Report of the Seventh Annual Line P Workshop, Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, March 18 and 19, 2014

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 2014 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 over 50 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 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 consisted of two parts: during the first day the speakers were the regular Line P cruises participants, presenting their research and results for work done all along Line P. The second day was mainly devoted to Station Papa and the various moorings operating in the area. Indeed, there is now an array of five moorings at Station Papa – the NOAA surface mooring (first deployed in 2007), the UW/APL waverider mooring (first deployed in 2010) and the NSF Ocean Observatories Initiative (OOI) set of subsurface profiling and flanking moorings deployed in summer 2013 making Station Papa the first "Global Node". Additionally, there are plans to deploy a NOAA noise reference station mooring in early 2015. This major expansion of full water column, multi-disciplinary observing capabilities makes Station P one of the World's most densely observed open ocean station. The 7th annual workshop therefore expanded to include a second day, dedicated to Station P studies.

Acknowledgements:

I would like to thank Tamara Fraser and Nina Nemcek from DFO/IOS for welcoming the attendants in the morning, as well as their help with laser pointers, 'noise cancellation', and wonderful Line P cupcakes (see photo at the end of this report).

Thanks to Mark Belton (DFO/IOS) for his help with receiving and loading the presentation on the auditorium computer.

Thanks also to Meghan Cronin (NOAA/PMEL) for introducing speakers during the morning of the second day.

Finally, thanks to Char de Reus (DFO/IOS) for all her work with the paperwork regarding hospitality and to Kevin Doxey (DFO/IOS) for delaying the "noisy cement work" until after the workshop.

Day 1: Line P day

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

Marie started the workshop by giving an overview to the new participants of what the DFO Line P Program consists of. First she reminded everyone what the main the goals of the Line P Workshop are: to promote collaborations between all scientists in order to better understand the Pacific Ocean; to maximise the use of ship time; and finally to discuss some issues that can potentially affect everyone involved in the program. She then described the basics of the Line P cruises; what sampling is done at what station, what is the distance/timing between stations, how long each cruise lasts, etc. She also described the paperwork needed and schedule for the next year:

- Requests for security clearances and radioisotope use have to be started two to three months prior to the cruise.
- Please contact **Marie Robert** if you want to participate in a cruise. Do NOT contact the DFO security clearance officer directly.
- The name of a student's supervisor will be sent to the security clearance officer with the intent that the supervisor can help his/her student fill-in the paperwork if there are any questions. Too many unnecessary questions are asked repeatedly to the security clearance officer.
- 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 we sail.
- The milli-Q water maker on board the Tully cannot be used for making large volume of distilled water. If you need large volumes please bring your own milli-Q water and use the system on board only as a back-up.

Marie then showed the line-up for berth reservations for the cruises of the next two years and the dates of this fiscal year's cruises:

Cruise 2014-18 will go from 8 June to 24 June 2014.
Cruise 2014-19 will go from 19 August to 4 September 2014.
Cruise 2015-01 will go from 10 February to 24 February 2015.

She then announced that the new Line P Website is finally ready and public. There are still many mistakes in it so if you find any please contact her for corrections. The new climatology is now also available to compute Temperature (T), Salinity (S), Sigma-t and Dissolved Oxygen (DO) anomalies. It includes data from 1981 to 2010 for T, S and sigma-t whereas the range of DO data is from 2001 to 2010.

Finally Marie presented an update provided by Doug Yelland regarding the meteorological sensors on the *CCGS John P Tully*. The sensors – air temperature, relative humidity, and wind speed and direction – are purchased and ready to install. There are three sensors for each – one in service, one spare on board, and one off being calibrated – and the installation will be done by Coast Guard electronics. There is a possibility to interface other sensors as long as they are

provided. The Line P program just bought two barometric pressure sensors to add to this list. The data will be made available on the Line P Website. Please let **Doug** know if there are other sensor requests (Doug.Yelland@dfo-mpo.gc.ca)

Andrew Ross (DFO/IOS): *The Line P iron program: exploring the biogeochemistry of trace elements and isotopes in the north-east Pacific.*

