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:** 5 February 2019 **TO:** 23 February 2019

SCIENCE CRUISE NUMBER: 2019-001 **SHIP'S PATROL NUMBER:** 18-12

CHIEF SCIENTIST[S]: Marie Robert

SCIENTIFIC PERSONNEL:

Female	Male
Isabelle Baconnais (U Sask)	Michael Arychuk (IOS)
Moira Galbraith (IOS)	Mark Belton (IOS)
Lian Kwong (UBC)	Robert Izett (UBC)
Marie Robert (IOS)	
Jade Shiller (UBC)	
Jasmine Wietzke (IOS)	

AREAS OF OPERATION: Saanich Inlet, Juan de Fuca Strait, Haro Strait, Strait of Georgia, North East Pacific, Line P, Station P, Dixon Entrance, Chatham Sound.

INTRODUCTION/PROGRAM BACKGROUND: Line P is a long standing program which surveys a 1400 km long section 3 times annually. Data have been collected along this line since 1956 and show 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.

CRUISE OBJECTIVE/OBJECTIVES: Repeat hydrography section (physics, chemistry, zooplankton); deploy two sponge-bob drifters and five Argo floats for IOS; retrieve a Glider for WHOI.

CRUISE DESCRIPTION: The planning of this cruise (2019-001) was mostly dictated by weather. Many storms interrupted our work along Line P and we had to adjust the order of stations around them. Once we reached station Papa a major storm was coming our way, and we had to go quite far north-east to avoid being stuck in it. Since we had to go more than half-way between Station P and Langara Island, and since some work was planned for Chatham Sound for February 2020, we decided to keep sailing to Dixon Entrance and perform the work planned for next year; it was a better use of ship time than waiting 3-4 days for a storm to go by. Before leaving the Station P neighbourhood we managed to recover a malfunctioning Glider for WHOI. After the Chatham Sd work we still had time to do some stations in the Strait of Georgia. All in all, despite missing 6 Line P stations, this cruise turned out to be really successful.

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

DAYS LOST DUE TO WEATHER: ~2.0, plus 2 half- and 6 full rosette casts.

SAMPLING:

- The Line P survey was ~80% successful. Stations P13 to P16, P23 and P35 were skipped. Two casts, P22 and P24, normally done to 10 m above the sea floor (~4000 m) had to stop at 2000 m.
- Two "cement Sponge-Bob"s were deployed for IOS.
- Five Argo floats were deployed for IOS: three ARVOR and two MetOcean.
- One Glider was recovered for WHOI.
- The samples collected include:
  1) Underway: **IOS**: Thermosalinograph (Temperature, Conductivity, Fluorescence), acoustic sounder, two pCO_2 – **UBC (Izett):** PIGI (O_2, total gas tension ~N_2), MIMS (O_2, Ar).
  2) "E-data" from CTD: Pressure, Temperature, Conductivity, Dissolved Oxygen, Transmissivity, Irradiance, Fluorescence.
  3) From the Rosette: **DFO-IOS:** dissolved oxygen, salinity, nutrients, DMS, DMSP, chlorophyll, pigments (HPLC), dissolved inorganic carbon (DIC), alkalinity, domoic acid, phytoplankton, DOC, TOC, CDOM, PIC, POC, Gels, $delO^{18}$ **– UBC (Shiller):** high-resolution bacterial DNA sequencing, number of cells per millilitre, single cell DNA analysis, virus analysis, viral counts – **UBC (Izett):** methane and nitrous oxide (N_2O) – **U Sask (Baconnais):** Chromium**.**
  4) From the various nets: **DFO-IOS and UBC (Galbraith, Kwong):** Zooplankton using vertical net hauls (Bongo to 250 m and 1200 m, single fine-mesh "Ring" net to 250 m).

RADIOISOTOPE USE:

None.

PROBLEMS [SCIENTIFIC GEAR AND OPERATIONS]:

The ADCP was tested at the dock and appeared to be pinging, and was triggering the echo sounders as usual. Once the ship was in Saanich Inlet however, the ADCP was not returning any current values. Upon closer inspection it appears as though the ADCP was pinging but not receiving a return signal, despite passing all built in tests. The unit was power cycled to no effect, and the control box was taken apart and inspected for damage. The ship left for the cruise during which the CCG IT tech performed testing on the cable and verified that there is either an issue with the cable or the transducer. The IT tech could not perform enough tests at sea and submitted an electronic defect to describe the problem. He will work with the science techs later to solve the issue.

