Regional Operations Centre
Canadian Coast Guard – Pacific

PACIFIC REGION CCG VESSEL - POST CRUISE REPORT

Line P Program – Fisheries and Oceans Canada

NAME OF SHIP/PLATFORM: John P Tully

DATE: **FROM:** 24 August 2021 **TO:** 07 September 2021

SCIENCE CRUISE NUMBER: 2021-008 **SHIP'S PATROL NUMBER:** 21-06

CHIEF SCIENTIST[S]: Marie Robert

SCIENTIFIC PERSONNEL:

Female	Male
Danielle Caleb (IOS)	Glenn Cooper (IOS)
Wylee Fitz-Gerald (UBC)	Rowan Fox (IOS)
Racquelle Mangahas (UBC)	Michael Livingston (UVic)
Marie Robert (IOS)	Steve Romaine (IOS)
	Kenny Scozzafava (IOS)

AREAS OF OPERATION: Haro Strait, Juan de Fuca Strait, Line P.

INTRODUCTION/PROGRAMS BACKGROUND:

Line P is a long standing monitoring program which surveys a 1400 km long section 3 times annually. Data have been collected along this line since 1956 and show evidence of the impact of climate variability on ocean productivity. It is the only Canadian long time-series that allows scientists to monitor climate changes so far offshore in the Pacific Ocean. It is also the best opportunity for other programs (e.g. Universities) to do research in the Pacific since the Line P data give them background as well as current water properties.

CRUISE OBJECTIVE/OBJECTIVES: Water properties, zooplankton, and trace metal sampling along Line P; deployment of drifters for UCSD.

CRUISE DESCRIPTION: Our departure on this cruise almost got compromised by some clutch issues on the *John P Tully*. Thanks to the hard work from the engineering department, we left only 6 hours past the first ETD. The first morning en route revealed many changes in the usual science equipment setup (see both "problems" sections) but eventually all equipment worked properly.

DAYS ALLOCATED: 14

DAYS OF OPERATION: 13

DAYS LOST DUE TO WEATHER: None.

SAMPLING:

- The cruise was very successful. Despite numerous gremlins showing up during the cruise all the work got done, with the exception of the bongo casts past station P8 due to winch issues (see sections below).
- The samples collected include:

  1) Underway: Thermosalinograph (Temperature, Conductivity, Fluorescence), acoustic sounder, ADCP, pCO_2.

  2) "E-data" from CTD: Pressure, Temperature, Conductivity, Dissolved Oxygen, Transmissivity x2, Irradiance, Fluorescence.

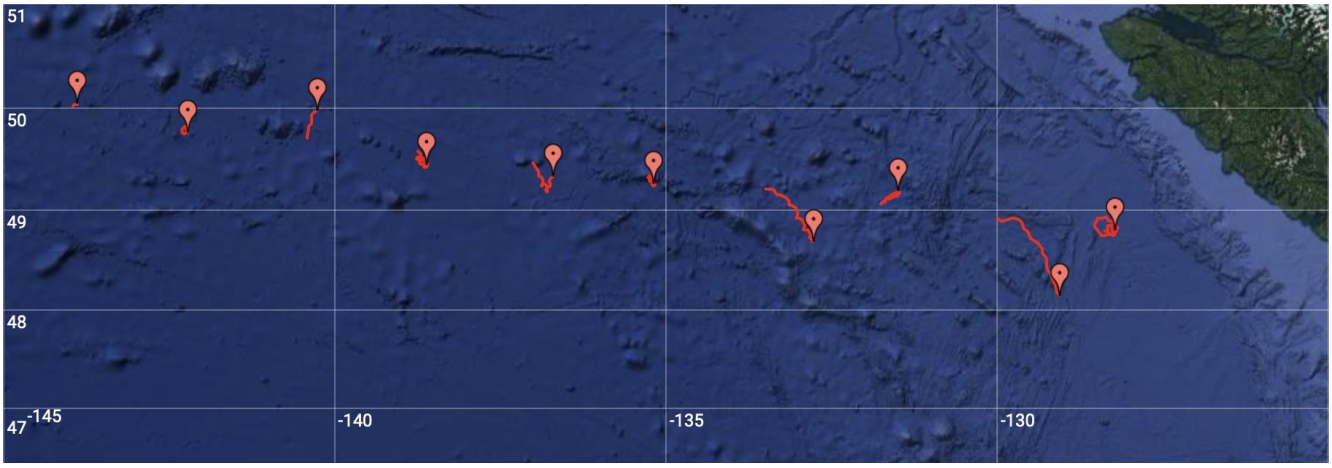
  3) From the Rosette: Dissolved oxygen, salinity, nutrients, chlorophyll, pigments (HPLC), dissolved inorganic carbon (DIC), alkalinity, phytoplankton, DMS, DMSP, total organic carbon (TOC) **– UVic (Livingston):** chlorophyll, particulate carbon and nitrogen, carbon gels, nutrients, particulate/biogenic silica, carbon update (size fractionated), silica update (size fractionated), nitrogen uptake = "new production" (size fractionated), bacteria, particulate phosphate, fatty acids, DNA – **UBC (Fitz-Gerald):** chlorophyll, flow cytometry, nutrients, DNA, RNA, phytoplankton identification, single cell genomics, C13, FRRF (fast repetition rate fluorometry).

