



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 June 2016 **TO:** 21 June 2016

SCIENCE CRUISE NUMBER: 2016-06 **SHIP'S PATROL NUMBER:** 16-03

CHIEF SCIENTIST[S]: Marie Robert

SCIENTIFIC PERSONNEL:

| Female | Male |
|-------------------------|-----------------------------|
| Marie Robert (IOS) | Nathan Anderson (NOAA/PMEL) |
| Jade Shiller (UBC) | Michael Arychuk (IOS) |
| Amanda Timmerman (UVic) | Glenn Cooper (IOS) |
| Theresa Venello (UVic) | William Higley (NOAA/PMEL) |
| | Robert Izett (UBC) |
| | Hugh Maclean (IOS) |
| | David Rivera (NOAA/PMEL) |
| | Andrew Ross (IOS) |
| | Bo Yang (UW) |
| | Doug Yelland (IOS) |

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.

CRUISE OBJECTIVE/OBJECTIVES: Repeat hydrography section (physics, chemistry, zooplankton), deploy seven weather data drifting buoy for NOAA/PMEL, five Argo floats for IOS, 5 "sponge-bob drifters" for IOS, deploy the NOAA mooring PA-010, recover NOAA mooring PA-009, service the NOAA subsurface mooring NRS-02.

CRUISE DESCRIPTION: This cruise (2016-06) was partially successful. Most of the Line P work was completed – although some Line P work got cancelled early in the cruise by the Chief Scientist to make sure we'd have enough time to do the mooring work once at Station P – but most of the collaborators' work had to be cancelled. Indeed, the acoustic sounder calibrations were due to be done at the end of the previous cruise (La Perouse) but got shifted to the beginning of the Line P cruise to accommodate ship stores deliveries planned by the Captain. Because of loading delays the calibrations eventually got cancelled. Also the mooring work at Station P (servicing of a subsurface mooring and recovery of the PA-009 surface mooring), as well as the recovery of the WHOI Gliders, got cancelled by the Captain because the wrong work boat (753) was on board instead of the 733 work boat as requested in the cruise plan. Fueling at the end of the cycle shortened the cruise by a full day.

Of the Line P planned work, the deep bongo at P8, the deep Go-Flo at P4, all multinet casts, and the surface Trace Metal sampling at P20 and P26 were all cancelled.

During the cruise we deployed five Argo floats and five “Sponge-Bob” drifters for DFO-IOS, and seven weather drifters for NOAA/PMEL.

DAYS ALLOCATED: 17

DAYS OF OPERATION: 15

DAYS LOST DUE TO WEATHER: A few hours at the beginning of the cruise up to P4 and a few hours just before getting to P26.

SAMPLING:

- All rosette casts were done for the Line P survey. The deep bongo at P8, the deep go-flo at P4, and all multinet casts were cancelled in order to have enough time once at Station P for the mooring work. The surface Trace Metal sampling at P20 and P26 was cancelled due to being unable to deploy the 753.
- Seven weather data drifting buoys were deployed for NOAA/PMEL, five Argo floats were deployed for IOS, and five “Sponge-Bob” drifters were also deployed for IOS. None of the Woods Hole Gliders were recovered again because of the 753.
- The samples collected include:
 - 1) Underway: **DFO-IOS:** Thermosalinograph (Temperature, Salinity, Fluorescence), acoustic sounder, ADCP, pCO₂ (two instruments) – **UBC (Izett):** dissolved nitrogen, oxygen, carbon dioxide, and argon (main lab); surface O₂ and total gas tension (transducer room), chlorophyll a (FRRF), particulate back-scatter and spectrally-resolved absorption spectra
 - 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 – **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 (N₂O), carbon-14 (¹⁴C) uptake experiments; **UBC (Pawlowicz):** samples for density anomaly measurement – **UVic (Timmerman):** ONAr, dissolved oxygen, triple oxygen isotope, dual tracer incubations, NH₄, nutrients, chlorophyll, trace metal, salinity, ¹⁸O, phytoplankton, noble gases – **UVic (Venello):** secondary productivity, zooplankton (for E. Pakhomov, UBC) – **UW (Yang):** dissolved oxygen, ONAr, ¹⁷O.
 - 4) **DFO-IOS and UVic (Yelland, Venello):** Zooplankton using vertical net hauls (Bongos to 250 m and 1200 m).
 - 5) From the X-Niskins and the Trace Metal pump: **DFO-IOS (Ross):** Filtered and unfiltered iron, ligands, salinity, nutrients.

RADIOISOTOPE USE:

C¹⁴ was used. The Rad-Van got loaded on the Tully at the beginning of the La Perouse cruise in order to save time between cruises. During La Perouse the crew needed access to the Rad-Van to set it up for Line P, but discovered that the handle wasn't working (it would not unlock). They had to access it using the double safety doors at the end of the container. A dead-bolt or at least a much better handle is needed. The Rad-Van refrigerator/freezer was broken, so ice had to be made continuously to keep fixed samples as cold as possible; otherwise the rad van was in good working order.

The Rad-Van got decommissioned at the end of the cruise and approved by Michael Arychuk, RSO on board.

PROBLEMS [SCIENTIFIC GEAR AND OPERATIONS]:

- 250 m of Kevlar had to be cut off because of two notches in the line.
- The Trace Metal pump is still not working properly because of the kinks in the tubing. This has been ongoing for at least two years now. The X-Niskins are very finicky and are leaking. The Trace Metal work is relatively time consuming so having equipment in good working order is necessary.
- The Science Security clearance process needs to be streamlined. Up to a few days before the cruise three people still had not received confirmation of their clearance. But by asking the Security office directly in Ottawa we found out that all was in order. Hopefully for the next cruises the Vancouver staff will have been introduced to the process. Thanks to Jill Rooke at IOS and Annette Doucet in Ottawa for their work and help.
- The PAR sensor situated on the helideck that normally provides light data for the incubations didn't work properly. Hopefully the new sensor will be available for the August cruise since more incubations will be done.
- Some troubleshooting had to be performed with the dissolved oxygen kit. Thanks to Kenny for his help.
- While not being "scientific gear": the dock at IOS is in a very dangerous state and many people twisted their ankle while loading and offloading. We're lucky that no one broke a leg or had more serious injuries.