The conductive cable linking the CTD deck unit in the closet to the CTD Hawboldt winch had to be re-spliced right at the beginning of the cruise. That cable stays onboard between cruises so it's normal that after years of use problems can occur. This problem illustrates the importance of having the CTD winch and rosette on board early during loading because there is no other way of identifying this kind of problem than by having the rosette on board and connected to the winch. In order for this to happen, the rosette needs to be available on the jetty while the LB crane loads the winch so they can both be loaded at the same time. If the CTD winch is already onboard, the rosette needs to be on the jetty as early as possible so that it can be loaded during the appropriate tide.

The transmissometer that came with the rosette at the beginning of the cruise had a faulty factory setting. We had to swap transmissometer, hoping that the spare one did not have the same problem.

Niskin 21 didn't close a single time during the whole cruise despite many tries. The latching mechanism got replaced after the Saanich Inlet cast, but it turned out that the problem was probably a failed magnet in the rosette pylon. Swapping the pylon will most likely solve the issue with that Niskin; unfortunately the weather was too rough during the cruise to perform this task.

The spigots on some of the Niskin bottles are too hard to pull, to the point that samplers had to use a tool when sampling the Chatham Sound stations because their fingers were too sore to sample.

There were problems with the dimethylsulfide (DMS) system this cruise that resulted in only stations, P2 and P4, being completed. Stations P12 and P26 were sampled and analyzed but the validity of the data is questionable based on the symptoms exhibited by the instrument. Unfortunately the system could not be repaired while at sea and further troubleshooting will be required in the laboratory to determine if the problem is one of a repairable nature or one that will require a new instrument entirely.
There was a comparison done on this cruise between the Arctic pCO_2 system and Line-P's pCO_2 system. Unfortunately, the Arctic pCO_2 system was not operating at its full potential due to instrument problems before the cruise. In any respect, it was still brought aboard and set up with the understanding that the data might not be conclusive. Equilibrator CO_2 readings were compared 3-4 times a day and overall the two instruments differed by an average of approximately 8 ppm. Atmospheric readings were also taken a couple times a day but those results differed by about 30 ppm. It should be noted that atmospheric readings on the Arctic system were also problematic in the laboratory so the difference of 30 ppm noted should not be cause for alarm. In fact, as stated above, the Arctic system was not fully operational and the comparison data gathered should not be considered a true representation of the Arctic pCO_2 system capabilities. If possible, a further intercomparison study should be done when the Arctic system is properly calibrated and fully repaired for the results to be considered valid.
The small chest freezer doesn't freeze anymore; a new one must be purchased.

SUCCESSES [SCIENTIFIC]:

We had to deal with lots of stormy weather during this cruise. We turned this "not able to work because of weather" situation into an opportunity to collect some winter nutrients data in Chatham Sound, which was supposed to happen in February 2020. Even though the extra sampling wasn't planned, everyone provided all they had available so we had enough supplies to make it worthwhile.

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

The loading priorities should be modified in order to try loading the rosette and rosette winch first, or at least as early as possible. See Science problem section.
There was a problem with the winches hydraulic system towards the end of the cruise; we had to skip one bongo cast.

SUCCESSES [SHIP]:

The loading for this cruise happened remarkably quickly and smoothly. Many thanks to the White crew for starting to load early and allowing us to show up before the standard "noon" time.
Weather forecasting played a huge role this cruise. We managed to do the work we did and change the plans mid-cruise (doing useful work instead of being stuck in very high seas) because of all the different weather forecasts we received, and Captain Gronmyr's interest in the subject. Having the ONC satellite dome on board is a huge help in getting the forecasts all the way to Station P and should really be provided with the other services on board the *Tully*.

DELAYS [OTHER THAN WEATHER]:

An hour or so on major stations for "Tank breaks".

SAFETY CONCERNS:

None.

HAZARDOUS OCCURRENCES:

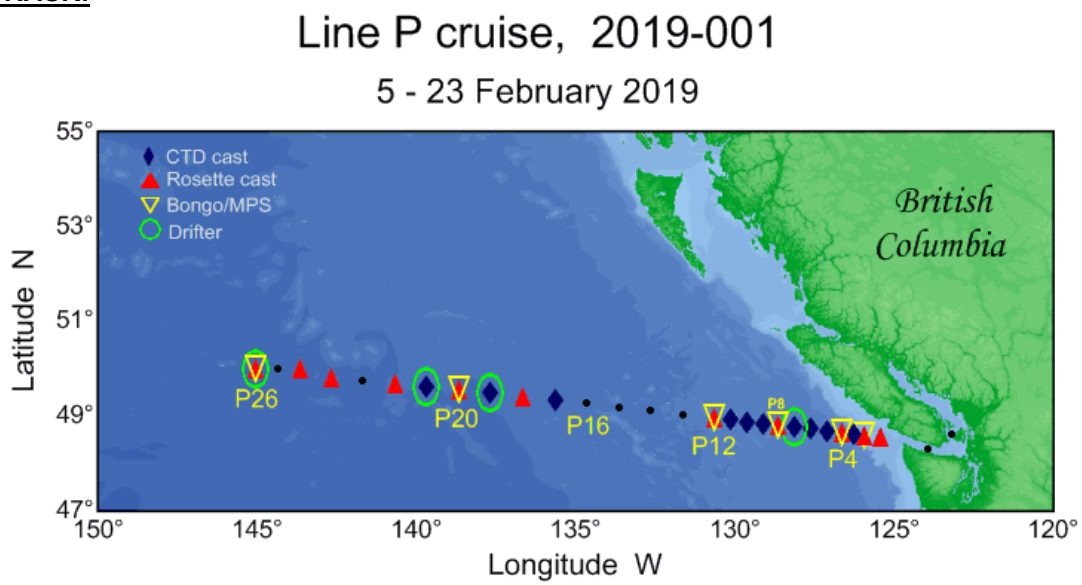
None.

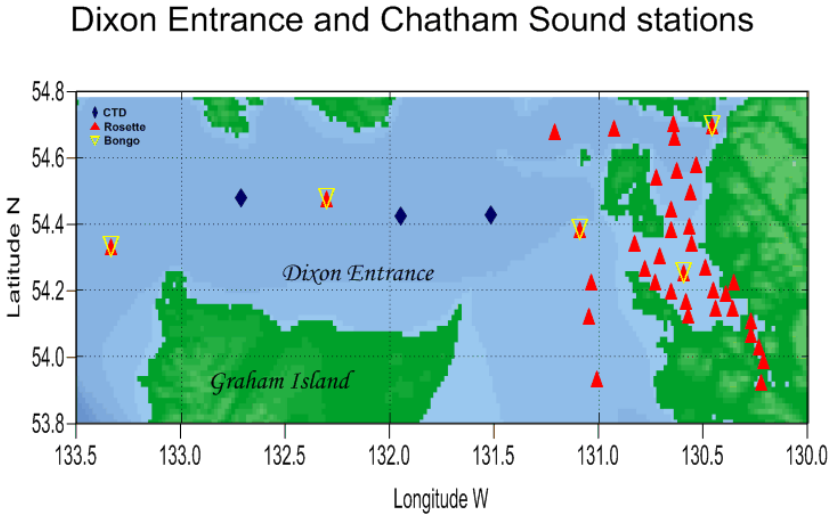
EVENT LOG:

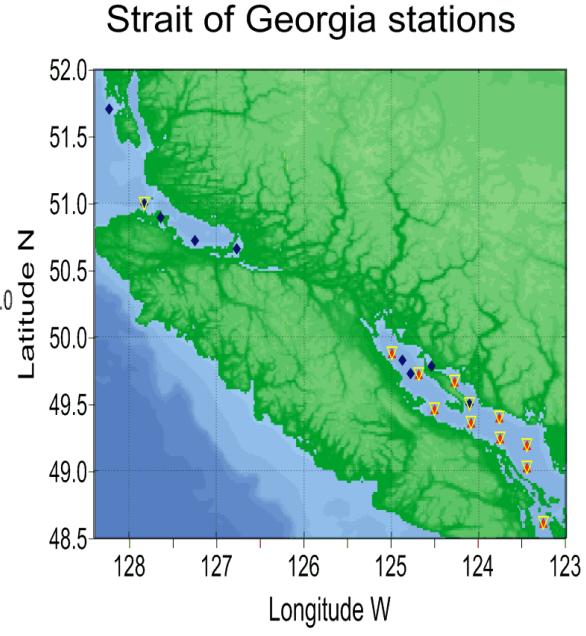
Tuesday 5 February:	Start loading scientific gear at 1000. Safety meeting at 1300. Departure from the jetty at 1630. Test cast in Saanich Inlet. Rosette communication issues. Two people go back to IOS around 2030, then departure to P1.
Wednesday 6 Feb:	Stations P1 to P5. Muster drill at 1000.
Thursday 7 Feb:	Stations P6 to P11. Deploy Argo (Arvor) float at P7.
Friday 8 Feb:	Station P12. Sail ahead of weather, skip stations P13 to P16.