  4) Zooplankton nets: Vertical net hauls using a Bongo, 236 µm mesh size, were done to 10 m off the bottom at Haro59 and JF2, 250m casts were done at P2, P4 and P8, and a 1200m cast was done at P8. Winch problems prevented further zooplankton sampling after station P8.

  5) Trace metal Go-flos: **IOS and UBC (Mangahas):** trace metals filtered, trace metals unfiltered, ligands, speciation of trace elements, lead, nutrients, salinity.

As part of the NOAA-funded Global Drifter Program (GDP; https://gdp.ucsd.edu/ldl/global-drifter-program/), 5 Surface Velocity Program Barometer (SVPB; https://gdp.ucsd.edu/ldl/svpb/) and 5 Directional Wave Spectra Barometer (DWSB; https://gdp.ucsd.edu/ldl/dwsbd/) drifters were deployed along Line P out to Ocean Station Papa to enhance the Global Drifter Array in this area. Surface drifters equipped with a barometer are known to have a sizeable beneficial effect on atmospheric reanalysis products as well as Numerical Weather Prediction models and atmospheric pressure measurements from drifters are not only an essential component to accurately constrain the large-scale sea level pressure field, but also to correct errors of numerical atmospheric models in case of fast evolving storms and explosive cyclogenesis [e.g., Centurioni et al., 2017]*.

*Centurioni, L., A. Horányi, C. Cardinali, E. Charpentier, and R. Lumpkin. 2017. A global ocean observing system for measuring sea level atmospheric pressure: Effects and impacts on numerical weather prediction. *Bulletin of the American Meteorological Society* 98(2):231–238, https://doi.org/10.1175/BAMS-D-15-00080.1.



RADIOISOTOPE USE:

Radioisotopes (^{32}Silica) were using during the cruise. The Rad-Van was decommissioned at the end of the cruise.

PROBLEMS [SCIENTIFIC GEAR AND OPERATIONS]:

The rosette pylon failed just before the test cast in Saanich Inlet and had to be replaced.

The vacuum pump used for filtering the chlorophyll samples seems to have a faulty pressure gauge. After a few days at sea it started to work only intermittently until it totally stopped working. Fortunately we had a spare pump on board.

One Go-Flo bottle got broken during the last Trace Metal cast. The Go-Flo bottles are secured in pair, one bungee cord securing two bottles. While passing one Go-Flo bottle to a co-worker the bungee did not get reattached so that the remaining bottle fell to the deck and broke. It is suggested that the Go-Flo bottles be secured individually.

The spigot of a Go-Flo bottle got damaged, either during deployment or recovery in the chains. The spigot most likely hit the railing of the chains.

The PCO_2 system disconnected from the GPS a couple of times at the beginning of the cruise and the PCO_2 system had to be re-booted to read the latitude and longitude. There was a gas leak from standard 2 at the fitting behind the large black box of the PCO_2 system that had to be tightened on day 2, no further gas leaking was observed. Just prior to P26 it was noted that the standard deviation was very high for all standards, this was due to the valves not switching over, the system was rebooted and the valves seem to be working well. The PCO_2 system was kept running for the steam back to IOS to collect data that may have been missed on the way out to station Papa.