Oceanographic data (e.g. temperature, salinity) have been collected along Line-P since 1956 and are among the few time series of sufficient quality and duration to be useful in examining the long-term variability of the oceans. Total and dissolved iron have been measured intermittently along Line-P since 1997, providing a unique series of such measurements between the iron-rich coastal waters of British Columbia and Station P in the HNLC waters of the Alaska gyre. In 2012 Fisheries and Oceans Canada scientists together with collaborators at the universities of Victoria, Laval and British Columbia established the Line-P Iron Program to ensure the continuity of iron measurements along Line-P and provide a framework for process-oriented studies of iron, copper and other trace elements in the NE Pacific. This presentation will show how different approaches (including in situ measurements, incubation studies, and mass spectrometry-based techniques) are being used to study the distribution, biological utilization, and speciation of trace elements and isotopes along Line-P and to support international efforts (including GEOTRACES) to better understand the roles of these elements in marine ecosystems and climate change.

John Smith (DFO/BIO) – presented by Andrew Ross (DFO/IOS): *Detection of Radioactivity from the 2011 Fukushima Accident on Line P – Updated.*

On March 11, 2011, an earthquake triggered tsunami on the northeast coastline of Japan severely damaged the Fukushima Dai-ichi Nuclear Power Plants resulting in discharges of radioactivity to the atmosphere and ocean that included as much as 50 TBq of ^{137}Cs. The Oyashio and Kuroshio ocean current systems off Fukushima led to the rapid transport of the radioactivity plume eastward across the North Pacific Ocean towards North America. We report the first detailed, systematic study of the arrival of the Fukushima radioactivity signal by ocean current transport in continental waters off North America. Baseline measurements in seawater targeted at Fukushima radioactivity were conducted during missions of the *CCGS John P. Tully* on Line P in the eastern North Pacific in June of 2011, 2012 and 2013 and February, 2014 and on the *CCGS Louis S. St. Laurent* in August, 2012 in the Beaufort Sea. Low levels of ^{134}Cs from Fukushima were measured at a monitoring station 1500 km west of Vancouver by June, 2012, and at the Canadian continental shelf off British Columbia by June, 2013, approximately 2.3 years following the accident. Levels of Fukushima-derived ^{137}Cs measured off the Canadian coastline in June, 2013 are in the range of 0.4 – 1.0 Bq/m^3. Comparison of these results with model predictions suggests that ^{137}Cs levels will increase over the next few years to levels in the range of 2-30 Bq/m^3 which would return North Pacific concentrations to fallout levels that prevailed between the 1950s and 1990s, but which are well below levels considered a radiological threat to human health or the environment.

Hollie Johnson (University of Victoria): *Is the Cascadia Basin an important site of denitrification?*

Denitrification and related processes strip nitrogen-based nutrients from the ocean and produce N_2 gas, which is generally not biologically available. The global rate of denitrification is very poorly known. The dissolved N_2/Ar gas ratio can be used as a tracer for denitrification as long as the different source water signatures of N_2/Ar can be accounted for. A measurable increase in N_2/Ar ratios has been observed from the subtropical North Pacific to the subarctic North Pacific at Station Papa, revealing greater amounts of N_2 gas between 2000-3000m. The same source waters feed the whole deep North Pacific, so it appears that excess N_2 at these depths must come from a biological source. A potential source is benthic denitrification in the Cascadia Basin, off the coast of Vancouver Island and Washington State, where the seafloor spans vast areas between 2000-3000m depths. To evaluate the potential of the Cascadia Basin as a source of biological N_2, we measured N_2/Ar at the major stations along Line P in June and August 2013. If the Cascadia Basin is the source of N_2 feeding increased N_2/Ar values in the subarctic North Pacific, we expect to see a decrease in N_2/Ar saturations across the Line P stations from P8 to P26. Here, we present our findings.

