

Report of the Ninth Annual Line P Workshop, Fisheries and Oceans Canada, Mary Winspear Centre, Sidney, BC, March 9 & 10 2016

Chaired by **Marie Robert**, Line P program manager, Institute of Ocean Sciences, Fisheries and Oceans Canada (IOS/DFO).

Introduction

Fifty ocean scientists and technicians met in March 2016 to share recent observations along Line P, as well as to present their current research interests and proposed future sampling plans. “Line P” is a 1400-km-long set of ocean stations off Canada’s West Coast, monitored for almost 60 years by weatherships and research vessels. It began with sampling from weatherships during their transits to and from Ocean Station Papa (OSP) at 50N, 145W, from the 1950s until 1981. Fisheries and Oceans Canada has financed ship time and core scientific programs since 1981. With more international and academic partners joining the program, leading to more diverse studies, it became useful to meet annually to compare insights and plan future sampling programs. At the 1st workshop in February 2008 scientists met to discuss future experiments and techniques. The 2nd workshop in March 2009 focused more on scientific results, as well as on promoting collaborations and optimizing ship time and space. Since then the workshop has been very beneficial every year in allowing scientists to share their observations of conditions along Line P as well as in introducing new partners into the Program. This year the workshop was held over two days at the Mary Winspear Centre in Sidney, thanks to our sponsor **Ocean Networks Canada**, who provided the room rental and the catering. About two thirds of the participants showed up for both days, whereas the others were present for either the first or the second day only.

Marie Robert (DFO/IOS): *Overview of the Line P Program.*

Since quite a few new Line P Program or workshop participants were present this year, the full version of the “overview of the Line P Program” talk was presented, detailing the work that DFO employees perform on Line P cruises and giving important details for those who sail on Line P cruises. The main points of interest were:

- Requests for security clearance and radioisotope use have to be started preferably three months prior to a cruise. Please contact **Marie Robert** if you want to participate in a cruise. Do NOT contact the DFO security clearance officer directly. Regarding radioisotope use please contact **Michael Arychuk** (Michael.Arychuk@dfo-mpo.gc.ca) or **Kyle Simpson** (Kyle.Simpson@dfo-mpo.gc.ca), keeping Marie Robert in the loop so that the Rad-Van can be booked and loaded on the Tully.
- Try not to send untrained people on a cruise on their own. But if you have to, at least give them as much information about the cruise as possible. Tell them about the cruise report expected of them, and let them know that demands like “dry ice” need to be addressed well before the end of the cruise.
- A reminder was given to the supervisors that new students or technicians need to be informed on how to behave at sea (please see attached Appendix 1).

- If you are going to be a regular Line P participant, please invest in your own raingear.
- Respect the deadlines for the cruises and mainly for the workshop. Every year it's a problem.
- To obtain Line P data please go to the Website <https://www.waterproperties.ca/linep>, or contact me at Marie.Robert@dfo-mpo.gc.ca. The DFO Website is presently not being updated.
- Only 16 berths are available at the moment for science on the Tully because of the addition of a Supplies Officer to the crew. Modifications will be done to the cabins to accommodate more people in the future but the timing of these changes is unknown for now.
- There is now a Wifi on the Tully which allows people to access "Internet at sea". Internet access is usually available along Line P until around P18 or so. There are rumours that the "tully-sciencelab" and "tully-chiefscientist" email accounts will no longer be available after June 2016. If this happens, we will not have any means of communicating with 'land' once we lose internet access, except for Coast Guard's very expensive satellite phone.
- The Tully will be undergoing a "VLE" – Vessel Life Extension – from November 2017 to May 2018. These dates may vary (many changes in dates have already been announced, these are the latest at the time of the workshop). It is fairly certain though that the February 2018 and the June 2018 Line P cruises will not happen on the Tully. Coast Guard is presently looking for a vessel to replace the Tully while she's out of service, but no final choice has been made yet.
- The 2016-2017 Line P cruises will be as follow:
 - 2016-06 will go from 5 June to 21 June 2016.
 - 2016-08 will go from 16 August to 1 September 2016.
 - 2017-01 will go from 5 to 23 February 2017 → 18 days instead of 14!
 Please note that from now on the cruise numbers will be -01 for the February cruise, -06 for the June cruise and -08 for the August cruise.

Finally two slides were presented with berths reservations for the next two fiscal years, up to February 2018. These slides are included in Appendix 2. Please confirm your berths bookings, or let me know as soon as possible if you would like to have your name on the waiting list.

Tetjana Ross (DFO/IOS): *Line/Station P 60th anniversary plans*

I will present our current thinking of plans for an event to celebrate the 60th anniversary of Line/Station P. I will solicit input on the best time to hold the event and the best way to structure it to maximize participation of Line/Station P participants both past and future.

Amanda Timmerman (UVic): *Improving the Niskins for phytoplankton sampling*

Biological sampling assumes the measured parameter reflects the in situ environment. However, contamination by trace metals and toxins can cause this assumption to be wrong. Most of the Niskin closure mechanisms are made of coated metal springs, which could contaminate the sample water with trace metals. Black rubber is used for some of the Niskin closure mechanisms and all Niskin O-rings, but the material has been proven to be toxic. Chavez and Barber (1987) show severe primary production inhibition from samples collected using Niskins compared to

buckets and GO-FLO. Further, Marin et al. (1993) found an increased Zn concentration from samples collected using Niskins compared to other methods, resulting in about 25% decrease in primary production. It is believed that the Zn poisoning is due to the manufacturing process of the rubber.