SUCCESSES [SCIENTIFIC]:

We managed to find and recover a mooring for PBS. See SUCCESSES [SHIP] section. Although this entry had to go "somewhere", it really was a team effort and belongs in both sections, with special kudos to Glenn Cooper.

It seems that many 'regular' settings had been modified by previous users of the ship. We managed to go through all the issues one by one and get the science equipment work the way it normally does.

The DMS GC system worked very well for the entire trip, no issues were noted.

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

There was an issue plugging-in the DMS container as we got on board. The ship end of the plug was missing a thread-in collar that the container end of the plug needs to screw in. Fortunately the plug is in a very low risk area and the engineers managed to get power to the container in a safe way.

The acoustic sounder lost communication with the transducers during the first night. Thanks to Chelsea Stanley for her help in getting the communication going again.

The counter on the bongo winch stop functioning at P4 so the deep bongo had to be cancelled. Thanks to the engineers we were back in action shortly after leaving that station.

At station P8, the bongo winch had a brake failure during the upcast of the 1200 m bongo. The winch could not be safely used for the rest of the cruise.

The 12 kHz sounder stopped functioning just before Station P. It could not detect the bottom anymore despite all our attempts. Thanks to CCG IT technician Chad Paget (via MS Teams) we found out that the sounder was mistakenly set on RAM instead of HULL.

The server rack in the lab was cleaned up and cables/power cords were labelled. There were a few floating power bars that were secured as well. We noted that the power line feeding the port "Triplite" power bar was quite warm to the touch likely due to the many draws on that power bar. There is an un-used circuit feed in the rack that likely the ONC satellite dish power could be moved to when back at IOS to reduce current on this circuit.

SUCCESSES [SHIP]:

The Tully weather stations seems to be giving much better data.

We managed to find and recover a mooring for PBS, thanks to the "instinct" of Captain Shuckburgh and the great skills of the crew. This was a great team effort and the people from the Whale Group at PBS are extremely grateful:

> *Not only are we recovering very valuable equipment but also a year of data that is particularly important because of the unprecedented abundance of the (extremely rare) sei whales in the area. This will answer a lot of questions about their timing and movements.*
>
> *Thomas Doniol-Valcroze*

DELAYS [OTHER THAN WEATHER]:

~9 hours because of clutch and/or engine issues.
~6 hours for fueling.
A few hours for tank breaks.

SAFETY CONCERNS:

None

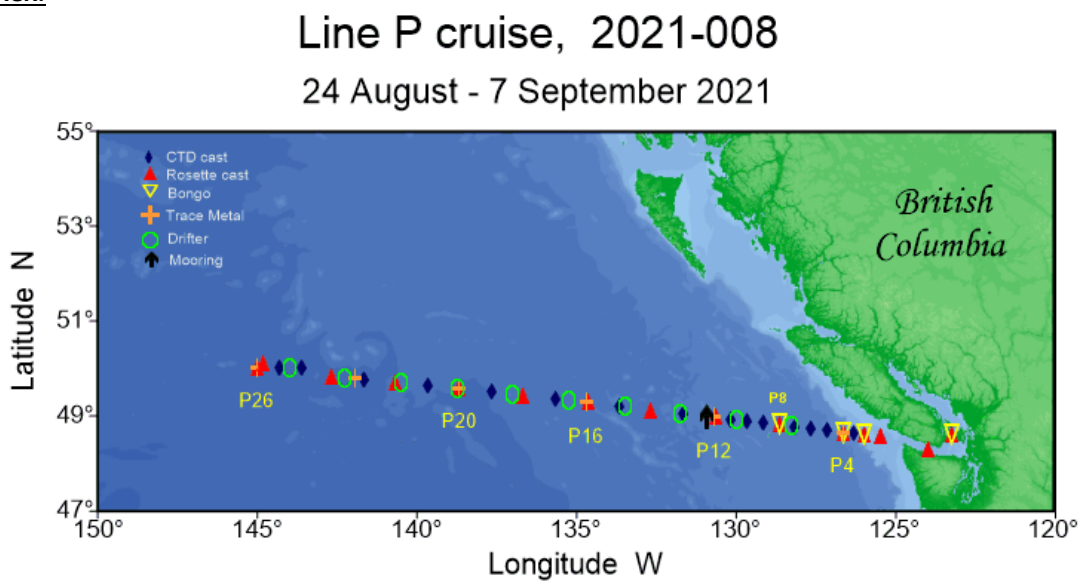
HAZARDOUS OCCURRENCES:

