Regional Operations Centre
Canadian Coast Guard – Pacific

PACIFIC REGION CCG VESSEL - POST CRUISE REPORT

Line P Program – Fisheries and Oceans Canada

NAME OF SHIP/PLATFORM: John P Tully

DATE: **FROM:** 17 August 2010 **TO:** 2 September 2010

SCIENCE CRUISE NUMBER: 2010-14 **SHIP'S PATROL NUMBER:** 10-06

CHIEF SCIENTIST[S]: Marie Robert

SCIENTIFIC PERSONNEL:

Female	Male
Amy Cain (UBC)	Michael Arychuk (IOS)
Constance Couture (UBC)	Michael Bentley (CWS)
Veronica Lance (Columbia Uni	Glenn Cooper (IOS)
Martine Lizotte (U Laval)	Keith Johnson (IOS)
Rebeccah McLean (UVic)	Hugh Maclean (IOS)
Josiane Mélançon (U Laval)	Jason McAlister (UBC)
Marie Robert (IOS)	Craig Mewis (UBC)
Nes Sutherland (IOS)	Scott Rose (IOS)
Rebecca Taylor (UBC)	David Semeniuk (UBC)
Jody Wright (UBC)	

AREAS OF OPERATION: North East Pacific, Line P, Station P.

INTRODUCTION/PROGRAM BACKGROUND: Line P is a long standing program which surveys a 1400 km long section 3 times annually. Data has been collected along this line since 1956 and shows evidence of the impact of climate variability on ocean productivity. It is the only Canadian long time-series that allows scientists to monitor climate changes in the Pacific Ocean. It is also the best opportunity for other programs (e.g. Universities) to do research in the Pacific since the Line P data give them background as well as current water properties. In addition, it is the best occasion for other projects (e.g. CWS) to access offshore waters.

This cruise (2010-14) was very successful despite many problems with the CTD and fewer days of operation than planned. All stations were completed but one Argo float could not get deployed because of lack of time.

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CRUISE OBJECTIVE/OBJECTIVES: Repeat hydrography section. Deploy two Argo floats. Perform a DMS Diurnal Cycle Experiment.

DAYS ALLOCATED: 16.5 **DAYS OF OPERATION:** 14.5

DAYS LOST DUE TO WEATHER: None.

SAMPLING:

- The Line P survey was 100% successful. All stations were visited. Only one surface trace metal sampling by 733 could not be performed due to weather.
- Only one Argo float was deployed for DFO (at P26). We did not have time to deploy the second one west of Papa.
- We managed to sample the DMS Diurnal Cycle Experiment for a period of 28 hours. Our goal was to do the experiment over a period of 36 hours, but we ran out of time. The experiment itself (following the drogue and sampling every 2 hours) went really well, despite the amount of work it created for the analysts.
- The samples collected include:

1) Underway: **IOS**: Thermosalinograph (Temperature, Salinity, Fluorescence), pCO_2, acoustic sounder. **– UBC (Couture):** N_2, O_2, CO_2, Argon, DMS.

2) "E-data" from CTD: Pressure, Temperature, Conductivity, Dissolved Oxygen, Transmissivity, Irradiance, Fluorescence.

3) From the Rosette: **IOS:** dissolved oxygen, salinity, nutrients, chlorophyll, HPLC, DIC, Alk, DMS, DMSP-p, DMSP-t, pH – **UBC (Wright/Couture/Mewis):** Bacterial genomic (DNA, RNA), CO_2, CH_4, N_2O, viral particles, bacterial cells, nitrite (NO_2), 15^N incubations, and ammonia (NH_3) – **UVic (McLean):** Oxygen, ONAr (Oxygen, Nitrogen, Argon), Salinity, Alkalinity/DIC, O17, and DOC – **City Uni. NY (Lance):** Thorium, Polonium, Total Chlorophyll, 5µm Chlorophyll, Total HPLC, 5µm HPLC, FCM, µplankton.

4) From the pump/X-Niskins: **IOS:** Iron – **U. Laval (Mélançon, Lizotte):** Chl *a* concentrations, nutrients, phytoplankton enumeration and identification, bacteria enumeration, photosynthetic efficiency (Fv/Fm ratio), dissolved iron and iron speciation, particulate organic carbon (POC) and particulate organic nitrogen (PON), dimethylsulfoniopropionate (DMSP) concentration, DMS concentration, and rates of nitrate assimilation ($K^{15}NO_3$) – **UBC (McAlister, Cain):** Aluminum, gallium, lead – **UBC (Semeniuk, Taylor):** total dissolved Fe, total dissolved Cu, Cu ligands, chl a, nutrients, HPLC, phytoplankton enumeration (microscope), flow cytometry samples (bacteria and picoyeuks), primary productivity, Fe assimilation rates, Fv/Fm

5) **IOS and City Uni. NY (Lance):** Zooplankton using vertical net hauls.

RADIOISOTOPE USE:

The following radioisotopes were used in the Rad-Van: $^{55}FeCl_2$ (0.1M HCl), $H^{14}CO_3$, ^{14}C-DFB. Wipe tests were done in all appropriate areas of the ship upon completion of the studies and the lab was decommissioned at the end of the cruise.

PROBLEMS [SCIENTIFIC GEAR AND OPERATIONS]:

The CTD/Rosette system was really pathetic during this cruise. We have had problems for many, many cruises, the problems (supposedly) got addressed, and yet they *still* re-occur. The main CTD acquisition computer used to reboot during casts, while the CTD was in the water. Then it stopped rebooting but started to simply freeze. Then it would freeze, but only while closing a Niskin. And this cruise, the computer didn't freeze at all, but there were spikes in the data that will make the CTD data processing very tricky and time consuming. The CTD/Rosette system is our **main instrument** on board. No CTD, no cruise. Yet cruise after cruise after cruise the system does not work properly. What will it take to get a working system on board????
(See Scott Rose's "CTD Issues Report below).
Most sincere "Thank you" to Scott Rose and Hugh Maclean for their patience and perseverance in trying, and so far managing, to fix the CTD/Rosette/Deck Unit/Computer package.

Many Niskin bottles on the Rosette need to be replaced. The top and bottom caps are getting old and do not close properly anymore which contaminate the water in the Niskin by mixing it with water from a different depth.

We also need a new Rosette frame that can be used with the LARS (mid-ship station). No one wants to have to do rosettes from the aft-deck anymore, the LARS being so much SAFER and efficient. But there is only one rosette at the moment that has the appropriate head to fit the latching mechanism of the LARS and appropriate extra weight and height underneath the main frame. We do have a spare rosette on board, but it can only be used for parts … or on the aft-deck, which is not a desirable option.

The fluorometer on the thermosalinograph shows a constant increase in fluorescence, to abnormally high values. By brushing it out there is a temporary return to something of a correct value but it begins increasing again immediately. A proper cleaning is needed (at least) or a replacement to a newer model, less prone to fouling.

CTD ISSUES REPORT FOR 2010-14: Scott Rose.

