# 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:** 11 September 2018 **TO:** 28 September 2018

**SCIENCE CRUISE NUMBER:** 2018-040 **SHIP'S PATROL NUMBER:** 18-07

**CHIEF SCIENTIST[S]:** Marie Robert

**SCIENTIFIC PERSONNEL:**

| | |
|---|---|
| Michael Arychuk (IOS) | Marie Robert (IOS) |
| William Burt (UBC) | Jade Shiller (UBC) |
| Jay Cullen (UVic) | Yuanji Sun (UBC) |
| Moira Galbraith (IOS) | Robyn Taves (UVic) |
| Roberta Hamme (UVic) | Sachia Traving (UBC) |
| Sile Kafrissen (UVic) | Theresa Venello (UVic) |
| Lian Kwong (UBC) | Jasmine Wietzke (IOS) |
| Hugh Maclean (IOS) | Cynthia Wright (IOS) |

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

**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); repeat Trace Metal survey along Line P; spend two days at the EXPORTS study site near Station P; deploy two drifters for UW.

**CRUISE DESCRIPTION:** This cruise (2018-040) went really well. Most instruments worked fine, with a few exceptions (see the Problems: Scientific Gear section), and the weather was really good most of the time. Being a full complement of scientists on board the lab was really crowded but everyone managed to do their work with the space allocated. The EXPORTS part of the cruise occurred during the allocated time (see Roberta Hamme's contribution to the *Projects and Results* section).

**DAYS ALLOCATED:** 15 (DFO) + 2 (NSERC) **DAYS OF OPERATION:** 17

**DAYS LOST DUE TO WEATHER:** None.

**SAMPLING:**

- The Line P survey was 100% successful. All stations were visited and all standard casts were performed. Two casts, P10 and P11, normally done to 2000 m had to stop at 1000 m.
- Trace Metal samples were collected at P4, P12, P16, P20, P26, and four of the five EXPORTS stations.
- Two floats were deployed for UW at the EXPORTS-C station although one float had to be recovered.
- The samples collected include:

1) Underway: **IOS**: Thermosalinograph (Temperature, Conductivity, Fluorescence), acoustic sounder, ADCP, $pCO_2$ – **UBC (Burt):** PIGGY ($O_2$, total gas tension ~$N_2$), optics (backscatter and absorption at ~1 Hz resolution).

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, pH, domoic acid, phytoplankton, HAB, DOC, TOC, CDOM, PIC, POC, Gels **– UBC (Shiller, Traving):** high-resolution bacterial DNA sequencing, number of cells per millilitre, single cell DNA analysis, virus analysis, viral counts, extracellular enzyme activity, remineralization experiments, fluorescent *in situ* hybridization – **UBC (Burt, Kwong, Sun for Izett):** methane and nitrous oxide ($N_2O$) – **UVic (Venello):** secondary productivity, zooplankton **– UBC (Kwong):** 'bugs' – **UBC (Burt, Sun):** Dissolved PBDEs, $^{234}$Thorium, Chromium – **UVic (Hamme):** dissolved oxygen, ONAr, $^{17}$O, dissolved neon, argon, krypton, and xenon – **UVic (Kafrissen):** Net primary production and new production**.**

4) From the Trace Metal Rosette: **UVic (Cullen):** trace metals filtered, trace metals unfiltered, ligands, nutrients, salinity.

5) From the various nets: **DFO-IOS, UVic and UBC (Galbraith, Venello, Kwong):** Zooplankton using vertical net hauls (Bongo to 250 m and 1200 m, single fine-mesh net to 250 m, two MPS to 2000 m).

**RADIOISOTOPE USE:**

The fume hood of the Rad-Van was tested at the beginning of the cruise. $^{230}$Thorium and $^{32}$Silica were used during the cruise. The Rad-Van was decommissioned at the end of the cruise.

**PROBLEMS [SCIENTIFIC GEAR AND OPERATIONS]:**

The ADCP seems to interfere with the sounders. Some "trial and errors" modifications are done to the way the ADCP collects data but someone really has to understand how that instrument works.
The new Trace Metal container was not ready for use at the beginning of the cruise despite months of notice that it would be needed.
The Trace Metal winch base was not assembled to the winch at the beginning of the cruise when it got delivered to the Tully.
The DMS system suffered a valve failure while running standards in preparation for P2. A spare valve was available but the system had to be shut down for six hours for repairs and valve replacement. Consequently, station P2 was not sampled for DMS.
One of the tables in the lab was secured in a such a way that it was blocking access to the fume hood. Better care has to be taken next time as to the position of the table.
The CTD laptop froze at some point before the CTD cast at P10. Because of that we are missing the bottle information from P9 and we had to sample P10 and P11 only to 1000 dbar (instead of 2000 dbar) because of time lost rebooting. The problem was some interference between various COMM ports and has been solved (thanks to Gavin).
The dissolved oxygen sensor malfunctioned and had to be changed mid-cruise. It was already presenting some problems during the previous cruise but comparison of samples and sensor data confirmed the needed exchange.

The $pCO_2$ system worked well for the first few days when it was noticed that the atmospheric values were scattered. Although one would expect some scattering due to stack gases the concentrations were not high enough to draw that conclusion and a more detailed inspection of the system found that the pump used to draw the atmospheric air into the system had seized. The pump head was actually hot to the touch and as a result the system was immediately shut down for safety concerns. The pump was removed and given to the Chief Engineer who cleaned and lubricated the bearings and returned the pump with limited optimism. The pump was installed and worked the remainder of the cruise which included the EXPORTS experiment. The system was down for approximately 30 hours.
The Trace Metal Rosette conductive Kevlar cable jumped sheave while the rosette was at ~270 m and got jammed between the sheave and the sides of the block. The crew managed to free the Kevlar and recover the rosette but the conductive cable had to be reterminated and roughly 300 m of cable got cut off.
Of the two drifters deployed for the University of Washington one had to be recovered because of a malfunction.
Niskin 21 did not close on the last three casts. The latching mechanism needs to be cleaned.

**SUCCESSES [SCIENTIFIC]:**

The work for the EXPORTS program went really well, mainly the coordination with the people ashore. The calibration cast of the Lagrangian Float was particularly successful with the float and the CTD starting their descent at the same time. The fact that the Internet was available so far offshore was a big part of this success and should be part of the regular services offered on board.
There was an unusual catch: a bathypelagic ostracod, Gigantocypris agassizii, was captured in the deep cast from P8. I was able to keep it alive for more than a week but unfortunately I do not have the proper equipment for the housing of animals and it died. I transferred it to ethanol for bar coding. These deep water ostracods are rare to collect intact, it was quite big (20 to 30 mm) and had two large parabolic lenses for concentrating light; a very unique find. (Moira Galbraith).