None.

EVENT LOG:

Tuesday 24 August:	Load cube van, load equipment on the ship. Science meeting at 1545, safety meeting at 1600.
Wednesday 25 August:	Leave the dock around 0000. Saanich Inlet test cast cancelled because of failed pylon. Replace pylon while underway. Haro59, JF1 to JF4, P1 to P3. Fire and boat drill at 1300.
Thursday 26 August:	24-hr inspection of the clutch. P4 to P7. Deploy one drifter for UCSD.
Friday 27 August:	P8 to P11, start P12. Second (science) COVID testing. Deploy one drifter for UCSD.
Saturday 28 August:	Complete P12, P13, P14, P15. Deploy two drifters for UCSD.
Sunday 29 August:	P16 to P18. Deploy one drifter for UCSD.
Monday 30 August:	P19 to P21. Deploy two drifters for UCSD.
Tuesday 31 August:	P22 to P24. Deploy two drifters for UCSD.
Wednesday 1 September:	P25, P35, P26, PA-015. Deploy one drifter for UCSD.
Thursday 2 September:	Start heading east.
Friday 3 September:	Transit east. Third (science) COVID testing.
Saturday 4 September	Transit east.
Sunday 5 September:	Transit east. CTD cast at P2 and P1. Arrive in Pat Bay in the evening.
Monday 6 September:	Fuel. Offload. More fuel.

CRUISE TRACK:



SUMMARY/FINAL COMMENTS:

- First of all, a 'million thank you' to Captain Shuckburgh for ensuring that the Line P cruise did not get compromised by the issues assailing the previous users. This cruise could have been greatly delayed and we would not have had time to make it to Station P, let alone recover the PBS mooring or allow the UBC students to pump Trace Metal clean water for their experiment. Thank you for keeping the cruise on schedule, and for everything during the cruise.
- The same 'million thank you' are due to Chief Engineer Andrew Weaver and his team (Brendan, Oliver, Shauna, Kelvin, and cadets Angelo and Josh) for working so hard to get the clutch problems fixed. Needless to say, this was crucial work and they worked very hard so we could sail on time. And despite all that hard work on the clutch they were still available to deal with our questions and demands when we got on board (e.g. the constant requests for retention ☺). Thank you very, very much. And a special thanks to Chief for constantly keeping me in the loop; this is much appreciated.
- Big thanks to Dale for making things run so smoothly, and for Adam, Emily (and cadet Max) for hours of station keeping as well as the "10-min warnings" before stations and drifter deployments.
- Spencer and your crew: your help was invaluable, especially with the Trace Metal work in the chains. Thank you.
- And last but definitely not the least, thank to Derek and your whole galley team (Megan, Brandon, Kerstin, Brad and Evelyn) for great meals, wonderful service, and smiles all around. Cabin service was particularly appreciated. And special thank you to Megan for making the vegetarian meal option available as a menu item.
- Thanks to NRCan for paying for the ONC high bandwidth in August, and for OSD to cover the costs for September.
- Finally, thanks to "the science gang" for offloading; you know who you are ….

  Marie Robert

- We would like to thank the entire science team and ship crew for their hard work helping make this happen and for Kyle Simpson's trace metal supplies.

  Wylee Fitz-Gerald

- I would like to thank Marie Robert and the rest of IOS for the opportunity to conduct research alongside them. Special thanks to Glenn Cooper, Steve Romaine & Rowan Fox for helping me with the Go-Flos. Thank you to Kyle Simpson for providing the advice and resources needed for the trace metal sampling, as well as for the incubation. Thanks to the captain and crew of the J.P. Tully for providing a safe, welcoming and warm accommodation, as well as those who helped with the Go-Flo deployments and 'pumping the chains' for the incubation.