SUCSESSES [SCIENTIFIC]:

- The new fiberglass grating was mounted by the engineers at the beginning of the La Perouse cruise above the sink in the TSG corner of the lab. This grating was to replace the piece of plywood that was mounted there. It was much easier to set-up the instruments on the grating than on the plywood. This is definitely the way to go, or as Robert Izett said in his report: "the grating was great"! ☺
- The new 2000 m-rated PAR sensor allowed us to have PAR data on most of the CTD casts so that we didn't have to do two separate casts (one deep, one shallow with 1000 m-rated sensor) when light data was required.
- We had a brand new CTD cable on the main Hawboldt winch which worked flawlessly.
- *On this cruise we once again had two PCO2 systems on board for comparison. There was excellent agreement between the two systems with respect to atmospheric values but not so good agreement with respect to equilibrator values. To some degree this is not completely surprising because the equilibrators for the systems are different in design and size. Additional work will have to be done in the lab to try and determine what is causing the differences.*
Michael Arychuk

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

- The main Hawboldt CTD winch had to be loaded prior to the cruise. When the winch got loaded from the yard to the forklift it was still plugged in, tearing apart the power cord. A new power cord had to be spliced before we could use the winch.
- No DFO employee could access their DFO email using the Outlook Web App. When we are at sea, we are at work, and therefore need access to our work email. Many thanks to Laura Murray at IOS for trying so hard (unsuccessfully) to give me access to the OWA by resetting passwords and trying different approaches.
- The Captain and Chief Engineer allowed the scientists to use the new TullySE (Senior Engineer) email account so that we could email work while outside of internet range. While this was extremely invaluable – email being essential while at sea for various reasons, with two examples being the deployment of drifters or the malfunction of instruments – it is totally contrary to the DFO IT policy to share a password and an email account. DFO IT should provide DFO scientists with email accounts while on board the *John P Tully* so that personal information can remain private.
- All "Google pages" were blocked off for a day by CCG IT. Since we could not access our work email using the OWA (see above), we had to create new "work" email account to do business. Some of us created Gmail accounts. Those accounts were not available for a while.
- Timing and planning seemed to be an issue on this cruise since some casts got cancelled, the gliders didn't get recovered, neither did the NOAA mooring, yet we had time to be back on Sunday evening, nine full hours before fueling had to start.
- The 753 was on board despite the 733 being requested in the cruise plan. The 753 was not appropriate to do the mooring work nor to recover the gliders.
- Four vessels were in port during our offloading: the Tully, the Ricker, the Vector and the Laurier, causing congestion on the wharf and delaying loading/offloading for all crews. With the ship schedule available in December of the previous year, this kind of situation should be avoidable.

SUCSESSES [SHIP]:

- The two Officers of the Watch did an amazing job of very, very rarely using the bow thrusters. Thanks! ☺
- The Captain and Chief Engineer allowed us to use the Senior Engineer's email account. Despite the problem of "shared information" (see the section above) it was extremely invaluable to be able to communicate with the office while out of internet range. Thanks for the use of this email account.
- Thanks also to the 2nd officer for the "Weather emails", including the Grib file, every morning!

DELAYS [OTHER THAN WEATHER]:

A day for fueling, a half-day for loading.

A half-day waiting for "absolutely perfect" weather conditions at Station P (which didn't materialise according to the Captain).

SAFETY CONCERNS:

The 753 cannot be used in case of an emergency unless the weather is absolutely perfect.

HAZARDOUS OCCURRENCES:

None involving scientific personnel.

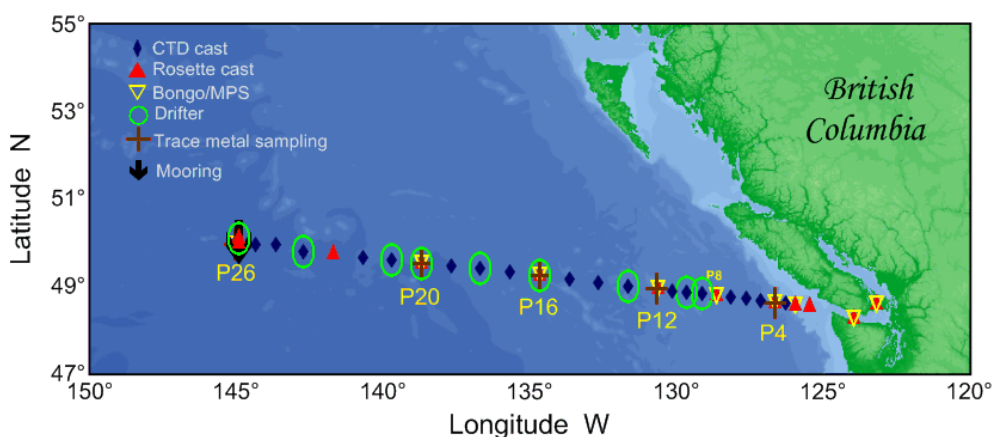
EVENT LOG:

| | |
|--------------------|---|
| Sunday 5 June: | Start loading scientific gear around 0830. Crane needed for loading main CTD Hawboldt winch on boat deck. Safety meeting at 1600. Science meeting at 1800. Leave Pat Bay at 1815. Test cast in Saanich Inlet. Station Haro59. |
| Monday 6 June: | Stations JF2 to P4. Fire and boat drill at 1300. |
| Tuesday 7 June: | Stations P4 to P8. Cancel the deep bongo at P8 due to potential lack of time. |
| Wednesday 8 June: | Stations P9 to P12. |
| Thursday 9 June: | Stations P12 to P16. |
| Friday 10 June: | Stations P16 to P20. |
| Saturday 11 June: | Stations P20 to P21. |
| Sunday 12 June: | Stations P22 to P24. |
| Monday 13 June: | Stations P25, P35, P26 (4 rosette casts). |
| Tuesday 14 June: | Station P26: 6 Go-flo casts, 2 bongos, 1 rosette. |
| Wednesday 15 June: | Deploy surface NOAA mooring, 1 rosette, 2000m go-flo cast. |
| Thursday 16 June: | Cancel surface mooring recovery and subsurface mooring servicing at 0730, start sailing east. |
| Friday 17 June: | Keep sailing east. |
| Saturday 18 June: | Keep sailing east. |
| Sunday 19 June: | Stop at P4 to re-sample. Arrive at IOS at 2000. Offload UBC and UVic overnight. |
| Monday 20 June: | Fuel all morning, offload DFO and NOAA in the afternoon. |

CRUISE TRACK:

Line P cruise, 2016-06

5-19 June 2016



SUMMARY/FINAL COMMENTS:

- Many thanks to everyone at IOS who helped make this cruise a success: Kenny, Nina, Kyle, Moira, Tamara ... your help is always greatly appreciated! Thanks for the extra hand (and backs!) while loading and offloading ...
- Many thanks to Lawrence Kuromi and Gerald Rohatensky for setting up the new Chief Scientist email account on Sunday June 5.
- Thanks to Doug Yelland and the La Perouse program for loading the containers at beginning of La Perouse cruise.
- Thanks to the engineers for setting up the thermosalinograph on the new grating at the beginning of the La Perouse cruise!
- And mainly, thanks to everyone on board for such a successful and enjoyable cruise! Once again the galley crew did an amazing job, and everyone was such a joy to work with. Hoping to see you all again in August 2017!

