BERING STRAIT NORSEMAN II 2023 MOORING CRUISE REPORT

Research Vessel Norseman II, Norseman Maritime Charters_*Nome-Nome, 4th-14th July 2023*

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Microplastic opportunistic sampling: Monica Orellana (UW)

As part of the Bering Strait project funded by NSF-AON (Arctic Observing Network), in July 2023 a team of US scientists undertook a ~11 day cruise in the Bering Strait and southern Chukchi Sea region on the US vessel Norseman II, operated by Support Vessels of Alaska, Inc..

The primary goals/activities of the expedition were:

1) **recovery of 3 moorings** carrying physical and biogeochemical oceanographic instrumentation (Woodgate & Peralta Ferriz, NSF-AON funding) and whale acoustic instrumentation (Stafford, separate funding). These moorings were deployed in the Bering Strait region in 2022 from the Norseman II.
2) **deployment of 3 moorings** in the Bering Strait region, carrying physical and biogeochemical oceanographic instrumentation (Woodgate & Peralta Ferriz, NSF-AON funding) and whale acoustic instrumentation (Stafford, separate funding).
3) search, using a portable Norbit multibeam system, for a mooring that was unable to be found last year.
4) a set of **CTD sections** studying water properties in the region, with some **sampling for nutrients and salinities** (Woodgate & Peralta-Ferriz),
5) collection of **trace metal/nutrient water samples** using a pumped system at selected CTD casts (Jensen)
6) collection of accompanying ship's **underway data**, viz. surface water temperature and salinity, ADCP velocity data and meteorological data (Woodgate & Peralta-Ferriz),
7) deployment of a **glider** (PIs: Statsecwich et al.),
8) taking of opportunistic and exploratory samples for **microplastic studies** (Orellana), and
9) opportunistic sampling of unexpected features of the region (this year, strange white debris in the water).

The cruise loaded and offloaded gear and people in Nome, Alaska.

As a Covid precaution, the science team undertook social distancing pre cruise, including masking during flights to Alaska and masking when with others inside, and a set of pre-cruise Covid tests.

Key Statistics:

3 moorings recovered, 3 moorings deployed,
78 CTD casts on 4 CTD lines, with 194 nutrient samples and 6 salinity samples
trace metal/nutrient water samples taken on 30 stations

SCIENCE BACKGROUND

The ~50m deep, ~ 85km wide Bering Strait is the only oceanic gateway between the Pacific and the Arctic oceans.

The oceanic fluxes of volume, heat, freshwater, nutrients and plankton through the Bering Strait are critical to the water properties of the Chukchi [*Woodgate et al.*, 2005a]; act as a trigger of sea-ice melt in the western Arctic [*Woodgate et al.*, 2010]; provide a subsurface source of heat to the Arctic in winter, possibly thinning sea-ice over about half of the Arctic Ocean [*Shimada et al.*, 2006; *Woodgate et al.*, 2010]; are ~ 1/3rd of the freshwater input to the Arctic [*Aagaard and Carmack*, 1989; *Woodgate and Aagaard*, 2005]; and are a major source of nutrients for ecosystems in the Arctic Ocean and the Canadian Archipelago [*Walsh et al.*, 1989]. In modeling studies, changes in the Bering Strait throughflow also influence the Atlantic Meridional Overturning Circulation [*Wadley and Bigg*, 2002] and thus world climate [*De Boer and Nof*, 2004].

Quantification of these fluxes (which all vary significantly seasonally and interannually) is critical to understanding the physics, chemistry and ecosystems of the Chukchi Sea and western Arctic, including sea-ice retreat timing and patterns, and possibly sea-ice thickness. The Bering Strait oceanic heat flux has been found to be the best predictor of Chukchi sea ice retreat [*Serreze et al.*, 2016]. Understanding the processes setting these fluxes is vital to prediction of future change in this region, in the Arctic, and beyond. The Bering Strait is the only Arctic gateway where observations currently show significant interannual change [*Østerhus et al.*, 2019].