Nina Schuback (University of British Columbia): *The effect of iron and light on the coupling of ETR_{PSII} and C-fixation along Line P.*

Fast repetition rate fluorometry (FRRF) provides a non-intrusive, instantaneous and potentially autonomous technique to monitor phytoplankton photo-physiology with unmatched spatial and temporal resolution. A number of studies have examined the feasibility of deriving bulk primary productivity estimates from FRRF measurements. We present FRRF data collected in August 2013 along a coastal to open ocean (HNLC) transect in the subarctic NE Pacific and during iron addition experiments. Whole community rates of electron transport at photosystem II (ETR_{PSII}) estimated from FRRF measurements were compared to ^{14}C-assimilation rates to explore the feasibility of deriving 'ecologically relevant' rates of C-assimilation from FRRF-based ETR_{PSII}. We found that the interacting effects of iron and light had significant effects on the coupling of the two rates, due to changes in the electron requirement of carbon fixation ($\Phi_{e,C}$) and/or the amount of chlorophyll *a* associated with each reaction centre II (n_{PSII}). These results allow insight into the flexibility of phytoplankton photo-physiology in response to environmental forces and its effects on rates of primary productivity.

Jean-Pierre Desforges (University of Victoria): *Microplastics in coastal and offshore waters of British Columbia.*

Large plastic debris has long been recognized as a threat to marine biota while microplastics (<5 mm) are currently receiving increased attention due to their ubiquity, persistence, risk of ingestion and transport of contaminants. As a pilot project, we used the saltwater intake system of the *CCGS Tully* during the August 2012 Line P and September 2012 La Perouse cruises to collect sub-surface sea water in order to qualify and quantify sub-surface microplastics. Water was filtered with a coarse 5 mm filter, then passed through sieves (250, 125 and 62.5 μm) and plastics were collected in glass vials. After acid digestion in the lab, microplastics were identified and counted using light microscopy. One hundred percent of sites contained microplastics, ranging from 8.5 to 9179 particles/m^3. Microplastic concentrations were at least four times higher in coastal waters (west Vancouver Island) than Pacific offshore waters (Line P) (316.5 vs

1426.8 particles/m^3; p=0.012). Similarly, plastic concentrations were three times higher in inland waters of eastern Vancouver Island than coastal waters off the west coast of Vancouver Island (5021.0 vs 1721.9, p=0.004). Plastic particles were assigned to two product types: fibres/filaments and plastic fragments; and divided into four size categories: <100, 100-500, 500-100 and >1000 μm. Fibres/filaments accounted for the majority of plastics for Line P samples (65 ± 23%) and the average size of particles decreased with distance offshore along Line P (r^2=0.79, p<0.05). This served as a successful pilot project which tested collection methods and laboratory techniques. Next steps for microplastic studies will include quantifying plastics in depth profiles at several sites along Line P, in ocean and beach sediment, and examining plastics in biota (i.e. plankton). This work will be an important component of the Vancouver Aquarium's new Ocean Pollution Research Program.

Philippe Tortell (University of British Columbia): *Announcing the August 2014 DMS diel cycle experiment.*

Philippe discussed upcoming plans to conduct a ~ 36 hour diel study of DMS/P/O cycling at Ocean Station P. This diel study is designed to improve our understanding of the temporal dynamics of various S species in relation to environmental forcing over a day-night cycle. The work will build upon a previous diel cycle study conducted in 2010. In this year's experiment, we will utilize a suite of newly developed autonomous, high-resolution sensors to monitor S concentrations in near real-time. Improved sampling resolution will provide better data to constrain the DMS modelling efforts by N. Steiner *et al*.

David Semeniuk (University of British Columbia): *Impact of Cu speciation on primary productivity along Line P.*

Few studies have investigated the bioavailability of *in situ* bioactive metal complexes due to low dissolved metal concentrations and the lack of radioisotopes with suitably high specific activities. As such, *in situ* phytoplankton metal uptake rates and intracellular requirements remain largely unknown. Using the carrier-free radioisotope ^{67}Cu, we measured *in situ* Cu uptake rates, Cu speciation, and primary productivity at multiple depths along a 1400km coastal-open ocean transect in the NE subarctic Pacific Ocean. Free Cu concentrations (pCu) were positively correlated with biomass-normalized copper uptake rates measured over 24h (r^2= 0.42, p<0.05), and negatively correlated with volumetric net primary productivity (r^2= -0.77, p<0.05). Interestingly, free Cu concentrations measured along the transect were on par with those that induce Cu limitation in laboratory monocultures. A bottle enrichment incubation conducted midway through the transect demonstrated that biomass-normalized C-fixation rates increased as Cu bioavailability was artificially decreased using a strong Cu ligand. These data provide the first tentative evidence that Cu bioavailability may influence primary productivity in this region.