Marie Robert

- Sincere thanks to Doug Yelland, Hugh Maclean and Glenn Cooper for their expert assistance in deploying the pump and bottles for trace metal sampling. Thanks also to the Red Crew for their help and professionalism throughout, especially when operating the winches and re-positioning the ship under difficult conditions.

Andrew Ross

- We would like to thank all of those who assisted in the collection of these (DIC and alkalinity) samples. Your help was greatly appreciated.

Glenn Cooper

- Thank you to the Captain, officers and crew of the JP Tully. I also want to thank Robert, Theresa, Nathan, Marie, Hugh, Glenn and Bo for their help sampling. I really appreciate everyone who helped carry bottles to and from the incubator. Thank you especially to Marie for her support and accommodating my sampling requests, Doug for his help with the PAR cast, Andrew for his help with the trace metal samples and IOS personnel for analyzing samples. I want to thank Sarah Thornton for loaning me science equipment.

Amanda Timmerman

- 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

- I'd like to thank the crew of the *Tully* for their assistance, excellent work, and upbeat mindset throughout the cruise. Thanks to Kara and the rest of the galley team for their delicious meals. Thanks to the IOS team and the scientists onboard for their help and their humour on deck and in the lab. And finally, a great big thank-you to Marie for flawlessly organizing the entire cruise.

Jade Shiller

- As always, it was a pleasure to be involved in this cruise, and to work with our colleagues from IOS, UVic, and NOAA/PMEL. We greatly appreciate all of the help we received – particularly in accommodating our objectives and instrument setups, the additional efforts to collect Winkler O₂

calibration samples, and in overseeing the process of conducting radioisotope work on the ship. Thank you as well to everyone who helped to collect gas samples.

Thank you to the entire crew of the Tully for their assistance. We also greatly appreciate the extra effort from the Chief Engineer, and the engineering crew who installed the infrastructure to accommodate Miss Piggy in the transducer room, and for their continued help throughout the duration of the cruise, and beyond as we work to optimize our setup.

Finally, we would like to note that from the combined Line P and preceding La Perouse (25 May – 4 June) cruises, we were able to collect a comprehensive dataset with very broad spatial coverage. Due to the nature of the cruises, we also obtained strong temporal coverage. Indeed, through the combined surveying of the LB and LC lines of the La Perouse trip, and the outbound and inbound legs of the Line P trip along the same cruise track, we acquired measurements from the coastal-to-open ocean region off the Southern West Coast of Vancouver Island on three separate occasions in the span of just four weeks. We were also able to re-sample P4 on the return leg for N₂O measurements. All of our underway instruments were running throughout this period. We are grateful for the opportunity to obtain such coverage.

Robert Izett

- We would like to thank the crew of CCGS John P Tully, the scientists from IOS, NOAA buoy deployment team, U Vic Dr. Hamme lab, and all other cruise participants for their help on this cruise.

Bo Yang

- The NOAA mooring was safely deployed on this mission. The Ocean Climate Stations group would like to extend a sincere thank you for the provided ship time, as well as the opportunity to collaborate with the scientists and crew of the TULLY. Our gratitude extends to IOS for their continued partnership, hard work, and cooperation that make this ocean reference station mooring at Station P possible:

TULLY Red Crew – CCCG

Marie Robert – IOS, Chief Scientist

Bo Yang – UW, Post-Doc Researcher and Assistance with bridle sensors and DIC sampling

Doug Yelland – IOS, Watch Leader (day)

Hugh Maclean – IOS, Watch Leader (night)

Nathan Anderson, David Rivera, William Higley

PROJECTS AND RESULTS:

Water masses – Marie Robert, DFO/IOS.

Two interesting features were present in the section plots for this cruise. The first one is what looks like an eddy signature in the temperature and sigma-t profiles at station P20 (Figure 1). Once back at IOS it was possible to confirm that effectively a small eddy was situated on this station (Figure 2). The other interesting feature is a “pool” of fresher water at the surface near station P14, better seen in the salinity anomaly field. It was first believed that maybe the conductivity sensors on the CTD were not functioning properly during that cast but a look at the thermosalinograph data confirmed the presence of this fresh water (Figure 3).

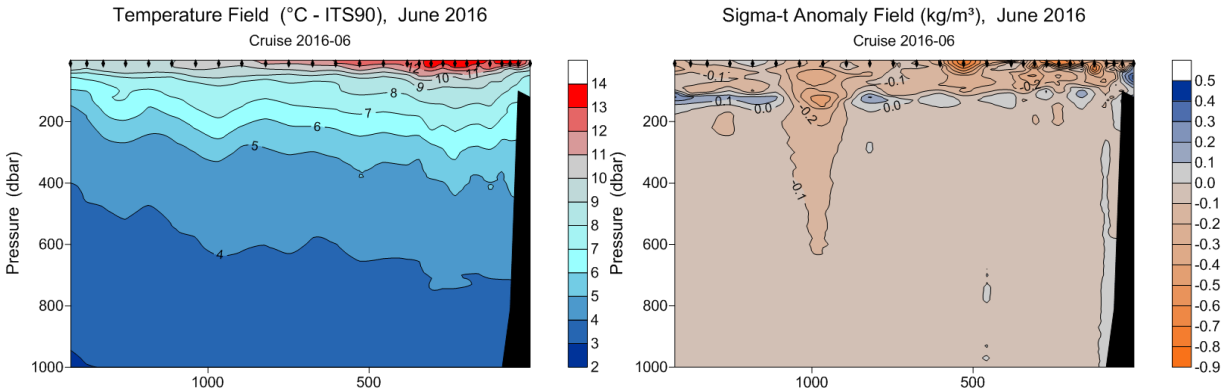


Figure 1: Temperature field (left panel) and Sigma-t anomaly field with respect to the 1956 – 1991 averages (right panel) for June 2016, showing the eddy signature at Station P20.