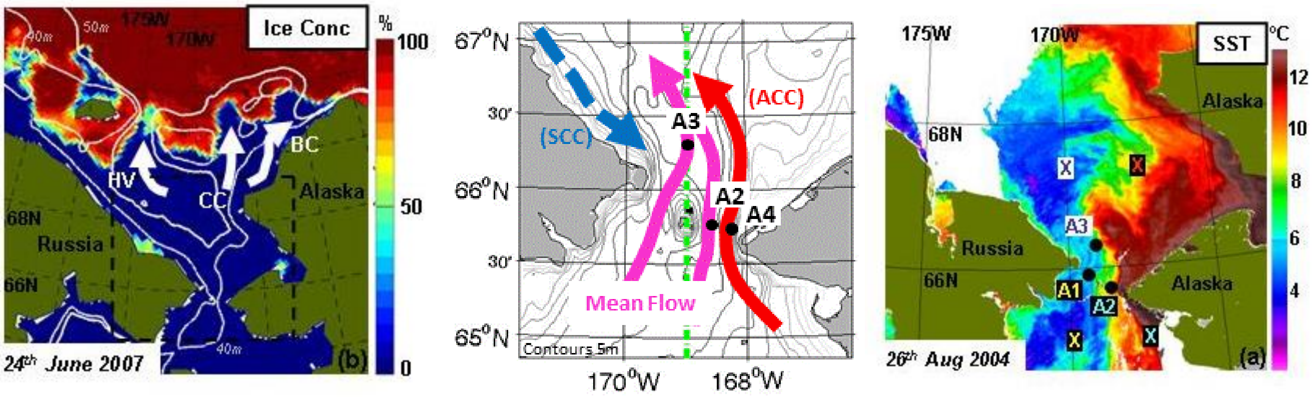


Figure 1: (Left) *Chukchi Sea ice concentration (AMSR-E) with schematic topography. White arrows mark three main water pathways melting back the ice edge [Woodgate et al., 2010].*
(Middle) *Detail of the Bering Strait, with schematic flows and mooring locations (black dots – A2, A3, A4). The main northward flow passes through both channels (magenta arrows). Topography diverts the western channel flow eastward near site A3. The warm, fresh Alaskan Coastal Current (ACC) (red arrow) is present seasonally in the east. The cold, fresh Siberian Coastal Current (SCC) (blue dashed arrow) is present in some years seasonally in the west. Green dashed line at 168º58.7'W marks the US-Russian EEZ (Exclusive Economic Zone) boundary. Note all moorings are in the US EEZ. Depth contours are from IBCAO [Jakobsson et al., 2000]. The Diomede Islands are in the center of the strait, shown here as small black dots on the green dashed line marking the US-Russian boundary.*
(Right) *Sea Surface Temperature (SST) MODIS/Aqua level 1 image from 26th August 2004 (courtesy of Ocean Color Data Processing Archive, NASA/Goddard Space Flight Center). White areas indicate clouds. Note the dominance of the warm ACC along the Alaskan Coast, and the suggestion of a cold SCC-like current along the Russian coast [Woodgate et al., 2006].*

Since 1990, year-round moorings have been maintained almost continually year-round in the Bering Strait region, supported by typically annual servicing and hydrographic cruises [*Woodgate et al.*, 2015; *Woodgate*, 2018]. These data have allowed us to quantify seasonal and interannual change [*Woodgate et al.*, 2005b; *Woodgate et al.*, 2006; *Woodgate et al.*, 2010; *Woodgate et al.*, 2012; *Woodgate*, 2018; *Woodgate and Peralta-Ferriz*, 2021], and assess the strong contribution of the Alaskan Coastal Current (ACC) to the fluxes through the strait [*Woodgate and Aagaard*, 2005; *Woodgate*, 2018]. These data also show that the Bering Strait throughflow increased ~50% from 2001 (~0.7Sv) to 2011 (~1.1Sv), driving heat and freshwater flux increases

[*Woodgate et al.*, 2012], with more recent fluxes also being high (e.g., 2014, 1.2Sv, [*Woodgate*, 2018; *Woodgate and Peralta-Ferriz*, 2021], see Figure 2).

