Regional Operations Centre
Canadian Coast Guard – Pacific

PACIFIC REGION CCG VESSEL - POST CRUISE REPORT

NAME OF SHIP/PLATFORM: John P Tully

DATE: **FROM:** 18 August 2009 **TO:** 4 September 2009

SCIENCE CRUISE NUMBER: 2009-10 **SHIP'S PATROL NUMBER:** 09-06

CHIEF SCIENTIST[S]: Marie Robert

SCIENTIFIC PERSONNEL:

Female	Male
Janet Barwell-Clarke (IOS)	Michael Arychuk (IOS)
Jennifer Rae Brum (Hawaii)	Michael Bentley (CWS)
Karina Giesbrecht (UVic)	Glenn Cooper (IOS)
Hollie Johnson (UVic)	Marty Davelaar (IOS)
Kendra Mitchell (UBC)	Damian Grundle (UVic)
Marie Robert (IOS)	Hugh Maclean (IOS)
Jody Wright (UBC)	Scott Rose (IOS)
	Johan Schijf (U Maryland)
	Toby Westberry (OSU)

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 (2009-10) was very successful. Even though the weather was somewhat bumpy at times, we managed to visit all the stations, some of them twice, by going straight to Station P from station P20 and working on the way back. This was the first cruise where the new LARS system was officially used.

CRUISE OBJECTIVE/OBJECTIVES: Repeat hydrography section. Deploy Argo float.

DAYS ALLOCATED: 18 **DAYS OF OPERATION:** 16

DAYS LOST DUE TO WEATHER: ~1 day.

SAMPLING:

- The Line P survey was 100% successful. All stations and casts were completed. 3 stations were visited twice.
- We used the new mid-ship LARS to do the rosette casts from Saanich Inlet to P18.
- The samples collected include:
- Underway: **IOS:** T, S, fluorescence, pCO_2, acoustic sounder. –**UBC (Mitchell/Allers):** N_2, O_2, CO_2, Argon, DMS.
- Discrete (casts): T, S, fluorescence, oxygen, transmissivity, irradiance.
- Water: **IOS:** dissolved oxygen, salinity, nutrients, chlorophyll, HPLC, DIC, Alk, DMS, DMSP-p, DMSP-t, pH – **UVic (Grundle):** onboard incubation experiments to estimate daily rates of nitrification. Water samples were also collected to measure dissolved NH_4^+, NO_3^-, NO_2^-, PO_4^{3-} and $Si(OH)_4$ concentrations, total bacterial biomass (through the use of DAPI staining) and nitrifying bacterial biomass using FISH (fluorescent *in situ* hybridization). N_2O concentrations were also measured at 150, 300 and 600 metres in addition to the previously stated depths. At each of these additional depths the previously mentioned dissolved nutrient concentrations were also measured. – **UVic (Giesbrecht)/UW (Emerson):** Oxygen, ONAr (Oxygen, Nitrogen, Argon), Salinity, Alkalinity/DIC, C13, O17, DOC, and C13/N15 productivity experiments – **UBC (Mitchell/Allers):** Bacterial genomic (DNA, RNA), CO_2, CH_4, N_2O, viral particles, bacterial cells **– OSU (Westberry):** hyperspectral particulate absorption (a_p), attenuation (c_p), and backscattering (b_{bp}), chlorophyll fluorescence, CDOM fluorescence, above water incident PAR, derived parameters from Fast Repetition Rate Fluorometry (F_v/F_m, τ, σ, etc.).
- Zooplankton using vertical net hauls.
- Pteropods using the live net (white net).

PROJECTS AND RESULTS:

WATER MASSES: Marie Robert, IOS

2008 was a year especially cold and somewhat fresh compared to long-term averages as well as compared to more recent data (2001 to present). In June of 2009, the surface waters were still colder than normal, whereas the deeper waters seemed to warm up with respect to the long-term average (1956-1991). By August, the surface waters were warming up significantly, but some residual colder waters could still be observed below 100 dbar. As for June 2009, the top 200 dbar or so are fresher than the long-term average (Figure 1).
According to the altimetry data it also seems like we sailed through two eddies, one situated around P8, and the other around P14. We can see the eddy waters both in the temperature profile (warmer waters reaching higher pressures) as well as in the dissolved oxygen profile (lower oxygen waters. Figure 2).

