Report of the 13th Annual Line P Workshop, Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, 27 February 2020

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

Introduction

Fifty-five ocean scientists and technicians met in February 2020 to share historical and recent observations along Line P, as well as to present their current research interests and proposed future sampling plans. "Line P" is a 1425-km-long set of ocean stations off Canada's West Coast, monitored for 64 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. Here is a short summary of each presentation from this 13th annual workshop.

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

Since there are always new Line P Program or workshop participants present every 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 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. Again the process has to be started **at least three months prior to the cruise.**
- Line P data are available on the Website at https://www.waterproperties.ca/linep, or contact me at Marie.Robert@dfo-mpo.gc.ca.
- 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 a cruise.
- Although this year a reminder was not read to the supervisors on how new students or technicians need to behave at sea, the reminder is still included in Appendix 1 of this report.
- Please invest in your own raingear.

- 15 berths are available at the moment for science on the *Tully*. Modifications will be done to the cabins to accommodate more people in the future but the timing of these changes is unknown.
- 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 'might' be Internet access available all the way to Station P in the near future; negotiations are underway with Coast Guard and Ocean Networks Canada.
- The Tully ADCP has been fixed and is operational.
- If you leave chemicals at IOS between cruises, **make sure to leave SDS with the chemicals, as well as very clear contact information of the owner. Unidentified chemicals left at IOS will be disposed of.**
- The 2020-2021 Line P cruises will be as follow:
    - 2020-006 will go from 1 May to 19 May 2020 and is mainly a "mooring cruise".
    - 2020-008 will go from 22 August to 8 September 2020 and is mainly a Trace Metal cruise.
    - 2021-001 will go from 1 February to 18 February 2021 and we're hoping to do some coastal work at the end, weather permitting.
- Everyone participating to a Line P cruise has to stand a 6-hour watch.

Finally, a slide was presented with berths reservations for the next fiscal year, up to February 2021. This slide is included in Appendix 2. **Please confirm your berths bookings, and/or let me know as soon as possible if you would like to have your name on the waiting list.**

I would like to thank Ocean Networks Canada for providing the catering during breaks, Steve Romaine for IT support, and Moira Galbraith and Germaine Gatien for their "welcoming duties".

Akash Sastri (DFO/IOS): *The La Perouse/WCVI long term monitoring program: survey overview and participation opportunities.*

The La Perouse/WCVI monitoring program is a long-term oceanographic survey started in 1979 at shelf, slope and offshore stations off the southern west coast of Vancouver Island. The survey area has since expanded northward into Queen Charlotte Sound to include multiple sampling lines extending from shelf to the offshore. The present-day survey includes 112 standard sampling stations on the outer coast and 14 stations in the Salish Sea. The cruise track typically starts on the southern shelf and heads north. Standard stations activities include a CTD profile, water sampling and zooplankton sampling (Bongo nets). Core measurements include: zooplankton and phytoplankton abundance, biomass and taxonomy; physical and chemical water column properties; and underway sea-surface temperature and salinity. There are two 11-13 day annual surveys taking place in late May/early June (typically preceding Line P) and in late August/early September (typically following Line P). The 2020 surveys are scheduled for May 19th-June 2nd and September 8th- 22nd. Given the increased interest in this survey as a sampling platform we are planning a tentative November workshop to coordinate research goals/interests among current participants.

Bill Crawford (DFO/IOS – emeritus): *Changes in oxygen in subsurface waters along Line P.*

Bill Crawford and Angelica Peña

We have examined trends in oxygen concentration (O_2) near the bottom of the continental shelf off the southwest coast of Vancouver Island and in subsurface waters along Line P. For the past three summers, O_2 was at or near the lowest observed in four decades in late summer on the continental shelf. Much of the variability in the past three decades can be explained by changes in water mass, whereby saltier and denser waters are lower in O_2. This relationship does not account for the sudden decrease in O_2 in the early 1990s.

In contrast, O_2 at 200 and 250 metres depth on the continental slope at Line P station P4 in the past decade has been at or near the highest observed over the past four decades. As is observed on the continental shelf, saltier and denser waters tend to be lower in O_2 over the past three decades, but not in earlier years.

To include observations in all seasons and at all main Line P stations since 1950, I interpolated O_2 onto the 26.5, 26.7 and 26.9 constant density surfaces (densities of 1026.5, 1026.7, and 1026.9 kg/m^3) and included data from surrounding waters. In general there is a long-term trend of decreasing O_2 on these surfaces, especially on the 26.9 surface. Some of these surfaces are decreasing in depth, such that at some stations, generally the eastern ones, O_2 at constant depth is decreasing less slowly, or not at all.