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

There is a very loud noise on the aft-deck at a certain engine RPM.
The LARS sheaves started to "sing" towards the end of the cruise with a loud high pitch noise.
Because of problems with some membranes the retention tank had to be used to hold black waters on a few occasions. The vent of that tank is right next to the main lab doors. The sewage smell was noticeable near the lab once in a while and on a couple of occasions the smell was so strong that people considered actually evacuating the area. The main lab doors had to be kept closed during those times.
Despite starting to make some arrangements with the ship and the ROC back in June, and confirming the number of science crew in July, there was still one extra person scheduled to be on the ship (a cadet) at crew change who unfortunately had to sail on a different vessel.
There is some grease falling on the top of the rosette at random intervals. The bosun thinks that it may come from the CTD wire.

**SUCCESSES [SHIP]:**

The recovery of the University of Washington drifter was very impressive; great team work between the Captain at the wheel and the bosun on the aft deck.
The aft deck configuration had to be modified every time we would go from using the bongos to using the trace metal rosette or the multinet. All "deck swaps" were done without issues.

**DELAYS [OTHER THAN WEATHER]:**

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

**SAFETY CONCERNS:**

None.

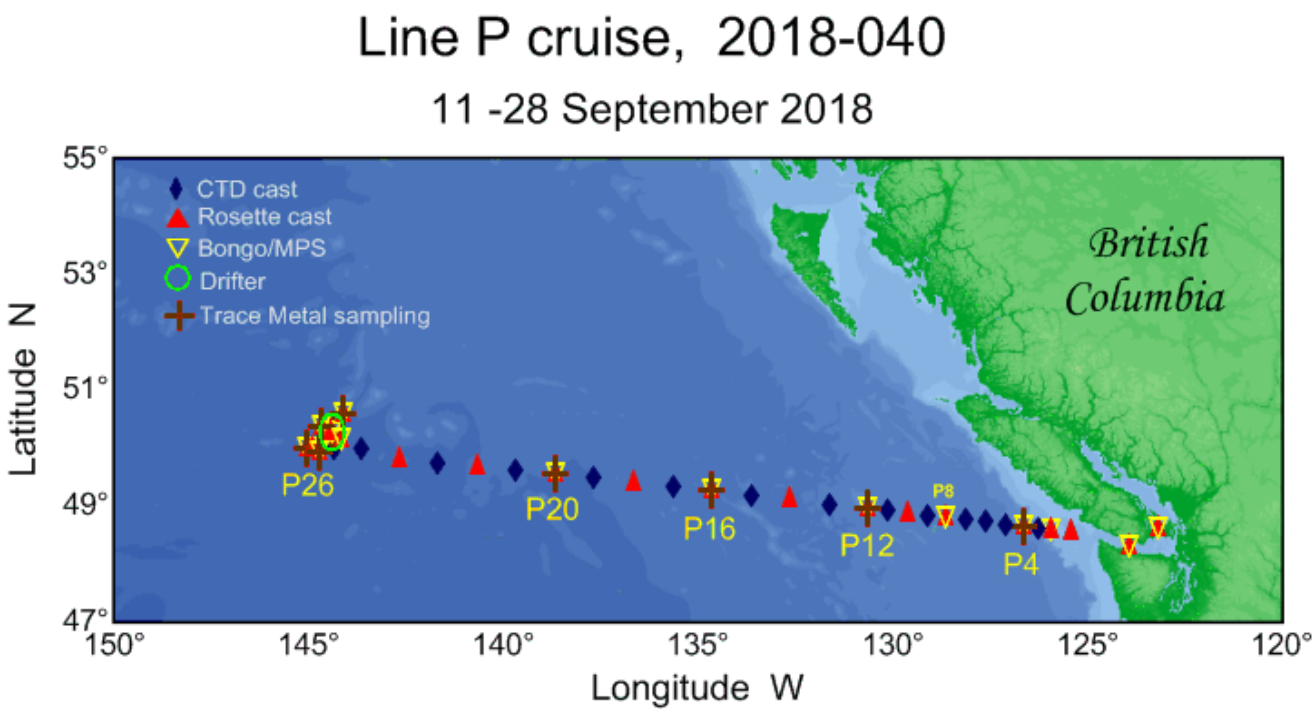
**HAZARDOUS OCCURRENCES:**

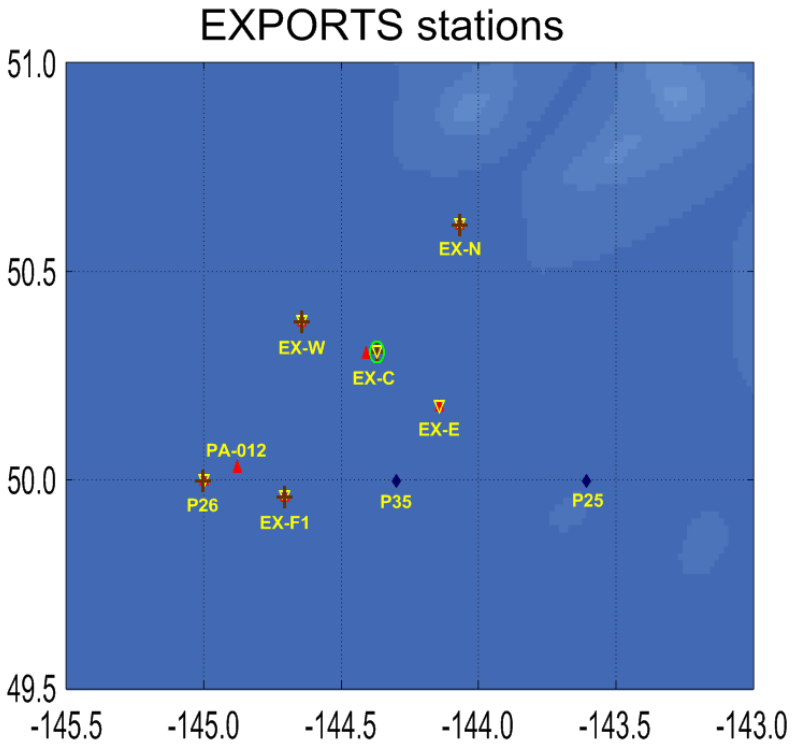
None.