Saturday 9 Feb:	Stations P17 to P20. Deploy Argo (MetOcean) float at P19.
Sunday 10 Feb:	Stations P20 to P22. Deploy Argo (Arvor) float at P21.
Monday 11 Feb:	Weather day, sail to P26.
Tuesday 12 Feb:	Stations P26 to P24. Deploy to Argo (1 Arvor, 1 MetOcean) at Papa, recover WHOI Glider. Skip station P35, cut station P24 at 2000m instead of 4045m.
Wednesday 13 Feb:	Weather day. Run away from the storm towards Haida Gwaii.
Thursday 14 Feb:	Station DIX5 (western side of Dixon Entrance).
Friday 15 Feb:	Stations DIX4 to DIX1, HECS5 to HECS8, EDR.
Saturday 16 Feb:	Stations AB1, CH1 to CH6, CH10 to CH13, CH15, CH17.
Sunday 17 Feb:	Stations CH14, CHAT2A, CH18 to CH25, CHAT1, PRHR74.
Monday 18 Feb:	Stations CH26, CH27, MP55, CH31, OGCH50, OGCH46.
Tuesday 19 Feb:	Stations HAK1-C, CPE1, LBA-1, QCS3, QCS1.
Wednesday 20 Feb:	Stations 14, SOGN-D, N Ajax, 12, 20, 22, 24, CPF2, CPF1.
Thursday 21 Feb:	Stations 28, GEO1, 38, 42, 59. Back to IOS, offload UBC gear.
Friday 22 Feb:	Offload winches and containers and the rest of the scientific gear.

CRUISE TRACK:







SUMMARY/FINAL COMMENTS:

- Many thanks to everyone at IOS who have helped make this cruise a success, as much in the lab getting things ready as on board getting the ship ready. Special thanks to Lindsay and Scott who came with us for the Saanich Inlet cast and had to return to IOS late in the evening. Also a special "thank you" to Germaine who looked at many casts to help figuring out the problems with the Transmissometer, and to all the analysts at IOS who will have to deal with the "extra samples" coming from the Chatham Sound stations.

- Many thanks also to all the samplers on board for braving the February temperatures of Chatham Sound and sampling in the freezing outflow winds.

- Big thank you to Shane for your help with our side of the network and our instruments, as well as fixing so many little things here and there that made a world of difference. Thanks for dealing with AVOS and keeping an eye on the weather station, as well as working with Lindsay to sort out the ADCP problems.

- Thanks to Captain Gronmyr for his help with the weather forecasts and station planning.

- And as usual a big thank you to everyone on board who made this cruise the success it was! See you all next June.

  Marie Robert

- I'd like to thank the captain and crew of the *Tully* for their excellent work and their interest in and support of our scientific program. Thanks to the galley crew for keeping us happy and extremely well fed. Thanks to the IOS team and my fellow scientists for their help and their humour on deck and in the lab. And finally, a great big thank-you to Marie for all of her work and her amazing ability to fit together many pieces of an ever-changing jigsaw puzzle and make a whole, coherent research cruise from them.

  Jade Shiller

- This cruise on the line-P was my first, and stormy February was a bliss thanks to the outstanding Captain and crew members (not to mention the Valentine's chocolates and personalized cards we got from them). I also would like to thank the science team on-board, with which I learnt (or re-learnt) a lot about sampling methods for Oxygen, DIC, Nutrients, Chlorophyll etc… and the local oceanography. Most importantly, I would like to thank Marie Robert, without whom this cruise would not have been running so smoothly. She handled so well the last minute re-routings and designed sampling plans (with all the last minute changes and wishes) in such short amount of time, it had to be appreciated. Finally, thank you all science team, crew members and IOS administrative personnel (Mary Chan) for allowing me to live and/or share this experience with you all.

  Isabelle Baconnais

- Thanks to the Captain and crew of the *CCGS John P. Tully* for their continued assistance and support throughout the cruise. Winch operators during this voyage were particularly helpful when it came to Ring net deployment. Thanks to the IOS science crew and my fellow scientists for their assistance and guidance both on deck and in the lab. Finally, a special thanks to Marie Robert for having me on board and continuing to accommodate my sampling needs.