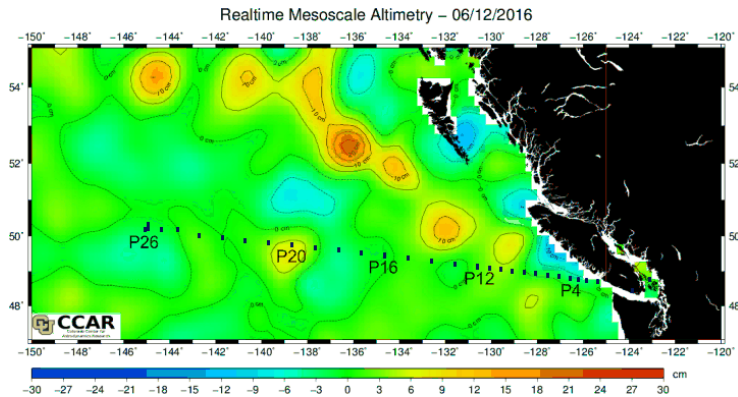


Figure 2: Altimetry on 12 June 2016 showing the small eddy around Station P20. Data from the Colorado Center for Astrodynamic Research.

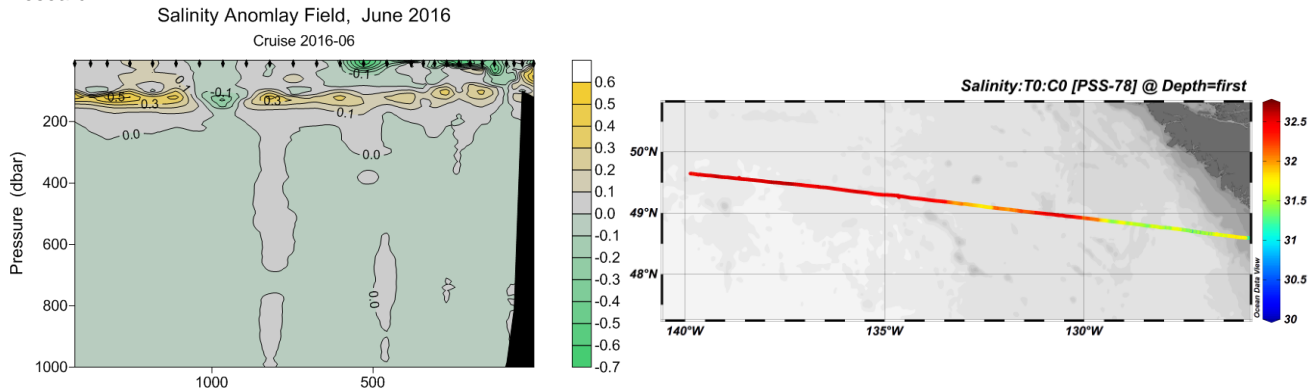


Figure 3: Salinity anomaly field in June 2016 with respect to the 1956-1991 averages (left panel) and surface salinity from the thermosalinograph data.

Trace metal sampling – Andrew Ross, DFO/IOS

Overview: Seawater samples for the determination of dissolved (0.22-µm filtered) and total dissolvable (unfiltered) trace elements were collected at all major stations (P4, P12, P16, P20 and P26) and at 12 discrete depths to a maximum of 800 m. Target depths were 10, 25, 40, 50, 75, 100, 150, 200, 300, 400, 600 and 800 m. Depths were confirmed using an RBR Solo-D and were typically within X% of the target depth.

Sample Collection: Seawater collection was performed using up to four Teflon-lined bottles (one Go-Flo and three X-Niskin) per cast, deployed on a Kevlar line from the ship's starboard chains and tripped with Teflon messengers. On return to the surface the bottles were removed from the line and sampled beside the Class-100 (MAC10) HEPA flow bench in the Wet Lab. Samples for dissolved trace metal analysis were filtered through a 0.22-µm Opticap Durapore cartridge filter (Millipore). All samples were acidified within 24 hours with 1 ml of 6N Seastar Baseline HCl per 250 ml seawater.

Surface sampling at station P4 was initially attempted using an air-driven, double diaphragm all-Teflon pump (ASTI) to move seawater through Teflon-lined tubing deployed from the starboard chains. Seawater flowed through the tubing to the HEPA flow bench in the Wet Lab, where filtered and unfiltered samples were collected from 10, 25 and 35 m. However, kinks in the tubing made sampling difficult and potentially unreliable, despite previous attempts to repair it by splicing with HDPE tubing (inside) and silicon tubing (outside) and joining with vinyl electrical tape. The pump struggled to bring water as far as the Wet Lab flow bench, and it was by no means certain that water was being sampled from the target depth, despite allowing the pump to run for at least 10 minutes before sampling. A partial vacuum was apparent on disconnection from the pump, confirming that the problem lay with the tubing. It was decided not to use the pumping system at the remaining stations but to obtain samples at all depths using the bottles. Bottle-sampling at P4 was deferred until the return leg so as not to contaminate the bottles with the relatively high concentrations of iron found in coastal waters.

The Go-Flo bottle (no. 7) was apparently leaking slightly from the lower ball-valve upon recovery during the first, shallow (50 m) cast at station P12. Only slight dripping was observed from this bottle during subsequent casts until the second (200 m) cast at P20, during which it began leaking badly. Although only slight dripping was observed during the next (800 m) cast it was decided not to use this bottle at stations P26 and P4 but instead to perform a greater number of casts with the three remaining (X-Niskin) bottles.

The smaller (10-l) X-Niskin (no. 6) did not trip during the initial shallow cast at P12 and was redeployed once the other bottles (nos. 7, 10 and 11) had been recovered. The bottle did not trip at the second attempt; however, the third deployment was successful.

Careful manoeuvring of the ship was required at P16 to prevent the line from rubbing against the hull during recovery of the bottles from the final, deep cast (to 800 m). Nevertheless, apparent fraying of the Kevlar line at around the 250 m mark required it to be trimmed back to that point, which still left over 4,000 m of line on the winch.

All casts at station P20 went without incident. However, the smaller X-Niskin bottle (no. 6) again failed to trip at 75 m during the second cast at P26. Once the remaining casts had been completed, one of the larger X-Niskins (no. 11) was successfully deployed at 75 m to complete the profile at P26. Filtered, un-acidified samples were also collected from 10 m and 40 m at P26 for organic ligand analysis. With 24 sampling bottles still remaining, an additional cast was successfully performed at P26 to collect water from 1000, 1500 and 2000 m. The remaining bottles were used to collect samples from 10, 25, 40, 100, 200 and 400 m at station P4, since there was only time for two casts.

Due to inclement weather conditions the Zodiac was not deployed at stations P20 and P26, and so no “true” surface water was collected

Acknowledgements

Sincere thanks to Doug Yelland, Hugh Maclean and Glenn Cooper for their expert assistance in deploying the pump and bottles for trace metal sampling. Thanks also to the Red Crew for their help and professionalism throughout, especially when operating the winches and re-positioning the ship under difficult conditions.