We propose to improve the Niskins used on Line P cruises by removing sources of trace metals and toxic rubber. This would be accomplished by replacing all the spring and rubber tubing closing mechanisms with silicone (from McMaster Carr part number 5236K89 or 3184K6). Both tubing options are similar however the first option cannot be acid washed while the second one can. We would also like to replace all rubber O-rings with silicone (from Mykin Inc with silicone 70 material and part numbers AS568-336, AS568-012, AS568-312 for the end cap, spigot and vent, respectively). A test run was conducted on the February 2016 Line P cruise where the O-rings and springs were replaced on bottles 17-24 using the non-acid washable tubing. Out of the eight Niskins, two Niskins were slightly leaky. To prevent this, the tubing will be shortened by an inch or two instead of having 35 inches of tubing.

Chavez, F. P., & Barber, R. T. (1987). An estimate of new production in the equatorial Pacific. *Deep Sea Research Part A. Oceanographic Research Papers*, 34(7), 1229-1243.

Martin, J. H., Fitzwater, S. E., Gordon, R. M., Hunter, C. N., & Tanner, S. J. (1993). Iron, primary production and carbon-nitrogen flux studies during the JGOFS North Atlantic Bloom Experiment. *Deep Sea Research Part II: Topical Studies in Oceanography*, 40(1), 115-134.

Meghan Cronin (NOAA/PMEL): Station Papa NOAA & UW/APL Mooring Activities.

As of 2015, there are now 6 moorings deployed in the Station Papa area: the NOAA surface mooring, the UW/APL waverider mooring, the NOAA Noise Reference Station (NRS), and the 3 NSF OOI moorings. In general we want to deploy the NOAA surface mooring first before recovering the old mooring. Thus during mooring operations there is a 7th mooring also deployed. In order to have safe operations, we need to have a 5.5 km avoidance circle radius. No moorings should be deployed in the avoidance circle ! For scientific reasons, we want the alternating year NOAA surface moorings and NSF OOI profiling mooring to be as close as is safe. These therefore have overlapping avoidance circles. Please be mindful of this during all mooring operations. The NOAA surface mooring watch circle radius is 1.25 km. Please do not take any CTD casts within the watch circle. The NOAA Ocean Climate Stations group respectfully requests shiptime aboard the June 2016 Line P cruise to turn around the NOAA surface mooring. Dave Rivera and Bill Higley from PMEL can participate on this cruise. In summer 2017, the NOAA surface mooring, UW/APL waverider mooring and NOAA NRS subsurface mooring will all need shiptime. We are all pursuing many options. During the past year, the NOAA OCS website has been updated to better serve the mooring data and its metadata. Please visit: www.pmel.noaa.gov/OCS/. Two key papers have been published: Cronin et al. (JGR 2015) and Fassbender et al. (GBC 2016). Please notify Meghan.F.Cronin@noaa.gov if you have published a paper using NOAA surface mooring data. We are keeping a publication list on the OCS website. **Meghan** is also organizing a possible special collection of AGU papers. The proposed title of this is “Record NE Pacific Anomalies: Forcing and Impacts”. Let her know your thoughts about this.

Noel Pelland (UW): *Insights into Physical and Biogeochemical Processes from Seaglider Surveys at Station Papa, 2008-2010.*

University of Washington Seaglider autonomous underwater vehicles surveyed near the NOAA Ocean Climate Stations surface fluxes mooring and moored ADCP at Station Papa (OSP) from 8 June 2008 to 21 January 2010. Seagliders, which profiled from the surface to 1000 m within a 50x50 km box surrounding the mooring, provided increased resolution of the three-dimensional temperature, salinity, and dissolved oxygen field with persistence over more than one annual cycle. The goals of these surveys were to estimate local-scale horizontal gradients and horizontal advection, and if possible, use this information to estimate vertical advection and diffusion in order to describe the evolution of heat, freshwater and dissolved oxygen in the upper ocean. Consistency between geostrophic currents estimated by Seagliders, the moored ADCP, and satellite sampling indicates that surveys can adequately resolve the mesoscale flow at a monthly time scale. Seaglider surveys took place during a period of anomalous circulation at OSP -- combining Seaglider data with Argo, satellite, and *Tully* sampling shows that this was likely due to an anticyclonic meander in the North Pacific Current moving across the mooring site. This meander appeared to bring to OSP water from the southeast, which was warm, saline, but oxygen-rich in the main pycnocline relative to that in the Gulf of Alaska. At monthly time scales, large imbalances were present between estimated surface fluxes of heat and freshwater, and the storage of these quantities in the upper 200 m, implying removal or addition by horizontal or vertical advection. An inverse problem constructed from the heat and salt budgets estimates a net upwelling of cool, saline water and horizontal import of fresh water over the duration of the surveys. Vertical diffusivities determined from the inverse problem approach $10^{-3} \text{m}^2 \text{s}^{-1}$ within the weakly stratified surface layer, and diminish rapidly with depth. The balance of dissolved oxygen in the upper 200 m was found to have character similar to the temperature balance shallower than the main pycnocline (~120 m), and the salinity balance deeper. Steady oxygen decline with time during summer and fall in the region deeper than the surface layer and shallower than the permanent pycnocline suggests net biological respiration there. Using results from the inverse problem, respiration was isolated from the effects of advection and diffusion of oxygen, giving a net vertically-integrated apparent oxygen utilization in this zone of $\sim 1.2 \text{ mol O}_2 \text{ m}^{-2} \text{ yr}^{-1}$ ($0.8 \text{ mol C m}^{-2} \text{ yr}^{-1}$). This rate implies that 30-50% of the organic carbon that is vertically exported from the surface ocean euphotic zone during each growing season is respired before it can reach the deep ocean. Overall, these results demonstrate the feasibility of autonomous vehicle surveys of this type to capably resolve monthly and seasonal features of upper-ocean tracer balances in this climatically and ecologically important region of the northeast Pacific Ocean.