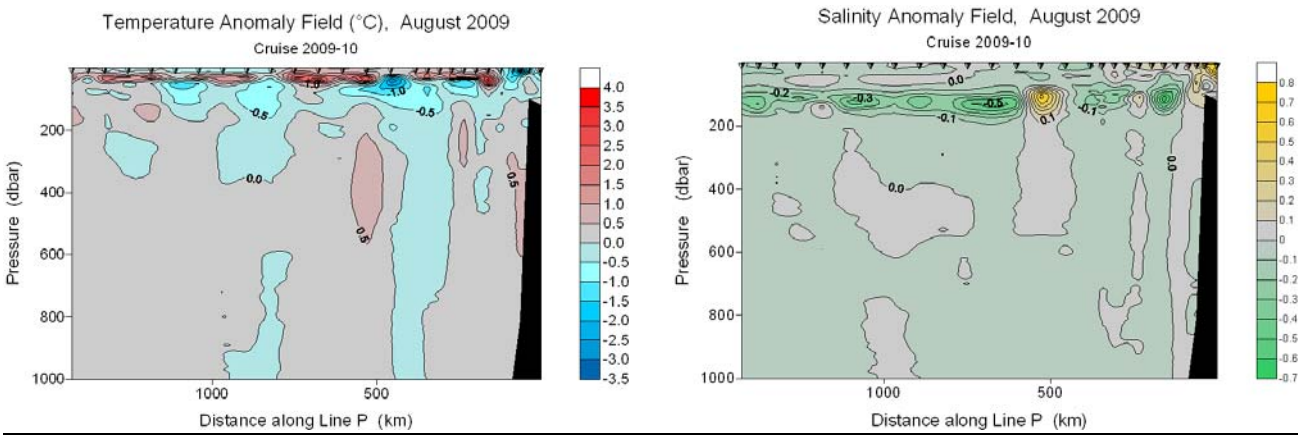

Figure 1: Temperature and Salinity anomalies along Line P with respect to the 1956 – 1991 averages.