The first problem was bottle firing was locking up the computer. The computer's onboard com port that was used to run the pylon was suspected to be faulty. A USB to serial converter was used instead of the computer's onboard com port and this immediately cured the system of the initial problem. We set sail and the CTD didn't show any other symptoms until after a few stations had been done.

The next problem was spikes in the data, typical of an electrical short due to a pressure related leak. Instruments and y-splice cables were stripped off to try and narrow down the leak, but the spiking continued even with a CTD that only had the temperature and conductivity sensors attached. A retermination of the sea cable looked to be in order and was carried out. The spikes still persisted and the decision was made to swap the CTD out with the spare.

The spare showed the same symptoms, and as we have had issues with the pylon causing errors on the previous cruise, I decided to swap out the pylon for our brand new spare. In removing the pylon, it was notice that the bulkhead connector was loose an potentially leaking sea water into the pylon's electronics. We were convinced this was the source of the spiking, but we were sadly mistaken. We still had spikes after the new pylon was in place.

The status window was reporting a scan length error at the same time as the spiking occurred, and upon further research on the internet, it was found that the latest version of Seasave was designed to handle scan length errors that previous versions could not. I was able to download the new version at P20 surprisingly and install the new version. The spikes persisted, but the scan length error message no longer displayed in the status window when the spiking occurred. When the spiking did occur, we would simply stop the cast at it's current depth, start a new cast file and the spikes would not return for quite a while. Usually we would only have to stop the cast once, occasionally twice, and not at all on some casts. The problem was intermittent and quite illusive.

I called Sea-Bird Electronics as I was out of trouble shooting ideas. They didn't have any suggestions that I had not already carried out. As we had com port issues to start, I asked them if they have had trouble running the CTDs with USB to serial converters, they have had trouble with certain converters in the past and have taken the time to test various converters so they could recommend a few converters that work well with the CTD's frequency rates. We didn't have any of the approved converters onboard, so I chose to return the CTD to being run off the computer's onboard com ports as the pylon had now been replaced and that problem should not return. The computer's onboard com port worked perfectly for the rest of the cruise.

The pylon was a potential source of the original problem as the com port was locking up the system, the USB to serial port converter was most definitely a problem, and we will only have approved converters on the ship from now on, and if at all possible, the CTD will be run off the computer's onboard com ports.

SUCCESSES [SCIENTIFIC]:

We used to have problems with the latching mechanism of the rosette; some bottles would consistently NOT close. All the Niskins were closing properly this time.

PROBLEMS [SHIP'S EQUIPMENT/OPERATIONS/PLATFORM SUITABILITY]:

Some email accounts on the ship's email system are still not set-up properly and therefore not working.

The AVOS system needed rebooting many times during the cruise. This problem seems to be aggravating as it never used to fail before. All OOW should know how to reset this system so that we don't have to wait for one specific person to get the data back when the system fails.

The Rosette got "dropped" about 3 metres while deploying. It is unknown what exactly happened in the LARS head, but some cable got paid out even though the rosette was not going down and when the latching mechanism finally let go the rosette suddenly dropped almost to the surface of the water. The termination had to be redone and approximately 25-30 m of cable got cut off.

The Rosette hit the side of the ship a few times during deployment and recovery while inexperienced crew were on watch.

SUCCESSES [SHIP]:

We had no problem with the loop system, despite having three big incubators on the heli-deck.

Thanks to Captain McGregor for using two engines on the way from P20 to Papa. Without the time gained this way we would not have been able to accomplish all our planned work at Papa.

DELAYS [OTHER THAN WEATHER]:

One day for fuelling.
1.5 hour to get ready for departure because of new crew.
A few hours to train new crew on rosette deployment.
Half a day for repair of the 733.

SAFETY CONCERNS:

Rosette got dropped from LARS head. See comment above.

HAZARDOUS OCCURRENCES:

None involving science personnel.

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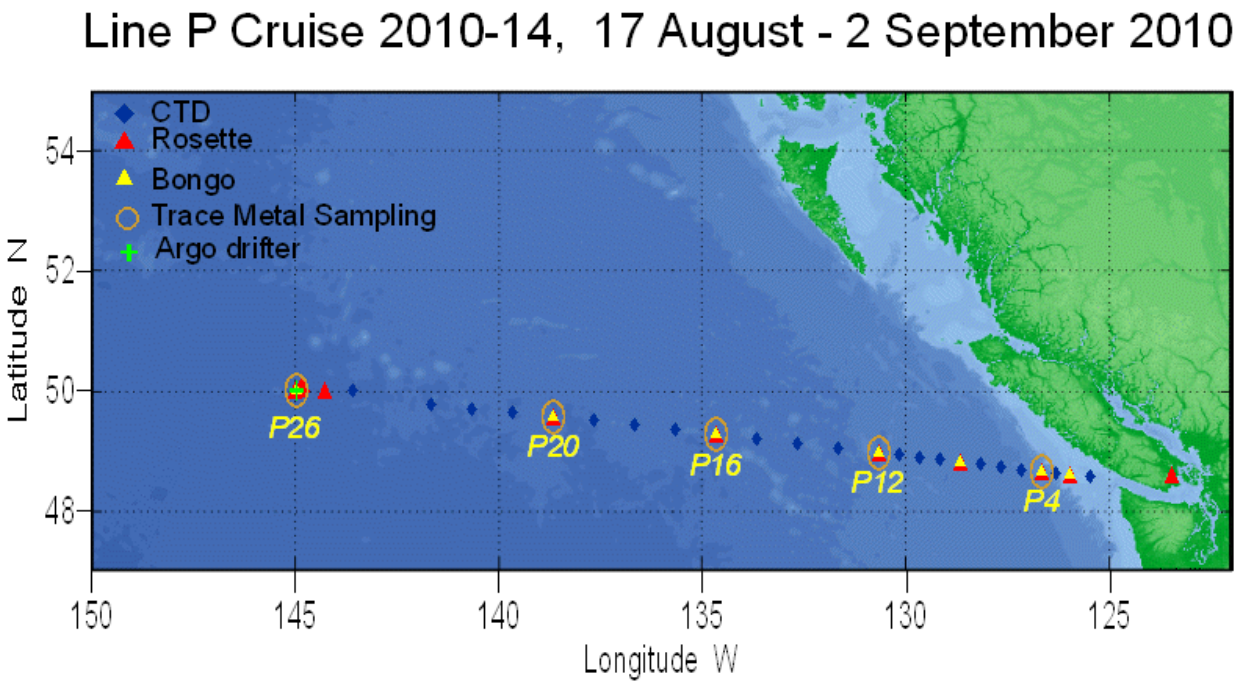
EVENT LOG:

DATE		OPERATIONS
Tuesday	17 Aug:	Start loading the ship at IOS.
Wednesday	18 Aug:	Fuel until about 1300. Depart at 1630. Saanich Inlet cast.
Thursday	19 Aug:	Start Line P.
Wednesday	25 Aug:	Complete Station P20. Go straight to Station Papa.
Thursday	26 Aug:	Sample by Pa-004 mooring. Start Station P sampling.
Friday	27 Aug:	Complete Station P sampling. Start DMS diurnal cycle experiment (DCE).
Saturday	28 Aug:	Complete DMS DCE. Deploy Argo. Start the series of CTDs from P35 to P21.
Tuesday	31 Aug:	Re-sample P15 to P12 because of CTD problems on the way out.
Wednesday	1 Sep:	Quick CTD and bongo at P2 for different experiments.
Thursday	2 Sep:	Arrive at IOS and offload.

