal investigator: Don Deibel, Memorial University

Cruise participants: Tara Businski, Simon Lebel, Sohei Matsuda, Anna Prokopowicz, Marc Ringuette and Makoto Sampei

General objectives

The beginning of the winter season is of a large interest for our group. The reproductive and growth state, the lipid content and the total biomass of the mesozooplankton community are under scrutiny here like never before for this time of the year. The key interest is how this community copes with the harsh conditions of the winter season and is able to grow and survive.

We represent 3 different institutions with broad interests within the mesozoplankton reel that go from marine snow up to Arctic cod by way of apendicularia, copepoda, chaetognaths and amphipoda, all relating to how the carbon flowsthrough the food chain. The following sections will reflect the sampling done by the entire group, and the specific objectives of each group.

Sampling

This section represents the core mezooplankton sampling. Variations by each subgroup will be dealt with later. The sampling scheme included weekly sampling from the moon pool starting 9 December 2003 (Day 1) using the Hydrobios (Stratified, Stock assessment and Live animals, all 200µm nets). The two different VPRs, focussing on different particle sizes, were deployed on day 2. Zooplankton in these videos will be identified and fine-scale vertical distribution of mesozooplankton examined. On day 5, at the ice station Dukuduku, a 0.5 m diameter ring net with 200µm-mesh net coupled with a 10 cm diameter, 50µm-mesh net was deployed every week. A CTD cast using a SBE 19 was also done at the same time. In addition, live animals were collected every day in order to supply everyone's experimental needs, with a particular effort at collecting *Themisto libellula,* which are difficult to catch in large numbers with vertical net tows. We also tried to catch them with a 1 m^2 drift net deployed from the moon pool and a 0.5m diameter drifting ring net from the station ice Dukuduku.

We also sampled at 4 hour intervals for a period of 24 hours to evaluate variation in mesozooplankton diel vertical distribution and the gut evacuation rates of copepod and chaetognath communities.

Table 1: Summary of the zooplankton team sampling ewffort in CASES 2003-2004 Leg 3

	Moon pool sampling					Ice station Dukuduku					Measurements				
Date	Hydrobios	VPR	Vertical nets	Drift net	Water sampling	Drifting nets	Baited traps	Ring nets	Water sampling	CTD	Epr	Gut evacuation rates	Fecal pellets	Dry weight	CHN
09/12/2003	X						X								X
10/12/2003	X		X				X					X	X		
11/12/2003		X					X								
12/12/2003							X				X				
13/12/2003					X		X								
14/12/2003							X	X	X	X	X				
15/12/2003							X								
16/12/2003	X						X					X	X		X
17/12/2003		X		X			X								
18/12/2003			X			X					X				
19/12/2003			X		X	X									
20/12/2003			X			X		X	X	X					
21/12/2003			X		X	X			X					X	
22/12/2003	X		X			X					X	X	X		X
23/12/2003		X	X	X		X									
24/12/2003			X			X			X						
25/12/2003			X			X									
26/12/2003			X		X	X		X	X	X	X				
27/12/2003			X		X	X									
28/12/2003	X		X			X						X	X		X
29/12/2003			X	X	X	X			X		X				
30/12/2003	DVM	X	X			X						X	X		X
31/12/2003	DVM	X	X			X						X	X		X
01/01/2004			X			X		X	X	X	X				
02/01/2004			X			X									
03/01/2004	X		X		X	X						X	X		X
04/01/2004		X	X	X		X					X				
05/01/2004			X												
06/01/2004			X			X		X		X					

Specific subgroup objectives and preliminary results:

Most of the work performed here consists of collecting samples that will be analysed back in our respective laboratories in the coming year. Given that, very few preliminary results can be put forward here. Table 1 summarizes our sampling effort and the following 3 sections will present the work of each of our subgroups.

5.1. Memorial University (Tara Businski)

Rationale

The goals of my work on this leg were (1) to determine the source (i.e. terrestrial-based or marine-based) of food material in the diets of zooplankton, including the composition of the suspended particulate matter (SPM) to obtain biomarker end-member values for available food particles, (2) to determine the food sources and feeding relationships between hyperbenthic zooplankton using fatty acid biomarkers and CNP ratios, and (3) to examine small-scale spatial distribution of zooplankton using Video Plankton Recorders (VPR) and to calibrate video data with quantitative net tows.