Sophia Johannessen (DFO/IOS): *Constraining upper-ocean carbon export using a multi-platform approach.*

In collaboration with Andrea Fassbender and William Haskell, Monteray Bay Aquarium Research Institute, USA.

The vertical export of organic and inorganic carbon from the surface layer represents a short-cut to carbon sequestration in the deep ocean. The objectives of this project are: 1) to determine net community production of phytoplankton in the surface waters near Station P; 2) to determine the relative proportions of dissolved and particulate organic carbon and particulate inorganic carbon produced; and 3) to compare rates of carbon export determined from biogeochemical profiling floats, satellite ocean colour imagery, and in situ water samples.

Early results from biogeochemical floats indicate that dissolved organic carbon (DOC) represents about 25 % of the total organic carbon (TOC) produced by phytoplankton. In contrast, the DOC/TOC ratio measured in situ is about 0.96, illustrating that most of the DOC in the upper ocean is old, refractory material. Satellite and biogeochemical estimates of net community production match well, while estimates of carbon export using the two methods differ in both magnitude and timing. The discrepancy is likely due to differences in the export ratio determined by the two methods.

Jonathan Kellogg (Hakai Institute and CIOOS Pacific): *CIOOS: A new tool to explore Line P and IOS data.*

The Canadian Integrated Ocean Observing System (CIOOS) Pacific Regional Association is a new cooperative initiative dedicated to fostering access to oceanographic data. Funded by Fisheries and Oceans Canada and the Marine Environmental Observation, Prediction, and Response Network (MEOPAR), CIOOS has three regional associations across the country. Hosted at the University of Victoria, CIOOS Pacific partners with the Institute for Ocean Sciences, Ocean Networks Canada, the Hakai Institute to assemble data from the west coast. Together, and in cooperation with their national partners, they have developed an interface where users may search and query a database to access assets at either the national or regional level. The goal of this effort is to improve the utility of marine data in research, industry, and public understanding.

Part of this effort is demonstrating the utility of marine observation and monitoring. With over sixty years of data, Line P monitoring has contributed much to our understanding of ocean processes, but remains under-appreciated. CIOOS Pacific's public facing website will delve into the apparent trends from Station Papa, history and evolution of monitoring at the site, and other notable discoveries from this effort. While not meant to be comprehensive, this site will continue development and is seeking feedback that will guide these efforts.

Jim Thomson (APL/UW) and Meghan Cronin (NOAA): *Surface moorings at Station P.*

Presented by Tetjana Ross.

We present an update on the surface moorings at OWS-P. Data collection is ongoing from 1) the NOAA mooring measuring surface meteorology, carbon dioxide flux, ocean acidification and upper ocean profiles, 2) a NOAA ocean noise reference mooring and 3) the UW-APL mooring measuring surface waves and ambient noise. Recent observations and seasonal trends will be presented, including the modulation of short wind-waves by ocean swell. The UW-APL mooring was serviced in Dec 2019 as part of a dedicated science cruise studying bubble plume generation during surface wave breaking. The NOAA moorings respectfully request shiptime aboard the May 2020 Line P cruise for servicing in May 2020.

Tetjana Ross (DFO/IOS): *Gliders along Line P.*

Ocean gliders have been collecting data along Line P since July 2019. This presentation will overview glider technology and its advantages, discuss the data that have been collected so far and how to access it.

Jody Klymak (UVic): *Update on the Canadian-Pacific Ocean Observatory Facility (C-PROOF).*

Jyotsnamani Mohanta (U Sask): *Determination of chromium speciation in seawater.*

J.Mohanta and Chris Holmden

In recent years, chromium isotopes have emerged as a promising new proxy for reconstructing past redox conditions in the oceans, and marine carbonate sediment is being investigated as a substrate that might record these redox-driven changes. Our analysis of shallow water carbonate sediment from the modern Caribbean Sea showed difference of –0.45‰ ($\Delta^{53}Cr_{(CaCO3\text{-}SW)}$) between seawater ($\delta^{53}Cr$=1.14‰) and bulk carbonate sediment ($\delta^{53}Cr$=0.69 ‰), implying partial Cr(VI) reducion to Cr(III) during its removal from seawater. Bulk carbonate sediment from different locations yields a range of $\delta^{53}Cr$ values from 0.49‰ to 0.96‰, despite the fact that seawater is presumed to be constant in all of the studied locations along the Yucatan coast (1.14‰). The variation in bulk sediment $\delta^{53}Cr$ values cannot be due to variations in carbonate producers or mineralogy, but could be related to different rates of Cr(VI) uptake from seawater, and local factors affecting Cr isotopic fractionation during uptake, which could include carbonate mineralogy, grain size and the age of the sediment. The increase $\delta^{53}Cr$ and Cr conc in sediments with respect to time suggests that there is an additional flux of isotopically heavy Cr after the carbonate is released by the organisms to form a sediment.