CRUISE TRACK:



SUMMARY/FINAL COMMENTS:

- Thanks to the competency of ships crew (“white”), chief scientist (Marie Robert), science watch officers (Hugh Maclean and Scott Rose) and the entire scientific crew, the researchers met all of their August 2010 Line P sampling objectives. Special thanks to bosun Len Bilbey and deck crew for constructing a bench and finding 9 milkcrates to borrow for the Po samples which were housed on the aft deck. This setup greatly streamlined the processing of Po samples which importantly contributed to the overall success of this cruise for our work. Not trivially, Veronica was also extremely thankful to the guys for the tremendous improvement in working conditions and ergonomics. The research team looks forward to success in future Line P cruises in the coming seasons.

Veronica Lance

- We wish to thank the Tully crew for their assistance and excellent work throughout the cruise. Thanks to Marie Robert and the scientists onboard for their help on deck and in the lab. Special thanks to everyone who helped us collect samples and to Keith Johnson and Mike Arychuk who helped set up the gas tanks with a flowmeter.

  Jody Wright, Constance Couture and Craig Mewis

- Many thanks are extended to our talented cooks, providing hearty fare and consistent quality. Availability of omelets during many lunches were very welcomed and represented a wide variety of omelet options included spinach and feta, smoked salmon, as well as traditional morning omelet options. Particularly memorable were the spirits lifted by banana splits!

  Jason McAlister

- There is absolutely no doubt in our minds that the success of this cruise and of our experiments is greatly related to the qualities of the chief scientist Marie Robert. Marie we would like to reiterate our heart-felt appreciation for your incredible efficiency, patience and overall cheery and helpful disposition. In all of our time spent at sea you definitely and positively stand out as chief scientist. Our most sincere thank you goes out to Michael Arychuk for not only analyzing extra (many!) DMS samples for us during the cruise but also for his help months prior the actual cruise by acting as our IOS-collaborator and taking care of our material and chemicals. It is a real pleasure working with you Mike. We wish to thank Keith and Nes for their professionalism and on-going tips for TMC work as well as for their tireless efforts with Fe analysis. We truly appreciate all your help on board as well as on land; this experiment would not have been possible without your generous help and time preparing the material in the clean-room. Special thanks to Glenn Cooper for his assistance in pH-related test experiments. A great big thank you to Darren Tuele for pre-cruise preparations. Thank you to all fellow scientists on board which made the trip so enjoyable and to collaborators involved in this project. We would also like to extend our thanks to Captain McGregor, the officers Corrie Cole, Rhona Lettau, Silviu Isache, Chief Engineer Scott Ware and his gang, bosun Len Bilbey and the entire crew of the CCGS John P. Tully for their invaluable help and assistance. Everyone has been so keen to help out and we are so grateful to have worked alongside such a friendly crew. Last but not least, thank you to Vince Gabas and Ian Meranger for their hard work and smiles and a special thank you to the cooks Alex Wright, Phil May and Phil Padgham for delicious meals!

  Martine Lizotte and Josiane Mélançon

- A new 3-way SS valve was installed on the HEPA stand as the old one was getting corroded. Thanks to Dave (Tully engineer) who helped with the seized parts to make this possible.

  Keith Johnson

- Overall, the cruise was a great success for our group, and we look forward to partaking in another as soon as we can! We would like to thank IOS, Marie, and everyone on board for their logistical support. We would also like to dearly thank Keith and Nes for their help sampling all of our water and running of dissolved Fe samples. Without their expertise, our work would not be possible.

  David Semeniuk and Rebecca Taylor

- We would like to thank the Officers (Corrie, Rhona, and Silviu) as well as the Deckhands (Sarah, Stephen, Bill and Gord) for constantly keeping an eye on the drogue during the DMS experiment. This was no easy task. Thanks also to bosun Len and his crew (Glen and Gord) for the deployment, recovery, and 'fine tuning' of the drogue buoyancy. Thanks to the engineers led by Chief Scott for their help on setting up the LICOR on the heli-deck. And many thanks to Captain McGregor for orchestrating all these people, as well as for the "two engines" when needed. Finally heartfelt thanks to Martine Lizotte for the design and preparation of the DMS experiment, and to Darren Tuele at IOS for making the drogue for us with very short notice and during a very busy field season. Thanks to the galley staff, Alex, Phil and Phil, for such a wonderful BBQ! And special thanks to Gord B. for the live entertainment. Finally, thank you to everyone at IOS who has helped make this cruise a success: Janet, Wendy, Marty, Darren, Kelly, Moira, Melissa, Nina, *et al …*

  Marie Robert

PROJECTS AND RESULTS:

DMS Diurnal Cycle Experiment: Marie Robert, IOS

Objective:

The production of the climatically active gas dimethylsulfide (DMS) in the ocean is controlled by numerous biological processes acting on different time scales. Studies have reported large fluctuations in surface concentrations of DMS on hourly time scales. Causes for these rapid variations are still unclear but have been related to physiological responses of phytoplankton to changes in the daily light regime, on the impact of light on bacterial utilization of DMS and its precursor dimethylsulfoniopropionate (DMSP), as well on the vertical migration of dinoflagellates, strong DMSP producers. The principal objective of this experiment was to establish the presence of a DMS diurnal cycle in the surface waters of the Northeast Pacific as well as to determine the factors responsible for these potential variations in DMS concentrations.

The main collaborators of this study are Nadja Steiner, Michael Arychuk, Marie Robert and Angelica Peña from Fisheries and Oceans Canada, Martine Lizotte and Maurice Levasseur from Université Laval, and Philippe Tortell, Steven Hallam, Jody Wright, Kendra Mitchell and Constance Couture from UBC.

Method:

A Lagrangian-type experiment was conducted in order to minimize spatial patchiness in pools of DMS. In order to do so, a coherent water mass was marked with a drifting buoy equipped with an underwater drogue deployed early during the experiment and then followed during a 28-h period. The drogue was 10 m long centered at 10 m. We used the minimum possible buoyancy in order to keep the drogue very low at the surface, thus insuring that the drogue was being moved by the currents as opposed to the winds. We followed the drogue mainly by keeping it in visual range, although it also carried a VHF transmitter and a strobe light on the main float.