Based upon a sparse existing literature for the Beaufort Sea Shelf (BSS) and preliminary data from the CASES02 cruise, I predicted that herbivorous copepods feed selectively on marine phytoplankton, whereas appendicularians and other non-selective feeders consume particles in proportion to their availability in the water column and therefore feed proportionally on more terrestrial source material than do copepods (Parsons et al. 1989). Feeding on SPM by zooplankton affects the fate of those particles because zooplankton repackage small, slowly-sinking particles into large, fast-sinking faecal pellets and soma. Pellets and diatoms sink at from 10's to 100's of m d^{-1} (Hamm 2002, Dagg et al. 1996), while small (i.e. < 0.2 μm diameter) lithogenic particles sink at < 1 m d^{-1} (Dagg et al. 1996). This means that food particles that would otherwise be remineralized in the water column may be repackaged into faecal pellets that sink rapidly to the bottom.

Hyperbenthic zooplankton live just above the sediment surface and are not adequately sampled either by nets or benthic samplers so their food webs are poorly understood. This community has a potentially large impact on the fate of organic matter reaching the benthos, but it is largely unstudied.

Video plankton recorders can resolve objects ranging in size from diatom chains to adult copepods. These images will be used to determine the fine scale vertical distribution of mesozooplankton and their prey. The VPR package includes a SeaBird CTD and *in situ* fluorometer, so that zooplankton distribution can be related to hydrographic and phytoplankton vertical structure.

Methods

I collected each type of sample every 6 days from10 Dec 2003 through 6 Jan 2004 at the overwintering site. Water was collected from the rosette at 3 depths and up to 15L filtered onto a GF/F filter. I placed each filter, including one blank, in a separate lipid-clean vial, added 2ml of chloroform, purged the headspace with N_2 and froze at -20°C. These samples will be analyzed for lipid classes aand fatty acids to distinguish terrestrial

and marine food sources available to zooplankton. Bottom-tripping Niskin water was filtered onto 5 filters. Four of these filters plus 2 blanks were placed in petri dishes and frozen at –20°C for measurement of carbon, nitrogen, and phosphorus. The remaining filter plus one blank were treated as rosette water above for lipid class and fatty acid analyses.

Water column zooplankton were collected from a 220 to10m tow on the same day as rosette water was collected. I picked *Calanus hyperboreous* C6 females, *C. hyperboreous* C4, *C. glacialis* C4-6, *Eukrohnia hamata*, *Oikopleura* sp., and hyperiid amphipods when abundant. The first 20 animals of each taxon were measured and staged. I picked up to 40 animals into lipid-clean vials, added 2ml of chloroform, purged the headspace with N_2, and froze them at –20°C. These samples will be analyzed for lipid classes and fatty acids to distinguish terrestrial and marine food sources. Up to 20 additional animals were picked into microcentrifuge tubes and frozen at -20°C for CHN analysis.

Water column zooplankton and surface water were also collected from the ice station Dukuduku to examine the possible effects of the ship on lipids and fatty acid biomarkers. These samples were preserved as above for lipid and fatty acid analyses.

Hyperbenthic zooplankton were collected in traps baited with meat scraps. These animals were collected the same day or the day after the bottom-tripping Niskin was deployed. Animals were preserved in the same way as water column zooplankton above.

Faecal pellets from water column zooplankton were collected the day after the hydrobios tow using a 50µm-mesh phytoplankton net. Codend contents were sieved onto a 50µm-mesh disc and 2-3 appendicularian faecal pellets were picked with a micropipettor into a microcentrifuge tube for mineralogy analysis (in collaboration with A. Mucci, McGill Univ.). The remainder of the codend contents were frozen at -80°C under N_2 for lipid class and fatty acid analyses.

References

Dagg, M.J., E.P. Green, B.A McKee, P.B. Ortner. 1996. Biological removal of fine-grained lithogenic particles from a large river plume. *J. Mar. Res.* 54: 149-160.

Hamm, C.E. 2002. Interactive aggregation and sedimentation of diatoms and clay-sized lithogenic material. *Limnol. Oceanogr.* 47: 1790-1795.