**EVENT LOG:**

| | |
|---|---|
| Tuesday 11 Sept: | Start loading after lunch. Safety meeting at 1500. |
| Wednesday 12 Sept: | Load the rest of the science gear and the winches/container. Rad-Van fume hood tested at 0900. Science meeting at 1000. Fire&boat drill at 1300. Departure at 1530. Station 59. |
| Thursday 13 Sept: | Stations JF2 to P4. |
| Friday 14 Sept: | Stations P4 to P10. |
| Saturday 15 Sept: | Stations P11 to P13. |
| Sunday 16 Sept: | Stations P14 to P16. |
| Monday 17 Sept: | Stations P16 to P19. |
| Tuesday 18 Sept: | Stations P20 to P22. |
| Wednesday 19 Sept: | Stations P23 to P35. |
| Thursday 20 Sept: | Station Papa and EX-F1. |
| Friday 21 Sept: | Station EX-C. Deploy two UW floats, recover one. |
| Saturday 22 Sept: | Stations EX-W, EX-N, EX-E. Start heading east. |
| Sunday 23 Sept: | Heading east. |
| Monday 24 Sept: | Heading east. |
| Tuesday 25 Sept: | Heading east. "CasTrack" exercise. |
| Wednesday 26 Sept: | Revisit stations P4 and JF2. "Show and tell" presentations. |
| Thursday 27 Sept: | Back to IOS, offload scientific gear. |
| Friday 28 Sept: | Offload winches and containers. LB crane at 1000. |

**CRUISE TRACK:**






**SUMMARY/FINAL COMMENTS:**

- Many thanks to everyone at IOS who have helped make this cruise a success, as much in the "land labs" getting things ready as on board setting up the equipment. Special thank you to Germaine who looked at many casts to help figuring out the problems with the Oxygen sensor, and to all the analysts at IOS who will have to deal with the "extra samples" coming from the extra EXPORTS stations.
- Big thank you to Gavin 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. Special thanks for your help when we started the drifters.
- Thank you to Captain Corfield for allowing some of the work that had to happen "after hours", and thanks to those who actually worked those long days.
- Thanks to "Jas$^2$" for sharing their talents with us; it was a great show!
- Thanks to the White Crew for loading some of our containers at the end of their patrol.
- And as usual a big thank you to everyone on board who made this cruise the success it was! See you all next August.

  Marie Robert

- Much gratitude to the Engineers and specifically the Chief Engineer for his help with the DMS and $pCO_2$ problems. The corroded DMS valve and rotor were cleaned by the Engineers and the Chief Engineer personally took apart the $pCO_2$ pump and cleaned and repaired it so that we could be operational for the rest of the cruise. Without their help and expertise the cruise would not have been nearly as successful.

  Michael Arychuk

- Many thanks to the Captain and crew for making the Tully such an excellent scientific sampling platform.

  Moira Galbraith

- We'd like to thank the Captain and crew of the *Tully* for all their assistance and hard work throughout the cruise. Thanks to Marie Robert and the IOS science crew for having us on board to do this work and accommodating sampling needs.

  Theresa Venello and Lian Kwong

- Thanks to all the science crew who participated in collecting the DIC samples. Thanks to Mike Arychuk for sampling for pH and for analyzing the EX-F1 pH samples. Thanks to Lian Kwong for collecting the TOC and Gels samples during the night. Finally thanks to Theresa Venello and Lian Kwong for assisting with the filtration process of the PIC/POC samples and for the other watch participants who helped collect the water.

  Cindy Wright

- 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 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 organizing everything flawlessly, regardless of the challenges that fieldwork inevitably presents.

  Jade Shiller

- I'd like to thank the captain and crew of the CCGS *John P. Tully* for their excellent work and their interest in and support of our scientific program. Thanks to the IOS team and my fellow scientists for their help during sampling, and at all other times, and their good spirits on deck and in the lab. And finally, a very big thank you to Marie for finding a spot for me and organizing everything down to the smallest detail, regardless of the challenges that fieldwork inevitably presents.

  Sachia Traving

- As usual, a successful sampling program was facilitated by a well-organized and highly collaborative scientific group led by Marie Robert. We'd also like to thank Mike Arychuk for all his help to facilitate our isotope work in the RadVan. As always, the ship's crew were extremely friendly and helpful fixing issues in our flow-through system, and assisting in our deployment of the large volume pumps. Our group at UBC is very grateful to be a part of this wonderful program.

  Will Burt and Yuanji Sun

- Our sincere thanks to the captain and crew of the John P. Tully for a very successful mission. The ship maneuvered very close to the EXPORTS floats when required, and successfully deployed and recovered Eric D'Asaro's floats. Bravo! Our sincere thanks also to Marie, the watch leaders, and other scientists on board. You were patient with our many sampling requests, out-of-order tripping of Niskins, and helpful with early morning sampling. A special thanks to Marie for dealing with the many e-mails occasioned by coordinating with EXPORTS scientists to get the very most out of our sampling possible. Also a big thanks to all involved in the recovery of the UW drifter for a well done, professional job.

  Roberta Hamme and Sile Kafrissen

- As noted above the trace metal rosette wire was damaged when it jumped the block during the deep P26 cast. Only the quick thinking and action of the crew prevent loss of the TMR rosette. Their performance in this matter was exemplary. The wired needed to be cut and reterminated; Hugh R. Maclean provided materials and expertise to reterminate the seacable and is thanked for doing so.

  Jay Cullen

## PROJECTS AND RESULTS:

**Water masses** – Marie Robert, DFO/IOS.

The weather during this cruise was excellent. All the stations were done in order and without any delay. In June 2018 we sailed through an eddy at Station P20. (See figure 1). This eddy is still in the area as seen in Figure 2. The eddy signature can still be seen in the temperature anomaly field (See figure 3).

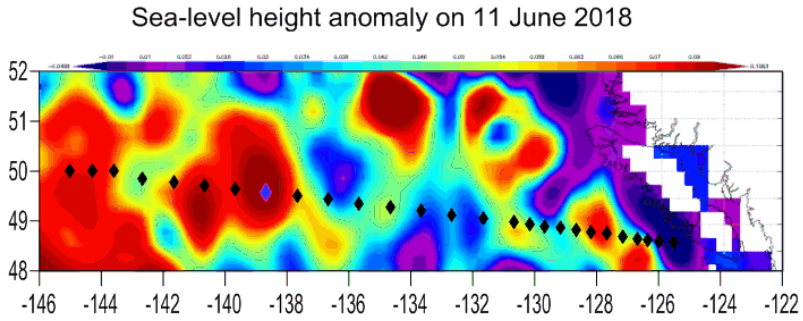



Figure 1: Sea-level height anomaly from the AVISO site, centered on 11 June 2018, showing the eddy at Station P20.

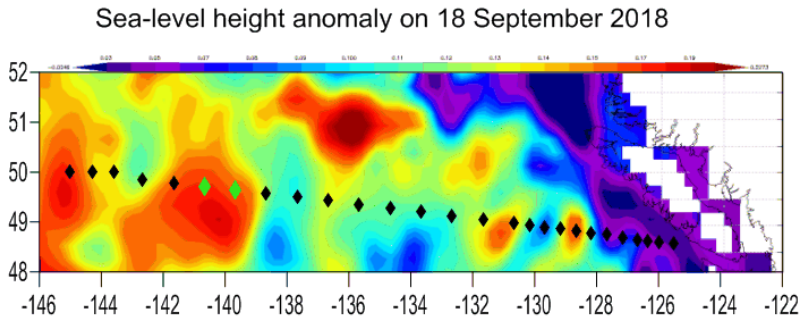



Figure 2: Sea-level height anomaly from the AVISO site, centered on 18 September 2018, showing the eddy at Stations P21 and P22.