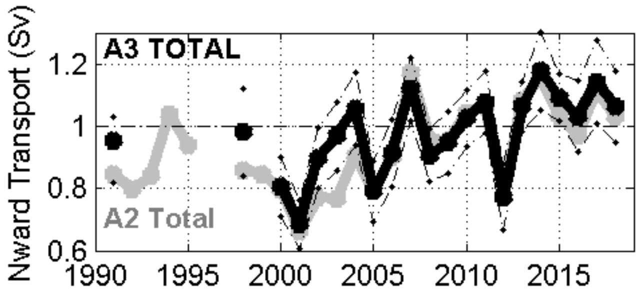


***Figure 2:** Annual mean (x-axis, time in years) of Bering Strait mooring data from 1991 to 2018, showing transport for the whole strait, as estimated from A2 (grey) or A3 (black).*

Analysis [*Woodgate*, 2018] indicates this long term trend is driven by large scale changes between the Pacific and the Arctic oceans, with no significant trends in the winds in the strait. Thus, satellite-sensed data sets (winds, SST) prove insufficient for quantifying long-term variability, indicating interannual change can still only be assessed by in situ year-round measurements [*Woodgate et al.*, 2012]. The work to be accomplished on this cruise will extend this mooring time-series to mid-2023.

In addition, this cruise aims to provide a high resolution survey of the water properties of the strait and southern Chukchi Sea in early-summer. A particular goal is to quantify the early season heat and salt content of the waters, which have been unusually warm and fresh in the last 4 years (see Figure 3).

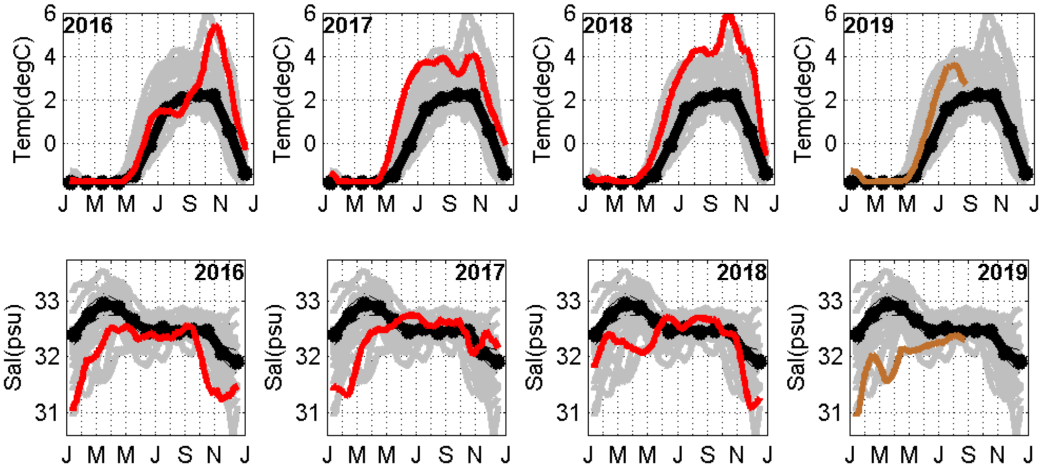


***Figure 3:** 30 day smoothed near-bottom A3 temperature **(top)** and salinity **(bottom)**, data for recent years **(columns)**, showing labeled year in color, climatology [Woodgate et al., 2005b] in black, and all prior years (1990-present) in grey. X-axis labels show month (J=January,etc.), [Woodgate and Peralta-Ferriz, 2021].*

The winter freshenings observed are particularly remarkable and suggest Pacific waters are entering the Arctic 50m shallower than before, and no longer refreshing the cold layer which historically protected the sea ice from warmer Atlantic waters below. The impacts of this on Arctic climate are currently unclear.

In a new addition to the project last year, we will also recover the first year-round biogeochemical measurements on the moorings, particularly to quantify the flux of oceanic nutrients through the strait. This effort will be supported by water sampling for nutrients during the cruise, to gain an understanding of the spatial variability of oceanic nutrients in the region. In addition to physical oceanographic goals, our work also supports long term marine mammal acoustic monitoring in the Strait (PI: Stafford).

International links: Maintaining the time-series measurements in Bering is important to several national and international programs, e.g., the Arctic Observing Network (AON), started as part of the International Polar Year (IPY) effort in 2007; various NSF, ONR and NPRB projects and missions in the region. For several years, the work was part of the RUSALCA (Russian-US Long Term Census of the Arctic). Some of the CTD lines are part of the international Distributed Biological Observatory (DBO) effort. The mooring work also supports regional studies in the area, by providing key boundary conditions for the Chukchi Shelf/Beaufort Sea region (a current focus on ONR Arctic programs); a measure of integrated change in the Bering Sea, and an indicator of the role of Pacific Waters in the Arctic Ocean.