Parsons, T.R, D.G. Webb, B.E. Rokeby, M. Lawrence, G. Hopky. 1989. Autotrophic and heterotrophic production in the Mackenzie River/Beaufort Sea Estuary. *Polar Biol.* 9: 261-266.

5.2. NIPR, Japan (Sohei Matsuda and Makoto Sampei)

Rationale

Total particulate organic carbon flux is known to be closely correlated with primary production. However, previous studies have shown marked variability in biogenic components such as phytoplankton remains and zooplankton fecal pellets in settled material collected in sediment traps both locally and seasonally. Zooplankton, and especially copepods, may play an important role in carbon cycles and sinking processes of particulate organic carbon through production and/or consumption of fecal pellets in

the Arctic ecosystem. My objective is to determine seasonal changes in sinking processes of particulate organic carbon.

Methods

During the leg 2, zooplankton and water sampling were conducted to determine gut evacuation rates, fecal pellet composition and suspended POC ($d^{13}C$), PON ($d^{15}N$) to compare with swimmers and particulate matter in the long-term sediment trap. Zooplankton samples were collected with Hydrobios almost once a week (see Table 1) for gut evacuation rates and fecal pellet composition. The remainder of each sample was preserved for stable isotope analyses. Water samples were collected (see Table 1) and filtred on pre-combusted Watman GF/F glass fiber filters for suspended POC ($d^{13}C$) and PON ($d^{15}N$) analyses. For Japanese participants studying micro-zooplankton, water samples were also collected (see Table 1) and preserved for determination of micro-zooplankton composition and population.

Experiments were also conducted to study Chaetognath ecology. Animals were collected 5 times using Hydrobios (See Table 1) to estimate their digestion time and analyze their gut contents. Each specimen was picked up carefully from the samples and incubated in one of 2l poly-carbonate bottles filled with sea water. The rest of the samples were fixed for gut content analysis. In addition, samples were collected 6 times in 24 hours by using the Hydrobios at every 4 hours to compare the diel changes in gut contents of chaetognaths. The samples were fixed with 5 % buffered form-aldehyde immediately.

Talbe 1. zooplankton sampling list.

DEPTH (m)	STATION	DATE	LCT	CAST NO.	COMMENTS
10-100	MOON POOL	10-Dec-03	16:25	02	Gut evac.
10-100	MOON POOL	10-Dec-03	16:25	02	Fecal pellts
100-205	MOON POOL	10-Dec-03	16:25	02	Gut evac.
100-205	MOON POOL	10-Dec-03	16:25	02	Fecal pellts
10-100	MOON POOL	16-Dec-03	12:49	03	Gut evac.
10-100	MOON POOL	16-Dec-03	12:49	03	Fecal pellts
100-215	MOON POOL	16-Dec-03	12:49	03	Gut evac.
100-215	MOON POOL	16-Dec-03	12:49	03	Fecal pellts
10-100	MOON POOL	22-Dec-03	12:55	05	Gut evac.
10-100	MOON POOL	22-Dec-03	12:55	05	Fecal pellts
100-200	MOON POOL	22-Dec-03	12:55	05	Gut evac.
100-200	MOON POOL	22-Dec-03	12:55	05	Fecal pellts
10-100	MOON POOL	28-Dec-03	12:45	07	Fecal pellts
100-215	MOON POOL	28-Dec-03	12:45	07	Fecal pellts
10-100	MOON POOL	30-Dec-03	14:15	011	Gut evac.
10-100	MOON POOL	30-Dec-03	14:15	011	Fecal pellts
100-200	MOON POOL	30-Dec-03	14:15	011	Gut evac.
100-200	MOON POOL	30-Dec-03	14:15	011	Fecal pellts
10-100	MOON POOL	31-Dec-03	2:10	015	Gut evac.
10-100	MOON POOL	31-Dec-03	2:10	015	Fecal pellts
100-200	MOON POOL	31-Dec-03	2:10	015	Gut evac.
100-200	MOON POOL	31-Dec-03	2:10	015	Fecal pellts
10-100	MOON POOL	3-Jan-04	12:44	017	Gut evac.
10-100	MOON POOL	3-Jan-04	12:44	017	Fecal pellts
100-200	MOON POOL	3-Jan-04	12:44	017	Gut evac.
100-200	MOON POOL	3-Jan-04	12:44	017	Fecal pellts

Table 2. Water sampling list for stable isotope analyses.