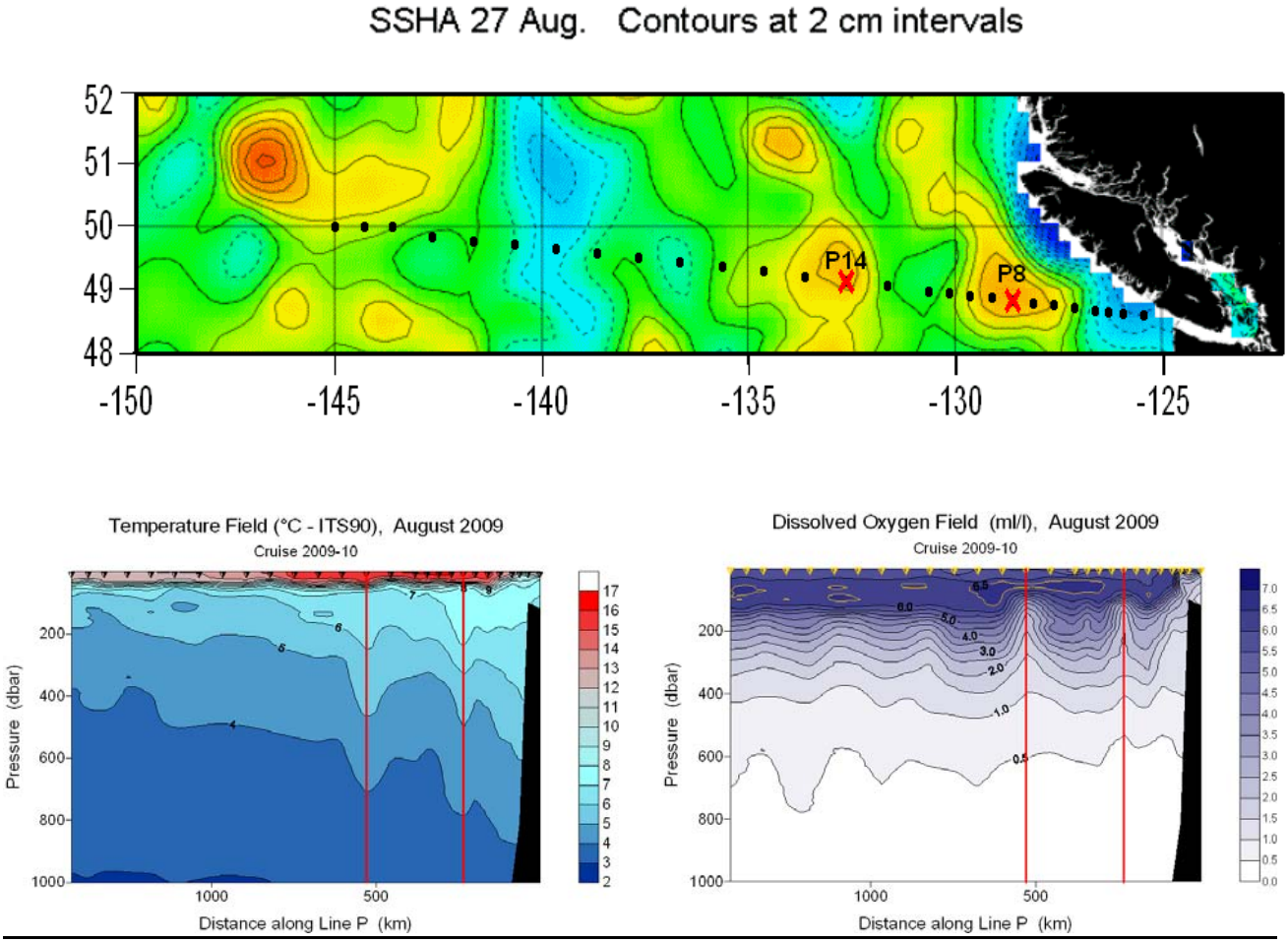

Figure 2: Altimetry contours, and Temperature and Dissolved oxygen profiles. Stations P8 and P14 are indicated by red X on the altimetry graph and by red lines on the profile graphs.

Damian Grundle and Hollie Johnson (University of Victoria, Canada)

Data collected during this cruise was part of an ongoing study of nitrification (i.e. the biological oxidation of NH_4^+ to NO_3^-) along Line P in the NE Pacific Ocean. During previous Line P cruises we discovered significant rates of nitrification occurring in the euphotic zone of the NE Pacific. Traditionally, nitrification was thought to be limited to depths below the euphotic zone indicating that any NO_3^- present in the euphotic zone was a direct result of upwelling and consequently any NO_3^- based primary productivity was considered to be "new primary production". A number of studies of "new primary production" have been conducted along Line P and these rates have been used to estimate *f*-ratios and potential carbon export rates in the NE Pacific ocean. However, our finding that nitrification occurs within the euphotic zone suggests that previously calculated rates of "new primary production" and potential carbon export have been overestimated. In order to revaluate previously calculated rates of "new primary production" and carbon export from the euphotic zone a much better understanding of the spatial and temporal variability of euphotic zone nitrification along Line P is required. To this end, the primary objective of this cruise (and future Line P cruises) was to measure nitrification rates throughout the euphotic zone at each of the major sampling stations (i.e. P4, P12, P16, P20 and P26) along Line P, and to assess how varying chemical, physical and biological factors affect these rates.

At P4, P12, P16, P20 and P26 samples were collected from depths corresponding to 100, 55, 30, 10 and 1% of surface incident irradiance for the purpose of conducting onboard incubation experiments to estimate daily rates of nitrification at each station. Water samples were also collected to measure dissolved NH_4^+, NO_3^-, NO_2^-, PO_4^{3-} and $Si(OH)_4$ concentrations, total bacterial biomass (through the use of DAPI staining) and nitrifying bacterial biomass using FISH (fluorescent *in situ* hybridization). N_2O concentrations were also measured at 150, 300 and 600 metres in addition to the previously stated depths. Previous results have indicated that ammonium oxidation rates are substrate limited at ammonium concentrations less than approximately 0.5 µmols L^{-1}. Samples were therefore collected to run ammonium oxidation rate incubations under artificially elevated ammonium concentrations in parallel with ammonium oxidation rate incubations under ambient ammonium concentrations. These comparisons were conducted at all 5 of our sampling depths at P4, P16 and P20. Finally, CTD instrumentation was used to obtain vertical profiles of temperature, salinity, PAR, *in situ* fluorescence (chlorophyll *a* + phaeopigments), and oxygen concentrations.