Jim Bishop (UofC - Berkeley): *Carbon Flux Explorer observations of carbon export near P16 June 2013.*

In June 2013, we deployed twin Carbon Flux Explorer (CFE) floats for 9 days at P16 to observe using an imaging system, the flux systematics of particulate organic and inorganic carbon (POC and PIC) at hourly frequency at 150, 370, and 600 m depths. Images taken under transmitted, transmitted-cross-polarized, and dark field illumination are processed to yield particle attenuation – a proxy for POC, cross-polarized photon yield – a proxy for PIC, and dark field counts. We provide a brief overview of Carbon Flux Explorer and highlights of its observations in California coastal waters during 2012/2013 (Biogeosciences, doi:10.5194/bg-2016-62). At P16, as in

California waters, we found that vertical flux is dominated by >mm sized aggregates; however, the structure of these particles is completely different. In California Coastal waters, many of the aggregates appeared to be abandoned appendicularian houses, at P16, many of the aggregates were loose aggregations of *Rhizosolenia* frustules. We were surprised to find abundant ~50-100 μm sized juvenile *Cleodora* pteropods arriving in the CFE at 150 m over a several day period; cyprid barnacle larvae were also frequently seen. Animations of imagery will be presented along with optical estimates for POC flux.

Future plans for Line P work. This year, specially modified CFEs are being constructed to obtain samples to enable the calibration of our imagery (we found that surface tethered sediment traps significantly under sample large aggregates). These CFE-Cal systems will be deployed in August 2016 in the California Current, and we hope to resume our efforts with CFEs and in-water optics along Line P in 2017.

Hannah Bourne (UofC - Berkeley): *Controls on particulate Cd/P along Line P.*

Stéphane Gauthier (DFO/IOS): *Multi-frequency acoustic data time series on the Line P survey: an untapped resource.*

In this presentation I will highlight the acoustic data that has been collected as part of the line-P surveys over the years. I will demonstrate some of the information that could be extracted and exploited from these high-resolution data and discuss potential links with oceanographic and environmental features. The purpose of this talk is to provide background information to initiate discussions and encourage exchange of ideas among potential collaborators.

Jennifer Long (UVic): *Diatom productivity and silicon cycling in the subarctic northeast Pacific.*

Diatoms are a group of phytoplankton which account for a significant proportion of global marine primary productivity. They require silicon (Si) to build their biogenic silica frustules, and dominate the cycling of Si in marine surface waters. Consequently, biogenic silica concentrations and production rates are useful as indicators of diatom biomass and production. Here we present an overview of samples collected since 2006 by the laboratory of Dr. Diana Varela to investigate phytoplankton and biogenic silica dynamics in the northeast subarctic Pacific and nearby coastal regions. In 2012, the contribution of different diatom taxa to community silica production was determined using PDMPO, a fluorescent dye, during two cruises along the west coast of Vancouver Island. These results indicate that diatom genera most important to silica production were often not the most abundant, and rarer diatom genera may play a larger role in assemblage productivity than previously thought.

Amanda Timmerman (UVic): *Carbon export and efficiency along Line P by comparing methods.*

Biological productivity is an important process controlling the export of carbon to the deep sea. By comparing methods, primary production, carbon export and efficiency can be better quantified. Using measurements of O_2/Ar (net community production; NCP) and NO_3^- uptake (new production) as a way to estimate carbon export, there is no clear trend along Line P or over time when comparing August 2014 and June 2015. Similarly, carbon efficiency (export/primary

production) estimated from the ratio of O₂/Ar-NCP to ¹⁸O incubations (gross primary production) showed no trend along Line P in June 2015. However, O₂/Ar-NCP to triple oxygen isotope (gross primary production) shows an offshore-onshore gradient, with higher efficiency offshore that decreases toward shore. We hope to continue to have the opportunity to sample on future Line P cruises to investigate this trend further.

Moira Galbraith (DFO/IOS): *Line P Anomalies: Zooplankton vs Climate Indices*

The Institute of Ocean Sciences has been sampling zooplankton along Line P for over 20 years now as an unbroken time series. Previous to 1995 the zooplankton measurements varied from nothing being sampled to select species being identified making the data difficult to quantify. Line P is interesting because it is oceanic, less influence from the land and more from the north central Pacific circulation/weather pattern. To compare time series, data were extracted from the database as numbers per cubic meter and then averaged yearly. To accommodate the difference in sampling intensity between regions when analysing the data, monthly geometric means were first calculated for each region and then a monthly anomaly for each sampled month (log₁₀). An annual anomaly was then calculated as the mean of the monthly anomalies in each year. Because our sampling is only 3 times a year this annual is biased to the late winter, summer and early fall anomalies. This study combines data from the inner and the outer Line P to look at the interannual variability of zooplankton in the NE Pacific with the various climate indices for our area.