An understanding of chemical speciation of trace metals in natural water is important because the effect of trace metals on ecological and biological systems are generally influenced by their chemical forms. Elderfield (1970) found, using thermodynamic calculations, that $Cr(VI)O_4^{2-}$ should be the predominant species in oxygenated water. But he also showed, through direct measurements, that in certain cases, the concentration of Cr(III) is higher than Cr(VI). Soluble Cr(III) is complexed with organic ligands because both enzymatic and chemical reductions of Cr(VI) in the presence of organics generate stable, soluble organo-Cr(III) complexes (Puzon et al., 2002; Puzon et al., 2005). Since Cr(III) concentrations in most cases are very small, it is convenient to measure Cr(total) and Cr(VI) using Fe(II) method while calculate Cr(III) with the difference.

In this talk I will present the results from the study of Cr isotopic composition of marine carbonates. I would also be talking about the preliminary results from my speciation experiments conducted on standards. In addition to this, I would discuss the implementation of the speciation method on natural waters to demonstrate the extent to which various pools of dissolved Cr species exist in rivers, estuary and seawater.

Robyn Taves (UVic): *Iron and nutrient inventories along Line P during the 'Blob'.*

The subarctic northeast Pacific Ocean experienced a sea surface temperature (SST) anomaly from 2013-2015, colloquially known as the Blob. Summer surface warming and diminished winter convection caused strong stratification and anomalously high sea surface temperatures over much of the subarctic northeast Pacific. The anomalous conditions were associated with a change in phytoplankton community composition and a reduction in mixed layer nutrient concentration. Currently there is little known about the trace metal dynamics and distribution within the mixed layer during the Blob.

Mixed layer depths from 2013-2015 were calculated along with their respective dissolved iron and phosphate concentrations. Iron and phosphate inventories along Line P were generally lower during 2014-2015 compared to 2013, suggesting the conditions during the Blob had an effect on trace metal and nutrient distributions. Future work will compare dissolved metal to nutrient ratios and potential correlations to phytoplankton community composition.

Richard Nixon (UVic): *Evidence for the production of copper-complexing ligands by phytoplankton along Line P.*

Richard L. Nixon, Andrew R.S. Ross, Jasper George, David J. Janssen, Sarah L. Jackson, Jay T. Cullen, Kyle G. Simpson and Marie Robert

Organic complexation affects the uptake of copper and other bioactive metals by phytoplankton, with important implications for marine productivity and climate change. However, relatively little is known about the origin and identity of marine copper-complexing ligands. We used immobilized copper(II)-ion affinity chromatography (IMAC) to isolate dissolved (< 0.2 µm) copper ligands from seawater samples collected during the 2015 Canadian Arctic GEOTRACES expedition and recent Line P cruises. UV detection at 254 nm was employed to monitor elution of the compounds retained by IMAC. The areas of the resulting peaks were used to generate depth profiles showing the distribution of marine copper ligands in the Canadian Arctic and along Line P. The depth of highest ligand concentration was generally found to coincide with the chlorophyll maximum depth. Correlations between ligand concentration and *in situ* chlorophyll-a fluorescence further suggest that marine phytoplankton or cyanobacteria could be an important source of copper ligands. Spectroscopic analysis of fractions collected during IMAC provides additional information about the composition and structure of these ligands. Use of this information to better understand and predict how copper complexation and bioavailability might affect or be influenced by plankton ecology and climate change will be discussed.

Sile Kafrissen and Michael Livingston (UVic): *Ecology and physiology of phytoplankton along oceanographic gradients in the northeast Pacific.*

The Line-P transect represents an ideal setting to examine how phytoplankton communities change along natural environmental gradients, both spatially and temporally. By examining a variety of ecophysiological factors along these gradients we can begin to interpret how these communities respond to environmental changes. We collect samples and perform in-situ uptake experiments at five major Line-P stations, beginning in June 2019. Measurements are taken for phytoplankton ID, total and size fractionated Chl-a and particulate biogenic silica, dissolved nutrients, carbon, nitrate and silica uptake, transparent exopolymer (TEP) production, bacterial biomass, POC, PON, POP, and phytoplankton fatty acids. By examining how these key traits vary along natural environmental gradients, we can build a better predictive model of how functionality of the primary producer community may change in response to environmental shifts. We discuss current project goals and present preliminary data from both spring and summer 2019 Line P cruises assessing the relationships between phytoplankton biomass, community structure, overall productivity and POC/TEP production. Additionally, we present updated primary productivity data from the Line-P 2018-040 and EXPORTS cruise.