I am extremely grateful to Marie Robert and the rest of the IOS science party for allowing me to participate in this cruise and for accommodating my sampling requirements. Sampling requirements and sampling schedules were organized in a very efficient manner, which was key to ensuring that samples were collected at each of my planned sampling stations and that onboard experiments were run immediately following sample collection. Thanks also to Janet Barwell-Clarke and Wendy Richardson for allowing me to use the IOS TD-700 fluorometer to measure dissolved NH_4^+ concentrations. I would also like to thank the Captain and crew of the CCGS John P. Tully for all their help in the collection of samples and for ensuring that the needs of the scientists onboard were met.

Karina Giesbrecht – University of Victoria.

Biological productivity is an important process controlling the export of carbon to the deep ocean. There are a variety of methods that have been developed to estimate this process, a number of which have been previously employed at Station Papa. This project aims at using a combination of dissolved gas measurements of **O**xygen, **N**itrogen and **Ar**gon (**ONAr**) and stable carbon and nitrogen isotope incubations to estimate biological carbon export along Line P.

Incubation samples were collected in the Euphotic zone at 5 light depths (100, 55, 30, 10 and 1%) at P4, P16 and P26. Samples were incubated for 24 hours under a constant flow of seawater from the ship's intake. DIC, nutrient and chlorophyll samples were also collected at all light depths and run by IOS. In addition, ONAr samples to a depth of 75 m were collected at P4 and P16 and to a depth of 250 m at P26. Surface (5 m) ONAr

samples were collected at P12 and P20. In collaboration with the University of Washington, additional samples for ONAr, $\Delta^{17}O$, DOC, DIC/Alk and Kr, Xe and Ar gases were collected at Station Papa. ONAr and DIC samples were collected to a depth of 30 m at the site of the Station P mooring.

Many thanks to Marie Robert for all her help and support as well as to the rest of the science crew, the Capitan, officers and crew of the JP Tully, not only for your help, which is greatly appreciated, but also for making this such a fun and productive cruise.

Cruise report J.P. Tully mission 2009-10. Johan Schijf, assistant professor

During this mission I collected pteropod shells of the species Clio pyramidata, which were caught with 30-minute net tows behind the vessel. All tows were performed in the dark between midnight and 6 AM. The net, fitted with a standard 10-Gal bucket, was deployed consecutively at depths of 200 m, 150 m, and 100 m (wire out), for 10 minutes each, maintaining a vessel speed of about 2 kts to assure a wire angle of about 45°-60°. Upon recovery, the net was hosed down with seawater near the top and bottom. The bucket was then detached from the net and its contents distributed over 2 smaller buckets.

Inside the lab the contents of both buckets were visually inspected in a shallow plastic tray. Pteropods of sufficient size were visually identified and transferred to a plastic Petri dish with seawater. After the entire catch was processed, the organisms were removed from their shell with entomology tweezers under a dissecting stereomicroscope. The shells were briefly rinsed with NaOH-buffered tapwater (pH ~ 9) to remove seawater without causing dissolution of the shell, preventing the formation of sea salt crystals. Any remaining broken pieces or debris adhering to the outside of the shell were also removed. The shell was then carefully wicked dry with a Kimwipe, and the dry shell stored in a clean plastic Petri dish, which was sealed with tape. Between 2 and about 120 shells were collected per cast.