  Racquelle Mangahas

PROJECTS AND RESULTS:

Water masses – Marie Robert, DFO/IOS.

Two features were of note during this cruise. The first one being very low oxygen values at depth on the coast of Vancouver Island. Figure 1a shows the dissolved oxygen signal at station P1 in August or September from 2011 to 2021, whereas figure 1b shows the same variable at station P2. The 2021 values, represented in the red line, are clearly the lowest that we have seen just above the sea floor during the last decade.

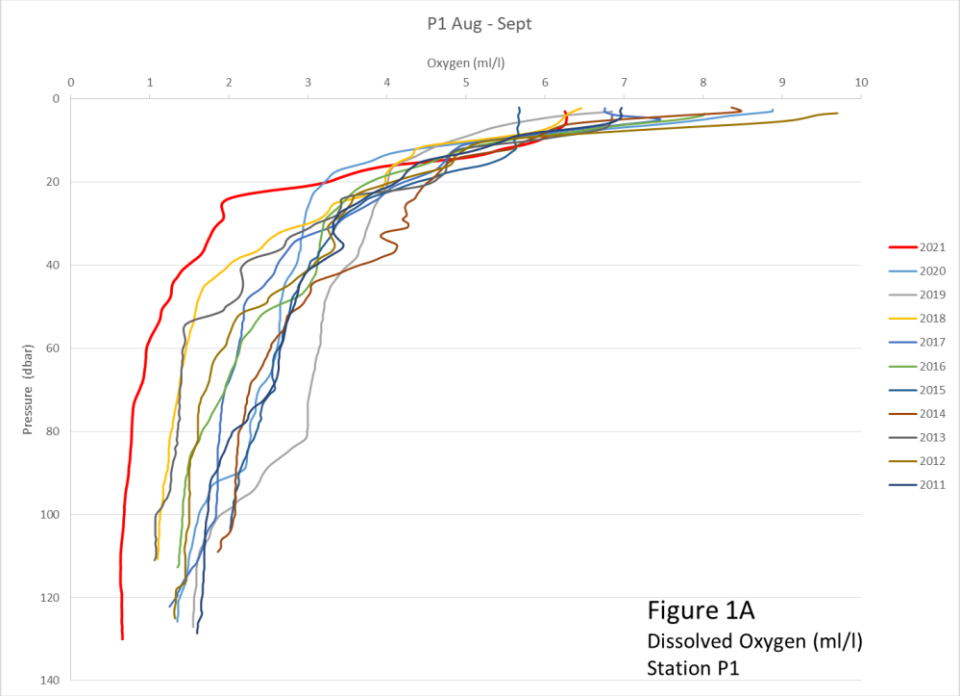


Figure 1A
Dissolved Oxygen (ml/l)
Station P1

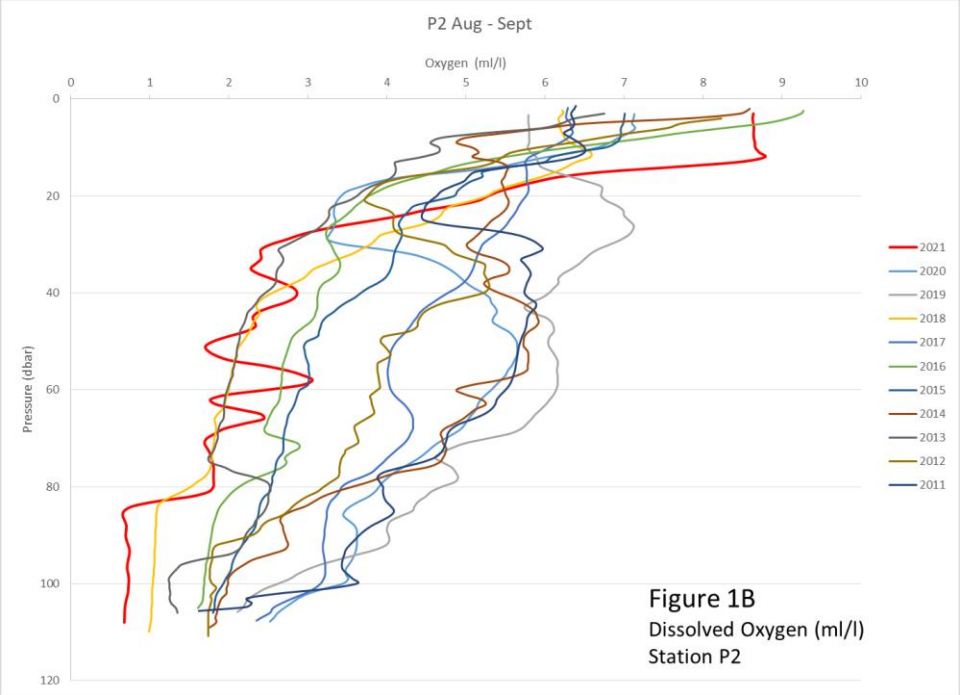


Figure 1B
Dissolved Oxygen (ml/l)
Station P2

The second feature is the offshore near surface stratification where warm and fresh water can be found in the upper ~50 m (for temperature) and ~200 m (for salinity). Inshore of station P8 the pattern is very different, with cooler and saltier water. The panels of figure 2 below show the temperature field, temperature anomaly field, salinity field, salinity anomaly field, density field, and density anomaly field, respectively. Note that the anomalies are calculated with respect to the 1956-1991 averages. Very strong storms will be needed to mix the less dense surface waters, and the absence of those strong winds could mean the advent of another marine heat wave.