Sampling:

Sampling was performed using the CTD/Rosette package. Every two hours samples were taken for dimethylsulfide (DMS), total and dissolved dimethylsulfoniopropionate (DMSP-t and DMSP-d), chlorophyll, and nutrients. Every 6 hours, samples of HPLC pigments, phytoplankton, RNA, DNA, bacterial cell abundance, and preserved cells for single cell genomics were also taken. All these samples were collected at two depths: 5 m and 20 m, this second depth corresponding to the DMS maximum as determined during the "DMS cast" performed at Station Papa the previous day. During the experiment we were continually recording the ambient photosynthetic active radiation (PAR) using a LICOR light meter installed starboard of the helideck. We also used a membrane inlet mass spectrometer (MIMS) to measure the dissolved gases at the surface (loop water). The gases of interest were nitrogen (N2), oxygen (O2), carbon dioxide (CO2), argon (Ar) and dimethylsulphide (DMS). The ratio O2/Ar was automatically computed to instantly infer Net Community Production. The measurements were taken every 16 to 18 seconds for the entire experiment duration.

The experiment started at noon (PDT) on Friday 27 August and the last sample was taken at 1600 the following day. The ideal experiment would have been conducted over 36 hours, but we ran out of time. We did however manage to sample over 2 "local noons", which was around 1500 PDT.

Results and observations:

Samples of chlorophyll and DMS were analysed directly on board the ship. The remaining samples will be analyzed by the numerous collaborators involved in this experiment at their respective institutions in the coming weeks and months. For this reason, it will take some time to colligate the results in order to obtain the complete picture. Despite not having all the results, we would like to repeat this experiment. However, building on this year's experience, we would perform it slightly differently. Instead of taking duplicate samples for DMS, DMSP-t, DMSP-d, and chlorophyll at only two depths, we would sample more depths in order to refine the vertical

resolution in DMS concentrations within the upper water column, while taking random duplicates for a check on precision. Achieving a finer vertical resolution would enhance our capacity at detecting such features as dinoflagellate vertical migrations within the water column. Furthermore, now that we know what quantity of samples can be handled by the analysts we can design further experiments more efficiently.

We would like to thank the Officers (Corrie, Rhona, and Silviu) as well as the Deckhands (Sarah, Stephen, Bill and Gord) for constantly keeping an eye on the drogue during the experiment. This was no easy task. Thanks also to bosun Len and his crew (Glen and Gord) for the deployment, recovery, and 'fine tuning' of the drogue buoyancy. Thanks to the engineers led by Chief Scott for their help on setting up the LICOR on the heli-deck. And many thanks to Captain McGregor for orchestrating all these people. Finally heartfelt thanks to Martine Lizotte for the design and preparation of the experiment, and to Darren Tuele at IOS for making the drogue for us with very short notice and during a very busy field season.

Jody Wright, Craig Mewis and Constance Couture (UBC) Line P – August 2010

Objectives:
Describe the taxonomic and metabolic diversity of the bacterial communities involved in the cycling of major nutrients and gases along Line P, focusing on the communities in the Oxygen Minimum Zone. Establish underway surface and depth distributions of the climate active gases nitrous oxide (N_2O), methane (CH_4), carbon dioxide (CO_2) and dimethylsulfide (DMS), measure underway surface O_2/Ar gas distributions to infer Net Community Production.

Sampling plan:

Measure dissolved nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), argon (Ar) and DMS continuously at the surface using a membrane inlet mass spectrometer (MIMS).

At the 5 major stations, 1) filter large volumes (20L) of seawater at 4 depths across the oxygen minimum zone (OMZ) to create genomic libraries of the bacterial communities; 2) filter 1 L samples at 16 depths for high resolution bacterial DNA and RNA extraction and sequencing (also done at a 6th station – P8); and 3) measure the bacterial abundance and the concentration of greenhouse gases (CO_2, CH_4 and N_2O), as well as nitrite (NO_2), and ammonia (NH_3) along a 16 depths vertical profile.

At two of the major stations (P4, P26) we performed a series of 15N incubations to infer the potential rate of denitrification at 400, 600, and 1000m depth at these locations.

At one of the major stations (Station Papa) we collected viral particles as well as bacterial cells from the seawater samples of several depths for Elke Allers and Jenn Brum from the University of Arizona in order to analyze the viral community within the OMZ and also interactions of virus and potential bacterial hosts.

At P26, we assisted in collecting 4 types of samples for the diurnal cycling experiment every 6hrs: RNA, DNA, bacterial cell abundance, and preserved cells for single cell genomics.

Comments:
This cruise went very well, although to continue measuring nutrients and chemistry (ammonia, thiosulfate and nitrite) and/or to repeat the 15N incubation experiments, our group would continue to require a 3rd berth. We particularly liked having the filtration area near the gas tanks this time for use in the 15N incubations, but would be happy to move back to our regular location near the sinks in future cruises if we are not going to be performing incubations. All Line P stations were visited and we mostly sampled according to plan.
The sampling and filtering for all the bacterial genomics work went smoothly. On deck measurements of temperature seem appropriate for detecting misfires and we will continue that precaution on future cruises where we collect large volumes for bacterial concentration. We particularly liked the new "lollipop" thermocouple

used by IOS to check temperature on the niskins and will purchase one ourselves. This cruise we had no misfires.

We have gone back to the membrane inlet for the underway gas sampling. This set up is slightly more complicated and requires the use of 2 water baths. However the sensitivity of the instrument to the gases, especially DMS, is much better and will likely be continued in the future. We would like to have the same space for the MIMS (on it's own table next to the sink with the loop) on future cruises if at all possible.

We wish to thank the Tully crew for their assistance and excellent work throughout the cruise. Thanks to Marie Robert and the scientists onboard for their help on deck and in the lab. Special thanks to everyone who helped us collect samples and to Keith Johnson and Mike Arychuk who helped set up the gas tanks with a flowmeter.

POC production, POC export and POC-210Po-234Th interactions in relation to plankton community structure in the subarctic NE Pacific

PI's: Gillian Stewart, City University of New York, Queens College, Flushing NY USA
Bradley Moran, University of Rhode Island, Graduate School of Oceanography, Narrangansett, RI USA
Michael Lomas, Bermuda Institute of Ocean Sciences, St. George, BERMUDA

2010-14 August Line P Cruise Participant: Veronica P. Lance, City University of New York, Queens College, Flushing NY USA and Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY USA

The overarching goal of this collaborative project is to investigate the relationship between variability in plankton community structure with variability in POC production, POC export and POC-210Po-234Th interactions in the subarctic NE Pacific.

This study is motivated by the need to illuminate the role of euphotic zone ecosystem processing in predicting the eventual fate of export flux in the mesopelagic. The project will provide a mechanistic understanding of the processes controlling the production and export of POC and associated elements in the upper subarctic Pacific. Specifically, we will investigate and directly test hypotheses on ecosystem processes that link variability in plankton community structure to variability in particle production, export, and POC-210Po-234Th interactions in the upper ocean (Fig. 1). We anticipate that outcomes from field work at Line P in conjunction with laboratory experiments will demonstrate strong and consistent relationships between planktonic food webs and the rates of carbon, 210Po, and 234Th packaging, sinking, and remineralization. Further, the information gathered will guide future use of radionuclide tracers, including mechanistic justifications for which tracer to use, when and where to use each tracer, as well as insight into the specific aspect of carbon that 210Po and 234Th are tracing. This project is relevant to several national and international research programs. These include: GEOTRACES, which is focused on the global-ocean distribution of trace elements and isotopes in seawater; and IMBER, which is focused on the structure and functioning of ocean ecosystems. This project will also build upon the results of earlier process studies at OSP including SUPER (Subarctic Pacific Ecosystem Research, Miller 1993), VERTEX (VERTical EXchange, Martin et al. 1987) and the Canadian JGOFS study.