  Lian Kwong

- As always, it was a pleasure to be involved in this cruise, and to work with my DFO and university-based colleagues. I <u>greatly</u> appreciate all of the help I received – particularly in accommodating my objectives (thanks very much Marie!) and the additional efforts to collect and analyze Winkler O_2 samples (thanks Mark and Moira!). Many thanks to Marie, Jade and Lian for your assistance with the gas sampling. Finally, I would like to thank the crew of the Tully for their great assistance, and for taking such good care of us – as always.

  Robert Izett

PROJECTS AND RESULTS:

Water masses – Marie Robert, DFO/IOS.

Two features are worth noticing from these February data.
Back in June 2018 were was an eddy centered on P6-P7 (see fig 1a). In September 2018 the eddy had moved west, being centered on P8 (fig 1b). In February 2019 we cannot see the eddy signature in sea-level height anymore. (fig 1c). Nevertheless, the eddy signature is still present at depth around P11, as seen in the temperature, salinity, and dissolved oxygen sections (fig 2).

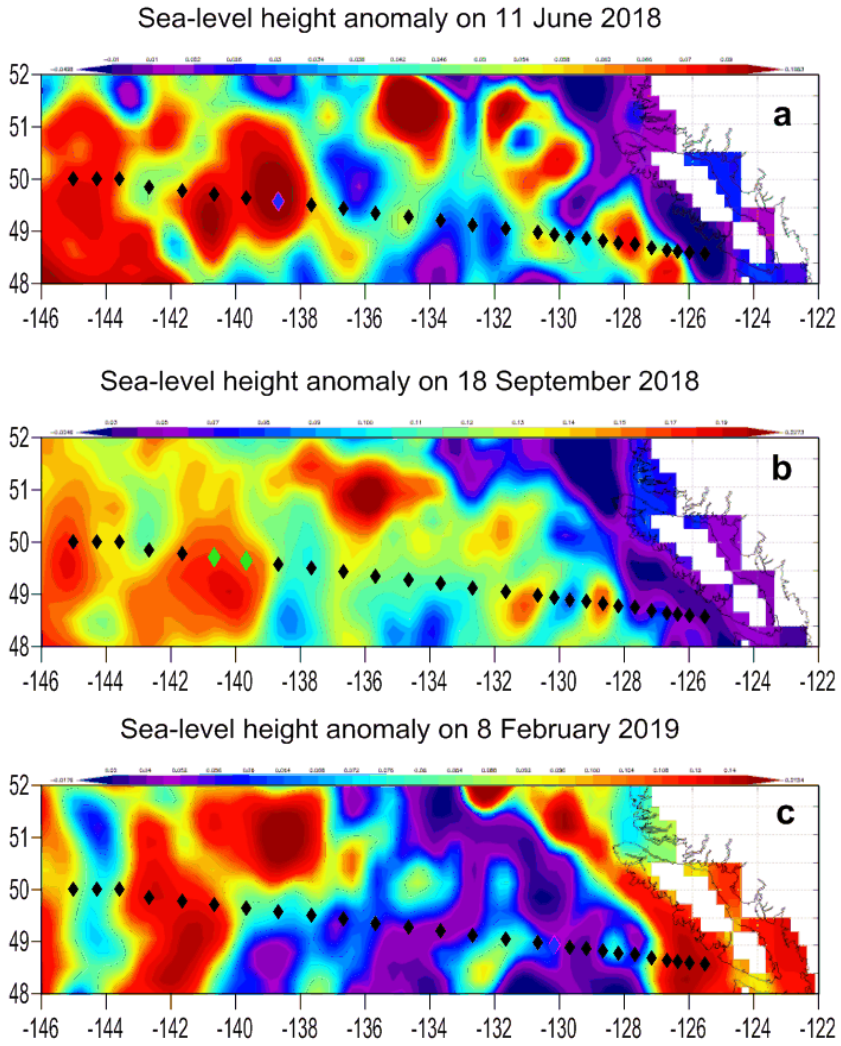


Figure 1: Sea-level height anomaly from the AVISO site, centered on 11 June 2018 (panel a), 18 September 2018 (panel b), and February 2019 (panel c), showing the eddy at Stations P6-7 and P8. Note that the scales are different on each panel, going from a. -0.01 m to 0.09 m, b. 0.03 m to 0.19 m, and c. 0.02 m to 0.14 m