DEPTH (m)	STATION	DATE	LCT	CAST NO.
10	MOON POOL	13-Dec-03	6:43	009
19	MOON POOL	13-Dec-03	6:43	009
50	MOON POOL	13-Dec-03	6:43	009
75	MOON POOL	13-Dec-03	6:43	009
200	MOON POOL	13-Dec-03	6:43	009
220	MOON POOL	13-Dec-03	6:43	009
10	MOON POOL	19-Dec-03	6:44	021
20	MOON POOL	19-Dec-03	6:44	021
50	MOON POOL	19-Dec-03	6:44	021
75	MOON POOL	19-Dec-03	6:44	021
200	MOON POOL	19-Dec-03	6:44	021
219	MOON POOL	19-Dec-03	6:44	021
10	MOON POOL	19-Dec-03	18:40	022
20	MOON POOL	19-Dec-03	18:40	022
50	MOON POOL	19-Dec-03	18:40	022
75	MOON POOL	19-Dec-03	18:40	022
200	MOON POOL	19-Dec-03	18:40	022
219	MOON POOL	19-Dec-03	18:40	022
1	DUK DUK	24-Dec-03	13:00	-
10	MOON POOL	3-Jan-04	6:42	051
23	MOON POOL	3-Jan-04	6:42	051
50	MOON POOL	3-Jan-04	6:42	051
75	MOON POOL	3-Jan-04	6:42	051
200	MOON POOL	3-Jan-04	6:42	051
219	MOON POOL	3-Jan-04	6:42	051
10	MOON POOL	3-Jan-04	18:38	052
23	MOON POOL	3-Jan-04	18:38	052
50	MOON POOL	3-Jan-04	18:38	052
75	MOON POOL	3-Jan-04	18:38	052
200	MOON POOL	3-Jan-04	18:38	052
219	MOON POOL	3-Jan-04	18:38	052

Talbe 3. Water sampling list for microbial zooplankton.

DEPTH (m)	STATION	DATE	LCT	CAST NO.
1	DUK DUK	21-Dec-03	13:33	-
5	DUK DUK	21-Dec-03	13:25	-
10	MOON POOL	21-Dec-03	19:25	028
25	MOON POOL	21-Dec-03	19:25	028
50	MOON POOL	21-Dec-03	19:25	028
100	MOON POOL	21-Dec-03	19:25	028
150	MOON POOL	21-Dec-03	19:25	028
200	MOON POOL	21-Dec-03	19:25	028
10	MOON POOL	26-Dec-03	16:55	021
10	MOON POOL	26-Dec-03	21:00	021
10	MOON POOL	27-Dec-03	1:05	021
10	MOON POOL	27-Dec-03	5:05	021
10	MOON POOL	27-Dec-03	9:05	022
10	MOON POOL	27-Dec-03	12:55	022
10	MOON POOL	27-Dec-03	17:00	022
10	DUK DUK	29-Dec-03	18:40	-
10	MOON POOL	29-Dec-03	18:40	045

5.3. U. Laval (Marc Ringuette, Anna Propokowicz and Simon Lebel)

Rationale

Our group is working mainly on annual cycle processes and on the spatial scale comparison of the four main biota we sampled throughout this year-round project i.e. the polynya, Mackenzie shelf, the shelf break, and Franklin Bay. Our knowledge of zooplankton overwintering strategies is limited, even for well known species like *Calanus* sp. Our goal is to maintain the continuity in the measurements of copepod reproduction, lipid content and respiration, and feeding and physiological state of *Themisto libellula* and fish (Arctic cod).

Methods and preliminary results

Copepod egg production and gonad maturation was monitored with bi-weekly egg production experiments for all the large calanoid species. *Calanus glacialis*, and *Metridia longa* are not producing anymore eggs at this time of the year and *Calanus hyperboreus* have just started to produce eggs. Nevertheless, we are conducting a long-term experiment that consists of a comparison the timing of the production between a population kept in captivity and the natural population. These results will allow us to estimate the feasibility of future studies on this species using animals caught in the late fall and kept in laboratory.