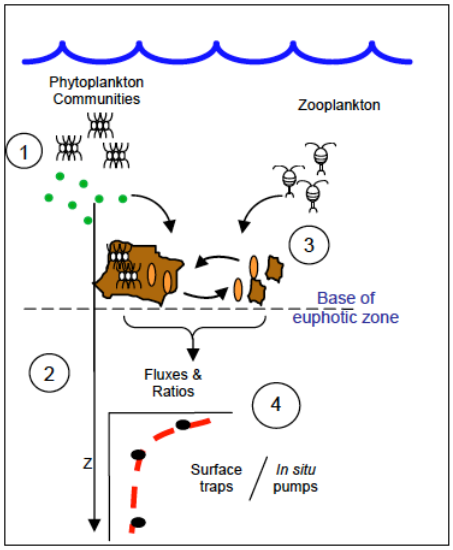


Figure 1 Processes and measurements to be addressed in the current project at OSP. 1: Euphotic zone phytoplankton community structure and size-fractionated euphotic zone nuclide/C ratios. 2: Size fractionated nuclide/C ratios both in the suspended (pumps) and the sedimenting material (traps). 3: Zooplankton nuclide/C ratios including analysis of fecal material. 4: Particle decomposition experiments.

Observations on August Line P:

Initial observations in support of this project were conducted on the August 2010 Line P cruise. Generally, 4 major categories of observations were made: 1) Phytoplankton biomass and assemblage (fluorometric chlorophyll, HPLC pigments, flow cytometry, and preserved phytoplankton for microscopy); 2) Small volume Thorium profiles; 3) Polonium profiles; 4) Size-fractioned particle distributions. Phytoplankton primary production rates will be modeled from ^{14}C incubations done by Dave Sem….. (UBC), on deck PAR observations collected by Martine ….., and in situ PAR measured on CTD casts.

Specifically, our work on Line P was as follows:

At 5 major stations (P4, P12, P16, P20 and P26) a discrete rosette/CTD cast was made near midday to collect the large volumes of seawater necessary to accomplish our measurements. At each cast, 13 depths were sampled of which 12 were fixed depths (5, 10, 20, 30, 50, 75, 100, 150, 200, 300, 400, 500m) and 1 was the chlorophyll maximum (DCM) which was chosen based on a visual observation of the instrument traces (fluorometer, transmissometer) and which varied at each station but generally ranged between 25-40m. Water samples were processed on board (described below) for later analyses at respective PI laboratories.

Phytoplankton structure profiles were measured from 7 depths (DCM, 5, 10, 20, 30, 50, 75m).

Fluorometric chlorophyll - 200ml filtrations each for "total" (GF/F filters, nominally 0.7µm) and 5 µm (polycarbonate membrane filters) size fractions in duplicate, stored in -80°C.
HPLC pigments – 1L filtrations each for "total" (GF/F filters, nominally 0.7µm) and 5 µm (polycarbonate membrane filters) size fractions, occasional duplicates, stored in -80°C.
Flow Cytometry – 4ml samples preserved with 200 µl paraformaldehyde, stored in -80°C.
Preserved microplankton – 200ml samples preserved with 10ml buffered formalin and 1 ml alkaline lugols solution, stored in the dark at room temperature.

Thorium profiles were measured on 12 depths (DCM, 10, 20, 30, 50, 75, 100, 150, 200, 300, 400, 500m). 4L samples were pH adjusted with 8 drops NH_4OH, a subset of 3 of the 12 samples were spiked with ^{230}Th tracer. All samples were oxidized with 25 µl $KMnO_4$ then spiked with 10 µl $MnCl_2$ to form a MnO2 precipitate which was collected on GM/F filters which were air-dried and stored at room temperature.

Polonium profiles were measured on a subset of 10 depths chosen based on visual observations of in situ instrument traces (i.e. always the DCM, 10, 20, 100, 150, 200, 300, 500m and 2 additional depths being some combination of 30, 50 and 75, depending on the actual DCM and water column structure). 10.1L samples were drained from dedicated Niskin bottles into 20L cubitainers (contained in milk crates for easier handling). Samples were pH adjusted with HNO_3 then spiked with 25 µl ^{210}Po tracer, 1 ml Pb standard and 5 ml $FeCl_3$. Samples were pH adjusted again with NH_4OH, oxidized with 1 ml $NaCrO_4$, pH increased again with more NH_4OH. Samples were allowed to precipitate and sediment for at least 10-12 hours. Samples were decanted to reduce the volume of sample down to about 1L which contained most of the sedimented particles.

At Ocean Station Papa (P26, or OSP), **multi-size fractioned particles** were collected from 3 depths (20, 50 and 250m). Water samples of 80L per depth came from 3 separate casts on 2 different days, but all in the vicinity of OSP. Contents of 8 Niskin bottles were combined into 4 x 20 L carboys. Water was passed through an inline series of 5 sizes of Nitex mesh (5, 10, 53, 70 and 100 µm) contained in 25mm "Swinnex" filter holders via a vacuum filtration system. Nitex filters were placed on a microscope slide and preserved with a drop of alkaline lugols solution and covered after air-drying.

In order to minimize the downtime of the CTD/Rosette, sample collection was assisted by the chief scientist (Marie Robert), the science watch officer (Hugh …) and sometimes additional watch standers when available. This assistance was greatly appreciated as sample processing operations were labor intensive and generally took about 12-18 hours to complete all aspects (not including Po settling time). Stations P12 and P16 were fairly close together in time resulting in overlap of sample processing operations for these stations. Veronica also stood daily 6 h watches (however, sample processing operations took priority when overlapping with other

casts) in order to participate in the standard Line P sampling or to assist other researchers in collecting water samples from Rosette casts.

Thanks to the competency of ships crew ("white"), chief scientist (Marie Robert), science watch officers (Hugh Maclean and Scott Rose) and the entire scientific crew, the researchers met all of their August 2010 Line P sampling objectives. Special thanks to bosun Len Bilbey and deck crew for constructing a bench and finding 9 milkcrates to borrow for the Po samples which were housed on the aft deck. This setup greatly streamlined the processing of Po samples which importantly contributed to the overall success of this cruise for our work. Not trivially, Veronica was also extremely thankful to the guys for the tremendous improvement in working conditions and ergonomics. The research team looks forward to success in future Line P cruises in the coming seasons.

CO-EFFECT OF ASIAN DUST DEPOSITION AND OCEAN ACIDIFICATION ON THE NORTH PACIFIC ECOSYSTEM AND CLIMATE.