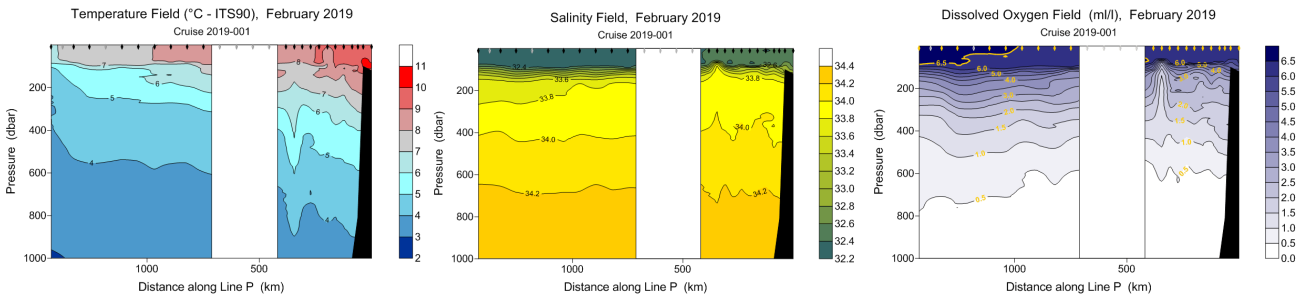


Figure 2: Section of Temperature, Salinity, and Dissolved Oxygen along Line P in February 2019, showing an eddy signature at P11.

The second feature worth of notice is the temperature anomaly field on the offshore section of Line P (fig 3). The surface temperature is quite warmer than the 1956-1991 average down to a depth of about 80 m; it will be interesting to see if this anomaly is still present on the next cruise in June 2019.

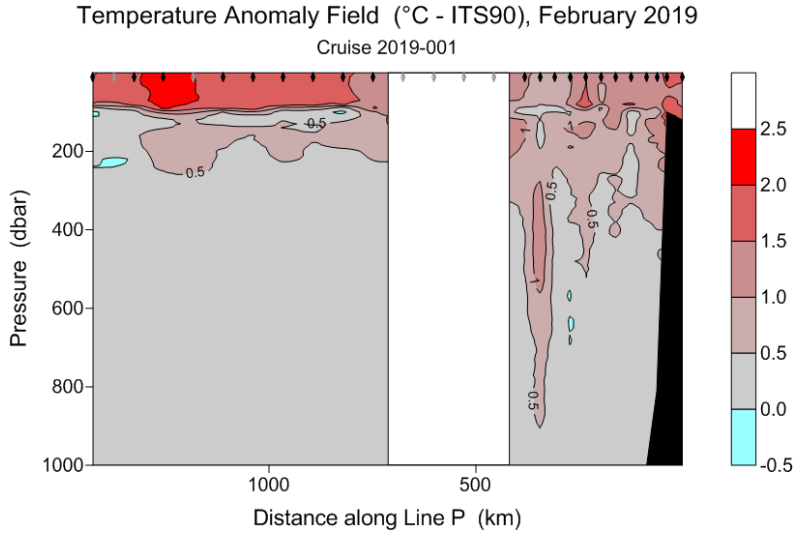


Figure 3: Temperature anomaly field with respect to the 1956 – 1991 averages for February 2019 showing warmer waters at the surface of the offshore end of Line P.

Hallam lab, UBC (Jade Shiller) – February 2019 Line P

Objectives:
Describe the taxonomic and metabolic diversity of the microbial communities in the cycling of major nutrients along Line P, focusing on the communities in the oxygen minimum zone.

Sampling summary:
At 5 stations (P4, P12, P16, P20, and P26),

1) 2 L seawater samples (at 16 depths) for high-resolution (HR) bacterial DNA sequencing were filtered.
2) 30 mL seawater samples were taken per depth to count microbial population density using flow cytometry and single cell DNA analysis. Samples were aliquoted and preserved using glutaraldehyde and glycerol+trisEDTA, respectively.

Additionally, at 3 major stations (P4, P12, and P26), the following were sampled at four depths: 10, 500, 1000, and 2000 (bottom+10 at P4) across the oxygen minimum zone:

1) Large volumes (20 L; LV) at each depth were filtered to create genomic libraries of the bacterial communities. From each sample, the first 2 L were preserved for RNA sequencing. The remaining 18 L were preserved for DNA.
2) 30 mL seawater samples were collected per depth to count microbial population density using flow cytometry and single cell DNA analysis. Samples were aliquoted and preserved using glutaraldehyde and glycerol+trisEDTA, respectively.

Comments:

My sampling objectives for this cruise were fulfilled at all stations where we were able to sample. Station P16 was skipped and no samples were collected due to weather and timing concerns. The work area distribution was convenient for my sampling needs.