Carbonate studies – Glenn Cooper, DFO/IOS.

1) Seawater pH analysis:

Seawater pH was determined using the spectrophotometric method developed by Clayton and Byrne (Deep Sea Research, 1993). Seawater was collected directly from the rosette niskins into 10cm path length glass cuvettes.

Meta-cresol purple was used as the indicator dye and was validated prior to the cruise at IOS. All work was performed in the temperature control lab on the John P. Tully.

The following major stations were sampled: P1, P2, P4, P12, P16, P20, and P26. One set of triplicate samples were taken at stations P1 and P2, whereas all other casts had two sets of triplicates sampled. Replicates will be used to determine precision for the entire cruise. A calibration cast was performed at P23 where triplicates were taken from 5 Niskins which were closed at all the same depth of 2005m.

After the deployment of the NOAA/PMEL PA-010 mooring at Station papa, a rosette calibration cast occurred in close proximity to the mooring allowing PMEL to compare water samples to their onboard pCO₂ instrumentation. The same samples collected by PMEL were also collected and the pH analyzed allowing for an inter-laboratory comparison.

2) DIC/alkalinity sampling

DIC/alkalinity samples were collected into 500ml glass bottles and preserved with 100ul of saturated HgCl₂ at the following stations: Haro59, JF2, P1, P2, P4, P12, P16, P20, P26. A calibration cast was performed at P23 where triplicates were taken from 5 Niskins, all of which were closed at same depth of 2005m. Stoppers were greased with Apeizon grease and taped closed with electrical tape, placed into a walk-in cooler until unloaded at IOS for onshore analysis. At P26, a complete extra set of samples were collected for archiving.

For the NOAA mooring calibration cast as mentioned above, DIC and alkalinity samples were also collected at the same depth as samples collected by PMEL allowing for an inter-laboratory comparison. IOS collected both 5 and 10 meter samples however PMEL only took 5 meter samples so the 10 meter is redundant.

We would like to thank all of those who assisted in the collection of these samples. Your help was greatly appreciated.

2016-06 Cruise Report - Amanda Timmerman, University of Victoria

Biological productivity is an important process controlling the export of carbon to the deep ocean. There are multiple methods to estimate production and I focused on two techniques: dissolved gas ratios and incubations. Dissolved gas ratios included measurements of oxygen, nitrogen and argon (ONAr) ratios and triple oxygen isotope ratios. Incubations included ¹⁸O and dual ¹³C/¹⁵N additions.

ONAr: Samples were collected in duplicate at two depths within the mixed layer at P4, P12, P16, P20 and P26. ONAr samples collected on this cruise will be analyzed at the University of Victoria to obtain precise measurements of O₂/Ar.

Dissolved oxygen: Duplicate samples were collected at 5 m, 100%, 50%, 30%, 15% and 1% light levels at P4, P12, P16, P20 and P26. Dissolved oxygen samples were analyzed on board using the Winkler titration method with a visual endpoint.

Triple oxygen isotope: Duplicate samples were collected within and below the mixed layer at P4, P12, P16, P20 and P26. The below the mixed layer depth was chosen based on the oxygen profile. Samples will be analyzed for the 16, 17 and 18 oxygen isotopes.

Dual tracer incubations, NH₄, nutrients, chlorophyll: Samples were collected at 5 light depths (100, 55, 30, 10 and 1%) at P4, P12, P16, P20 and P26. Two sets of incubations were done using NaH¹³CO₃ and either ¹⁵NO₃ or ¹⁵NH₄. Each set of samples was done in triplicate at 100% and single samples at all other depths. A blank and dark were collected at 100% light level for each ¹⁵N nutrient. All incubations were incubated for 24 hours under a constant flow of seawater and then filtered. Duplicate NH₄ samples and single nutrient and chlorophyll samples were collected at the 5 light depths as well. To test if the niskins modified with Viton o-rings and silicone tubing closure mechanisms affected production, an additional ¹³C/¹⁵NO₃ incubation was collected from a non-modified niskin for comparison.

Trace metal: Trace metal samples were collected in duplicate at 10 m from niskin 15 (unmodified) and niskin 24 (modified) at P26.

Salinity: Samples were collected below the mixed layer, within the oxygen maximum and at 50%, 30%, 15% and 1% light levels at P4, P12, P16, P20 and P26.

¹⁸O incubations: Triplicate samples were collected at 5 light depths (100, 55, 30, 10 and 1%) at P4, P12, P16, P20 and P26. Samples were spiked with ¹⁸O labeled water and incubated for 24 hours under a constant flow of seawater. After 24 hours, the samples were collected into flasks and will be analyzed at the University of Victoria.

Phytoplankton: Samples were collected at a single depth in the surface water at P12, P16 and P20. The following preservatives were used: lugol, formalin and glut.

Noble gases: Duplicate samples were collected at 3000, 2500, 2000, 1500 and 1000 m at P26.

Acknowledgements: Thank you to the Captain, officers and crew of the JP Tully. I also want to thank Robert, Theresa, Nathan, Marie, Hugh, Glenn and Bo for their help sampling. I really appreciate everyone who helped carry bottles to and from the incubator. Thank you especially to Marie for her support and accommodating my sampling requests, Doug for his help with the PAR cast, Andrew for his help with the trace metal samples and IOS personnel for analyzing samples. I want to thank Sarah Thornton for loaning me science equipment.

Line P - June 2016 – Theresa Venello, UVic.

Objectives: Quantifying secondary (crustacean zooplankton) production along Line P using the chitobiase-method. Comparing loop sample production from the *Tully's* seawater system and 5 m rosette bottle production.

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. Loop seawater samples (500 mL) were also taken at each of these stations.

In addition, loop seawater samples were taken at P6, P10, P14, P19, P22, P24 to increase the spatial resolution of our production estimates.

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 for 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.

Line P – June 2016 – 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)

- 1) 2 l seawater samples (at 16 depths) for high-resolution (HR) bacterial DNA sequencing were filtered.
- 2) 50 ml seawater samples were taken per depth to count the number of cells per milliliter using flow cytometry and single cell DNA analysis. Samples were aliquoted and preserved using glutaraldehyde and glycerol+TE, 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 of 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.
- 4) 50 ml seawater samples were taken per depth to count the number of cells per milliliter using flow cytometry and single cell DNA analysis. Samples were aliquoted and preserved using glutaraldehyde and glycerol+trisEDTA, respectively.