Martine Lizotte and Josiane Mélançon (PI Maurice Levasseur), Université Laval, Québec City, Qc, Canada

Objective

Building on investigations from previous Line P cruises held in June 2009 and June 2010, the central objective of this project was to pursue our research efforts on determining the impact of atmospheric dust deposition originating from the Asian deserts on the North Pacific ecosystem and on climate. Concomitant to this central goal was the objective of determining the effect of ocean acidification on plankton species, particularly coccolithophores, phytoplankton susceptible to low pH that are well known for their high production of the climate cooling gas dimethylsulfide (DMS), as well as to determine the effect of ocean acidification on the bio-availability of iron to communities in a High Nutrient – Low Chlorophyll (HNLC) region of the Northeast Pacific Ocean.

We proposed to further our previous investigations by fertilizing water samples from the North Pacific with standardized dust samples (fully characterized for chemicals) collected from Chinese deserts. We also proposed to run acidification experiments following guideline methods described in EPOCA documentation. Our experiments will help us to determine the impact of dust fertilization on the plankton ecosystem in general and more particularly on the dynamics of carbon dioxide (CO_2) and DMS, two highly climate-relevant gases. Results from our experiments will also help us determine the potential effect of a High-CO_2 (low pH) ocean on the production and fate of these gases.

During this cruise, water samples were collected at Stations P4 and P26 at 10 m depth by pumping water with a teflon diaphragm pump to avoid trace metal contamination. Samples were collected in acid-clean 5-L labtainer gas-tight collapsible bags for incubation. Before the start of the incubation, the water samples were subjected to the following treatments (in triplicate):

Identification	**Treatment**
Control	No addition
Treatment 1	Addition of $FeSO_4$ (+ 0.6 nmol L^{-1})
Treatment 2	Addition of standardized dust CJ2 (+ 2.0 mg L^{-1})
Treatment 3	Acidification (target PPM = 750)
Treatment 4	Acidification (750 PPM) and addition of FeSO4 (+ 0.6 nmol L^{-1})
Treatment 5	Acidification (750 PPM) and addition of standardized dust CJ2 (+ 2.0 mgl L^{-1})

The incubation bags were hermetically sealed and incubated during 96 h in outdoor incubators at *in situ* temperature and irradiance on the helicopter deck of the CCGS John P. Tully. Continuous ambient photosynthetic active radiation (PAR) was determined using a LICOR light meter installed starboard of the helideck by the engineers of the Tully and water temperature inside the incubators was monitored periodically. The following variables were monitored at T0, T48 and T96: chlorophyll *a* (chl *a*) concentrations, nutrients, phytoplankton enumeration and identification, bacterial enumeration, fluorescence, photosynthetic efficiency (Fv/Fm ratio), dissolved Fe concentration, Fe speciation, particulate organic carbon (POC) and particulate organic nitrogen (PON), dissolved inorganic carbon (DIC), alkalinity, dimethylsulfoniopropionate (DMSP) concentration, and DMS concentration. Precautious sub-sampling of the incubation bags took place inside a trace metal clean (TMC) laminar flow hood located in the main lab. Furthermore, 500 mL bottle incubations were run in parallel to the bag incubations to determine rates of nitrate assimilation ($K^{15}NO_3$). Samples of DMS, dissolved Fe, and chl *a* were analyzed onboard the ship within hours of collection. The remaining samples will be analyzed at the Institute of Ocean Sciences (IOS), the University of Victoria (UVic), the University of British Columbia (UBC) and Laval University in Quebec City.

This cruise represented our first time working in the main lab (work from the previous 2 cruises had been conducted inside the radvan). The work area provided in the main lab was very satisfactory and we were able to efficiently carry out all of the different facets related to our experiments: from TMC work, to filtrations, to chemical spiking, to running a small incubator in the sink next to our work station. Perhaps the only downside of that work area would be the lack of storage space, a problem that can easily be solved by securing large boxes underneath the table in front of the counter. Although most of our work ran smoothly we did however encounter some problems with trace metal contamination in some of our samples. Thanks to the iron experts, Keith Johnson and Nes Sutherland, we were able to show that the contamination originated from the sub-sampling itself and was not related to the actual incubation bags. Also thanks to Keith and Nes, samples for Fe speciation and dissolved Fe were taken directly inside the “bubble” for our last sampling point of the P26 incubations (T96 hours) to avoid sub-sampling contamination of those variables.

There is absolutely no doubt in our minds that the success of this cruise and of our experiments is greatly related to the qualities of the chief scientist Marie Robert. Marie we would like to reiterate our heart-felt appreciation for your incredible efficiency, patience and overall cheery and helpful disposition. In all of our time spent at sea you definitely and positively stand out as chief scientist. Our most sincere thank you goes out to Michael Arychuk for not only analyzing extra (many!) DMS samples for us during the cruise but also for his help months prior the actual cruise by acting as our IOS-collaborator and taking care of our material and chemicals. It is a real pleasure working with you Mike. We wish to thank Keith and Nes for their professionalism and on-going tips for TMC work as well as for their tireless efforts with Fe analysis. We truly appreciate all your help on board as well as on land; this experiment would not have been possible without your generous help and time preparing the material in the clean-room. Special thanks to Glenn Cooper for his assistance in pH-related test experiments. A great big thank you to Darren Tuele for pre-cruise preparations. Thank you to all fellow scientists on board which made the trip so enjoyable and to collaborators involved in this project. We would also like to extend our thanks to Captain McGregor, the officers Corrie Cole, Rhona Lettau, Silviu Isache, Chief Engineer Scott Ware and his gang, bosun Len Bilbey and the entire crew of the CCGS John P. Tully for their invaluable help and assistance. Everyone has been so keen to help out and we are so grateful to have worked alongside such a friendly crew. Last but not least, thank you to Vince Gabas and Ian Meranger for their hard work and smiles and a special thank you to the cooks Alex Wright, Phil May and Phil Padgham for delicious meals!

IRON/TRACE METAL SAMPLING JP TULLY 2010-14, August 18th to September 2nd.
W. K. Johnson, & Nes Sutherland

Line P trace metal sampling was carried out with IOS's normal clean sampling methods using the Asti all Teflon pump for 5 to 40m samples and 12L X-Niskins for 50m to 800m. The HEPA hood is set up on deck by the new "Chains" just outside the Wet lab. The clean hood is used for all pumped samples, 5-40m samples for both unfiltered and filtered (0.2u Opti cartridge) and bulk seawater sampling. The Kevlar (~850-900m) seemed to fit much better over the 6000m steel line than it did in June 2009. This Kevlar is twelve years old so a new piece should be considered. The winch has had the iron rollers changed too UMHWPE eliminating the potential contamination from rusty rollers.

The Zodiac or (733 FRC) was used for subsurface sampling at all the iron stations except P20 were weather was marginal. We seem to be adapting to the use of the 733 as sampling seemd to go easier than previously. Samples were filtered in the temporary clean "bubble" using pre-cleaned Durapore 0.2u membrane filters. Sampling from the 733 was much improved by the use of a harness that was attached to the opposite side of the craft and allowed the sampler to lean over the edge further without falling in.