Sonia Batten (SAFHOS): *Lower trophic level observations from a “Line P-like” transect.*

This presentation provides information on a ship-of-opportunity monitoring program that is analogous to Line P, in an effort to raise awareness of available data that could be used to compliment Line P research. The Continuous Plankton Recorder is towed behind a commercial vessel on a great circle route from the mouth of Juan de Fuca Strait to Japan. The program began in 2000 and three transects are usually sampled each year, normally in April, June and September. This transect is typically a little further north than Line P, and location does vary between transects, particularly in spring and fall when significant storms may be avoided by the vessel. Once the instrument is returned to the lab, plankton are identified and counted on every 4th sample collected and all samples are archived. There are several hundred taxa in the database, but summary indices can be calculated. The data have also been summarised into shelf samples (equivalent to Line P stations 1-4), central (equivalent to stations P5-12) and outer (equivalent to stations P13-26 and beyond to 150°W). A few examples are presented here, focussing on 2014-2015 which was anomalously warm. The data show that large diatoms were low in number during this period and biased towards long, pennate types of cells. Zooplankton were biased towards smaller organisms. The CPR has been fitted with a CTD-F instrument since 2007, which logs the along-transect, in situ temperature, salinity and chlorophyll-*a* fluorescence at the depth of the CPR (typically ~7m) every 5 minutes. The CTD data are available for download from the PICES website (http://www.pices.int/projects/tcpsotnp/CTD_data/CPR_CTD%20data.aspx), plankton updates are also available there, and data can be obtained from **Sonia Batten**. Samples from the archive can also be made available for specific studies.

Theresa Venello (UVic): *Spatiotemporal variability in secondary production along Line P.*

Crustacean zooplankton secondary production will be measured at the 7 main zooplankton-sampling stations (P2, P4, P8, P12, P16, P20, P26) along Line P from February 2016 onwards. Surface secondary production measurements will also be made using the *Tully's* seawater loop system at 6 intermediate stations (P6, P10, P14, P18, P22, P24). Crustacean zooplankton production is measured using the chitobiase method. The chitobiase enzyme is produced during the pre-molt phase in crustaceans to breakdown chitin in the old exoskeleton and partially recycles chitin for the new exoskeleton. Chitobiase is released into the water column when exoskeleton is shed in an amount proportional to individual body size. Therefore, the rate of production of chitobiase in the water column is equal to the biomass production rate (BPR) of the entire crustacean zooplankton community.

Ed Dever (OSU): *NSF Ocean Observatories Initiative (OOI), Station Papa 2016 Deployment: 4 Activities and Data Return.*

The 2016 OOI cruise to Station Papa occurs from 20 June – 9 July 2016 on board the R/V Ronald H Brown. The cruise has similar objectives to past years - namely the deployment and recovery of a profiling mooring in the vicinity of the NOAA surface mooring, the deployment and recovery of 2 subsurface flanking moorings and the retrieval of 3 gliders and deployment of 5 gliders at the site. CTD casts and the usual underway ship observations will also be taken on the cruise. In past years, the cruise has been performed by scientists from Scripps Institution of Oceanography and Woods Hole Oceanographic Institution (WHOI). This year the team will be from Oregon State University and WHOI.

The 2015 as deployed mooring locations are indicated below.

Mooring	Target Position	Actual Position	Deployment Date & Time (UTC)
GP02HYPM-00003	50° 04.82' N 144° 48.03' W	50° 04.79' N 144° 48.18' W	2015-06-04 23:38
GP03FLMA-00003	49° 58.65' N 144° 14.74' W	49° 58.60' N 144° 14.77' W	2015-06-06 22:40
GP03FLMB-00003	50° 19.88' N 144° 23.85' W	50° 19.82' N 144° 23.90' W	2015-06-08 21:25

Information about the OOI Station Papa observational platforms and instruments can be accessed at: <http://oceanobservatories.org/array/global-station-papa/>

The OOI Station Papa observations include profiled CTD, O₂, chl-a fluorescence and optical backscatter, and point velocity from 310 to 4000 m. Two profiling gliders are assigned to sample the upper 1000 m near these profilers. These gliders have photosynthetically available radiation and nitrate in addition to the other parameters. Fixed subsurface sensors include pH, temperature and conductivity at multiple depths, acoustic Doppler current profilers and three channel active bio-acoustics sensors.

The OOI Station Papa moorings have been maintained since June 2013 and have been turned on a yearly basis in June. OOI data are now coming online. Interested users can register at the OOI website (oceanobservatories.org). The most complete data can be accessed via the THREDDS

data server. Data return thus far has been reasonable, but data quality control is not yet implemented.

OOI contacts include:

- Global Scale nodes Project Manager: Paul Matthias, WHOI, pmatthias@whoi.edu
- Global Scale nodes Project Scientist: Bob Weller, WHOI, rweller@whoi.edu
- 2016 Station Papa deployment cruise chief scientist: Ed Dever, Oregon State Univ., edever@ceos.oregonstate.edu
- Data Manager: Mike Vardaro, Rutgers Univ., vardaro@marine.rutgers.edu
- Communications: Leslie Smith, Consortium for Ocean Leadership, lsmith@oceanleadership.org

Bill Crawford (DFO/IOS-Emeritus): *Decadal changes in Oxygen in subsurface waters along Line P.*

Previous studies revealed that oxygen concentration (O₂) has been declining since 1980 on the continental shelf of southwest Vancouver Island, and at Line P stations P4 and Ocean Station P, at depths below the surface mixed layer. This decline is a concern because O₂ on the BC continental margin is naturally low, and these waters lower O₂ is an indicator of more acidic seawater. Our recent studies reveal that lowest O₂ on the continental shelf was observed in late summer of 2006 and 2009, but not since then. At Line P station P4 a minimum was also observed in about 2009, followed by increasing O₂ on constant density surfaces that are usually found from 175 to 400 metres depth. In addition, observations prior to 1980 show that O₂ at and near P4 increased from 1950 to 1980 on these same constant depth surfaces. Similar decadal trends are observed at P8 and P12. In contrast, O₂ has been decreasing since the 1950s at P20 and at Ocean Station P, with an increase in the rate of decline in the 1990s. Additional details are due to be published in *Atmosphere-Ocean* in April 2016 at this on-line address: <http://dx.doi.org/10.1080/07055900.2016.1158145>