I'd like to thank the captain and crew of the *Tully* for their excellent work and their interest in and support of our scientific program. Thanks to the galley crew for keeping us happy and extremely well fed. Thanks to the IOS team and my fellow scientists for their help and their humour on deck and in the lab. And finally, a great big thank-you to Marie for all of her work and her amazing ability to fit together many pieces of an ever-changing jigsaw puzzle and make a whole, coherent research cruise from them.

Sampling for total dissolved chromium concentration and isotopic ratios studies – Isabelle Baconnais (USask), Chris Holmden.

Studying total dissolved chromium (dCr_T) concentration and its stable isotope ratios ($\delta^{53}Cr$) onto the Line-P gives us a unique opportunity to (hopefully) observe the potential release of dCr from the continental shelf and its impact onto $\delta^{53}Cr$ at a local and global scale, allowing us a deeper understanding of the origin and cycle of dCr into the Ocean.

Sampling for dCr_T was done from the rosette using pre-rinsed tygon tubing attached to the Niskin's spigot. For all planned stations, samples of two times 1L were collected in HDPE bottles dedicated for each Niskin and pre-rinsed once with deionized water and three times with the seawater to collect. All sampling bottles were acid-leached ahead of the cruise in the same fashion as indicated in the 2017 Geotraces sampling and sample-handling protocol (Cutter et al., 2017). Samples were thereafter transported into the lab and filtered and acidified before storage. Filtering was done at a speed of 160 to 210 $mL.min^{-1}$ using a peristaltic pump, acid-leached tygon and Teflon tubings, and 0.45µm Aquaprep® filters (Pall Corp.). One filter per station and per depth was used. Filtered samples were transferred into 1L HDPE acid-leached bottles, and acidified using ~1mL of general grade ~38% concentrated HCl (Fisher). Approximative pipetting was done using pre-acid leached transfer pipettes of 2mL. All samples were then parafilmed and double-bagged before storage into 150QT coolers.

A total of nine stations were planned for sampling: P2 (7 depths), P4 (18 depths), P8 (23 depths), P12 (23 depths), P14 (24 depths), P16 (23 depths), P18 (24 depths), P20 (23 depths) and P26 (24 depths). However, technical difficulties with Niskin #21 and the proximity of two storms did not allow us to sample for all depths and stations (*i.e.* P14 and P16). On the way back from P26, the John P. Tully was re-routed toward Chatham Sound, giving us the amazing opportunity to sample for "bonus" stations in Haida Gwaii. A volume of 1L per sample was collected instead of the 2L required for Line-P stations in order to sample more diverse stations in and around Chatham Sound (*e.g.* trenches, highly-productive areas, river mouths).

This unique opportunity also allowed us to conduct tests for filtration and acidification. At station DIX3, three times 1L were collected for each depth and treated as follow: (1) seawater is filtered and acidified; (2) seawater is filtered (no acidification); (3) seawater is stored without filtration nor acidification. We hope that comparing results from samples which underwent these three different treatments will give us information on the behaviour of dCr_T during sampling and whether current sampling methods for this trace element need adjustments.

An additional test was conducted at station CH27. Two times 1L of seawater were collected into duct-taped sampling bottles alongside regular sampling at bottom-5m and at 5m deep. These bottles were left ~5hrs on the bench alongside regular samples of similar depth before being filtered and acidified as described previously. As a full station contains 23 depths and 46 samples, filtration and acidification can take between 6 and 8hrs. Photo-reduction is a natural process affecting dissolved Cr(VI), reducing it into particle-reactive Cr(III) and resulting in a loss of dCr (*e.g.* Kieber and Helz, 1992). This final test will allow us to observe whether photo-reduction occur into samples left on stand-by during this period, ultimately affecting the resulting $[dCr]_T$ and $\delta^{53}Cr$ of the samples. No publication has yet reported the direct rate of photo-reduction into non-filtered seawater at pH~7.8.

A total of 6 blanks of Milli-Q water 18.2MΩ (MQW) were also collected to account for potential contamination on board. Milli-Q water was poured into randomly selected sampling bottles, which were pre-rinsed once with deionized water and three times with MQW. Blanks were then filtered in the same fashion as for seawater samples, and acidified with ~1mL of concentrated HCl. Blanks were then parafilmed, double-bagged and stored alongside the seawater samples.