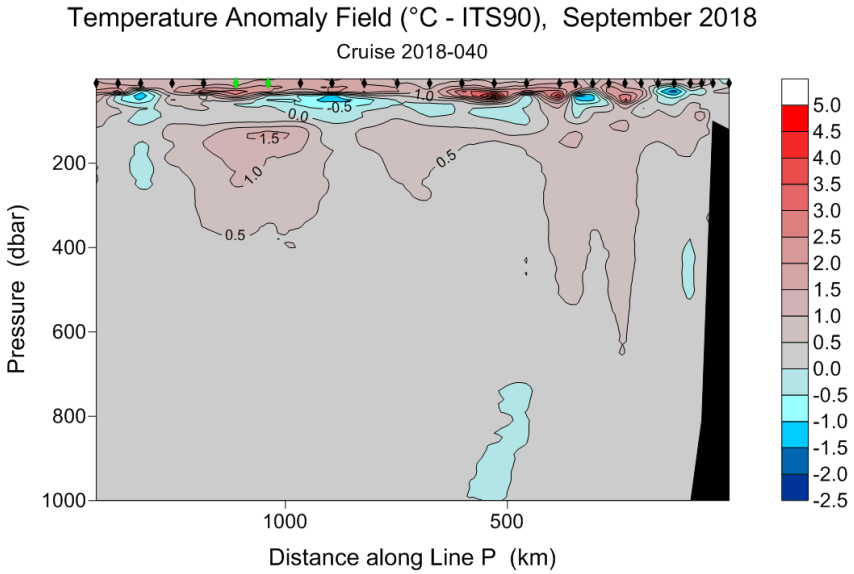



Figure 3: Temperature anomaly field with respect to the 1956 – 1991 averages for September 2018 showing the eddy "signature" at P21 and P22.

**Net Operations** – Moira Galbraith, DFO/IOS.

I was able to get 2 deployments of the multiple plankton sampler (MPS), at P12 and P16; each from a depth of 2000m, stratified by depth for a total of 5 samples per cast. There were no hitches with the winch or the deck unit electronics; deck deployment and recovery was very smooth. Planned cast at P26 was dropped due to poor sea state. The weird noise from propeller continues be irritating but it was not as high pitched on this cruise compared to the June Line P trip.

Bongo nets samples, using 236 micron mesh were collected from a depth of 10 m above bottom floor at 59, JF2, and P2; from 250 m at P4, P8, P12, P16, P20 and P26; and from 1200m at P4, P8, P20 and P26. Additional bongos were done at P4 and JF2 on the return trip. At the EXPORTS site, one bongo sample was taken at centre and each of the four corners.

A portion of each of deep samples was set aside in ethanol for DNA work up back in the lab. A small number of euphausiids from the bongo flowmeter side were sacrificed for the secondary productivity analysis on board.

Ring net samples, using 64 micron mesh, were done from a depth of 250 m at P2 (100m), P4, P8, P12, P16, P20 and P26. Samples will be transferred to Evgeny Pakhomov's lab via Lian Kwong.

There was an unusual catch, a bathypelagic ostracod, Gigantocypris agassizii, was captured in the deep cast from P8. I was able to keep it alive for more than a week but unfortunately I do not have the proper equipment for the housing of animals and it died. I transferred it to ethanol for bar coding. These deep water ostracods are rare to collect intact, it was quite big (20 to 30 mm) and had two large parabolic lenses for concentrating light; a very unique find.
Many thanks to the Captain and crew for making the Tully such an excellent scientific sampling platform.

**$pCO_2$** – Mike Arychuk, DFO/IOS.

The system worked well for the first few days when it was noticed that the atmospheric values were scattered. Although one would expect some scattering due to stack gases the concentrations were not high enough to draw that conclusion and a more detailed inspection of the system found that the pump used to draw the atmospheric air into the system had seized. The pump head was actually hot to the touch and as a result the system was immediately shut down for safety concerns. The pump was removed and given to the Chief Engineer who cleaned and lubricated the bearings and returned the pump with limited optimism. The pump was installed and worked the remainder of the cruise which included the Exports experiment. The system was down for approximately 30 hours.

**Zooplankton Productivity and Net Community Production** – Theresa Venello-UVIC (Dower Lab), Lian Kwong- UBC (Pakohomov Lab).

**Objectives:** Quantifying secondary (crustacean zooplankton) production along Line P using the chitobiase-method.

**Sampling:**
500mL of seawater was taken from 6 depths (5, 10, 20, 50, 150, 250 m) at all 7 major stations that have a bongo net cast (P2, P4, P8, P12, P16, P20, P26). All samples were collected on the way out to OSP.

Water was taken from the rosette, filtered through 54µm mesh and into 500 mL Nalgene bottles. Water samples were then 'spiked' with a homogenate made from ground amphipods, krill or copepods (depending on what was in the bongo sample); filtered every three hours over a 12 hr period to create a decay of the moulting enzyme chitobiase. Samples were assayed and read using a fluorometer while on board.

Zooplankton samples were also collected from the rosette at P2, P4 and P26 by filtering whole Niskin bottles at three depths (5, 50, 100) through a 50µm sieve. Additionally, a 64- µm mesh ring net was deployed at each of the major stations to 250m. This work was conducted for Lian Kwong and Evgeny Pakhomov at UBC.

**Comments:**
All of our sampling goals for this cruise were met.

We'd like to thank the Captain and crew of the *Tully* for all their assistance and hard work throughout the cruise. Thanks to Marie Robert and the IOS science crew for having us on board to do this work and accommodating sampling needs.

**Dissolved Inorganic Carbon and Alkalinity sampling** – Cindy Wright, DFO/IOS.

Samples were taken at several stations along the Line as well as EX-F1 and EX-C. Water was collected directly from Niskins in 500ml glass bottles. Volume was overflowed approximately 1.5x and fixed using 100µl of mercuric chloride. Apeizon greased stoppers were used to seal the bottles and electrical tape to secure the stoppers. Samples were kept in cool conditions until transport to IOS.

Thanks to all the science crew who participated in collecting these samples.

**Seawater pH** – Cindy Wright, DFO/IOS.

Seawater pH was collected directly from Niskins into 10cm quartz cuvettes and determined spectrophotometrically using purified meta-cresol purple dye (Standard Operating Procedures , Deep Sea Research, 1993). All work was performed in the JP Tully's temperature controlled room. Dye perturbation tests were performed on 30% of the samples. Samples were taken at EXPORTS station only (EX-F1, W, N, E and C) primarily to compare with DIC/Alkalinity and calibration of pH sensors on the EXPORTS float. Some sampling depths were "lost" as the Teflon plugs from the cuvettes were pushed out during water expansion in the incubator block.

Thanks to Mike Arychuk for sampling into the cells and for analyzing EX-F1 samples.

**TOC/DOC/CDOM/Gels/Particulate Organic and Inorganic Carbon** – Cindy Wright, DFO/IOS.

Samples for these variables were taken as part of the long term study by Hansell for carbon production, behaviour and fate and also, as part of the EXPORTS program.