Shells were collected at the major Line P stations: P4, P8, P12, P20, P26 on the way out, and P20, P16, and P12 on the way back. Few pteropods were found at P4 and P8. By far the most individuals were found at P12 (both times), where the catch consisted almost entirely of pteropods, including gymnosomes (Clione limacina). At P16–P26, fewer individuals were found which were generally smaller and the species distribution shifted towards very small Limacina helicina. No ‘giant’ pteropods of the species Clio balantium were found at any station. At P12 the cast consisted of a coherent mucose mass embedding hundreds and maybe even a few thousand pteropods, many of microscopic size, as well as sparse Neocalanus cristatus copepods and other unidentified organisms and microalgal cells. There was also a fair number of empty shells, some of which were collected. Whereas shells were often completely transparent and seemingly flawless, many shells were fully or partially opaque and brittle, broken, or malformed. It was unclear if the mucus was produced by the pteropods (for feeding or reproductive purposes?). Due to time constraints, only the largest 100 or so individuals could be collected and the remainder was thrown back. None of the by-cast was preserved, in formalin or otherwise.

The shell samples, which consist of pure aragonite-$CaCO_3$, will be returned to the Chesapeake Biological Laboratory of the University of Maryland Center for Environmental Science, where they will be analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for rare earth element (YREE) concentrations, in support of the new ARRA project “Investigating YREE Co-Precipitation with Phosphate and Biogenic Aragonite as Possible Indicators of Ocean Acidification” (NSF, PI Johan Schijf). It is hypothesized that the pH-dependent adsorption of REEs on aragonite may serve as a new proxy for current and ancient ocean acidification events. Some shells will also be used as seed material in laboratory precipitation experiments. This mission has been extremely successful for me and I hope that I may participate again on a Line P cruise in 2010, possibly accompanied by one graduate student trainee.

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Cruise Report – Line P August 2009 (#2009-10)

Group of Michael Behrenfeld and Toby Westberry representing Oregon State University, Corvallis, OR, USA.

Objective: Measure in-water surface optical properties with special interest in particulate backscattering. Data to be used for general calibration/validation of satellite algorithms and to inform specific hypotheses based on satellite ocean color data. Collection of discrete water samples for common biogeochemical quantities (phytoplankton pigments, particulate organic carbon/nitrogen, flow cytometry). Also, deployment of second generation Irridium profiling float outfitted with novel bio-optical sensors (WETLabs Inc.).

Results: During the course of this cruise we have recorded 14 days of continuous (24 hr) underway measurements at >1 sample per minute. Specific parameters measured include:

- hyperspectral particulate absorption (a_p), attenuation (c_p), and backscattering (b_{bp})
- chlorophyll fluorescence, CDOM fluorescence,
- above water incident PAR
- derived parameters from Fast Repetition Rate Fluorometry (F_v/F_m, τ, σ, etc.).

We have also collected water samples at 15 unique locations, coinciding with all major stations along Line P and many of the minor stations. These discrete samples are for HPLC analyses, combustion analyses of total particulate material (CHN), and flow cytometric determination of cell density and size distribution of several phytoplankton groups. All samples have been stored in liquid N_2 for analysis at a later date.

Preliminary conclusions: Although, the optical data requires substantial post-processing there are a few aspects which are noteworthy. Figure 1 shows a two day period from 23-25 Aug showing F_v/F_m. Three feature to note are a dawn maximum, mid-day suppression, and a nocturnal decrease. These feature were reported by our group in the Equatorial Pacific and are indicative of iron stress (Behrenfeld et al., 2001; Behrenfeld et al., 2006). The fact that the subarctic Pacific is iron limited is not news of course, but our recent findings based on satellite measured fluorescence suggest that the phytoplankton in this region respond differently than other HNLC regions in terms of their photophysiology (Behrenfeld et al., 2009). Hopefully these measurements will enlighten us as to why and provide some context for basin-scale analyses with satellite data.