Sachia Traving (UBC): *Microbial carbon transformation potential along the Line P transect.*

The oceans play a fundamental role in regulating the Earth's climate system by sequestering vast amounts of carbon, including ~30 % of the carbon emitted to the atmosphere by fossil fuel burning (Ciais *et al.,* 2013). Marine organic matter is a significant component of the global carbon cycle and one of the most dynamic reservoirs. The amount of carbon bound in dissolved organic matter (DOM) alone is on the order of 700 Pg C, equivalent to the amount of atmospheric CO_2. Microbes are the engines driving breakdown of DOM in the ocean, with a metabolic repertoire that is directly linked to carbon sequestration. Microbial carbon uptake is

size-limited and extracellular carbohydrate active enzymes (CAZymes) facilitate the initial breakdown of substrate into molecules sufficiently small for transport (~600 Da, Weiss *et al.*, 1991). These enzymes are often the rate-limiting step in microbial turnover of organic carbon in the ocean (Arnosti, 2011). Here we present the first explorations of 42 shotgun metagenomic datasets from the Line P transect traversing coastal to open stations and defined gradients of light, temperature and energy with emphasis on the distribution and diversity of CAZymes. We identify spatial and temporal patterns associated with specific CAZyme families, and the next step will be to link these patterns to specific taxonomic groups using both single-cell genomes and metagenome assembled genomes as recruitment platforms providing a foundation for genome-resolved metabolic reconstruction of DOM transformation in the northeastern subarctic Pacific Ocean.

Roberta Hamme (UVic) for David Siegel (EXPORTS): *Highlights from the 2018 EXPORTS work near Station P.*

EXPORTS is a US NASA funded program that conducted an intensive study of the offshore NE Pacific near P26 in August-September 2018. The primary science questions involve understanding how the upper ocean ecosystem affects export, what controls the efficiency of transport deep into the water column, and how to reduce uncertainties in estimating export. The 2018 field campaign near P26 was meant to fully quantify a low export / low transfer efficiency ecosystem. A glider measured increased chlorophyll fluorescence and backscatter starting after the EXPORTS ships left the site and continuing into mid-October. The 13C-primary production measured at the central station during the Sept 2018 Line P cruise was much higher than the values during the main EXPORTS time period, supporting the glider-based increase in productivity. Net community production from glider O2 measurements were variable, but also peaking in mid-Sept, coincident with Line P O2/Ar measurements. 234Th and sediment trap samples from EXPORTS suggested generally lower fluxes in Aug-Sep 2018 than historically seen on Line P. Several lines of evidence suggest large shifts in the region during the main EXPORTS program, including: surface T and S changes, shifts in the bacterial community composition from genomics data, shifts to greater diatom and dinoflagellate numbers from the flow cytobot, and a large contribution of salps in the early part of the experiment. EXPORTS will put together a special issue in Elementa, which Line P scientists are invited to join. Data can be submitted to SeaBASS and BCO-DMO to link up with the main EXPORTS dataset.

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 DFO's 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: Berths reservations for 2020-21.

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 15.

June 2020 — 15

DFO-IOS	5
Chief Scientist (Robert)	
CTD watch (Galbraith)	
CTD watch (Romaine)	
DMS (Arychuk)	
TM (Simpson)	

UBC	5
Hallam - 1 (Hallam)	
Tortell - 3 (Tortell, Sezginer, Schuler)	
Maldonado - 1 (Mangahas)	

UVic	2
Varela - 2 (Livingston, Kafrissen)	

NOAA	2
Anderson, Higley	

MUN	1
Reader - 1 (Zheng)	

Waiting list	
Reader	1
Stevens	1
Morgan	1

August 2020 — 15

DFO-IOS/BIO	5
Chief Scientist (Robert)	
CTD watch (Rados)	
CTD watch (?)	
DMS (Arychuk)	
Cesium (Nelson)	

UBC	3
Hallam - 1	
Maldonado - 2	

UVic	5
Varela - 2 (Livingston, Kafrissen)	
Cullen - 3	

U Sask	1
Holmden - 1	

MUN	1
Reader - 1	

Waiting list	
Stevens	1
Morgan	1

February 2021 — 10

DFO-IOS	5
Chief Scientist	
CTD watch (Belton)	
CTD watch (Van Buren)	
DMS (Arychuk)	
Trace Metal	

UBC	2
Hallam - 1	
Maldonado - 1 (Mangahas)	

UVic	2
Varela - 1	
Stevens - 1	

MUN	1
Reader - 1	

Waiting list	
Morgan	1
Pakhomov	1