TOC was collected for the Hansell labs (UMiami) at primary deep stations along the Line and at P26 (P2, 4, 8, 12, 14, 16, 18, 20, 22, 24 and 26). Samples for comparison with the Johannessen Lab (IOS) were also taken at EX-F1, C, N, W and E. 40ml scintillation vials were rinsed 3x from the Niskin and filled with approximately 35ml of water. 100µl 4M HCl was added to preserve the samples and were stored at room temperature.

Gels were taken at all the same stations/depths as Hansell TOCs. These were taken for the study of prokaryotes and other microbes. Water was collected into 60ml HDPE bottles and filled to the neck after 3x rinsing. A small subsample from the bottles was transferred into a 5ml cryovial (approximately 4.5ml). 100µl of 5% sodium azide was added to the HDPE bottles as a preservative, caps taped and samples stored at room temperature. 25µl of 50% gluteraldehyde was added to the cryovials and samples were stored at -80 degrees C.

All TOC samples and gels for the Hansell lab were taken according to plan. Thanks to Lian Kwong for sampling during the night shift.

Additional samples for TOC, DOC and CDOM were taken at P4 and P12 and EX-F1, C, N, E and W for the Johannessen lab (IOS) as part of the EXPORTS program. For TOC, samples were collected into 40ml trace cleaned scintillation vials after 3x rinsing from the Niskin. Approximately 30ml was collected to ensure head space for freezing. DOC was taken by filtering directly from the Niskin using a 0.2µm Millipore Opticap filter (durapore filter). Similar to TOC, 30ml was collected into trace cleaned vials and both were frozen at -20 degrees for analysis back at IOS. CDOM samples were collected from the Opticap filter into 200ml amber bottles (3x rinse) and stored in cool conditions. Analysis will take place back at IOS.

PIC-POC

At the EXPORTS stations (F1, W, N, E and C), water was collected directly from the Niskins (sample bottle volumes ranged from 1.08ℓ to 1.24ℓ). Bottles were rinsed 3x and filled to the top for each PIC and POC. Water was filtered onto a precombusted GFF filter. Volume of water filtered was written on each filter lable. For PIC samples, 0.2µl filtered seawater was used to rinse the funnels and for POC, filtered seawater acidified to 10% with HCl was used. Filters were stored in plastic holders and transferred to the -80 degree C freezer for storage. Thanks to Theresa Venello and Lian Kwong for assisting with the filtration process and for the other watch participants who helped collect the water.

**Hallam lab, September 2018 Line P –** Sachia Traving, UBC.

**Objectives:**
Measure extracellular enzyme activity in the microbial community along the Line P transect, and taking samples for developing a method for targeting specific bacterial clades at P26.
Furthermore, work was carried out at specific Line P and EXPORTS Centre stations for collaborations with two EXPORTS teams, (Carlson and Marchetti Lab).

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

1) 2 x 50 ml seawater was sampled per depth (see table 1, EEA) to assay extracellular enzyme activity of the microbial community.

At two stations (P4 and P16):

1) 33 x 35 ml seawater samples were collected at 5 m for remineralization experiments done for the Carlson Lab (EXPORTS). The samples were stored in a small fridge at 9-8 C for the duration of the cruise. The experiment is looking at remineralization rates in microbial communities at more coastal stations.

At one station (P26):

1) 4 ℓ of seawater was collected at four depths (see table 1, FISH).
2) 1000-1500 ml seawater was filtered onto 0.2 polycarbonate filters for FISH (fluorescent in situ hybridization) incubated in Ethanol, before air dried and stored at -80 C.
3) 10-100 ml seawater fixed in 1 % formaldehyde final concentration was filtered on to 0.2 µm polycarbonate filters for microscopy and stored at -80 C.
4) Samples were also collected for cell counts and SAGs (Single Amplified Genome) preserved in glutaraldehyde or glycerol+TrisEDTA, respectively.

At one station (EXPORTS CENTRE):

1) 6 (surface) to 4 l of seawater was collected (see table 1, ERNA/EDNA) for RNA and DNA on to 0.2 µm sterivex filters, and flash frozen in liquid nitrogen.
2) From the same depths, samples were collected for cell counts and SAGs (Single Amplified Genome) preserved in glutaraldehyde or glycerol+TrisEDTA, respectively.

**Comments:**

Unfortunately, I brought the wrong platereader for measuring the extracellular enzymes on board of the ship. I used my backup solution and preserved samples from all stations and depths in 10 % glycerol final concentration stored at -80 C, and 50 ml untreated seawater frozen at -20 C for controls. I will test if this preservation method will work for naturally occurring enzymes by testing water from Saanich Inlet to compare enzyme activity between fresh and stored water samples; before processing the Line P samples. The rest of the sampling objectives occurred without incidence and the workspace allocated to me was adequate and very convenient.

I'd like to thank the captain and crew of the CCGS *John P. Tully* for their excellent work and their interest in and support of our scientific program. Thanks to the IOS team and my fellow scientists for their help during sampling, and at all other times, and their good spirits on deck and in the lab. And finally, a very big thank you to Marie for finding a spot for me and organizing everything down to the smallest detail, regardless of the challenges that fieldwork inevitably presents.

| depth [m] | P4 | P12 | P16 | P20 | P26 | EXPORT MAIN |
|---|---|---|---|---|---|---|
| Bot-10 | | | | EEA | | |
| 3500 | | | | | | |
| 3000 | | | | | | |
| 3000 | | EEA | EEA | EEA | EEA | |
| 2500 | | | | | | |
| 2000 | | | | EEA | FISH | |
| 1500 | | | | | | |
| 1250 | | | | | | |
| 1000 | EEA | EEA | EEA | EEA | EEA/FISH | |
| 800 | | | | | | |
| 600 | | | | | | |
| 500 | EEA | EEA | EEA | EEA | EEA/FISH | EDNA/ERNA/ESAG |
| 400 | | | | | | |
| 300 | | | | | | EDNA/ERNA/ESAG |
| 250 | | | | | | |
| 200 | | | | EEA | | |
| 175 | | | | | | |
| 150 | | | | EEA | | |
| 125 | | | | | | |
| 100 | EEA | EEA | EEA | EEA | EEA | EDNA/ERNA/ESAG |
| 75 | | | | | | |
| 50 | | | | EEA | | |
| 25 | | | | | | |
| 10 | EEA | EEA | EEA | EEA | EEA/FISH | |
| 5 | EEA/CAR | | EEA/CAR | | | EDNA/ERNA/ESAG |

**Hallam lab, September 2018 Line P** – Jade Shiller, UBC.

**Objectives:**
Describe the taxonomic and metabolic diversity of the bacterial and viral 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),

2) 2 L seawater samples (at 16 depths) for high-resolution (HR) bacterial DNA sequencing were filtered.
3) 50 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.
2) After adding iron chloride to the filtered water, the samples were filtered again for later virus analysis.
3) For viral counts, samples were taken and preserved using glutaraldehyde and betaine. Filtered seawater was also collected without preservatives in order to isolate and culture viruses in the lab.
4) 50 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:**

All of my sampling objectives for this cruise were successfully fulfilled. 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 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 organizing everything flawlessly, regardless of the challenges that fieldwork inevitably presents.