Egg carrying species are actually producing eggs but they are especially hard to study given the very long time they spent building a new egg sac when they lose it. *Oithona similis*, one of our target species, is known to produce eggs this time of year, but

very few females wearing an egg sacs were encountered, despite the fact that we found a large number of them in our samples. In fact, we found many egg sacs in our samples, but

rarely attached to the female. Given that, it is very difficult to measure the hatching time. But *Euchaeta* spp. is reltively easy to study and the robustness of the females allow them to keep there eggs.

Respiration measurements were carried out once within this leg according to our original plan for *Oithona similis* females*, Calanus hyperboreus, Calanus glacialis* and *Metridia females* and *CV*. Dry weigt, and total lipid samples were preserved after respiration experiments.

Themisto libellula is considered as a key player in the arctic food chain, but its role remains poorly understood, except with the higher trophic link, namely seals. In table 2 we present the catch result according to different sampling strategies used and the numbers of animals preserved for the different analyses.

Table 2. Preliminary catch results of *Themisto libellula* and measurements

Sampling method	**Total Catch**	**%**	**No. of deployement**
Moon pool			
HYDROBIOS (0.75 m^2, 200µm)	66	38.82	33
Vertical tows (1m^2, 200µm)	82	48.24	36
Drifting net (1m^2, 200µm)	3	1.76	5
Ice station			
Drifting net (50 cm diam. 200µm)	19	11.18	20
Traps	0	0	9
Total	**170**	100	103

Collected animals were used for:	
Lipids extraction	21
Dry weight	50
Full gut analysis	39
Empty gut analysis	44
	154

A total of 15 Arctic cod were caught, all from the moon pool sampling. With an average length of 103.6 mm, the smallest fish was a YOY at 34mm while the largest fish was at 204mm. The only other fish species caught was Liparidae (7 specimens). Competition with seals visiting in the moon pool, coupled with the poor efficiency of the vertical net technique for such large fish might explain the low abundance of fish in our samples.

And finally, in order to fulfill the objectives of the Contaminants group, we preserved sorted (*Calanus hyperboreus*, jellyfish, *Euchaeta* spp, Amphipoda and fish) and bulk samples for later estimation of contaminants in the pelagic food web.

Concluding remarks

The deployment of the Hydrobios from the "moon pool" is rather laborious, particularly the rinsing process. We should use a more powerful pump to make the process easier and ensure that no animals remain inside the nets.

Contrary to our expectations current direction varies a lot and can easily reverse direction. Specific mesozoolpankton communities respond to these changes accordingly. For example, some appendicularians are seen in samples only when the currents are from the western sector i.e. from the shore. Inversely, *Euchaeta* spp. are usually very abundant in our samples and many females are seen bearing their large, dark blue egg sacs, except when we have this same westerly current. Unfortunately, we did not take note on the daily current change at Dukuduku where we had to retrieve a drifting net at about the same time every day, but the current seems to vary by about 15 degrees counter clockwise each day. Given that information, the current shift seems to correspond to a tidally related phenomenon. This is an important factor when considering the timing of our future sampling.

6. Organic and inorganic fluxes

Principal investigators: Philip R. Hill (NRCan), and Robby Macdonald (Intitute of Ocean Sciences, DFO)

Cruise participants: Denis Brion and Cédric Magen

6.1. Sediment geochemistry (Christine Martineau and Sébastien Roy)

A total of 19 sediment cores were taken at wintering site (70°02'73 N 126°18'07 W) with the small boxcorer using the moon pool. Seven cores were sliced for bulk analysis (CHN, metals, porosity) and also for determining non-amino aliphatic (NAA) fraction in organic matter. The 0-7 cm layer of the sediment is brown and turns grey with a clay texture in the following layers. Surface sediment seems rich in organic matter and also in infauna. Experimentation was done on 12 cores. The objective of the experimentation was to simulate an input of fresh organic matter and measure within a timeline any change in redox conditions (Mn, Fe, O_2, I^-) using the Au/Hg electrode method and also in organic matter degradation or preservation. Five cores were used to evaluate the reduction kinetics at cold temperature for Mn and Fe oxy-hydroxydes present in the surface layer. Amphipods were used as an organic matter source and were mixed with the first sediment layer. The distribution of Mn(II) and Fe(II) was then monitored using several microelectrodes. Preliminary results showed a increase of Mn(II) at all depths along with a depletion of O_2 in surface waters. Mn(II) concentration were really high at the end of the experiments. The data have yet to be interpreted to determine whether or not Fe(II) was present.