Ania Posacka (University of British Columbia): *Probing the effects of copper availability on microbial assemblages in the NE Pacific Ocean.*

Copper is an important trace element for bacterial metabolism. This micronutrient is a co-factor in cytochrome oxidase for cellular respiration, as well as in laccases and amine oxidases involved in organic matter degradation. For the last year, we have focused on investigating the role of Cu nutrition in marine heterotrophic bacteria isolated from stations along Line P. Our preliminary lab results suggest that Cu limits the growth of some strains, highlighting the importance of this metal for their cellular function. During the 2012 August Line P cruise, we investigated the responses of the mesopelagic microbial assemblage (200m) at P16 to changing Cu availability. We present preliminary data of an 8-day experiment following additions of Cu (to increase Cu availability) or the strong Cu binding ligand Cyclam (to decrease Cu availability). We monitored bacterial abundance, productivity and organic matter re-mineralization. There was no significant difference between bacterial biomass among treatments, suggesting a tight coupling between bacterial biomass and their micrograzers. However, we observed a significant increase in bacterial productivity in response to the Cyclam addition. This increase in bacterial productivity was also associated with a significant drawdown of inorganic N and P. Our limited data set suggests that Cu availability might be affecting microbial assemblages along Line P.

Martine Lizotte (Université Laval): *Resistance to ocean acidification in late summer planktonic communities off the North Pacific coast.*

Coastal ocean waters undergo dramatic pH fluctuations from processes as various as upwelling of hypoxic waters, freshwater inflow, and local eutrophication. It is unclear whether these localized instabilities render the communities living there especially vulnerable to ocean acidification (OA), a phenomenon characterized by a reduction in surface water pH through atmospheric CO_2 input and likely to have diverse and potentially harmful impacts on marine biota, food webs and biogeochemical cycles. Contrasting responses due to OA on the dynamics of marine sulfur cycling and more specifically dimethylsulfide (DMS), a climate-active gas, have been demonstrated in recent years. The diversity of these impacts are thought to be linked to the complexity of the DMS cycle which is intimately connected with primary producers and other constituents of the food web such as viruses, bacteria and zooplankton. A 10 day microcosm experiment was conducted with water from station P4, a coastal station off the Canadian North Pacific Coast, in order to investigate the impact of OA on coastal planktonic communities and their production of DMS. The experimental setup included triplicate replication of controls, as well as two acidified treatments (pH reduction of 0.2 and 0.4 units). The 25L Labtainer^{TM} bags used were subsampled daily for several biochemical variables such as pH, alkalinity, DIC, nutrients, chl*a*, DMS and its precursor DMSP, as well as rates of primary production. As a whole, no significant differences were detected between controls and acidified treatments suggesting that late summer planktonic communities are resistant to a sudden acidification, both following moderate and severe pH modifications. While these waters inherently undergo pH fluctuations on daily and seasonal scales, certain of their planktonic communities may exhibit more capacity, rather than vulnerability, to cope with added pressure from OA through atmospheric CO_2 input.

Christina Schallenberg (University of Victoria): *Papa June 2012: the remnants of a dust event?*

The dissolved iron (dFe) and Fe(II) profiles for PAPA on the June 2012 cruise show maxima near the oxygen minimum that are beyond background open ocean concentrations. This feature could be explained by recent dust deposition at PAPA, which some satellite imagery alludes to, but as a whole, the satellite data are somewhat inconclusive. So the search is on for other indicators of something "unusual" going on at PAPA in June 2012. We will present the lines of evidence to date that point to a dust event as the most likely explanation for the observed data, and we are looking forward to further input and discussions at the workshop.