Andrew Ross (DFO/IOS): *Line P and the International Group for Marine Ecological Time Series (IGMETS): assessing global oceanic changes through joint time series analysis.*

Sustained time series observations provide a wealth of data on ocean physics, biogeochemistry and ecology that can be used to examine, test and refine hypotheses about the functioning of the ocean. Such time series not only allow us to observe processes such as ocean warming, circulation, eutrophication and deoxygenation but also generate information about key ecological processes and how the marine environment is being affected by climate change at the local, regional and global levels. Maintaining these time series is critical to identifying and predicting such changes; however, existing observations are limited in use if they are not made accessible. The International Group for Marine Ecological Time Series (IGMETS) was formed under the auspices of the UNESCO Intergovernmental Oceanographic Commission (IOC) with the aim of integrating and broadening the utilization of existing time series data to help promote cost-efficiency for new and established sampling programs, increase awareness of these programs and their importance, create a platform for modeling studies, and provide a strong basis for future predictions to support sound policy decisions and advice. This presentation describes how data from Line-P and other ocean observation programs have contributed to the first IGMETS Report, an assessment based on joint time series analysis to identify and interpret temporal and spatial patterns of key ocean parameters on a global scale.

Stephen Hallam (UBC): *A decade of microbial time series observations in the northeastern subarctic Pacific Ocean.*

Marine oxygen minimum zones (OMZs) are widespread and naturally occurring water column features that constitute ~7% of the global ocean volume, but contribute significantly to the overall marine budgets of carbon, nitrogen and climate active trace gases such as N₂O. Long term monitoring of OMZ microbial community, nutrients and trace gases is key to understanding the biogeochemical contribution of these expanding oceanic features to global cycles, climate change and ecosystem services. Here I describe the use of time resolved multi-omic datasets sourced from northeastern subarctic Pacific (NESAP) OMZs to chart metabolic networks linking key microbial players and processes along defined oxygen gradients. Knowing how microorganisms interact with and respond to oxygen starvation teaches us about organizing principles shaping ocean food webs and provides a paradigm for developing quantitative models describing metabolic coupling in the NESAP and beyond.

Steven Hallam is an Associate Professor in the Department of Microbiology and Immunology at the University of British Columbia, Leopold Leadership Fellow and Canada Research Chair in Environmental Genomics. He received his PhD from the University of California Santa Cruz where he studied developmental regulation of neuronal asymmetry and synaptic remodeling in *Caenorhabditis elegans*. Motivated by this experience in network dynamics he became a postdoctoral researcher at the Monterey Bay Aquarium Research Institute and later, Massachusetts Institute of Technology, where he studied marine microbiology and environmental genomics. His current research intersects microbial ecology, synthetic biology and bioinformatics with specific emphasis on the creation of functional screens and computational tools that reveal hidden metabolic powers of uncultivated microbial communities. In addition to his academic pursuits Dr. Hallam is a successful entrepreneur, cofounding MetaMixis, an integrated synthetic biology company that supports and develops microbial biotechnologies from natural and engineered ecosystems.

For more information contact:

Dr. Steven Hallam
University of British Columbia
Department of Microbiology & Immunology
Life Sciences Institute
2552-2350 Health Sciences Mall
Vancouver, BC Canada V6T 1Z3
T: 604-827-3420
E: shallam@mail.ubc.ca

URL: hallam.microbiology.ubc.ca/

The Power of Microbial Cooperation
<http://youtu.be/bhWyXPhwY9Q?list=PLsRNoUx8w3rOkIHfl-ez96ffRfrvr3sy0>

Maya Bhatia (UBC): *Microbial community metabolism along the Line P transect.*

Alyse Hawley (UBC): *Riding the big data waver from fjords to open oceans: metagenomic analysis of nitrogen cycling processes along the Line P transect.*

Angelica Peña (DFO/IOS): *Nutrients and phytoplankton time series observations along Line P.*

The composition of phytoplankton along Line P has been regularly monitored since 2006 to improve our understanding of factors determining the abundance and distribution of phytoplankton in this region. Phytoplankton community composition is determined by High Performance Liquid Chromatography (HPLC)-derived phytoplankton pigment concentrations and CHEMTAX analysis. This talk will focus on the effect of the anomalous warming of the surface waters in the Gulf of Alaska on nutrient concentrations, phytoplankton abundance and phytoplankton assemblage composition along Line P. The rapid and unexpected warming was observed in October 2013 and persisted until 2015. Nutrient concentrations are usually high (>5 mmol m^{-3}) and chlorophyll concentrations low (<0.5 mg m^{-3}) year around in the Fe-poor prymnesiophyte dominated offshore waters, whereas high seasonal variability in phytoplankton biomass occurs in the nutrient-rich diatom dominated inshore waters. In winters 2013/14 and 2014/15, nutrient renewal from vertical transport of nutrient-rich deeper water into the surface layer was restricted due to increased stratification. As a result, nitrate depletion extended farther westward along Line P in June and August 2015. Chlorophyll concentrations decreased and phytoplankton assemblage composition changed in the transition region of Line P but chlorophyll was within the range of values observed in previous years in the offshore region.