2023 CRUISE SUMMARY:

The 2023 mooring cruise was scheduled in July, to allow hydrographic sampling of the early summer season.

The science team flew commercial to Nome on **Sunday 2nd July 2023**. Cruise preparations (checking and starting instrumentation, building instrumentation into frames, picking up air cargo, etc. were completed on **Monday 3rd July**.

We joined the ship 0830 on **Tuesday 4th July,** and completed gear on-load by 1115. Setting up the Norbit system (and the much faster CTD system) took the entire afternoon. We sailed around 7:30pm and did a successful CTD test cast soon after sailing. At 2119 we reached a region near Sledge Island for the initial Norbit test, as it had the required shallow, sloping bottom, and was believed to have a ship wreck, which we might be able to identify. Norbit calibrations and testing took till 130am, but were finally successful in calibrating the system (but not in finding the wreck).

Details of cruise operations (for **Wednesday 5th July to Thursday 13th July**) are given in individual sections below, and in the cruise event log attached at the end of the report. These include:

- recovery of A2-22 on 8th July, A3-22 on 13th July, and A4-22 on 5th July (by dragging);
- deployment of A2-23 on 8th July on, A3-23 on 6th July , and A4-23 on 7th July ;
- proving the Norbit system's ability to find moorings on 5th and 6th July, and grid search for the missing mooring on 7th and 8th July;
- glider operations on the 9th July (glider recovered due to insufficient comms) and 10th July (Glider successfully deployed);

all interspersed with various CTD and underway sections, and water sampling, on these and other days, as detailed below.

As per schedule, we arrived in Nome early **on Friday 14th July** to offload, however the weather was so bad the ship snapped a line trying to tie up, so the science party left the ship on foot with samples and the ship left port without offloading. Cancellation of flights meant only a few of the science party were able to travel on from Nome that day arriving in Seattle (with frozen nutrient samples) on the red-eye flight on the am of **Saturday 15th July**. Meanwhile, the ship docked around midnight and offloaded, and the rest of the science party left Nome on the am of **Saturday 15th July**.

Summary of CTD lines.

BS *(Bering Strait)* (US portion) – the main Bering Strait line, run at the start and at nearly the end of the cruise. This line has been occupied by past Bering Strait mooring cruises. US portion only run here. This line was previously ~ 2nm resolution. On the first running of this section, we used the more recent station spacing of ~1nm to better resolve the structure in the strait. Previous runnings of this line have included two stations (BS23 and BS24) which fall south of the main line near Prince of Wales, extending the line along (rather than across) isobaths. Neither BS23 and BS24 were taken during this cruise**. CTD nutrient samples were taken on both runnings of this line in 2023. Pumped samples for trace metals/nutrients were taken on both runnings of this line in 2023.**

AL *(A3 Line)* (US portion) – another previously-run line (previously run at ~ 1.7nm resolution, run this cruise once at 0.85nm resolution), just north of the Strait, running from the Russian coast, through the mooring site A3, to where the main channel of the strait shallows on the eastern (US) side. US portion only run here**. Run with trace metal/nutrient sampling, and CTD nutrient sampling.**

Parts of **CCL *(Chukchi Convention Line)*** (US waters) – a line running down the convention line from the end of the LIS line towards the Diomedes (also run in 2003, 2004, 2011, 2012, 2013, 2014, 2015, 2016, 2017 and 2018, and in part in 2022), typically incorporating a rerun of the high resolution DL line at the southern end, run variously at 10nm (typical) or 5nm (rarely) resolution. Run only in parts in 2021. Run in part in 2023.

Re-run of BS line (at lower resolution) with trace metal/nutrient sampling, and CTD nutrient sampling

Summary of ADCP/Underway data lines

The ship's ADCP recorded for the duration of the cruise, and between lines steams were often positioned to give more useful underway information. The following were targeted underway surveys:

After A4 recovery east to shallow waters and then back to A2 and BS11, then NE across the strait, and NW back across the strait to A3.

Various runs along the Convention Line

See maps for details of these lines.