Jim Bishop (University of California – Berkeley): *PIC/POC dynamics along Line P: results from 2012 and 2013 CTD optics profiles, bottle filtration, and 2013 Carbon Explorer and Carbon Flux Explorer deployments.*

Nina Bednarsek (NOAA/PMEL, Seattle): *Pteropod vulnerability in the California Current ecosystem.*

Due to ocean acidification (OA), aragonite saturation horizon in the California Current Ecosystem (CCE) has shoaled, but only a few studies to date have demonstrated biological impacts of OA under present-day conditions. Pteropods are important for their role in carbon flux and energy transfer. In the CCE, conditions are becoming increasing unfavorable for sustaining shell maintenance because of enhanced dissolution. Our results show a strong positive relationship between the proportion of pteropods with severe shell dissolution and the percentage of the water column that is undersaturated with respect to aragonite. From this relationship, we approximated the extent of dissolution for the pre-industrial era, 2011, and 2050. Our calculations suggest that dissolution increased by 30% since the beginning of the industrial era, and could approach 70% by 2050. Although dissolution is occurring in most of the investigated pteropod species, based on vertically stratified sampling in the CCE-LTER region we observed some species to have changed their daily vertical distribution pattern by migrating to upper supersaturated waters to avoid corrosive waters, a potential indication of an adaptation strategy to OA.

Moira Galbraith (DFO/IOS): *Station Papa and the MPS: discovering the extraordinary biodiversity of the deep.*

The MPS, Multiple Plankton Sampler, has opened up new territory for researchers with the ability to sample to depths of 3000m, electronically open and close up to 5 nets at selected depths in a vertical profile and bring intact bathypelagic plankters to the surface for study. This talk will be a quick overview of some of the amazing creatures to be found in the deep waters off the west coast of Canada that have been collected to date.

Day 2: Station P day

Meghan Cronin (NOAA/PMEL, Seattle): *Analyses currently underway using Station P mooring data.*

As an introduction to the day's talks, Meghan Cronin (NOAA/PMEL) began with a list of the Station P observing system elements, and the speakers who would be discussing these elements through the day. It's getting crowded out there! At present there are five moorings deployed at Station Papa – the NOAA surface mooring (first deployed in 2007), the UW/APL waverider mooring (first deployed in 2010) and the NSF Ocean Observatory Initiative (OOI) set of subsurface profiling and flanking moorings deployed in summer 2013 making Station Papa the first "Global Node". Additionally, there are plans to deploy a NOAA noise reference station mooring in early 2015. Gliders, specialized floats and the various ships servicing these moorings in addition to the *CCGS Tully* are also all part of this Station P observing system. Meghan encouraged the group to consider themselves as partners and to cross-link their data and webpages.

Meghan showed base maps of the moorings. In general, moorings are deployed first and then recovered. Thus for at least one day, both the old and new moorings are in the water, making the cluster of moorings particularly tight and challenging for mooring operations. Ships and mooring operations should avoid entering the watch circle of the moorings. She expressed very deep gratitude to Marie Robert, the Line P scientists, and to the Captain and crew of the *CCGS Tully* for including the NOAA surface mooring turnaround on the June 2014 Line P cruise.

Meghan then described the NOAA surface mooring observations and some underway analyses. The NOAA surface mooring carries a suite of sensors to monitor air-sea exchanges of heat, moisture, momentum, and carbon dioxide; upper ocean temperature, salinity and currents; ocean acidification, and key aspects of the carbon cycle. The Carbon group at PMEL is responsible for the air-sea pCO2 system, pH, fluorometer and turbidity, and S. Emerson's University of Washington group is responsible for the Gas Tension Device, CTD, and O2 sensors. All data are publicly available through the project website (http://www.pmel.noaa.gov/ocs/Papa/) or the OceanSITES or Carbon Dioxide Information Data Analysis Center websites.