## **Cruise Report –** Will Burt & Yuanji Sun: UBC, Earth, Ocean & Atmospheric Sciences.

**Objectives:**

During this cruise, we continued our regular deployment of autonomous underway sensors across the Line P transect. The primary aim of these efforts was to continue quantifying net community production and various components of phytoplankton productivity at high spatiotemporal resolution. We continue to make adjustments to our instrument setups and automation packages, and this cruise provided yet another test of these improvements. These measurements will also add to the productivity-focused measurements made during the EXPORTS portion of the expedition.

In addition to our regular surface measurements, we collected discrete profiles of dissolved polybrominated diphenyl ethers (PBDEs, PI: Roger Francois, UBC), Chromium isotopes (PI: Dr. Holmden, USaskatchewan), and naturally-occurring Thorium isotopes (PI: Roger Francois, UBC).

**Biogenic Gas Measurements:**

To continue to our 10+ year timeseries of methane and nitrous oxide ($N_2O$) measurements, we collected duplicate surface samples from 21 of 27 stations along the transect to station P, and full depth profiles (10 depths) at each of the EXPORTS stations.

Over the past 3 years, Ph.D student Robert Izett has been developing a device capable of measuring surface biological oxygen uptake in a fully autonomous fashion. This device continuously measures surface $O_2$ and total gas tension by pumping seawater past an oxygen optode and a gas tension device (GTD) using a circulating pump, all housed in a pelican case for ease of transport and installation. This device, nicknamed PIGI, is a further improved design of the original instrument package (named "Miss Piggy"). For this trip, we ran PIGI alongside our Membrane Inlet Mass Spectrometer (MIMS), our original device for continuous gas measurements (of $O_2$ and Ar). Both instrument systems will be used to estimate NCP independently from $O_2/N_2$ and $O_2$/Ar measurements, respectively. We will assess the PIGI's performance in relation to the "tried-and-trusted", albeit considerably larger and more cumbersome, MIMS setup. As in previous cruises, discrete $O_2$ samples were also taken from the seawater loop at various major stations to calibrate the optode.

Overall, data quality from PIGI appears very good, with the instrument requiring nearly no maintenance. On the other hand, the MIMS system had some small issues relating to instrument temperature, malfunction of the water chiller, and bubbles in the lines.

**Optical Instrumentation:**

We continued our underway optical measurements from the seawater loop. As usual, we measured backscatter and absorption at ~1 Hz resolution. The system now includes an in-line flowmeter in an effort to keep flow rate consistent, and closely monitor potential filter clogging. As usual, the wall-mounted setup worked well. We experienced more biofouling on this trip than usual, which was curious, but at first glance this doesn't seem to impact the dataset because filtered 'blanks' followed the same increasing trend as raw measurements. Due to the calm weather throughout the trip, we seem to have obtained good measurements for nearly the entire expedition (pending processing), including continuous measurements throughout the EXPORTS survey.

**Dissolved PBDEs:**

Dissolved PBDE samples were collected as a part of the project to quantify the sources, sinks, and biogeochemical cycling of PBDEs in the coastal waters off British Columbia. Concentrations at P26 will be used as an input into a box model while concentrations at JF2 will be used to compare with the modeled results. Seawater was collected from 20 m and 160 m at JF2 (240 L per depth, on both outbound and return legs) and from 25 m at P26 (480 L), and drained into kegs. Kegs were weighed to calculate the volume of water before further processing. Water was first filtered through pre-combusted QMA filters to remove particles and then passed through an XAD column to absorb dissolved PBDEs.

**$^{234}$Thorium:**

In an effort to expand the dataset collected during the US EXPORTS cruise (collected ~3 weeks prior to our occupation), we measured vertical profiles (8 depths) of naturally-occurring $^{234}$Thorium at all 5 stations along our Canadian EXPORTS survey (40 samples in total). Samples were processed (i.e. spiked and filtered) onboard, and filters were shipped to the US for isotope counting. This work required addition of a radioactive $^{230}$Th spike (very low activity), which was done in the Rad-Van. Regular wipe tests revealed no contamination of any kind. In addition to vertical profiles from the rosette, which yields vertical export fluxes of Thorium (Th-flux), we deployed in-situ large-volume pumps (LVPs) at 5 depths at the EXPORTS central station (EX-C). This involved deploying large, heavy pumps off the aft deck, which was done in a safe and efficient manner by the ship's crew. One of the pumps failed (at 335m depth), but the other 4 performed well, pumping >500L from various depths in the water column. Each of these pumps yield a large filter containing particles, from which we will measure the ratio of Thorium-to-carbon. We then combine the ratio with Th-flux data to yield carbon export fluxes. Overall, this sampling was very successful, and should be a valuable addition to the US EXPORTS program.

**Comments:**

As usual, a successful sampling program was facilitated by a well-organized and highly collaborative scientific group led by Marie Robert. We'd also like to thank Mike Arychuk for all his help to facilitate our isotope work in the RadVan. As always, the ship's crew were extremely friendly and helpful fixing issues in our flow-through system, and assisting in our deployment of the large volume pumps. Our group at UBC is very grateful to be a part of this wonderful program.

## **EXPORTS –** Roberta Hamme and Sile Kafrissen (UVic)

EXPORTS

The US NASA-funded EXPORTS program is a large process study ($US 16 million total) that aims to develop a predictive understanding of the export of photosynthetically-produced organic matter from the surface ocean and its fate in deeper waters (http://oceanexports.org). EXPORTS conducted a two-ship, 28-day experiment near P26 from 13 August to 9 September 2018, ending just prior to the start of the Line P cruise. An NSERC ship time grant, led by Roberta Hamme, facilitated adding two extra days to the Sept 2018 Line P cruise to reoccupy the EXPORTS site and perform a small spatial survey in the area. This extra time allowed for Canadian scientists to bring our expertise on the biological pump and the ecosystem in this region to a collaboration with our US colleagues by mounting a Canadian contribution to the EXPORTS program. Our main objectives were: 1) to make measurements unique to the Canadian team, 2) to add a final time point to the EXPORTS time series, 3) to intercalibrate some of our methods such as nutrient and HPLC analysis, and 4) to perform a small spatial survey to look at mesoscale variability in the P26 region.