Brian Hunt (UBC & Hakai Institute): *Isotope based estimates of zooplankton trophic structure and implications for high seas salmon food webs.*

This presentation is given in two parts. The first part introduces project ISOZOO (<http://www.isofoo.org/>), investigating the role of nutrient supply and phytoplankton composition, specifically size structure, in driving the structure and function of pelagic food webs. The approach of this program is to combine biomass spectrum theory and stable isotope based estimates of trophic level to estimate three key food parameters: 1) Food Chain Length; 2) Predator Prey Mass Ratios; and 3) Energy Transfer Efficiency. Using this approach, this program is in the process of analyzing archived Line-P zooplankton samples with the aim to inform how spatial and temporal changes in productivity and phytoplankton size structure, drive zooplankton biomass.

The second part of this talk is entitled “Trophic baselines from a Line P like transect: summer stable isotope ratios of CPR zooplankton”. Preliminary stable isotope data are presented for zooplankton collected during the North Pacific Continuous Plankton Recorder Survey. High carbon and nitrogen isotope signatures on the BC Shelf, Aleutians Islands, and in the Bering Sea point to consistently high primary production in these regions from 2010 to 2013. Low interannual variability was observed within regions over this time period. The stable isotope data were used as a trophic baseline to estimate the trophic level of sockeye salmon returning to Rivers Inlet as \sim TL4.1, \sim TL4.5, and \sim TL5 in 2011, 2012, and 2013 respectively. These TL estimates combined with salmon carbon and nitrogen isotope values indicated significant changes in the organization of high seas food web between years.

Robert Izett (UBC): *Autonomous high-resolution measurement of primary productivity during the Line P and La Perouse survey cruises.*

Primary productivity serves as a baseline for regulating marine processes and key ecosystem services such as carbon dioxide sequestration, carbon export, and upper trophic level (e.g. fish) biomass production. Our present understanding of primary productivity in the Northeast Pacific Ocean is limited to discrete estimates. We thus lack an understanding of the links between climate variability, trophic dynamics, and ecosystem services. However, recent developments in autonomous instrumentation and remote sensing present new research possibilities. We propose a research plan coupling the deployment of autonomous instruments with discrete sample collection on Line P and La Perouse cruises over the next three years. The principal objective is to improve spatiotemporal estimation of primary productivity. Point samples of ^{14}C -derived estimates will calibrate underway observations of active phytoplankton fluorescence. By comparing the light-dependence of gross phytoplankton productivity and fluorescence, an empirical relationship predicting primary productivity on high-resolution spatial scales can be derived. Additionally, underway measurements of surface ocean gas concentrations (oxygen, argon, nitrogen) enable quantification of productivity through a mass balance equation relating measured biological oxygen saturation ($\Delta\text{O}_2/\text{Ar}$ or $\Delta\text{O}_2/\text{N}_2$) to air-sea gas flux, and net community production. However, this method typically neglects the impacts of physical processes (e.g. mixing and upwelling) on the oxygen pool, biasing estimates in dynamic regions; particularly near the coast. Computational and empirical corrections will be applied to account for these contributions. Field data will ultimately be used to calibrate regional satellite algorithms predicting primary productivity. The proposed research will contribute to an NSERC Strategic Program aiming to quantify and assess key ecosystem services in the Subarctic Pacific Ocean under ocean variability and climatic and anthropogenic disturbances (see Philippe Tortell's overview below).

Lindsay Fenwick (UBC): *Line P methane and nitrous oxide time series.*

Quantifying the distribution of greenhouse gases in the ocean water column is necessary to understand potential biogeochemical climate feedbacks. There are few time series measurements of methane (CH_4) and nitrous oxide (N_2O), and the sources and sinks of these gases are not well-defined. As the oxygen minimum zone in the subarctic Pacific expands and intensifies, the cycling of CH_4 and N_2O (which is strongly oxygen-mediated) will change, affecting the concentration and sea-air fluxes of these potent greenhouse gases.

We collected CH_4 and N_2O samples on the 2015 Line P cruises, building on our developing time-series with partial coverage of previous cruises back to 2011. We observe CH_4 concentrations that are at or below atmospheric equilibrium along the majority of the Line P stations. This results from microbial CH_4 consumption in oxygenated waters. At P4, however, CH_4 concentrations vary drastically by cruise, likely due to the differences in the off-shelf transport of methane derived from seeps on the continental slope. In contrast to the CH_4 profiles, N_2O concentrations reach a maximum in the oxygen minimum zone. Along Line P, N_2O concentrations show little seasonal variability, and well-correlated with AOU, implying that the N_2O is largely produced by nitrification. However, some signals of denitrification are observed, including a negative correlation between N_2O and N^* (i.e. nitrate deficit) over parts of the water column. Our observations show that concentrations of N_2O increased between February 2014 and February 2016. N_2O concentrations measured from 2011 and 2012 are consistent with the

2014 data, with higher values observed in 2015 and 2016. The recent increase in N₂O concentrations may be possible result of water column stratification associated with warming of surface waters (i.e. the blob). We plan to continue our time series measurements of N₂O and CH₄, integrating collaborations with the Hallam lab for microbiological sampling, and developing stable isotope measurements and underway gas sampling of surface waters.