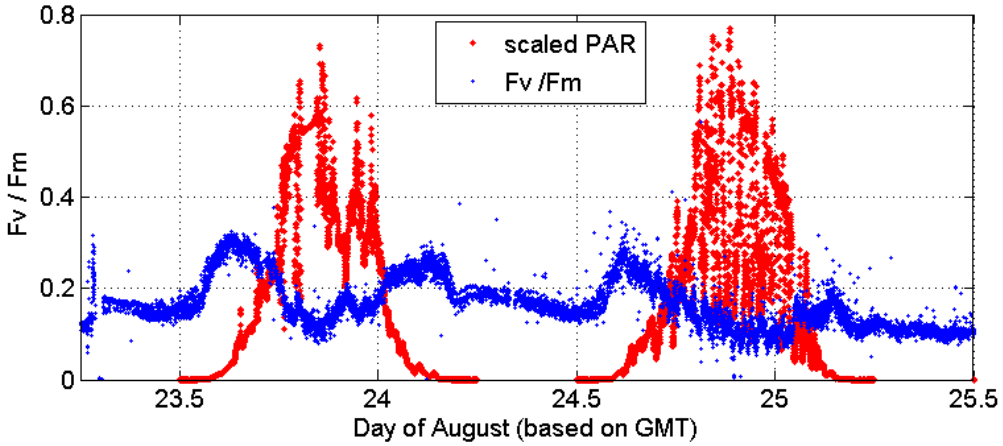

Figure 1. Variable fluorescence (Fv/Fm) over a two day period during the August 2009 Line P cruise. Also shown is a scaled value of incident PAR to give a sense of daily cycle.

Figure 2 shows absorption-based chlorophyll estimates and particulate backscattering measurements made around Station P. These backscattering measurements are certainly the first of their kind in this region and their mere measurement will add to the paucity of data available for satellite cal/val efforts. Also shown in the figure are the values of chlorophyll concentration and backscattering measured from the first 3 profiles of the Irridium equipped float that we deployed at Station P. Agreement is very good, but a proper matchup comparison between shipboard, float, and satellite estimates will be continued back at OSU.

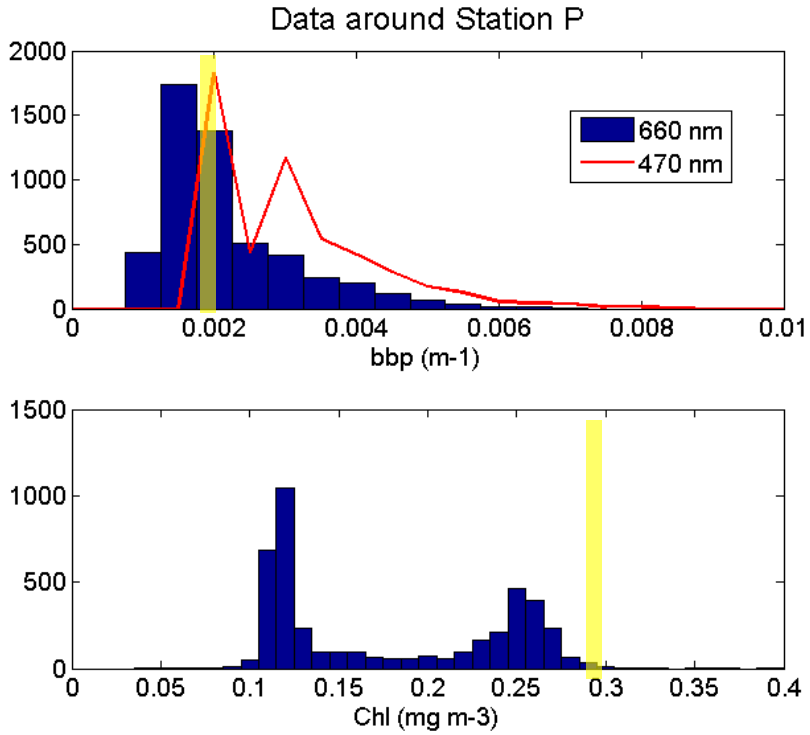

Figure 2. Distribution of optics-based chlorophyll concentration (mg m^{-3}) and particulate backscattering (b_{bp}, m^{-1}) at two wavelengths for data collected in the vicinity of Station P. Also shown are the mean values obtained from the first 3 profiles of the Irridium profiling float deployed at Station P (yellow bars).

In summary, we are very pleased with our suite of measurements and glimpses of what the data hold in store. We thank the Department of Fisheries and Oceans, Institute for Ocean Sciences, and in particular, Marie Robert for meeting and exceeding our groups requirements. We look forward to future involvement with the Line P program.