Uwe Send (Scripps Institution of Oceanography, San Diego, CA): *OOI observations at Station PAPA.*

Jim Thomson (Applied Physics Lab, University of Washington): *Waverider mooring results to date.*

Wave and wind measurements at Ocean Weather Station P (OWS-P, 50°N 145°W) are used to evaluate the equilibrium range of surface wave energy spectra. Observations are consistent with a local balance between wind input and breaking dissipation, as described by Phillips [1985]. The measurements include direct covariance wind stress estimates and wave breaking dissipation rate estimates during a 3 week research cruise to OWS-P. The analysis is extended to a wider range of conditions using observations of wave energy spectra and wind speed during a 2 year mooring deployment at OWS-P. At moderate wind speeds (5–15 m/s), mooring wave spectra are in agreement, within 5% uncertainty, with the forcing implied by standard drag laws and mooring wind measurements. At high wind speeds (>15 m/s), mooring wave spectra are biased

low, by 13%, relative to the forcing implied by standard drag laws and mooring wind measurements. Deviations from equilibrium are associated with directionality and variations at the swell frequencies. A spectral wave hindcast accurately reproduces the mooring observations, and is used to examine the wind input.
The wave mooring record is 3.5 years and counting (2010-present), and future work will tie this modern data set to the historical wave data from the Station P weathership program (1951-1981).

Ramsey Harcourt (Applied Physics Lab, University of Washington): *Wave impacts on upper ocean mixing at OWS Papa.*

Nearly all operational ocean models use air-sea fluxes and the ocean shear and stratification to estimate upper ocean boundary layer mixing rates. This approach implicitly parameterizes surface wave effects in terms of these inputs. We test this assumption using parallel experiments in a lake with small waves and in the open ocean at OWS-PAPA with much bigger waves, using Lagrangian floats and buoy measurements of surface wave spectra. Under the same wind stress and adjusting for buoyancy flux, we find the mixed layer average turbulent vertical kinetic energy (VKE) in the open ocean typically twice that in the lake. The increase is consistent with models of Langmuir turbulence, in which the wave Stokes drift, and not wave breaking, is the dominant mechanism by which waves energize turbulence in the mixed layer.
Investigating the impacts of waves on upper ocean mixing is extended in model-data comparisons of upper ocean shear from ADCP, and of dissipation and VKE profiles from Lagrangian floats.

Holger Klinck (Oregon State University and NOAA/PMEL): *Passive acoustic observations at Ocean Station Papa.*

We are currently involved in two projects at Ocean Station PAPA (OSP):

1. Marine mammal observations at OSP

In collaboration with Jeff Nystuen, APL-UW we are working on the analysis of a multi-year (2007-2012) acoustic data set collected with a Passive Aquatic Listener (PAL) at OSP. The analysis focuses primarily on [a] physical processes and sea surface conditions (wind speed, rainfall, sea state etc.) and [b] the presence of marine mammal vocalizations (especially endangered sperm whales) in the area.
Preliminary results indicate that within the 5-year deployment period sperm whales were acoustically present year round and that the number of acoustic sperm whale detections showed a seasonal trend with slightly higher numbers during the summer months. We are currently investigating the linkage between the occurrence of sperm whales and environmental conditions in the study area. Work funded by the Office of Naval Research.

2. Set-up of an Ocean Noise Reference Station (NRS02) at OSP

Passive acoustic monitoring of the ocean ambient sound field is a critical aspect of NOAA's mandate for ocean and coastal stewardship. This includes detecting and characterizing:
(1) sounds produced and used by living marine resources (e.g., endangered marine mammals); (2) natural sources of noise from physical oceanographic processes; and (3) anthropogenic noise sources that contribute to the overall ocean noise environment.

Noise generated by anthropogenic activities (especially commercial shipping and seismic oil & gas exploration) is increasingly being recognized as a potential threat to marine mammals which are protected in the U.S. by the Marine Mammal Protection Act and the Endangered Species Act. Additional concerns associated with the degraded acoustic quality of diverse habitats broaden these concerns to include possible repercussions for fish and invertebrate species, many of which NOAA manages as commercially-harvested resources, protects as resources within sanctuaries, or studies as key elements to sustaining healthy ecosystems. For these reasons it is important for science-based regulatory agencies, including NOAA, to monitor long-term trends and changes in the ocean ambient sound field. However, consistent and comparable multi-year acoustic data sets covering all major oceanic regions of the U.S. do not exist. We are currently in the process of establishing an Ocean Noise Reference Station Network to collect these critically important acoustic data sets to monitor long-term changes and trends in the underwater ambient sound field. One of these stations, *Noise Reference Station NRS02*, is intended to be deployed at Ocean Station PAPA. Work funded by the NOAA/NMFS Acoustics Program.