Philippe Tortell (UBC): *NSERC strategic program: Ecosystem services in the subarctic Pacific.*

I will give a short overview of a recently funded NSERC Strategic Project, aimed at generating new observational and modeling tools to quantify fisheries production and CO₂ uptake capacity in the Subarctic Pacific Ocean. Using sea-going instrumentation deployed on research cruises around Vancouver Island and into the off-shore Subarctic Pacific, we will characterize a suite of variables relating to marine environmental conditions and biological productivity. These field-based observations will then be used to generate satellite-based models quantifying ecosystem productivity and its response to various environmental perturbations. Output from these satellite models will be used, in conjunction with fisheries data, to examine linkages between fish yields and environmental variability. In particular, we seek to understand the potential impacts of climate change and human induced disturbances on ecosystem dynamics, CO₂ uptake capacity and fish biomass. The work will represent a strategic partnership between university based scientists and Fisheries and Oceans Canada, and the scientific results of this project will significantly increase the accuracy of fisheries stock assessments, leading to enhanced ecosystem-based management and enforcement of currently existing regulatory mechanisms concerning ocean fertilization activities.

General discussion / Strategic planning:

There were three main discussions during the workshop. During the first day, **Tetjana Ross** presented some ideas for the “60th anniversary of Ocean Station Papa” celebrations to be held in 2016. A Doodle Poll survey inquiring about to the best time to host these events as well as other organizational emails will be sent sometime in April. Stay tune for more information coming from **Tetjana**. If you have suggestions regarding invited speakers or other activities please contact her at Tetjana.Ross@dfo-mpo.gc.ca.

The other two discussions were held at the end of the Workshop, after the break on the afternoon of day two. The first speaker was **Roberta Hamme** (rhamme@uvic.ca) from the University of Victoria. The second was **Philippe Tortell** from the University of British Columbia.

Roberta Hamme (UVic): *Discussion: Core properties, Line P and other time series.*

Roberta presented a comparison of core measurements at Line P vs. a few other time series. Line P meets all the recommendations of the 2012 International Time Series Methods Workshop for core parameter measurements. The Hawaii Ocean Time-series has the largest set of core parameters. Bermuda falls between Hawaii and Line P. In general, the additional parameters that these other time series have chosen to focus on break down into a few categories (see list below): dissolved and particulate organics, primary production rates, sediment trap fluxes, and phytoplankton and microbial numbers/identification. Discussion centred on which of these parameters could be most useful in a long-term sense to add to Line P if funding / personnel / collaborations became available.

1. Dissolved organic carbon (DOC) may be a key parameter as recent carbon cycle investigations (Andrea Fassbender working on the Papa mooring) have pointed to a potentially important role over the annual cycle. IOS has recently acquired new instrumentation for DOC measurements that may allow it to be routinely measured. Also, DOC is easy to preserve, so collaborations could be sought with other labs to make the measurement if samples were collected.
2. Primary production rates were seen to be well covered for the next few years between Hamme's Lab and the Tortell-led new initiative. A robust calibration with satellite estimates could take the place of regular primary production measurements in the future, but concern was raised about whether anomalous events would be well-constrained by a satellite algorithm calibrated for more normal conditions. Agreed to revisit in a few years when the Tortell initiative is winding down.
3. Sediment traps present some difficulty because they require a few days deployment. This could be overcome by deploying sediment trap arrays on the way to P26 and picking them up on the way back. These types of samples are also laborious to process, so we would need to collectively think harder about their ultimate utility.
4. Flow cytometry analysis that would help identify the smaller organisms was thought to be a potential valuable addition. If funds for the necessary instrument could be found, the analysis could likely be done without a lot of additional labour. Suggestion to pursue this through a CFI acquisition possibly.
5. The mooring has downwelling solar radiation measurements but many thought that the addition of a PAR sensor would be valuable. Line P now has a PAR sensor that can go to 2000m, allowing many more PAR profiles than previously.
6. Suggestion was made to add the bird and mammal observations into the core dataset.

HOT vs. Line P (Red = both or only Line P, Black = HOT only)

CTD - Temperature, Salinity, Oxygen, Fluorescence, Nitrate, Multi-spectral Absorption, Transmissometry

Upwelling and downwelling PAR

Salinity, Oxygen, Macronutrients, Chlorophyll-a, Pheopigments

DIC, Alkalinity, pH

HPLC pigments, Phycoerythrin (cyanobacteria marker)

DMS, DMSP, Fe sometimes

Total Organic Carbon, Dissolved Organic Nitrogen and Phosphorus (TOC, DON, DOP)

Particulate Carbon and Nitrogen and Phosphorus (PC, PN, PPO₄)

Particulate Silica (PSi)

ATP (Adenosine 5'-triphosphate)

Primary production rates – sunrise to sunset, in situ array, ¹⁴C incubations

Particle flux – 60hr sediments traps at 150m, bottom moored sediment trap

Microbial numbers – flow cytometry

Phytoplankton numbers and functional group – Epi-fluorescence microscopy

Mesozooplankton size-fractionated biomass – 6 net tows per cruise

Underway - ADCP currents, Temperature, Salinity, Fluorescence, pCO₂, Acoustics

Philippe Tortell (UBC): *Blob papers?*

The last speaker was **Philippe Tortell**, leading a discussion regarding a joint paper describing how “the Blob” affected Line P at all levels, from viruses and microbes to marine mammals and seabirds, via the biogeochemistry and physics of the Pacific Ocean along Line P. If you would like to be part of that paper please contact Philippe Tortell at ptortell@eos.ubc.ca. Please note that although Philippe is willing to ‘get the ball rolling’, he doesn’t necessary want to be the lead author. Should you want to volunteer for this task please contact Philippe.

APPENDIX 1: Notes for supervisors, to pass on to students and technicians:

1. Going to sea with DFO is a privilege, not an entitlement or a right.

Your students have to understand that it's a privilege to go to sea with DFO, it's not an entitlement or a right. DFO will sail no matter if you guys are onboard or not, and if we have to say no we can and we will. Also the DFO mandate takes priority. Of course when a student is in the middle of a PhD, getting one more cast can seem like a matter of life and death, and sometimes they don't understand why I put priority on "only CTD casts" instead of their rosette cast. These CTD casts are part of our monitoring program.