Thank you very much

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RADIOISOTOPE USE:

No radioisotopes were used during this cruise.

PROBLEMS [SCIENTIFIC GEAR AND OPERATIONS]:

There were no log books and very few Rosette log sheets on the ship when we left. We had to go back to IOS from station SI03 with the 733 to get some books and logs. In future cruises we will bring our own stationary box for the main lab.

The CTD wasn't working properly in Saanich Inlet. It took about 3 hours to get it going.

The CTD data acquisition computer is still freezing up randomly, and it takes a long time to reboot it. There were also a few instances when the COM Port 1 (the CTD communication Port) stopped working. There was no 'official' spare computer for CTD data acquisition on board.

The thermosalinograph wasn't ready to go when we left Pat Bay (computer not set-up), even though the ship had been in port for a few days. It only got started off Victoria, so we missed the Strait of Georgia data on the way out.

The remote temperature sensor hooked to the thermosalinograph and the flow reading only got working and recorded from Station P26 inbound.

The time stamps were wrong in the thermosalinograph. We had to use a virtual COM port to import the GPS signal from the server. The thermosalinograph was set **again** to 6 second sampling rate instead of 30 seconds, which was part of the initial problem.

We had to re-terminate the sea cable three times because of kinks in the cable. These kinks were created while deploying the rosette using the LARS.

The server was periodically losing the GPS string.

There should be room for two monitors in the CTD lab.

Many Niskin bottles are leaking and/or not working properly.

SUCCESSES [SCIENTIFIC]:

We used the new LARS for the first 29 casts of the cruise. Despite some problems, this new system will be wonderful once it is working properly. It is MUCH safer, and a lot easier physically to deploy/recover the rosette. It also demands fewer personnel.

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

The "Email at Sea" system was not working great on the way offshore. Also, the ship's email wasn't working for about 5 days, which caused delays in fixing some of our instruments.

The navigation repeater in the CTD Lab was not working, so we could not tell how long before the next station, or even if we were on station. Because of this a few casts were off station.

The science GPS stopped working one night and had to be rebooted from scratch.

There should more than one LAN feed in the CTD lab in order to hook other computers than the CTD data acquisition computer.

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SUCCESSES [SHIP]:

See the notes in Successes (scientific) about the LARS. Thanks to the crew and engineers for their constant efforts in fixing and improving this new system, and trying - and succeeding - so hard to make it work!

Three days before loading the ship it was discovered that the ~3100m – 7-conductor sea cable on the Hawboldt winch was not working properly. It had been mentioned over a month previously that there were problems with that winch but nothing had been done about it yet. After being examined on the Friday prior to crew change it was decided that the sea-cable needed too much work to be ready on time for the cruise. The sea-cable was then removed from that drum and a "new" (10-year old) spare sea-cable was greased and wound on the Hawboldt drum. Thanks to Phil and his team for their quick work.

After having kinks in the sea-cable with the LARS system for the third time we decided to move the rosette to the aft-deck and use the regular heave-compensator system. The crew were very efficient in transferring the rosette from the LARS station to the aft-deck using both cranes.

DELAYS [OTHER THAN WEATHER]:

About 3 hours for fixing the CTD in Saanich Inlet
About 2 hours for training of crew on the new LARS.
About 2 hours for SAR call.

SAFETY CONCERNS:

None.