Prior lines not taken on this cruise:

DLS and DLN *(Diomede Line)* (previously one line DL) – two consecutive lines running north from the Diomede Islands to A3, the southern portion DLS (stations DL1-12) at 1nm spacing, the northern portion DLN (stations DL13-A3) was previously run at 2.5nm spacing, but on this cruise a station spacing of 1.25nm was used. Run both at the start and end of the cruise, although the second running is complete due to bad weather. These lines study the hypothesized eddying and mixing region north of the islands.

CS *(Cape Serdtse)* (US portion) – another cross strait line (~ 3.9nm resolution), run here from the US-Russian convention line (~168° 58.7'W) to Point Hope (US), but originally starting at Cape Serdtse-Kamen, in Russian waters. Also repeated during the cruise, both runnings adding stations to make station spacing ~1.9nm. First running done with trace metal/nutrient sampling in 2021. Not run in 2022.

NPH *(North Point Hope)* (US waters) - a line run before in 2016, and 2019, crossing from north of Point Hope to the WNW, at 1.25nm spacing near the coast, and 2.5nm spacing after NPH5, to chart the Alaskan Coastal Current transformation on its route along the Alaskan Coast. Extended in 2019 to the Convention Line (CCL). Run twice this cruise. First running westward only to station NPH13, second running (eastward) of complete line from CCL. Not run in 2022.

CD *(Cape Dyer)* (US waters) - a line new in 2016, taken also in 2017 and 2019, running west-east towards the Alaskan Coast, midway between Point Hope and Cape Lisburne, set just south of some apparent topographic irregularities, also to chart the Alaskan Coastal Current transformation on its route along the Alaskan Coast. Extended in 2019 to the Convention Line, but run in 2021 only from CD 14 to the coast. Not run in 2022.

LIS *(Cape Lisburne)* (US waters) – from Cape Lisburne towards the WNW, a previous RUSALCA line, run by us also in 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018 and 2019 and close to the CP line occupied in previous Bering Strait cruises in 2003 and 2004 (station spacing ~ 3.6nm). Note that due to the Quintillion cable, station Lis 9 is replaced by 2 new neighboring stations, Lis 8.5 and 9.5 . Run once during the 2021 cruise. Run with trace metal/nutrient sampling in 2021. Not run in 2022.

DLa and DLb – two other high resolution lines (1nm resolution), mapping the eddying/mixing region, parallel to DLS, allowing for a 2-dimensional mapping of the region.

AS – a line sampled only once before (2011) (although sometimes run for underway data), running from the eastern end of AL back towards the western end of the CS line, taken at variously 4nm or 2nm spacing (closer stations over steeper topography).

NNBS *(North North Bering Strait)* – a new line run only three times before (2015, 2017, 2019) west-east across the eastern strait, south of A3 and north of NBS, run at ~ 1.8nm resolution, to better map the Alaskan Coastal Current north of the Strait proper.