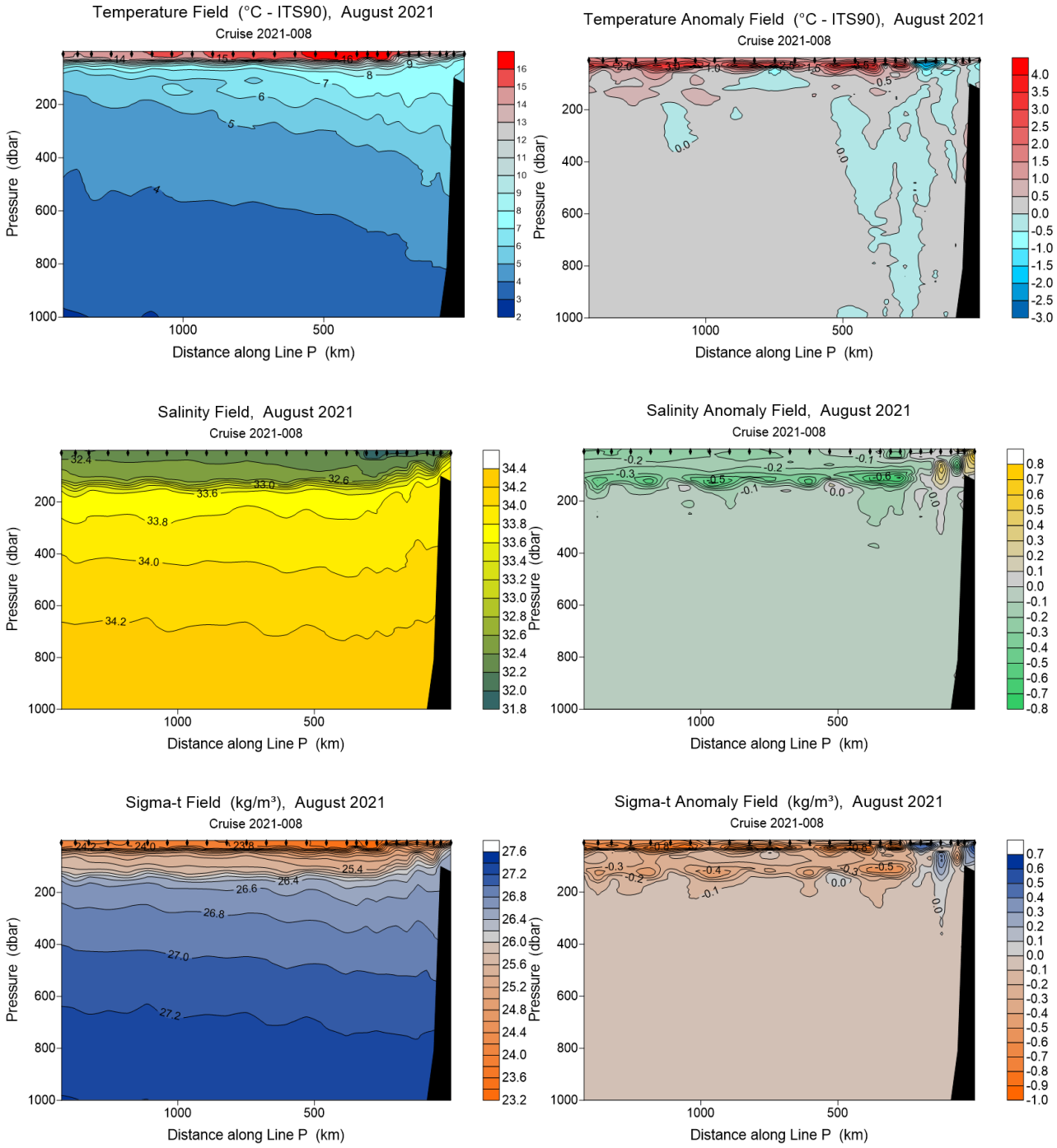


Figure 2: Conditions along Line P in August 2021.

Cruise report – Wylee Fitz-Gerald, UBC.

Westerly winds transport aerosols across the Pacific Ocean to the Line P transect. These Asian-derived aerosols are composed of a mixture of natural and anthropogenic aerosols. While natural aerosols are often enriched in essential trace elements (i.e. Fe), anthropogenic aerosols may contain high levels of potentially toxic metals (i.e. Cu). Our project aimed to mimic August aerosol deposition at OSP. Using aerosol filters collected at OSP during previous August 2019 and 2020 cruises and water collected using trace metal clean techniques at station P23 during this cruise, we performed a 5-day in-situ aerosol incubation. August 2019 aerosols represent a period prior to Covid-19 with typical aerosol emissions, while August 2020 aerosols represent a period during China's lock down when anthropogenic emissions were severely decreased, reducing the anthropogenic to natural aerosol ratio. The aim of this incubation was two-fold: to investigate the physiological and transcriptional response of marine microorganisms to environmentally relevant high and low aerosol depositions and to determine the impact aerosols, influenced by anthropogenic activities (e.g. Asian-derived aerosols), have on ocean micro-communities. We collected trace metal, speciation, RNA, DNA, single cell genomics, flow cytometry, chlorophyll, nutrient, fast repetition rate fluorometry (FRRF), C13 and phytoplankton ID samples.