III. Seminars activities

Marc Ringuette: From Mackenzie shelf to Laptev Sea 04/12/03 a 19h30

Alexandre Langlois: Snow physical and electromagnetic properties retrieval from microwave radiometry over first-year ice 09/12/03 a 19h30

Steve Vance: Arctic bacteria on Jupiter's second moon 16/12/03 a 19h30

Owen Owens: Gas measurement: concentration and movement in an arctic marine environment 23/12/03 a 19h30

Marc Ringuette: Unpuzzling the linkages between CASES, the CCGS Amundsen and Arctic Net 26/12/03 a 19h30

Sébastien Roy: Ecologie hivernale du reseau alimentaire microbien dans la baie de Franklin 30/12/03 a 19h30

Tara Businski: Terrestrial and marine-based food sources for zooplankton in the Beaufort Sea 02/01/04 a 19h30

Appendix A. CASES03 Leg3 daily sampling log

Ship's time (Central daylight, UTC-6hr, switching to Central standard, UTC-7, on October 26th)

10-déc-03					
Wednesday (DAY 1)	**06:30**	***to***	**08:30**	2	Rosette (Microbes+ primary production+CTD)
	08:30	***to***	**10:30**	2	Rosette (Zooplankton)
	12:30	***to***	**14:30**	2	Hydrobios
	18:30	***to***	**19:00**	0,5	CTD cast
11-déc-03					
Thursday (DAY 2)	**06:30**	***to***	**07:00**	0,5	CTD cast
	08:00	***to***	**10:00**	2	VPR+Particle camera
	10:00	***to***	**10:30**	0,5	Diatom net (no deck hand)
	12:30	***to***	**14:30**	2	Piston corer
	18:30	***to***	**19:00**	0,5	CTD cast
12-déc-03					
Friday (DAY 3)	**06:30**	***to***	**07:30**	1	Rosette (CTD+Makoto)
	15:30	***to***	**17:00**	1,5	Bottom Tripping Niskin
	18:30	***to***	**19:30**	1	Rosette (CTD+Makoto)
	19:30	***to***	**20:00**	0,5	Traps
13-déc-03					
Saturday (DAY 4)	**06:30**	***to***	**07:00**	0,5	Trap Recovery
	07:00	***to***	**07:30**	0,5	CTD cast
	08:30	***to***	**10:30**	2	Piston corer
	15:30	***to***	**17:00**	1,5	Bottom Tripping Niskin
	18:30	***to***	**19:30**	1	CTD cast
14-déc-03					
Sunday (DAY 5)	**06:30**	***to***	**07:00**	0,5	CTD cast
	18:30	***to***	**19:00**	0,5	CTD cast
15-déc-03					
Monday (DAY 6)	**06:30**	***to***	**07:00**	0,5	CTD cast