Comments:

All my lab objectives for this cruise were successfully fulfilled. The work area distribution was convenient for my sampling needs.

I'd like to thank the crew of the *Tully* for their assistance, excellent work, and upbeat mindset throughout the cruise. Thanks to Kara and the rest of the galley team for their delicious meals. Thanks to the IOS team and the scientists onboard for their help and their humour on deck and in the lab. And finally, a great big thank-you to Marie for flawlessly organizing the entire cruise.

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

Objectives:

Our participation in this cruise was focused on quantifying the distribution of biogenic gases and optical properties in surface and subsurface waters along the Line P transect. We deployed a number of automated instruments for real-time analysis, and collected discrete depth profile and surface samples for subsequent laboratory analysis. A key aim of these efforts was to quantify net community production at high spatiotemporal resolution along the Line P transect. We additionally conducted carbon-14 (^{14}C) uptake experiments to evaluate gross primary productivity at the major stations. The cruise provided an opportunity to test and troubleshoot new instruments setups and methods as well.

Gas Measurements and Quantification of Net Community Production:

At the major stations (P4, P8, P12, P16, P20, and P26) we collected discrete profile samples for analysis of methane and nitrous oxide (N_2O), contributing to an almost-ten year time-series of these gases along the Line P transect. Additional surface samples were collected for N_2O analysis at approximately 40-mile intervals. As N_2O is a proxy for upward transport, these measurements will be used to estimate vertical water column mixing to the surface.

We deployed a membrane inlet mass spectrometer (MIMS) in the main laboratory for underway measurement of mixed layer gas concentrations of dissolved nitrogen, oxygen, carbon dioxide, and argon. Of particular interest was the ratio of O_2/Ar , which enables quantification of surface ocean net community production. The discrete N_2O profiles and surface samples will be used to correct underway O_2 and NCP measurements for the upward advection of low- O_2 water.

After the February trip, we conducted a comprehensive testing of the MIMS system in the laboratory at UBC, ultimately upgrading and purchasing new hardware and software for the instrumentation. After overcoming software issues early in the cruise, the MIMS setup ran smoothly, and without problems for the remainder of the trip. Data quality appears to be good.

Continuous measurements of surface O_2 and total gas tension were made with an oxygen optode and gas tension device (GTD), respectively. Since the February trip, we have engineered a flow-through pressure case for the housing of these instruments in the ship's transducer space (dubbed "Miss Piggy", consisting of a watertight PVC tube for containment of the instruments, a SBE pump for circulation of water past the sensors, and an external flow meter, all branched from the main seawater line; Fig. 1). With the exception of a one-time rupture of the intake line to the casing (which actually occurred during the preceding La Perouse cruise when the inflow hosing slid off the bulk-head hose barb fitting), we consider it a large success that Miss Piggy remained both watertight and maintained a consistent flow rate. We did, however, encounter problems with the data quality near the end of the transect, which we suspect was related to a failure of the SBE pump, and termination of flow through the sensors. An alternative to the SBE pump, and an internal flow meter will be investigated for future setup. We are currently engaging with the ship's Chief Engineer and engineering crew to optimize this setup.

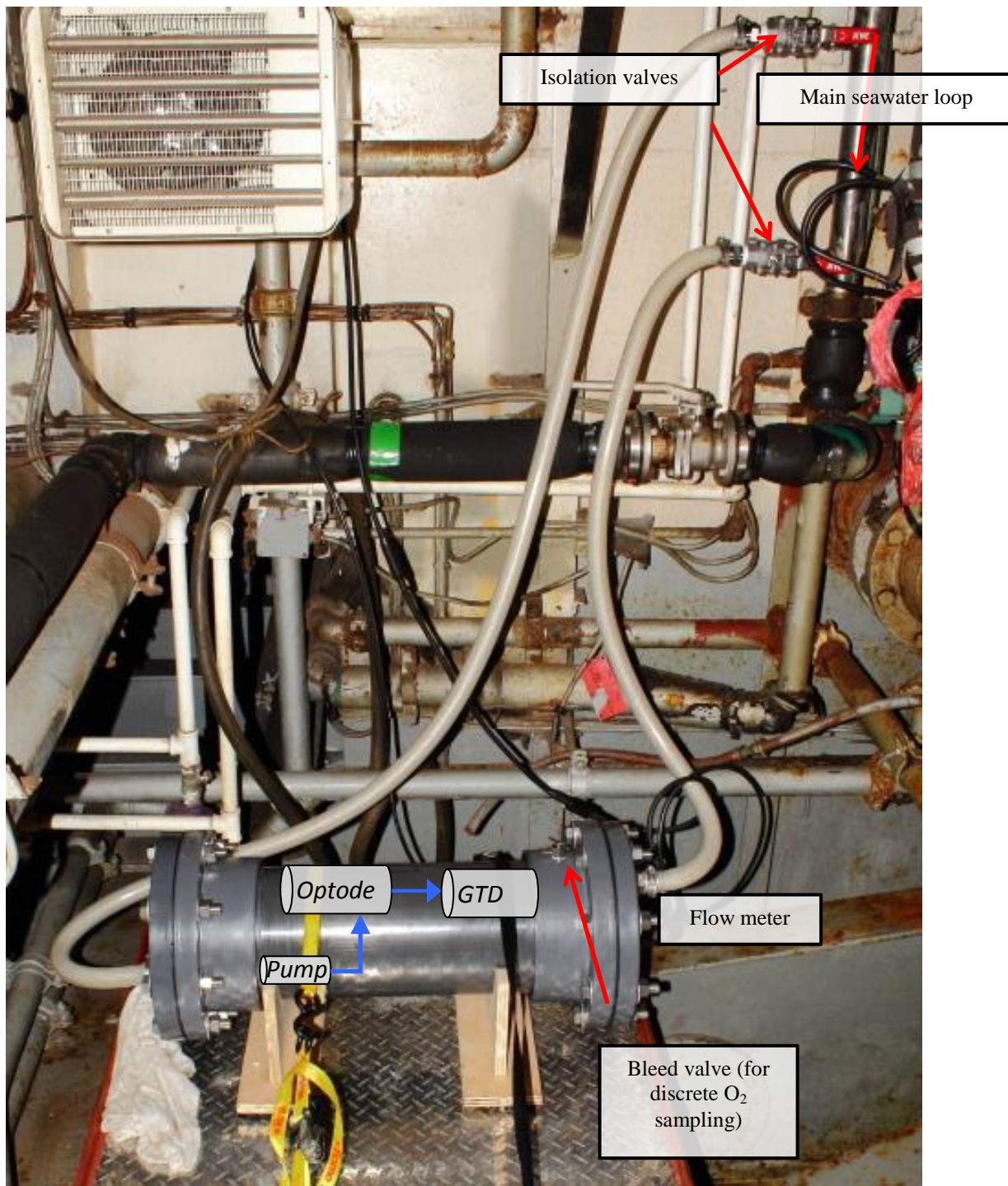


Figure 1. The setup of the GTD-optode system (“Miss Piggy”) in the ship’s transducer space.