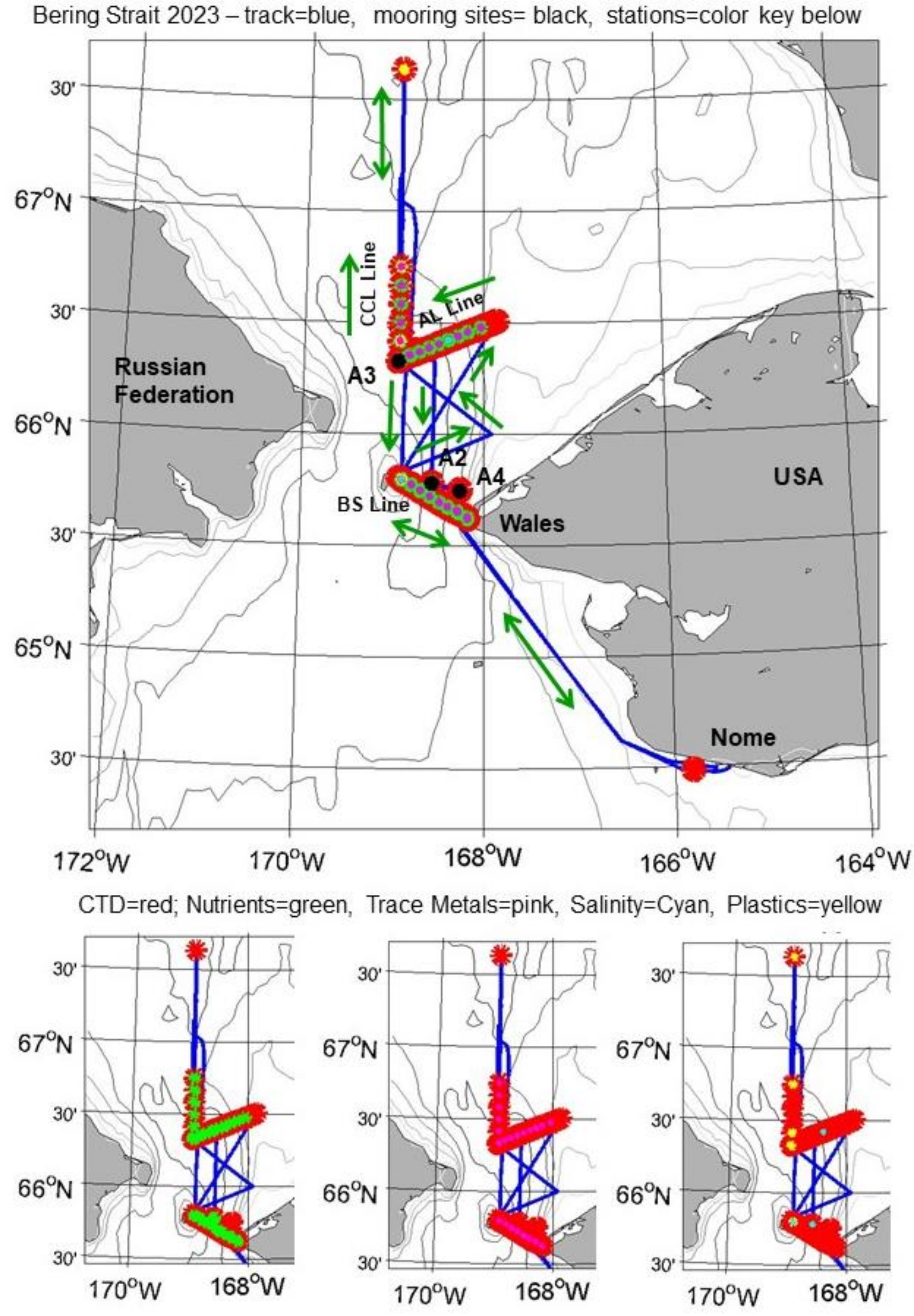
NBS *(North Bering Strait)* – an east-west cross-strait line ~ 8nm north of the Bering Strait line, run in previous years, with ~ 1.7nm resolution.

MBS *(Mid Bering Strait)* – an east-west cross-strait line ~ 10nm north of the Bering Strait line, run in previous years, with ~ 1.7nm resolution, with higher resolution near the coast

SBSnn – a previous line new in 2014, run only in 2014, 2015, 2017 and 2019, and then often only in part, just south of the strait, crossing the Alaskan Coastal Current before it enters the strait proper (previously and this year run at 2.2nm resolution, run in 2019 at 1.1nm resolution). This year run with the same alignment (i.e. from BS22 as used since 2019, and thus denoted SBSnn. (Previous SBS line started at BS24).

CONTENTS

BERING STRAIT 2023 CRUISE MAPs: *Ship-track, blue. Mooring sites, black. CTD stations, red. Water samples color code as per key. Green arrows show direction of travel. Depth contours every 10m from IBCAO (International Bathymetric Chart of the Arctic Ocean [Jakobsson et al., 2000].*



BERING STRAIT 2023 SCIENCE PARTICIPANTS

1. Rebecca Woodgate	UW	*Chief Scientist and UW PI*
2. Cecilia Peralta-Ferriz	UW	*Co-Chief Scientist and UW Co-PI*
3. Laramie Jensen (F)	UW	*UW postdoc & lead of trace metal/nutrient sampling*
4. Katy Christensen (F)	UW	*UW graduate student & co-lead of CTD measurements*
5. Robert Daniels (M)	UW	*UW mooring technician and cruise technical lead*
5. Jennie Mowatt (F)	UW	*UW mooring technician and Norbit lead*
7. Katie Kohlman (F)	UW	*UW graduate student*