	18:30	***to***	**19:00**	0,5	CTD cast
16-déc-03					
Tuesday (DAY 1)	**06:30**	***to***	**08:30**	2	Rosette (Microbes+ primary production+CTD)
	08:30	***to***	**10:30**	2	Rosette (Zooplankton)
	12:30	***to***	**17:00**	4,5	Hydrobios
	18:30	***to***	**19:00**	0,5	CTD cast
17-déc-03					
Wednesday (DAY 2)	**06:30**	***to***	**07:00**	0,5	CTD cast
	08:00	***to***	**10:00**	2	VPR+Particle camera
	10:00	***to***	**10:30**	0,5	Diatom net (no deck hand)
	12:30	***to***	**14:30**	2	Piston corer
	18:30	***to***	**19:00**	0,5	CTD cast
	19:00	***to***	**19:45**		Drifting net
18-déc-03					
Thursday (DAY 3)	**06:00**	***to***	**06:30**	0,5	Drifting net (Recovery)
	06:30	***to***	**07:30**	1	Rosette (CTD+Makoto)
	08:30	***to***	**10:00**	1,5	Vertical net tow
	18:30	***to***	**19:30**	1	Rosette (CTD+Makoto)
	19:30	***to***	**20:00**	0,5	Traps
19-déc-03					
Friday (DAY 4)	**06:00**	***to***	**06:30**	0,5	Trap Recovery
	06:30	***to***	**07:00**	0,5	CTD cast
	08:30	***to***	**10:30**	2	Piston corer
	13:30	***to***	**15:00**	0,5	Vertical net tow
	15:30	***to***	**17:00**	1,5	Bottom Tripping Niskin
	18:30	***to***	**19:30**	1	CTD cast
20-déc-03					
Saturday (DAY 5)	**06:30**	***to***	**07:00**	0,5	CTD cast
	08:30	***to***	**09:00**	0,5	Vertical net tow
	18:30	***to***	**19:00**	0,5	CTD cast
21-déc-03					
Sunday (DAY 6)	**08:30**	***to***	**09:00**	0,5	CTD cast

	09:00	***to***	**09:30**	0,5	Vertical net tow
	18:30	***to***	**19:00**	0,5	CTD cast
22-déc-03					
Monday (DAY 1)	**06:30**	***to***	**08:30**	2	Rosette (Microbes+ primary production+CTD)
	08:30	***to***	**10:30**	2	Rosette (Zooplankton)
	12:30	***to***	**17:00**	4,5	Hydrobios
	18:30	***to***	**19:00**	0,5	CTD cast
23-déc-03					
Tuesday (DAY 2)	**06:30**	***to***	**07:00**	0,5	CTD cast
	08:00	***to***	**10:00**	2	VPR+Particle camera
	10:00	***to***	**10:30**	0,5	Diatom net (no deck hand)
	12:30	***to***	**14:30**	2	Piston corer
	18:30	***to***	**19:00**	0,5	CTD cast
	19:00	***to***	**19:45**		Drifting net
24-déc-03					
Wednesday (DAY 3)	**06:00**	***to***	**06:30**	0,5	Drifting net (Recovery)
	06:30	***to***	**07:00**	0,5	CTD cast
	08:30	***to***	**10:00**	1,5	Vertical net tow
	18:30	***to***	**19:00**	0,5	CTD cast
25-déc-03					
Thursday (DAY 4)	**13:00**	***to***	**13:30**	0,5	CTD cast
	13:30	***to***	**15:00**	1,5	Vertical net tow
	18:30	***to***	***19:30***	*1*	*CTD cast*
	19:30	***to***	***20:00***	*0,5*	*Traps*
26-déc-03					
Friday (DAY 5)	**08:30**	***to***	**09:00**	0,5	Traps recovery
	09:30	***to***	**11:00**	1,5	Vertical net tow
	13:00	***to***	**13:30**	0,5	CTD cast
	13:30	***to***	**15:00**	1,5	Piston corer
	15:30	***to***	**17:00**	1,5	Bottom Tripping Niskin
	17:00	***to***	**17:30**	0,5	Niskin Bottles (No deck hand)
	18:30	***to***	**19:00**	0,5	CTD cast
	21:00	***to***	**21:30**	0,5	Niskin Bottles (No deck hand)
27-déc-03					