Sampling was focused on the major Line-P stations to 300m or 400m with only P26 down to 800m. Labile and dissolved iron analysis were completed onboard in the clean tent/bubble. We sampled and analyzed both filtered (compared IOS traditional method of buffering to pH 3.2 for ~2 hours to the GEOTRACES method of adding the equivalent of 2ml of 6N Seastar HCl to samples and letting stand for at least 12 hours. It should be noted that we found the pH for the GEOTRACES method to only drop the pH to 2.1 and not the 1.8 that is expected according to GEOTRACES. Samples were also collected from all depths and stations for Kristin Orians lab (UBC) – Jason, Jeffery and Amy. Samples for Anya were collected from P04 and P26 only.

Iron samples were also analyzed (GEOTRACE method) for incubation experiments that were being conducted by both Laval and UBC (Maite's lab – Dave Seminuk)

Laval conducted 2 incubation experimentsfrom which we were given a total of 108 samples (P04 12*3 ; P26 24*3) plus another ~10 for determining contamination sources related to handling and filtration (Laval) Due to some contamination problems with filtering for iron samples, IOS filtered all the T2 samples for P26 in the clean bubble.

UBC/Dave Seminuk conducted three incubation experiments, one at P04, one at P20 and one at P26. We analyzed 27 filtered samples for Dave that didn't have any iron added (all but one were very low confirming that their techniques for handling their samples was very clean with respect to iron.

Bulk Trace metal clean seawater was also collected for IOS, (2*25L) U Vic. (1*25L) and UBC (2*25L) at either P20 or P26 (10m).

Samples for total analysis were only collected at P26 and were acidified for later analysis for both total dissolved and total iron.

Due to the new Geotraces protocol for iron analysis we decided to collect extra samples at all stations to compare our normal procedures with their techniques. We normally collect 4 samples per depth 2 for analysis onboard (filtered and unfiltered) and two that are acidified with 1 ml of 1:1 conc. Baseline HCl per 125ml seawater for "total" analysis at a later date. Rather than collecting acidified samples for future analysis we collected 2 bottles per depth for 12 hour plus digestion at pH 1.8 as per GEOTRACES protocol. Station P was collected in duplicate.

Salinities and nutrient samples were collected from all sample depths greater than 50m to confirm depth of sample, although the mixed layer was below 100m.

Sampling Summary for Fe, profiles

Depth	P04	P12	P16	P20	P26
0m	X	X	X		XX
5m	X	X	X	X	XX
10m	X	X	X	X	XX
25m	X	X	X	X	XX
40m	X	X	X	X	XX
50m					XX
75m		X	X	X	XX
100m		X	X	X	XX
150m		X	X	X	XX
200m		X	X	X	XX
300m		X	X	X	XX
400m			X	X	XX
600m					XX
800M					XX

Notes:

1) A new 3-way SS valve was installed on the HEPA stand as the old one was getting corroded. Thanks to Dave (Tully engineer) who helped with the seized parts to make this possible.
2) The iron system was run on a 24 hour basis for most of the cruise in order to complete all the analysis.

CARBONATE STUDIES JP Tully 2010-14, August 18th to September 2nd
W. K. Johnson and Mike Arychuk:

We are monitoring four aspects of the carbonate system on expeditions to OSP. Both pH and underway continuous automated pCO2 are measured onboard the Tully. Samples for DIC and TA were collected preserved and returned to the shore-based lab for analysis.

1) pCO2

pCO2 was run using the seawater loop system for the entire expedition up until Juan de Fuca straits (~0800 on September 1st). New primary standards purchased from Praxair (+/- 0.5ppm CO2) were used rather than standards calibrated by Atmospheric Environment. At some point we need to send one of these standards to AES Downsview to confirm accuracy of the standards from Praxair.
As usual we ran the entire trip using the forward air intake. This resulted in some stack gases being analyzed at times but this data will be easy to remove from the file. The AVOS weather data collection worked seemed to go down more often this trip than June.

2) DIC/alkalinity sampling

DIC/alkalinity samples were collected in 500ml bottles at all major stations on line P. A new station P02 was added this trip and is to be considered a major station in the future. This made the first sampling day very busy with 2 major stations on one day (P02 &P04).
One duplicate was collected at each station between 1000 and 3000m as well as a duplicate bottle tripped at one of the deeper depths.

A calibration cast was conducted at P22 on the way back from OSP (5 bottles for DIC/TA were tripped at 2000m and each sampled in triplicate). Station P26 was sampled in duplicate so that C13 could be measured as well or duplicate DIC/TA if required. We may want to decide if this is necessary to continue in the future. All sampling was done by a variety of personnel.

Stn	sampler	preserved by	sealed by
P02	Keith J	Marie	Keith
P04	Keith J	Rebecca	Keith
P12	Keith J	Jason	KJ & Jason
P16	Mike A	Marie	Dave S
P20	Martine L	Keith	KJ & Mike A
P26	Jason M	Marie	Glenn & Marie
P35	Keith	Jason	KJ & Jason

3) pH

pH analysis was carried out by Glenn Cooper. See his report for details.

LINE P pH CRUISE REPORT – Glenn Cooper

Overview:

Seawater pH was determined using the spectrophotometric method developed by Clayton and Byrne (Deep Sea Research, 1993). pH was analyzed at the following stations: P2, P4, P12, P16, P20, and P26. A calibration cast was performed at station P35. Three other studies were performed during the cruise to try and determine why previous cruises were unable to obtain the same level of precision achieved by Clayton and Byrne.

At Sea Analysis.

The pH system was set up in the temperature control lab aboard the John P. Tully. Room temperatures were monitored and it was found best to set the air conditioning to turn on at 23.5^{o}C, due to the systems slow response time. Even though it's a controlled environment temperatures fluctuated between 23 to 26 ^{o}C. More importantly, sample temperatures were far more stable and typically ranged from 24.9 to 25.3^{o}C. The occasional low sample temperature could be associated with the air conditioning unit turned on and seemed to influence the temperature probe readings. All pH calculations are based upon 25^{o}C sample temperature. CTD salinity values were used for the pH calculation and were obtained from the hydro file generated by Marie Roberge for each sample depth.

Samples were collected at P2, P4, P12, P16, P20, and P26. A calibration cast was performed at station P35. Three duplicate samples were taken at all stations except P2 where only 2 duplicates where taken. Spectrophotometric cells were randomized and placed into the cell holder and incubated for one hour before being analyzed. The precision of the calibration cast was 0.0008. Using the replicates for all the major sampling stations, the precision (S_p) for the entire cruise was also found to be 0.0008, with one outlier removed based upon Chauvent's criterion.

Effects of incubation time on coastal and offshore sample's pH.

The first study was to ascertain if there was a difference between inshore and offshore samples' pH stability over time when incubated at 25^{o}C. Coastal samples were collected from station P2 at 5 meters and analyzed over a 12 hours period. All samples were collected from the same niskin and sampling order from the niskin recorded. Samples where then randomized and placed into the cell holder. At each time point (2, 4, 6, 8, 10, and 12 hours) replicate samples were analyzed.