Station [#]	Number of depths sampled [#]	Total volume sampled [L]
P2	7	14
P4	18	36
P8	22	44
P12	21	42
P18	19	38
P20	23	46
P26	23	46
DIX5	17	17
DIX3	13	39
HECS8	9	9
CH1	19	19
CH27	6	8
Total sampled		**358**

Acknowledgments: This cruise on the line-P was my first, and stormy February was a bliss thanks to the outstanding Captain and crew members (not to mention the Valentine's chocolates and personalized cards we got from them). I also would like to thank the science team on-board, with which I learnt (or re-learnt) a lot about sampling methods for Oxygen, DIC, Nutrients, Chlorophyll etc… and the local oceanography. Most importantly, I would like to thank Marie Robert, without whom this cruise would not have been running so smoothly. She handled so well the last minute re-routings and designed sampling plans (with all the last minute changes and wishes) in such short amount of time, it had to be appreciated. Finally, thank you all science team, crew members and IOS administrative personnel (Mary Chan) for allowing me to live and/or share this experience with you all.

Zooplankton Productivity – Lian Kwong – UBC (Pakhomov Lab)

Objectives: Quantifying zooplankton production along Line P using size distributions.

Sampling:
At 7 main stations (P2, P4, P8, P12, P16, P20, P26) where the bongo net (236 µm) was deployed the ring net (60 µm) was also deployed to cover an additional smaller size range of zooplankton. These samples will be analyzed in the laboratory for taxonomy and zooplankton biomass size spectra using a Laser Optic Particle Counter (LOPC) bench unit. Zooplankton secondary production will then be calculated using size-dependent rate models for growth and mortality.

Comments:
Except for P16, all my sampling goals for this cruise were met.
Thanks to the Captain and crew of the *CCGS John P. Tully* for their continued assistance and support throughout the cruise. Winch operators during this voyage were particularly helpful when it came to Ring net deployment. Thanks to the IOS science crew and my fellow scientists for their assistance and guidance both on deck and in the lab. Finally, a special thanks to Marie Robert for having me on board and continuing to accommodate my sampling needs.

Cruise Report – Robert Izett (Tortell Lab; UBC, Earth, Ocean & Atmospheric Sciences)

My primary objective for this cruise was to compare underway measurements of $\Delta O_2/Ar$ and $\Delta O_2/N_2$ obtained from separate continuous gas sampling systems. This involved the simultaneous deployment of the MIMS (O_2 and Ar measurements by membrane inlet mass spectrometry) and PIGI (O_2 and N_2 measurements by optode and gas tension device, respectively) systems. As Ar and N_2 are inert analogs for O_2, the O_2/Ar and O_2/N_2 ratios can be used to quantify the biological fraction of the O_2 pool (i.e. $\Delta O_2/Ar$ or $\Delta O_2/N_2$). Ar is conventionally preferred, but N_2 is easier to measure using ship-board sensors. However, as N_2 is less-soluble than O_2 and Ar, $\Delta O_2/Ar$ and $\Delta O_2/N_2$ can be expected to diverge under high-wind environments, as a result of the injection of bubbles. This cruise therefore presented an opportunity to compare signals and evaluate their differences following periods of high-wind speeds (did it ever!). This was also an opportunity to conclude the testing of our custom-built PIGI system, which is capable of making fully-autonomous, high-resolution O_2 and N_2 measurements. Samples for discrete O_2 analysis were obtained from the seawater loop to calibrate the underway optode measurements.

The $\Delta O_2/Ar$ and $\Delta O_2/N_2$ data will also be used to derive estimates of net community production at high-resolution along the Line P transect. These estimates contribute to previous efforts over the past 3 years and will ultimately be used to derive an empirical algorithm for predicting NCP from more commonly-measured variables on the Line P sampling program.

Finally, samples for the determination of nitrous oxide and methane concentrations were obtained as part of a nearly 10-year time-series of these gases. I obtained samples at 5 m at all stations (P1-P26), and depth-resolved profiles at the major stations (P4, P8, P12, P20, and P26). Surface measurements of nitrous oxide will also be used to correct $\Delta O_2/Ar$ or $\Delta O_2/N_2$ signals for biases associated with the vertical mixing flux of water from beneath the mixed layer. Applying this, more accurate estimates of net community production can be obtained.

Comments:
I experienced no major instrument issues and collected high quality data sets from each underway system. The discrete sampling also went smoothly.

As always, it was a pleasure to be involved in this cruise, and to work with my DFO and university-based colleagues. I greatly appreciate all of the help I received – particularly in accommodating my objectives (thanks very much Marie!) and the additional efforts to collect and analyze Winkler O_2 samples (thanks Mark and Moira!). Many thanks to Marie, Jade and Lian for your assistance with the gas sampling. Finally, I would like to thank the crew of the Tully for their great assistance, and for taking such good care of us – as always.