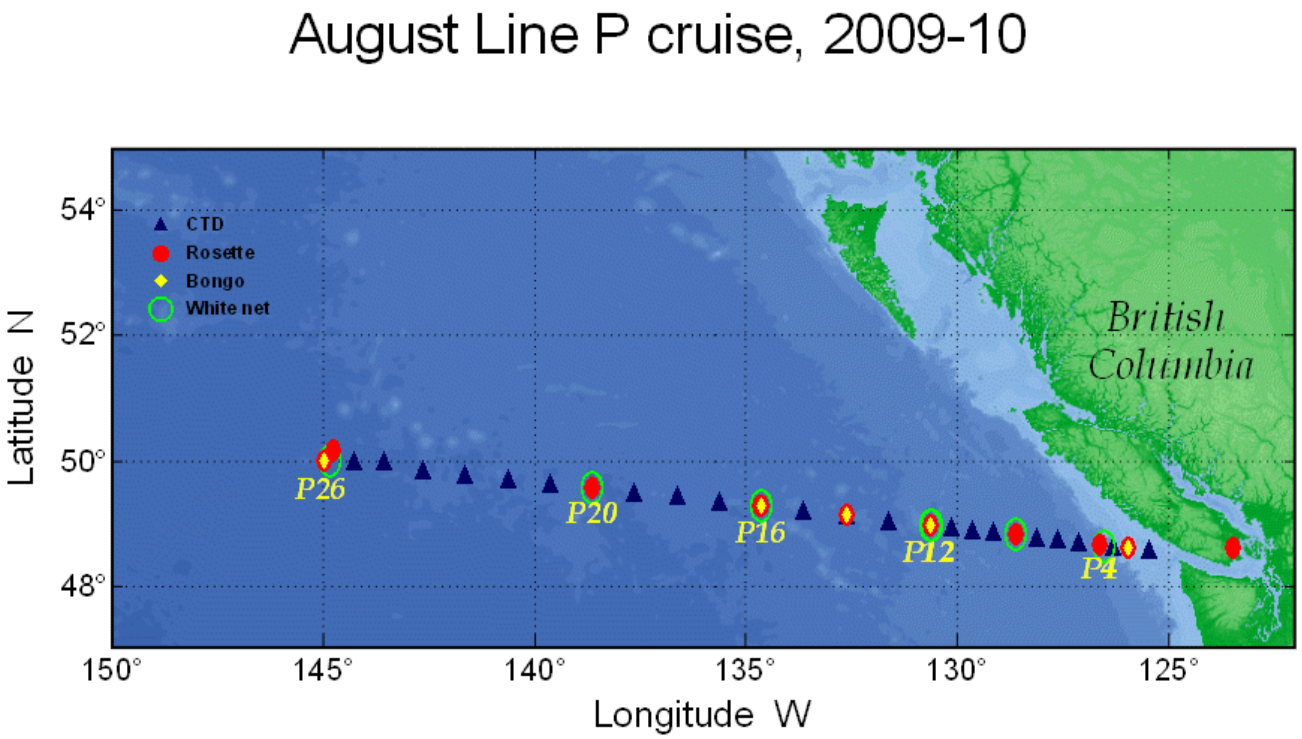
HAZARDOUS OCCURRENCES:

One science crew got a fairly deep cut in the palm of his hand from a DIC bottle that had just been spiked with mercuric chloride and broke as the lid was being put on.

EVENT LOG:

DATE		OPERATIONS
Friday	**14 Aug:**	**Start loading the ship at IOS.**
Wednesday	**19 Aug:**	**Finish loading. Test cast in Saanich Inlet. Leave Pat Bay.**
Thursday	**20 Aug:**	**Start Line P.**
Tuesday	**25 Aug:**	**Switch from mid-ship station to aft-deck winch.**
Wednesday	**26 Aug:**	**Go straight from P20 to P26 to avoid a storm and use the weather window at Papa.**
Thursday	**27 Aug:**	**Arrive at Station Papa. Do all the casts in one day. Leave b/o weather.**
Saturday	**29 Aug:**	**Re-visit P20.**
Monday	**31 Aug:**	**Re-visit P14.**
Thursday	**3 Sep:**	**Arrive at IOS and offload.**

CRUISE TRACK:



SUMMARY/FINAL COMMENTS:

- Thanks to **everyone** on board for such a successful cruise. EVERYTHING went well.
- Thank you to the deck crew for your loads of energy and constant enthusiasm.
- Thanks to Kerri and her awesome galley team, for the wonderful barbeques and the delicious meals, always.
- Welcome back to Captain Pennell, it was good sailing with you again!
- Finally, thanks to Captain McGregor and his White Crew for letting us load the IOS equipment before crew change. It makes setting up and getting the instruments ready a lot easier when the loading is done one group at a time.