As during the previous February trip, we collected discrete samples from the seawater loop in the transducer space and main lab for measurement of O_2 by Winkler titrations. The purpose of this was two-fold: 1) for comparison/calibration of the optode, and 2) for examination of the potential offsets in O_2 concentrations in the ship’s seawater supply lines, relative to Niskin observations. As shown in the figure (Fig. 2), there is an offset in the O_2 concentrations measured in the underway lines as compared to the Niskin bottles. In all cases, the sampling loop samples have higher concentrations of O_2 than the Niskin bottles, suggesting entrainment and dissolution of air/bubbles into the water. This offset is observed both in the transducer space, and in the lab.

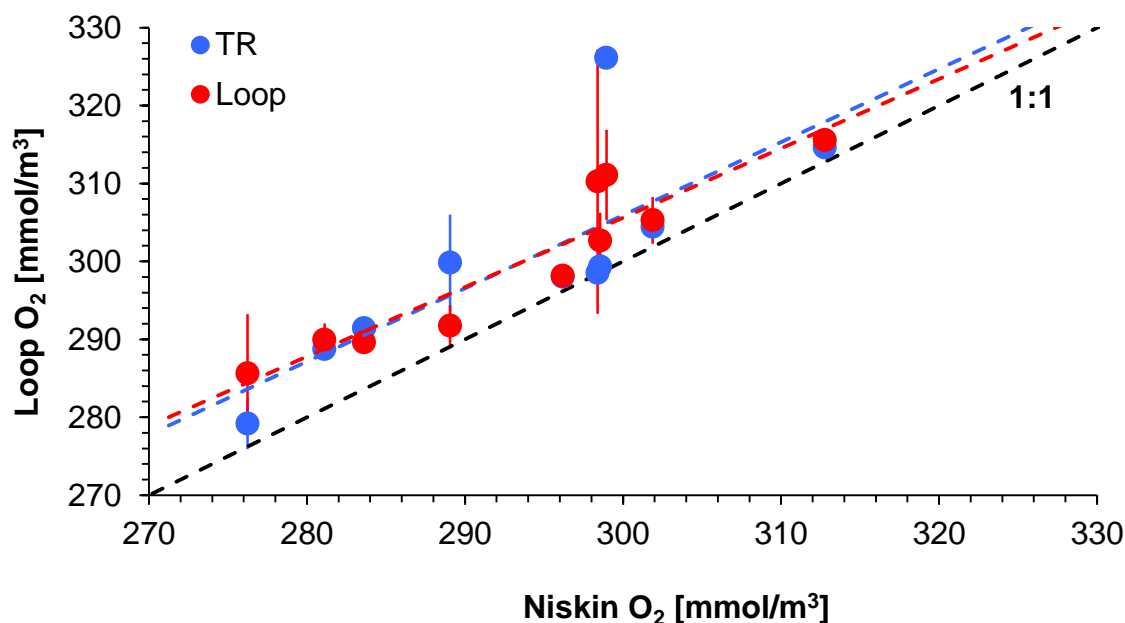


Figure 2. Comparison of Niskin and loop oxygen samples. The offset in the seawater loop samples is clearly shown. TR refers to the transducer room, where the Optode/GTD is contained.

Optical Instrumentation:

We continued our measurement of optical properties from the seawater loop, including particulate back-scatter and spectrally-resolved absorption spectra. These measurements will be used to derive an algorithm for predicting particulate carbon concentrations and the relative abundance of different pigment classes (which can be used to indicate phytoplankton taxonomic abundances) in surface waters. The sensors were newly purchased, so this cruise provided an opportunity to test the instruments and the software we have developed to visualize the real-time data. Overall, the setup worked very well, and the instruments appear to have produced good data. The installation of the grating above the sink in the main lab worked perfectly for mounting the instruments (in fact, you could say the grating was great!); we appreciate all support to accommodate our space and setup requirements.

Finally, we used a Fast Repetition Rate Fluorometer (FRRF) to continuously measure active chlorophyll *a* fluorescence along the ship's track. These data can be used to infer rates of photosynthetic electron transport around Photosystem II (as a proxy for gross primary productivity), and they also provide information on a number of phytoplankton photo-physiological properties. Data quality appears to be good from this sensor.

¹⁴C Experiments:

We conducted ¹⁴C uptake experiments for quantification of gross primary productivity at the major stations (P4, P12, P16, P20, and P26). These data will be compared with measurements of primary productivity made by Amanda Timmerman using ¹³C, and with measurements of secondary production made by Theresa Venello. The rad van refrigerator/freezer was broken, so ice had to be made continuously to keep fixed samples as cold as possible; otherwise the rad van was in good working order.

Comments:

As always, it was a pleasure to be involved in this cruise, and to work with our colleagues from IOS, UVic, and NOAA/PMEL. We greatly appreciate all of the help we received – particularly in accommodating our objectives and instrument setups, the additional efforts to collect Winkler O₂ calibration samples, and in overseeing the process of conducting radioisotope work on the ship. Thank you as well to everyone who helped to collect gas samples.

Thank you to the entire crew of the Tully for their assistance. We also greatly appreciate the extra effort from the Chief Engineer, and the engineering crew who installed the infrastructure to accommodate Miss Piggy in the transducer room, and for their continued help throughout the duration of the cruise, and beyond as we work to optimize our setup.

Finally, we would like to note that from the combined Line P and preceding La Perouse (25 May – 4 June) cruises, we were able to collect a comprehensive dataset with very broad spatial coverage. Due to the nature of the cruises, we also obtained strong temporal coverage. Indeed, through the combined surveying of the LB and LC lines of the La Perouse trip, and the outbound and inbound legs of the Line P trip along the same cruise

track, we acquired measurements from the coastal-to-open ocean region off the Southern West Coast of Vancouver Island on three separate occasions in the span of just four weeks. We were also able to re-sample P4 on the return leg for N₂O measurements. All of our underway instruments were running throughout this period. We are grateful for the opportunity to obtain such coverage.

Cruise Report – Bo Yang, University of Washington.