UW – University of Washington, US

Cabin Allocations:
Main deck (Cabin 4) - Robert
Lower deck, port aft (Cabin 8) - Rebecca & Cecilia
Lower deck, starboard aft (Cabin 7) - Laramie & Jennie
Lower deck, starboard forward (Cabin 5) - Katy & Katie

BERING STRAIT 2023 NORSEMAN II CREW

1. Mike Hastings (M)	SVA	*Master*
2. Mike Leifeste (M)	SVA	*Mate*
3. Casey Coates (M)	SVA	*Captain*
4. Jim Wells (M)	SVA	*Chief Engineer & Bosun*
5. Mike Rathibhan (M)	SVA	*Assistant Engineer*
6. Victor Chacon (M)	SVA	*Chef*
7. Dakota Moonin. (M)	SVA	*Deck*
8. James Longero (M)	SVA	*Deck*

SVA – Support Vessels of Alaska, Inc. , https://www.supportvesselsofalaska.com

Ship contract arranged by:

CPS Polar Field Services, partner of Battelle ARO
Adelaide Rosic, adelaide@polarfield.com

MOORING OPERATIONS (Woodgate/Daniels, assisted by others)

Background: The moorings serviced on this cruise are part of a multi-year time-series (started in 1990) of measurements of the flow through the Bering Strait. This flow acts as a drain for the Bering Sea shelf, dominates the Chukchi Sea, influences the Arctic Ocean, and can be traced across the Arctic Ocean to the Fram Strait and beyond. The long-term monitoring of the inflow into the Arctic Ocean via the Bering Strait is important for understanding climatic change both locally and in the Arctic. Data from 2001 to 2018 suggest that heat and freshwater fluxes are increasing through the strait [*Woodgate et al.*, 2006; *Woodgate et al.*, 2010; *Woodgate et al.*, 2012; *Woodgate et al.*, 2015; *Woodgate*, 2018; *Woodgate and Peralta-Ferriz*, 2021], with 2012 being a year of low flow, but 2013 to 2016 returning to higher flow conditions [*Woodgate*, 2015; *Woodgate et al.*, 2015; *Woodgate*, 2018]. The data recovered this cruise will indicate if recent years show further increase or a return to older conditions.

An overview of the Bering Strait mooring work (including data access) is available at http://psc.apl.washington.edu/BeringStrait.html. Data are also permanently archived at the National Oceanographic Data Center, now renamed the National Centers for Environmental Information (https://www.nodc.noaa.gov/ or https://ncei.noaa.gov).

A map of mooring stations is given above. Three UW moorings were recovered on this cruise. These moorings (all in US waters –A2-22, A4-22, and A3-22) were deployed from the Norseman II in September 2022, with mooring funding from NSF-AON (PIs: Woodgate and Peralta-Ferriz, *PLR2153942*).

Three UW moorings (A3-23, A2-23, A4-23) were deployed on this 2023 Norseman II cruise under funding from NSF-AON (PIs: Woodgate and Peralta-Ferriz, *PLR2153942*). All these deployments were replacements of recovered moorings at sites occupied since at least 2001 (A4) or 1990 (A2 and A3). Analysis of past data suggests data from these three moorings are sufficient to give reasonable estimates of the physical fluxes of volume, heat and freshwater through the strait, as well as a useful measure of the spread of water properties (temperature and salinity) in the whole strait [*Woodgate et al.*, 2015].

All moorings (recovered and deployed) carried upward-looking ADCPs (measuring water velocity in 2m bins up to the surface, ice motion, and medium quality ice-thickness); lower-level temperature-salinity sensors; and iscats (upper level temperature-salinity-pressure sensors in a trawl resistant housing designed to survive impact by ice keels). Both the recovered and deployed A3 moorings also carried marine mammal acoustic recorders. The A3-22 mooring also carried, instead of an iscat, the “Miscat”, a multiple instrument version of the iscat, designed to allow instruments to be lost sequentially from nearer the surface. For a full instrument listing, see the table below.

Our most recent NSF grant supports also biogeochemical measurements on the moorings. Thus A2 and A3 (recovered and deployed) carried also SUNA optical nitrate sensors, SBE37-ODO optical sensors for dissolved oxygen and WETLABS FLNTUSB optical sensors for fluorescence and turbidity. An additional WETLABS FLNTUSB sensor was also deployed on A4 (recovered and deployed).