Offshore samples were collected at station P18 from 5 meters and 2000 meters and incubated for 10 hours. All samples were collected from the same niskin and sampling order from the niskin recorded. Samples where then randomized and placed into the cell holder. At each time point (1, 2, 3, 4, 6 and 10 hours) replicate samples were analyzed.

Influence of stopper material on sample pH stability

The spectrophotometric cells have 2 inlet ports. Typically one is plugged with a Teflon stopper, the other a silicon stopper. We wanted to investigate if the stopper material had an impact on the sample's pH stability. In one inlet port a Teflon stopper was maintained, but three different stopper types were tried in the other inlet port: silicon, rubber, Teflon. Samples were taken at 2000 meters from station P23 and 5 meters at station P2. Replicates for each stopper type and each time point were analyzed.

Conclusion:

A difference does exist between coastal and offshore shallow water with regards to the samples pH stability. Shallow coastal sample's pH decreased over time, whereas the offshore 5 meter sample was stable over six hours. It is hypothesized that the increased biological activity of the coastal sample causes a change in the pH over time. The deep offshore sample increased in pH over the incubation period but this could be stabilized by using a Teflon stopper in place of the silicon stopper.

Stopper material does have an impact on the stability of the sample's pH. Evidence from the experiments suggests that Teflon is superior when analyzing shallow coastal water and deep offshore water. The spectrophotometric cells did not break, due to expansion, even with very cold sea water. Rubber stoppers behaved similarly to the Teflon stoppers but a slight offset was seen with the deep water samples which could not be explained.

Although Teflon stoppers did improve the sample's pH stability with a high biological content, it did not completely remove the downward trend. Further work is required to see if there are other techniques which could be employed (filtration or chemically killing the sample) to help stabilize the sample yet not alters the initial pH. Finally, this work clearly shows that pH is a time sensitive technique particularly when encountering water samples containing high abundance of phytoplankton.

TRACE METAL PHYSIOLOGY TEAM – David Semeniuk & Rebecca Taylor (Maldonado Group, UBC)

Objectives: our aims were three-fold on this cruise: to investigate the potential role that copper (Cu) plays in controlling phytoplankton growth along Line P; to develop and refine existing experimental protocols for measuring iron requirements of *in situ* marine microorganism communities; and to determine if marine microorganisms employ a non-reductive uptake mechanism for acquiring iron (Fe) bound to strong organic ligands like those found in seawater.

We were also pleased to be involved in two collaborations on this cruise: we made primary productivity measurements for Veronica's group at three stations (two depths), and we measured Fe uptake rates for the U. Laval group's grow out experiments at P4 and P26.

Lastly, we have made a number of suggestions to improve the rad van's usability and safety.

Specific Goals:

1) To determine whether marine bacteria and phytoplankton employ a non-reductive uptake mechanism for acquiring organically complexed Fe. The vast majority of dissolved Fe in seawater is bound to strong organic ligands. This source of strongly bound Fe plays an important role in mediating Fe bioavailability to marine microorganisms. While previous work has demonstrated that organically complexed Fe can be accessed via a reductive mechanism at the cell surface, recent work in our lab suggests that marine phytoplankton may employ a non-reductive mechanism (intracellular uptake of the Fe-ligand complex, or ligand-metal exchange at the cell surface) to acquire organically complexed Fe when Fe-limited. As such, at stations P4, P16, P20, and P26, we pumped water from 10m (using the TMC pump) into 0.5L or 2L polycarbonate bottles, and spiked the water with ^{14}C-labeled desferroxamine B (a strong iron chelator) bound with ^{55}Fe and/or Ga (a non-reducible analogue for oxidized Fe). The bottles were incubated on deck and harvested after 8, 16, and 24h.

2) To develop/refine a protocol for measuring the intracellular Fe content of *in situ* marine microorganisms. Although Fe-limitation has been recognized to control marine primary productivity in large regions of the global ocean, there are few tested protocols for measuring the intracellular Fe content of living cells in the field. While traditional laboratory methods employ radioisotopes (e.g. ^{55}Fe or ^{59}Fe), their specific activities are potentially too low to be used as true field tracers due to the sparingly low Fe concentrations found in open ocean surface waters. Alternatively, the metal content of particles can be measured directly without the use of radioisotopes, but a suitable wash solution (e.g. a modified oxalate wash) must be applied to the cells to ensure all non-biogenic Fe is removed. However, this method is time intensive and requires an ultraclean sampling and sample processing environmenet. At one station (P16), we decided to compare variations of these two methods using water collected at 10m (TMC pump).

3) To determine if phytoplankton in Fe-limited waters of the NE Pacific are co-limited by Cu bioavailability. In recent years, a link between Fe and Cu metabolisms has been discovered in marine phytoplankton, and our lab has been at the forefront of this investigation. The high affinity Fe uptake system in Fe-limited phytoplankton is dependent on Cu, and many phytoplankton species increase their intracellular Cu requirements in response to Fe limitation. Furthermore, the concentrations of Cu in the NE Pacific are on par with those of Cu-limited laboratory phytoplankton cultures. As such, we hypothesized that Cu may co-limit phytoplankton growth (by reducing Fe-uptake) at P20 and P26. We performed two classic bottle addition incubation experiments using 4L or 10L cubitainers with water collected from 10m (TMC pump) at P20 and P26, respectively. Treatments included +Fe, +Cu, +Fe+Cu, and the addition of reduced glutathione to modify the speciation of the *in situ* Cu. Since light and Fe availability can co-limit growth in high latitude regions (including the NE subarctic Pacific), we also investigated the relationship between light, Fe, and Cu availability on the phytoplankton community at P26. We sampled the grow outs three times over 4-5 day periods, and measured a suite of biological and chemical properties (e.g. nutrients, dissolved Fe/Cu, bacteria/peuk flow cytometry, chl a, HPLC, Fe uptake rates, etc.).

   In two previous grow-outs in Fe limited waters, the addition of Cu elicited a small increase in chlorophyll, suggesting that Fe-limited phytoplankton might be co-limited by Cu. However, it is possible that this increase in chl was due to a drop in grazing by micrograzers undergoing Cu toxicity. Thus, in order to determine whether Cu was having a direct effect on the photochemistry of the phytoplankton sampled, we assessed the photosynthetic competency of the phytoplankton in our containers using fluorometry (FIRE).

4) Radiation Van Report. Moving the radioactive work into a separate container was a great step towards preventing contamination throughout the ship. However, the current set-up in the rad van would do well with some significant improvements:

   1. The particle board shelving is not suitable for radioactive work, and should be replaced with stainless steel (with sufficient spaces for tying down filtering rigs).
   2. The drawers are not sea-worthy. Although we applied Velcro straps around each drawer, we had three come out and crash to the ground, breaking glassware on one occasion.
   3. When it's raining, water enters the rad van via the air intake near the door. We had water spray on our computer/instrument.

Overall, the cruise was a great success for our group, and we look forward to partaking in another as soon as we can! We would like to thank IOS, Marie, and everyone on board for their logistical support. We would also like to dearly thank Keith and Nes for their help sampling all of our water and running of dissolved Fe samples. Without their expertise, our work would not be possible.