Additionally, samples (DNA, phytoplankton ID, Flow cytometry, nutrients, chlorophyll and fast repetition rate fluorometry data) were taken along transect at 10m depth at P4, P12, P16, P20 and P26.

We would like to thank the entire science team and ship crew for their hard work helping make this happen and for Kyle Simpson's trace metal supplies.

Cruise report – Michael Livingston, UVic.

This project set out to accomplish two main goals on this cruise (and previous Line P cruises):
i) Develop statistical models to estimate carbon gel (TEP) concentrations, and ii) Determine rates of biological carbon, nitrogen and silica uptake rates and relate them to a variety of other measurements.

Predicting carbon gel concentrations in the Northeast Pacific Ocean:

Transparent exopolymer particles (TEP) are biogeochemically important carbon gels that play an essential role in the cycling of carbon within the upper layers of the ocean. This project has shown that TEP is strongly correlated with chlorophyll, nitrate, and dissolved oxygen concentrations, as well as the depth of the mixed layer. These relationships allow for the development of statistical models that accurately predict upper mixed layer TEP concentrations from the above variables. These models are currently being applied to the Line P dataset available on the Water properties website. This will allow for the estimation and identification of any changes or patterns in TEP concentrations from the years 1998 – 2021. This cruise was especially important as it provided more data on TEP (and its predictor variables) that will act as important validation points. All the data that created and validated these models were from Line P cruises (2019 – 2021).