EXPORTS deployed a Lagrangian float, that mainly drifted at 95 m, and centered their experiment around this target. The float remained at the site after the EXPORTS ships departed and became the location of our EX-C station. Float positions and discussion were transmitted to/from the ship via WhatsApp, a chat program for smartphones and computer. The ability to communicate with the shore via Internet was a huge help in successfully coordinating with the floats and determining the locations for the other stations. The float surfaced during our time on site, the ship located it, pulling within a ship's length of it, and a 300m chemistry cast was performed as the float sank again. EXPORTS also deployed a BGC-Argo (Biogeochemical-Argo) profiling float. This Argo float surfaced around local noon (17:38 UTC) on 20 September. Two casts, including a 2000m deep chemistry cast, were performed at that location (EX-F1) in the evening on 20 September. Finally, three additional EXPORTS stations were chosen to form a small spatial survey in the region, using recent satellite chlorophyll maps to target high, low, and medium chlorophyll levels. Oxygen, nutrients, pH, $N_2O$, TOC, DOC, CDOM, PIC, POC, Gels, HPLC, chlorophyll, $^{234}$Th, and $O_2$/Ar were collected at all EXPORTS stations. In addition, salinity, and DIC/alkalinity samples were collected at EX-C and EX-F1. Finally, productivity incubation samples and DMS were collected at EX-C along with a large volume pumping cast at 4 depths (5 planned but one pump failed). A deep trace metal cast occurred at EX-C and shallow trace metal casts at EX-C, EX-W, and EX-N.

In addition to the planned work at the EXPORTS stations, two UW/APL Lagrangian floats (Float # 86 and 87) were also deployed at the EX-C site for Eric D'Asaro at 16:47 21 Sept 2018 (UTC). Initial tests of the floats were good, but float 86 then developed a problem with the CPU. After surfacing in the early evening, the Tully located the float and brought the ship alongside. The float was hooked and brought safely aboard to be returned to shore. A big thanks to all involved in the recovery for a well done, professional job.

EXPORTS stations during Line P cruise

| | Latitude at bottom of chemistry cast | Longitude at bottom of chemistry cast | Time on station (UTC) | |
|---|---|---|---|---|
| EX-F1 | 49o 57.50'N | 144o42.34'W | 00:39-03:09 21 Sept 2018 | BGC-Argo float location |
| EX-C | 50o 18.47'N | 144o 22.51'W | 12:07 21 Sept 04:47 22 Sept 2018 | Lagrangian float location |
| EX-W | 50o 22.86'N | 144o 38.60'W | 13:38-15:33 22 Sept 2018 | High chlorophyll spatial survey station |
| EX-N | 50o 36.79'N | 144o 03.98'W | 19:47-21:49 22 Sept 2018 | Low chlorophyll spatial survey station |
| EX-E | 50o 10.69'N | 144o 08.48'W | 01:09-02:39 23 Sept 2018 | Medium chlorophyll spatial survey station |

**Productivity Measurements** – Sile Kafrissen (Varela Lab) and Roberta Hamme (both at University of Victoria)

Measurements designed to measure productivity rates in several ways were conducted at multiple stations. Accurate determinations of productivity rates are important because phytoplankton production forms the base of the food web and because organic matter exported from the surface layer to the deep lowers atmospheric carbon dioxide. Multiple methods exist to measure productivity, and method intercomparison was a secondary goal of this study. Net primary production was measured via carbon uptake, new production via nitrate uptake, recycled production via ammonia and urea uptake, net community production via $O_2$/Ar mass balance, gross primary production (photosynthetic rate) via $^{18}O$ incubations and triple oxygen isotope mass balance, and silica uptake via $^{32}Si$ incubations.

Four different types of 24-hr incubations were performed at P4, P12, P16, P20, and EX-C, with a fifth only at EX-C. Depths were chosen to correspond to light levels of 100%, 55%, 30%, 15%, 1%, and 0.1% based on the PAR profile during a daytime cast from the previous day (often at a different station). Only water from Niskins 17-24 was used for incubations. These Niskins have the internal springs replaced by silicone tubing to lower the potential for trace metal contamination of the water. All Niskins on the Line P rosette now use viton O-rings to lower the potential for toxic substances leaching from rubber. Water was generally collected into 1L polycarbonate bottles and spiked with an isotopic tracer. Added spikes were: 1) $^{32}Si$ as $Si(OH)_4$, 2) combined $^{13}C$ and $^{15}N$ as $NaHCO_3$ and $NaNO_3$, 3) $^{15}N$ as $NH_4^+$, 4) $^{15}N$ as urea ($CH_4N_2O$), and 5) $^{18}O$ as $H_2O$ in glass Winkler type flasks rather than polycarbonate only at EX-C. Samples were placed in an incubator on the helideck with tubes screened to reduce light levels especially in the long (red) wavelengths. Surface seawater was pumped through the incubator to keep temperatures similar to SST. 100% light level samples were not placed in tubes but simply allowed to float in the free spaces at the end of the tubes. After at least 24 hours, the samples were removed from the tubes. Most samples were filtered onto 0.75 µm combusted GFF filters, but $^{18}O$ incubations were sampled into vacuum flasks for analysis of $^{18}O$-$O_2$ similar to the $O_2$/Ar method described below. Filters were frozen, will be dried back in the lab, packed, and subsequently analyzed at the UC Davis Stable Isotope Facility (for $^{13}C$ and $^{15}N$) or with a Riso Ultra-low level beta counter (for $^{32}Si$). Incubations at 55% light levels were performed in 2L bottles with half of the water pre-filtered to remove the <5 µm fraction before filtering onto a 0.75 µm filter, and the rest filtered directly onto the 0.75 µm filter. Triplicate incubations were performed at the 100% light level. Samples for incubation blanks were collected from a Niskin in the mixed layer and spiked just prior to filtering. Dark incubations were also performed on water collected from the mixed layer (at 100% light level when possible) in bottles wrapped in electrical tape. At each light level, triplicate 20 mL samples of urea were taken (from the same niskin as the $^{15}N$ urea incubations) in 50 mL falcon tubes and frozen. Triplicate dissolved silica (dSi) samples were taken at each light level by filtering water through a 0.65 µm polycarbonate (PC) syringe filter into 15mL centrifuge tubes. At each light level, ~1 L of water was filtered directly onto a 0.65 µm PC filter for particulate silica analysis. About 600 mL of water from each light level was collected for total and size fractionated chlorophyll-a analysis. Half of the sample was filtered directly onto a 0.75 µm GFF (not combusted for chlorophyll) and half was filtered onto a 5 µm PC filter before being filtered into a 0.75 µm GFF. For both particulate silica and chlorophyll-a, triplicates were performed at the 100% light level. Additionally, at EX-C, particulate silica was also size fractionated at every light level. Ammonia samples were collected from the same Niskins as the ammonia incubations and analyzed via the Holmes (1999) fluorometric method. Several improvements were made to the method during the cruise, leading to the lowest blanks by Station EX-C.

At all of the productivity incubation stations, samples were collected for the triple stable isotopes of $O_2$ at 5m and at the $O_2$ max (or 10m below the base of the mixed layer). At all of the productivity incubation stations as well as at P26 and the 4 EXPORTS corner stations, $O_2$/Ar and Winkler $O_2$ samples were collected from the same depths (5m and $O_2$ max). Both triple oxygen isotopes and $O_2$/Ar samples were collected through $CO_2$-flushed tubing into previously evacuated glass flasks until approximately half full. The necks of the flasks were cleaned and filled with $CO_2$ trapped inside with a vinyl cap. Back at the lab, the flasks will be weighed, the water equilibrated with the headspace, and removed. Triple oxygen isotopes samples will be sent to University of Washington for analysis in Paul Quay's lab. $O_2$/Ar samples will be analyzed in Hamme's lab at University of Victoria by extraction through a cold trap to remove water vapour and $CO_2$, followed by analysis on an isotope ratio mass spectrometer. Rates are estimated from both of these measurements assuming a steady state mass balance between production and consumption of $O_2$ in the mixed layer and exchange with the atmosphere. $O_2$/Ar samples were additionally collected at 10, 5, and 2m at the NOAA mooring to calibrate mooring sensors, and will be sent to Steve Emerson's lab at University of Washington for analysis.