Saturday (DAY 6)	**01:00**	***to***	**01:30**	0,5	Niskin Bottles (No deck hand)
	05:00	***to***	**05:30**	0,5	Niskin Bottles (No deck hand)
	08:30	***to***	**09:00**	0,5	CTD cast
	09:00	***to***	**09:30**	0,5	Niskin Bottles (No deck hand)
	09:30	***to***	**11:30**	2	Vertical net tow
	13:00	***to***	**13:30**	0,5	Niskin Bottles (No deck hand)
	17:00	***to***	**17:30**	0,5	Niskin Bottles (No deck hand)
	18:30	***to***	**19:00**	0,5	CTD cast
28-déc-03					
Sunday (DAY 1)	**08:30**	***to***	**10:30**	2	Rosette (Microbes+ primary production+CTD)
	10:30	***to***	**12:30**	2	Rosette (Zooplankton)
	12:30	***to***	**17:00**	4,5	Hydrobios
	18:30	***to***	**19:00**	0,5	CTD cast
	19:30	***to***	**20:00**	0,5	Traps
29-déc-03					
Monday (DAY 2)	**06:00**	***to***	**06:30**	0,5	Traps (Recovery)
	06:30	***to***	**07:00**	0,5	CTD cast
	08:30	***to***	**09:30**	1	Bottom Tripping Niskin
	10:00	***to***	**10:30**	0,5	Diatom net (no deck hand)
	10:30	***to***	**11:30**	1	Piston corer
	14:30	***to***	**16:30**	2	Vertical net tow
	18:30	***to***	**19:00**	0,5	CTD cast
	19:00	***to***	**19:45**	0,75	Drifting net
30-déc-03					
Tuesday (DAY 3)	**06:00**	***to***	**06:30**	0,5	Drifting net (Recovery)
	06:30	***to***	**07:00**	0,5	CTD cast
	08:30	***to***	**10:00**	1,5	Hydrobios 1
	10:00	***to***	**11:00**	1	Mini VPR + Camera
	12:30	***to***	**14:00**	1,5	Hydrobios 1
	14:00	***to***	**15:00**	1	Hydrobios 2
	15:30	***to***	**16:00**	1	Mini VPR
	16:00	***to***	**18:00**	1,5	Hydrobios 1
	18:00	***to***	**18:30**	0,5	Mini VPR
	18:45	***to***	**19:30**	0,75	CTD cast
	20:30	***to***	**22:00**	1,5	Hydrobios 1
	22:00	***to***	**23:00**	0,5	Mini VPR+camera

31-déc-03					
Wednesday (DAY 4)	**00:30**	***to***	**02:00**	1,5	Hydrobios 1
	02:00	***to***	**03:00**	1	Hydrobios 2
	03:00	***to***	**03:30**	0,5	Mini VPR
	04:00	***to***	**06:00**	1	Hydrobios 1
	06:00	***to***	**06:30**	0,5	Mini VPR
	07:00	***to***	**07:30**	0,5	CTD cast
	13:30	***to***	**15:00**	1,5	Vertical net tow
	16:30	***to***	**17:00**	1	CTD cast
01-janv-04					
Thursday (DAY 5)	**13:30**	***to***	**14:00**	0,5	CTD cast
02-janv-04					
Friday (DAY 6)	**06:30**	***to***	**07:30**	1	CTD cast
	09:30	***to***	**11:30**	2	Vertical net tow
	13:30	***to***	**15:00**	1,5	Piston corer
	18:30	***to***	**19:30**	0,5	CTD cast
03-janv-04					
Saturday (DAY 1)	**06:30**	***to***	**08:30**	2	Rosette (Microbes+ primary production+CTD)
	08:30	***to***	**10:30**	2	Rosette (Zooplankton)
	12:30	***to***	**17:00**	4,5	Hydrobios
	18:30	***to***	**19:00**	0,5	CTD cast
04-janv-04					
Sunday (DAY 2)	**08:30**	***to***	**09:00**	0,5	CTD cast
	09:00	***to***	**11:30**	2,5	VPR+Particle camera
	11:30	***to***	**12:00**	0,5	Diatom net (no deck hand)
	18:30	***to***	**19:00**	0,5	CTD cast
	19:00	***to***	**19:45**	0,75	Drifting net
05-janv-04					
Monday (DAY 3)	**06:00**	***to***	**06:30**	0,5	Drifting net (Recovery)
	06:30	***to***	**07:00**	1	Rosette (CTD)
	08:30	***to***	**10:00**	1,5	Vertical net tow
	15:30	***to***	**17:00**	1,5	Bottom Tripping Niskin
	18:30	***to***	**19:30**	1	Rosette (CTD+Makoto)
	19:30	***to***	**20:00**	0,5	Traps

06-janv-04					
Tuesday (DAY 4)	**06:00**	***to***	**06:30**	0,5	Trap Recovery
	06:30	***to***	**07:00**	0,5	CTD cast
	08:30	***to***	**10:30**	2	Vertical net tow
	18:30	***to***	**19:30**	1	CTD cast