Carbon uptake and 'new production': a multivariate analysis

The second project undertaken on this cruise relates to biological carbon uptake, and the 'export potential' of organic carbon as determined from nitrogen and carbon isotopes. This project aimed to relate both carbon uptake and export potential to a wide variety of different measurements, including size fractionated carbon, nitrogen and silica uptake rates, phytoplankton community structure, TEP, particulate organic carbon, Dimethly sulfide, and environmental conditions. Importantly, it contrasts carbon uptake rates across different seasons and years. This data will also be compared with similar datasets from the early 1990s and 2000s to illuminate any potential changes in biological uptake rates along Line P over the last several decades.

Cruise Report: 2021-008 Line P- Racquelle Mangahas (University of British Columbia)

Asian-derived aerosols can undergo long range transport due to strong westerly winds, thereby crossing the Pacific Ocean and even reaching North America. These aerosols are chemically diverse; particles can be made up of dust, sea salt, fly ash, sulfate, nitrate, organics and/or – what I'm primarily interested in - metals. Aerosol particles from lithogenic sources (e.g. Gobi and Taklamakan deserts) are often characterized to be large in size and contain elements such as Fe, Ti, Mn, V & Al. Meanwhile, aerosols from anthropogenic sources (e.g. coal-fired power plants and heavy industries in China) are generally smaller in size (<2.5 μm) and known to contain elements such as Cu, Cd, Zn & Pb. During transit, aerosols experience atmospheric mixing, processing as well as aging which can consequently alter their composition and increase solubility. Aerosols can then be removed from the atmosphere and into the ocean by dry (i.e. turbulent diffusion & sedimentation) or - most dominantly in the North Pacific - wet deposition (i.e. in-cloud and below-cloud scavenging). The resulting oceanic ratio of essential to toxic trace metals, as well as their bioavailability can thus have an effect on phytoplankton communities.

The Line P program provides an amazing opportunity to investigate the temporal trends (i.e. seasonality) of Asian-derived aerosols, as anthropogenic aerosols are emitted year-long, but the dust season occurs mostly in the spring. Interestingly, aerosols have been continuously collected on Line P cruises since August 2019, and these samples may also provide insight to changes caused by the COVID19 pandemic, as anthropogenic emissions in Asia were shown to be significantly reduced during lockdown. Likewise, this program enables investigation of aerosol spatial trends, due to its stations spanning from coastal areas to the HNLC, Fe-limited regions of the open-ocean, where atmospheric inputs can have a significant influence on the biogeochemical cycling of trace metals.

During this cruise, I collected aerosols on Monkey's Island along the transect using a Total Suspended Particulate Volumetric Flow Controller High Volume Air Sampler (TE-5170V-BL). This instrument was connected to an Instromet Weather Systems Ltd wind speed and direction switch, in order to avoid the Tully's stack exhaust. From these samples, I will be determining trace metal concentrations, solubilities and deposition fluxes, as well as lead isotopic ratios. Likewise, at the 5 major stations (P4, P12, P16, P20 & P26), I deployed 10L Go-Flos on the Kevlar line via messenger release in order to collect 10m and 35m depth samples of dissolvable and total dissolvable trace metals, chemical speciation as well as lead isotopes. Aside from my own seawater samples, I collected trace metals for Kyle Simpson (IOS) and ligand samples for Andrew Ross (IOS). Lastly, Wylee Fitz-Gerald (UBC) & I collected 10m depth seawater at P23 and executed an incubation using aerosol samples collected from previous August cruises (more details in her cruise report).

I would like to thank Marie Robert and the rest of IOS for the opportunity to conduct research alongside them. Special thanks to Glenn Cooper, Steve Romaine & Rowan Fox for helping me with the Go-Flos. Thank you to Kyle Simpson for providing the advice and resources needed for the trace metal sampling, as well as for the incubation. Thanks to the captain and crew of the J.P. Tully for providing a safe, welcoming and warm accommodation, as well as those who helped with the Go-Flo deployments and 'pumping the chains' for the incubation.