2. We don't work for you.

Again this comes with the idea of "entitlement" that some students seem to have. We have our own work to do when we're out there, AND when we're at IOS. It may seem like nothing to "go receive my radioactive materials for me", but there is lots of paperwork involved with this and we have our own boxes to pick up. And at sea we have our own work to do. In the same vein, the crew doesn't work for you either. If we can we'll gladly help, but don't expect or request it.

3. We may not have PhDs but we do have experience that you can't get in textbooks.

Many students seem to think that, because we don't understand everything they do, either at sea or back in the lab, there's nothing we can teach them. I may only understand 10% of what you do with your samples or your instruments, but I know how to tie a bowline, and I've been in very rough seas. When we say "carry and store your chemicals in spill-proof containers", it's because we've seen what a spill can do. The experience we have accumulated at sea in 5, 10, or for some of us 25 or 30 years can be beneficial to them, if they can only be humble enough or smart enough to listen to us.

4. It's a small community out there and there has to be respect between people.

Without wanting to sound "old fashioned", there is something about today's generation that makes it seem very "me" oriented. When you're at sea with the same few people for a certain length of time, but isolated from the rest of the world, it's even more important to respect everyone around, and also to respect the environment you are in. Some rules are "sea rules", for example the famous "no hat in the mess", and it's not up to us to change these rules. These are mariners' rules, and when in Rome, do as the Romans do. It's the same thing regarding how you treat your cabin mate, or even your cabin. You would be surprised of the "notes" we take ... "oh yeah, I'd think twice before hiring this person, did you see the mess in the cabin!!!" It's a *society* out there, one we cannot get out of for the whole length of the cruise. When there's a bad feeling or attitude on board it spreads and creates problems in NO time.

It is therefore **very** important that the students/technicians coming to sail with us keep these things in mind.

Marie Robert

APPENDIX 2 a: Berths reservations for 2016-17.

If you would like to book a berth, have your name on the waiting list, or cancel a reservation already made please contact me at Marie.Robert@dfo-mpo.gc.ca. Please note that, until further notice, the maximum number of berths available for science on the Tully is 16.

June 2016 15

DFO-IOS	6
Chief Scientist	M. Robert
CTD watch	D. Yelland
CTD watch	H. Maclean
DMS	M. Arychuk
pH	G. Cooper
Trace Metal	K. Simpson

UBC	3
Tortell - 2	Izett/Burt
Hallam - 1	Shiller

UVic	2
Dower-1	Venello
Hamme-1	Timmerman

NOAA	3
Cronin-3	Rivera/Higley/Anderson

UW	1
Emerson-1	Yang

Waiting list	
Morgan	1
Orellana	2
Bishop	1
Zhang	1
Crowe	1

August 2016 16

DFO-IOS/BIO	7
Chief Scientist	M. Robert
CTD watch	M. Galbraith
CTD watch	H. Maclean
DMS	M. Arychuk
pH	G. Cooper
Trace Metal	K. Simpson
Cesium	R. Nelson

UBC	3
Tortell - 2	Izett/?
Hallam - 1	Shiller

UVic	6
Dower-1	Venello
Hamme-2	Timmerman/?
Cullen-3	

Waiting list	
Morgan	1
Orellana	2
Bishop	1
Zhang	1
Crowe	1

February 2017 15

DFO-IOS/BIO	7
Chief Scientist	M. Robert
CTD watch	D. Yelland
CTD watch	M. Belton
DMS	M. Arychuk
pH	G. Cooper
Trace Metal	K. Simpson
Cesium	R. Nelson

UBC	3
Tortell - 2	Izett/?
Hallam - 1	Shiller

UVic	1
Dower-1	Venello

UW	2
Orellana-2	

UofC - Berkeley	2
Bishop-2	

Waiting list	
Morgan	1
Zhang	1
Crowe	1

APPENDIX 2 b: Berths reservations for 2017-18.

If you would like to book a berth, have your name on the waiting list, or cancel a reservation already made please contact me at Marie.Robert@dfo-mpo.gc.ca. Please note that, until further notice, the maximum number of berths available for science on the Tully is 16. **Note also that the February 2018 cruise will NOT happen on the Tully therefore the number of available berths, as well as wire time available for non-DFO groups, will be different.**

June 2017	15	August 2017	16	February 2018	13
DFO-IOS	6	DFO-IOS/BIO	7	DFO-IOS/BIO	7
Chief Scientist		Chief Scientist		Chief Scientist	
CTD watch		CTD watch		CTD watch	
CTD watch		CTD watch		CTD watch	
DMS		DMS		DMS	
pH		pH		pH	
Trace Metal		Trace Metal		Trace Metal	
		Cesium		Cesium	
UBC	3	UBC	3	UBC	3
Tortell - 2		Tortell - 2		Tortell - 2	
Hallam - 1		Hallam - 1		Hallam - 1	
UVic	3	UVic	4	UVic	1
Dower-1		Dower-1		Dower-1	
Hamme-2		Hamme-1			
NOAA	2	Cullen-2		UW	2
Cronin-2				Orellana-2	
UW	1	UW	2		
Emerson-1		Orellana-2			
Waiting list		Waiting list		Waiting list	
Morgan	1	Morgan	1	Morgan	1
Orellana	2	Bishop	1	Zhang	1
Bishop	1	Zhang	1	Crowe	1
Zhang	1	Crowe	1		
Crowe	1				