Noel Pelland (University of Washington): *Seaglider and moored observations of mesoscale circulation and biogeochemical processes at Ocean Station Papa, 2008-2010.*

From June 2008-February 2010 Seagliders orbited near the multidisciplinary NOAA Ocean Climate Stations mooring at Ocean Station P, providing horizontal spatial gradient information, greater depth capability, and increased vertical resolution. We present an overview of early results from this time series, with emphasis on observations of circulation patterns and biogeochemical processes in the GoA. Seagliders observed geostrophic currents that suggest a weak anticyclonic eddy passed by the array; this is supported by subsurface observations of warm, saline water that is typically carried by coastally-generated anticyclones. Preliminary analysis of heat transport in the top 300 m during this time suggests that horizontal advection can be an O(~1) term in the seasonal thermocline in the fall, when horizontal gradients are large, though at other times the upper-ocean balance is primarily between diffusive convergence and local storage. Seaglider observations are also used to construct a budget of dissolved oxygen in the surface layer, which allows inference of summer rates of net biological oxygen production (related to carbon export) that are consistent with previous estimates. Ongoing analysis includes assessment of respiration of oxygen below the mixed layer and closure of the heat budget in the seasonal thermocline. These results are an important precursor to future glider observations that are currently being fielded as part of the NSF Ocean Observatories Initiative Station Papa node.

Seth Bushinsky (University of Washington): *Oxygen flux and net community production from a self-calibrating Argo-oxygen float at Ocean Station Papa.*

Estimates of annual net community production (ANCP) have largely been limited to long-term time series sites such as Ocean Station Papa (OSP). Expanding the network of biogeochemical sensors needed to make estimates of ANCP to mobile platforms such as Argo floats will be necessary to determine spatial variability of ANCP and ground-truth satellite based carbon export products. The oxygen mass balance method is well suited to use on profiling floats if oxygen can be measured accurately enough to constrain air-sea gas exchange and if the physical processes affecting gas saturation can be estimated.

Argo floats equipped with Aanderaa oxygen optodes have displayed good stability but poor accuracy. To address this issue we developed a modified Argo float equipped with optodes that

can measure atmospheric air for in-situ calibrations upon surfacing. One of these modified floats was deployed at OSP in June 2012 and has remained near the mooring. Oxygen saturation calculated from the float and mooring agree to 0.06 +/- 1.25%.

To estimate the impact of physical processes on the gas saturation we used a 1-D box model of abiotic oxygen evolution. A comparison of the modeled abiotic gas saturation changes agrees well with nitrogen data from the OSP mooring. Calculation of ANCP for 2012 from the combination of float oxygen and modeled abiotic oxygen yields a summertime oxygen production of 20 mmol O_2 m^{-2} d^{-1}, or 1.7 mol C m^{-2} yr^{-1}, which agrees well with the OSP mooring estimate based on oxygen and nitrogen data. Floats capable of in-situ oxygen calibration can now be used to estimate ANCP and point the way towards an expansion of our knowledge of where and when carbon export is occurring.

Craig McNeil (Applied Physics Lab, University of Washington): *Progress made on gas sensing floats: new optode calibration equation for O_2 and faster response gas tension device for N_2.*