## **Noble Gas Measurements** – Roberta Hamme (University of Victoria)

A short profile (5 depths between 100 and 2000m) of duplicate samples for analysis of dissolved neon, argon, krypton, and xenon was collected at P26. Noble gases in the ocean are affected by physical processes such as bubble-mediated gas exchange, temperature change, atmospheric pressure changes, or mixing between water masses of different temperatures. They are not affected by biology. Our previous sampling for noble gases has focused on deep depths, > 1000m, which we have used to infer physical processes in the remote locations where those waters were last at the surface. However, recent numerical modeling studies have suggested significant variation in the upper water column in the subarctic North Pacific. The samples collected on this cruise are a pilot study designed to look for such variations that we may target for finer sampling on future cruises.

Samples were collected through $CO_2$-flushed tubing into previously evacuated glass flasks until approximately half full. The necks of the flasks were cleaned and filled with $CO_2$ trapped inside with a vinyl cap. Back at the lab, the flasks will be weighed, the water equilibrated with the headspace, and removed. The gases will be extracted through a cold trap to remove water vapour, exposed to a hot getter alloy to remove all but the noble gases, spiked with a known amount of $^{38}Ar$, and analyzed on an isotope ratio mass spectrometer.

## **Winkler Oxygen measurements** – Roberta Hamme (University of Victoria)

In addition to dissolved oxygen samples collected in support of our productivity rate measurements, Winkler oxygen samples for analysis by UVic were collected for several other purposes. UVic Winkler samples used the IOS draw tube and draw thermometer but were otherwise completely independent, using all different reagents than IOS and a traditional analysis method utilizing a visual endpoint.

To intercalibrate with IOS, samples were collected from every Niskin bottle on the deep chemistry cast at P16 (with duplicates at two depths). Marie Robert sampled the Niskins for both IOS and UVic, while Roberta Hamme pickled the samples for both, and Jade Shiller recorded temperatures.

At P13, the integrity of oxygen samples within closed Niskin bottles was tested by firing 6 Niskins at the oxygen minimum (900m). In particular, I was curious whether the plastic of the Niskin bottles would outgas oxygen into the water if allowed to sit for long periods. The first Niskin was sampled immediately when the rosette arrived on deck and the others remained closed. After a half hour, the second Niskin was opened and sampled. After an hour, the third Niskin was opened and sampled, etc… until the final Niskin was sampled after 2.5 hours on deck. Preliminarily, an increase in oxygen concentration appears to be barely detectable over 2.5 hours but is less than 1 μmol $kg^{-1}$.

Each time that UVic oxygen samples were collected from the surface mixed layer, duplicate samples were also collected from the underway system (the loop) when the rosette was near 5m on the upcast. The IOS draw tube and thermometer were used with UVic reagents for pickling. Preliminarily, differences ranged from the loop being 1 μmol $kg^{-1}$ higher than the 5m Niskin to 1.5 μmol $kg^{-1}$ lower than the 5m Niskin. This range is larger than that observed during a similar underway vs. surface Niskin comparison during the SOGasEx program in 2008 aboard the R/V Ronald H Brown where the differences ranged from 0.3 to -0.4 μmol $kg^{-1}$.

Acknowledgements

Our sincere thanks to the captain and crew of the John P. Tully for a very successful mission. The ship maneuvered very close to the EXPORTS floats when required, and successfully deployed and recovered Eric D'Asaro's floats. Bravo! Our sincere thanks also to Marie, the watch leaders, and other scientists on board. You were patient with our many sampling requests, out-of-order tripping of Niskins, and helpful with early morning sampling. A special thanks to Marie for dealing with the many e-mails occasioned by coordinating with EXPORTS scientists to get the very most out of our sampling possible.

## **Trace Metal Sampling –** Jay T. Cullen (UVic), Robyn Taves (MSc student UVic) and Jasmin Wietzke (IOS)

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**Samples Collected**
Filtered (0.2 micro PALL Supor Opticap) seawater was collected for trace metal and organic ligand analysis. Unfiltered seawater samples were collected for nutrient and salinity analysis.

**Background**
Trace metal samples continue to be collected at the major Line P time series stations in support of ongoing investigations of trace-metal biota interactions and metal biogeochemistry. The sampling supports an ongoing GEOTRACES process cruise project between UBC-UVic and IOS and this particular trip was extended to sample in support of the NASA funded EXPORTS program (http://oceanexports.org/).

**Methods**
Seawater sampling was performed using a trace metal rosette (TMR) system that consists of a 12 position powder coated rosette frame equipped with 12 L, Teflon coated GO-Flo (General Oceanics, Miami, USA) bottles and a SeaBird 911 CTD/SBE 43 Oxygen sensor instrument package. Seawater was filtered in a new HEPA filtered 10ft container modified for this purpose after bottles were removed from the rosette and placed on racks inside the container. Seawater for trace metal analysis was acidified with 12 N HCl to a final pH of ~1.7. Archived samples will be returned to the laboratory for subsequent analysis for dissolved trace metals using offline pre-concentration followed by inductively coupled plasma mass spectrometry (ICP-MS). Samples for dissolved organic ligand analysis will be returned to the lab where ligands will be concentrated from seawater and determined by ESI-ICP-MS.

At P4 12 depths (to 1200 m) were sampled while at P12, P16 and P20 normally 24 depths were sampled to a maximum depth of ~2000 m. Only the upper 300 m was sampled at P26 given an incident where the TMR cable jumped the block and was trapped and damaged in the block cheek. In addition to Line P major stations 3 additional stations were sampled at the EXPORTS site EX-C (Centre), EX-W (West) and EX-N (North) with the TMR. At EX-C two casts were carried out to sample 24 depths down to a depth of 4000 m. At EX-W and EX-N the upper 300 m were sampled at 12 discrete depths.

**Cruise Notes**
As noted above the wire was damaged when it jumped the block during the deep P26 cast. There was approximately 270 m of wire out when the incident occurred. Only the quick thinking and action of the crew prevent loss of the TMR rosette. Their performance in this matter was exemplary. The wired needed to be cut and reterminated. Hugh R. Maclean provided materials and expertise to reterminate the seacable and is thanked for doing so. The captain and crew were consulted about how to improve the performance of the TMR when deployed from the aft A-frame and specifically how to ease recovery and to prevent cable jumping. Cullen will investigate adding weight to the frame and modifying the block before the next trip with the TMR.