Export of organic carbon from the surface ocean to depth (the biological pump) helps maintain the $p\text{CO}_2$ of the atmosphere and the O₂ content of the oxygen minimum zones of the ocean. In the upper ocean, at steady state over a seasonal cycle the net organic carbon export is equal to the Annual Net Community Production (ANCP). As a post-doc in Dr. Steven Emerson's lab at University of Washington, I am working on ANCP estimates based on oxygen measurements on Argo profiling floats and upper water column oxygen mass balance model.

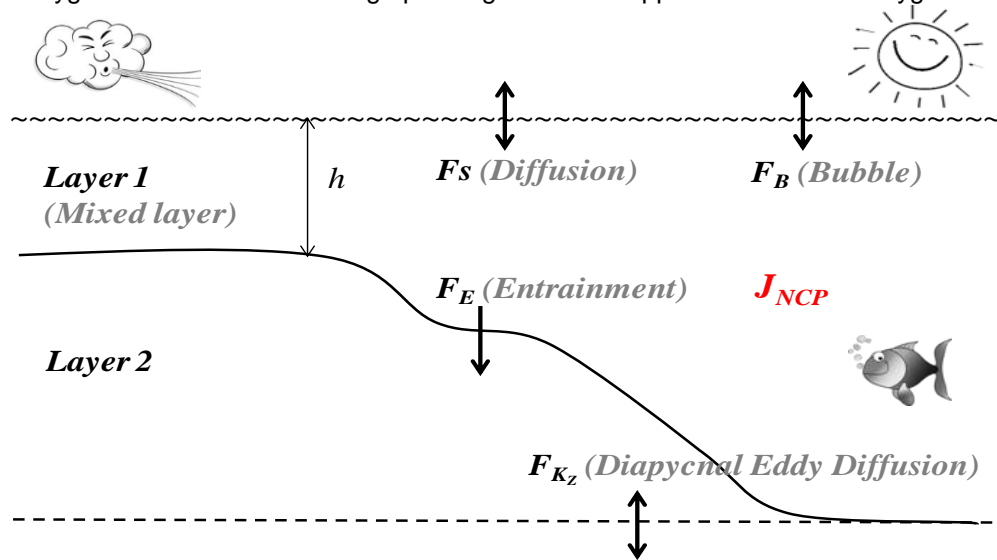


Figure 1 Upper water column oxygen mass balance model

Figure 1 demonstrates the concept of upper water column oxygen mass balance model, which can be described using the following equation.

$$\frac{dh[\text{O}_2]}{dt} = F_S + F_B + F_E + F_{K_z} + J_{NCP}$$

$dh[\text{O}_2]/dt$ is the oxygen concentration change in the upper water column over time, which can be measured using the oxygen measurements on Argo floats. F_S and F_B are fluxes due to air-sea gas diffusion and bubble injection, respectively. F_E is flux from entraining waters from blow mixed layer when mixed layer deepens. F_{K_z} is the diapycnal eddy diffusion flux from below the upper water column. For each time step, oxygen flux due to biological production (J_{NCP}) can be calculated by subtracting all non-biological fluxes listed above from $dh[\text{O}_2]/dt$. Then ANCP can be obtained by stepping forward J_{NCP} for a year.

Evaluating the role of bubble injection flux (F_b) in winter is critical to an accurate determination of ANCP. Algorithms relating F_b to directly measureable physical properties (i.e. wind speed, temperature) are developed by measurements of biologically inert gases like nitrogen (N₂) and argon (Ar).

On this cruise, we deployed a sensor package with a gas tension device (GTD) for N₂ measurement on the PMEL buoy at Station Papa. The annual N₂ measurements can help us to develop a more accurate algorithm for F_b and eventually improve the accuracy of ANCP estimate. Discrete water samples for dissolved oxygen (DO), ONAr (O₂, N₂, Ar), and ¹⁷O measurements were also collected at Station Papa for calibration purpose. Unfortunately the recovery of the old PMEL buoy was cancelled. We were not able to find out what happened to our sensor package on that buoy, which stopped transmitting data several months ago. We are not sure if there are some issues with the sensor itself, or it just stopped communicating with the PMEL buoy. In the latter case, all data should still be stored in the sensor and can be retrieved once the buoy is recovered. Furthermore, if the sensor on the old buoy is still working, the comparison between data from sensors on the new/old buoys may provide interesting insights of air-sea exchanges at Station Papa.

We would like to thank the crew of CCGS John P Tully, the scientists from IOS, NOAA buoy deployment team, U Vic Dr. Hamme lab, and all other cruise participants for their help on this cruise.

OCS Cruise Report Writeup: Papa Buoy Operations

NOAA Mooring Ops: William Higley, David Rivera, and Nathan Anderson

DEPLOYMENT:

Deployment of the PA010 mooring began at 19:41 UTC on June 15, 2016. Facing into the prevailing wind, the Tully began approximately 4.5NM from the anchor drop site. The buoy was deployed over the stern through the A-frame, via a block attached to the primary crane on deck. Tag lines were run to the sides of the A-frame, with an initial tag line on the bridle. Subsurface instruments were pre-attached to the top 60m of nilspin flaked out on deck. After the buoy was in the water, the prepared line was allowed to payout by hand. The 60 – 325m nilspin was routed around the capstan and 2 blocks for control, with these deeper instruments attached outboard of the block.

Once the nilspin was fully deployed at ~0.5 kts, the nylon was run through the capstan as the ship steamed toward the anchor drop location at 1-2 kts. The mooring was towed for about an hour, and a Sea Catch quick release was used to release the anchor off the stern at 00:21 UTC, for a total deployment length of 4:40. The anchor was dropped at 50° 03.251'N, 144° 53.313'W. After settling and just before the fly-by, the buoy position was reported as 50° 02.750'N, 144° 52.360'W. At fly-by, all systems and sensors were returning data. PMEL also reported a fully functional deployment in the subsequent hours.

RECOVERY:

PA009 was not recovered on this trip due to a combination of factors including weather. Recovery efforts will be coordinated with partner organizations in order to turn over the buoy for PA011.

ACKNOWLEDGEMENTS:

The NOAA mooring was safely deployed on this mission. The Ocean Climate Stations group would like to extend a sincere thank you for the provided ship time, as well as the opportunity to collaborate with the scientists and crew of the TULLY. Our gratitude extends to IOS for their continued partnership, hard work, and cooperation that make this ocean reference station mooring at Station P possible.

TULLY Red Crew – CCCG

Marie Robert – IOS, Chief Scientist

Bo Yang – UW, Post-Doc Researcher and Assistance with bridle sensors and DIC sampling

Doug Yelland – IOS, Watch Leader (day)

Hugh Maclean – IOS, Watch Leader (night)