Numerous oceanographic platforms equipped with dissolved O_2 sensors have been deployed at OWS-P over the last few years to study net community productivity and air-sea gas exchange. Deployments at OWS-P benefit greatly from co-located Winkler measurements. As many other have experienced, the optode on our Argo float deployed at OWS-P on February 2012 read nearly 10% lower than the Winkler measurements in the mixed layer. The cause of this offset is unknown, but a likely candidate is drift in the fluorescent properties of the foil since it was manufactured. Understanding the causes of optode drift has been hindered by lack of a physical based calibration equation. We present a new calibration equation based on the two site fluorescence quenching model of Demas et al. (1995) to describe the nonlinear Stern-Volmer response of the optode foil to oxygen partial pressure. We have also been developing a sensor to measure dissolved N_2 on the float by the gas tension method. Dissolved N_2 serves as a proxy for abiotic-O_2 outside of oxygen minimum zones and can be used to infer air-sea O_2 flux. Dissolved N_2 is more sensitive to bubble dissolution processes than O_2 because it is half as soluble as O_2. One technical challenge has been the development of a reasonably fast response unpumped membrane equilibrator for use on deeper profiling floats. Our new membrane equilibrator appears to solve many problems which arise when using our existing membrane equilibrators on deep profiling floats. Test data obtained using the new membrane equilibrator in a pressure test tank will be shown that quantifies the pressure dependence of the Henry's Law solubility coefficients for N_2 and O_2, an often overlooked dependence that only becomes apparent when directly measuring partial pressures of dissolved gases deep in the ocean.

Philippe Tortell (University of British Columbia): *Presentation of an NSERC strategic proposal.*

The outline of a proposed NSERC strategic grant proposal was presented. The proposed work seeks to purchase new underway biogeochemical sensors for the *John P. Tully*, to greatly expand the scope of high resolution biogeochemical measurements in surface waters. These new measurements will be used to parameterize regionally-calibrated satellite algorithms predicting primary production, export production, phytoplankton taxonomic composition and relative iron stress. Discrete measurements of various biogechemical properties will be included for

calibration purposes. Remote sensing data on phytoplankton production will be coupled to the analysis of fisheries data, linking productivity across trophic levels and exploring the effects of various environmental perturbations on ecosystem services. Results from this work will enhance DFOs ability to fulfill its monitoring and management mandate, and provide the best possible science-based information to policy makers.

General discussion, chaired by Meghan Cronin (NOAA/PMEL).

At the end of the second day there was a general discussion with the few people left led by Meghan Cronin. A few points were brought up:

- Meghan would like to see a "theme" or a scientific question discussed at each of the workshop. For example during the 2009 workshop many people talked about their unexplained results at Station P during the August 2008 cruise. This led to a paper written by Hamme *et al* (2010. Volcanic ash fuels anomalous plankton bloom in subarctic northeast Pacific. Geophys. Res. Letters. 37:L19604. doi:10.1029\2010GL044629). This year there is an important salinity and temperature anomaly in the Gulf of Alaska as seen from Argo data, mooring data, Line P data, and satellite data. Meghan would like to write a "Line P community" paper about this anomaly.

  Marie Robert's reserve about this theme idea was mainly because this could prevent some students whose work is not related to the theme to talk about their own research. The main goal of the workshop is again to promote collaboration, and to present what everyone does out there on the ocean. A 'theme workshop' could infringe this main goal. Also, some years there is nothing specific happening in the GofA.

  Christina Schallenberg suggested that when the call is done in November to announce the coming Line P workshop, participants could be invited to submit a theme if they have some interesting results or observations to discuss with the whole group. This approach will probably be the one implemented next year.

- Another issue brought up by Uwe Send was that it would be good to have more time during the workshop for either general discussions or group discussions.

  Marie explained that during the past workshops we used to have plenty of time for group discussions since all the talks that were given this year on Day 1 were then given over the two days of the workshop. But by adding all the talks on day 2 about Station P and the moorings less time was available for discussion. Three solutions suggested were:
  1) To reduce the number of talks – this would go against the main idea of this workshop;
  2) To reduce the time for each talk – some of which already having to be interrupted;
  3) To hold the workshop over 3 days instead of two. Steve Mihaly from Ocean Networks Canada said that they could then host the workshop at the University of Victoria if necessary. This would be a complicated option for DFO participants.
  Marie thinks that the best solution would be the commitment from all participants to the full two days of the workshop. Indeed, time was allocated at the end of the first day but

some people who had things to discuss were not present then. Similarly, at least half the participants were already missing when we had the 'general' discussing at the end of day 2. If everyone committed to two full days – 09h30 to 17h00 or even 18h00 – there would be slightly more time allocated to each presentation as well as possible discussion time at the end of each session.

Tamara Fraser's Line P cupcakes.