This coverage should allow us to assess year-round stratification in and fluxes through the strait, including the contribution of the Alaskan Coastal Current, a warm, fresh current present seasonally in the eastern channel, and known to be a major part of the heat and freshwater fluxes [*Woodgate and Aagaard*, 2005; *Woodgate et al.*, 2006; *Woodgate et al.*, 2015; *Woodgate*, 2018]. The ADCPs (which give an estimate of ice thickness and ice motion) allow the quantification of the movement of ice through the strait [*Travers*, 2012]. The marine mammal recording time-series measurements should advance our understanding of the biological systems in the region. The biogeochemcial sensors have returned the first year-round measurements of nitrate in the strait, with accompanying key biological parameters.

Calibration Casts: Biofouling of instrumentation has been an on-going problem in the Bering Strait. Prior to each mooring recovery, a CTD cast was taken to allow for *in situ* comparison with mooring data. Similarly, CTD casts were taken at each mooring site immediately after deployment. These post-deployment casts will allow us to assess how effective this process is for pre-recovery calibration. Since the strait changes rapidly, and CTD casts are by necessity some 200m away from the mooring and may be as long as 1hr separated in time from the mooring reading, it is inevitable that there will be differences between the water measured by the cast and that measured by the mooring. **Action item: On recovery, check the post deployment casts to see how reliable the comparison is.**

This year (as in 2017, 2018, 2019, 2021, and 2022), an on-deck calibration tank was also used for recovered instruments. This is discussed below.

2023 Recoveries and Deployments:

Our standard procedure for mooring recoveries was the following:

First a pre-recovery CTD cast was taken starting at a safe (~200m) distance from the mooring position and drifting way. Next, for ranging, the ship positioned ~ 200m away from the mooring so as to drift towards the mooring site. Ranging was done from the port mid corner of the aft deck of the ship, with the hydrophone connecting to the deck box inside at the aft end of the port laboratory. **Action item: Re check position as regards to ship's propellers.** Once the ship had drifted over the mooring and the acoustic ranges had increased to >70m, the mooring was released**.** This procedure was followed to prevent the mooring being released too close (or underneath) the ship since in previous years the moorings have taken up to 15min to release. **Action item: Be sure to distinguish between slant and horizontal range during soundings.** As site A3 is ~0.6nm from the Russian border, prior to ranging on A3, the Norseman II's small boat was prepared for launching, to cover the eventuality that if the mooring had to be dragged, the mooring would surface and drift towards Russian waters before the ship was able to recover it. **Action item: Continue to prepare for small boat operations at site A3.**

On all moorings, we use double releases, with springs to assist the mooring release. For all moorings, our usual routine is to communicate and range with one release and then attempt to release the other release (to test both instruments).

Biofouling and other release issues have frequently resulted in the mooring release being unsuccessful. In these cases, dragging gear (arouin d 6-8feet of weighted grapples, is attached to the ship's trawl wire. This is lowered to the sea floor and the trawl paid out as the ship drives a circle around the mooring position at a distance of ~100m (depending on the length of trawl wire used. Once this is laid, the ship steams slowly away, hauling in the trawl so as to catch the mooring with the retracting trawl. Our experience is that usually good pull on the mooring is sufficient to pull it free and typically the mooring surfaces before the trawl wire is recovered.

In all cases, once the mooring is on the surface, the ship repositions, bringing the mooring tightly down the starboard side of the ship. One boat hook and a pole with a quick releasing hook attached to a line are used to catch the mooring, typically on a pear link fastened to the chain between the float and the ADCP or on eyes welded to the float surface. The line from the hook is then passed back to through the stern A-frame, and tied with a "cat's paw" knot to a hook from the A-frame. This portion of the mooring is then elevated, allowing the second A-frame hook to be attached lower down the mooring chain, and tag lines to be attached if necessary. The iscat, if present, is recovered by hand at a convenient point in this operation, prior to recovery of most of the mooring. Then the entire mooring is then elevated, using both hooks from the aft A-frame, and recovered onto deck.

Recovery work is usually done by a deck team of 4 crew of the Norseman II – one on the A-frame controls, three on deck with on overhead safety lines ("dog runs") down each side of the deck (one of these working forward of the deck on tag lines), assisted by UW personnel further forward on the aft deck. Once on deck, the moorings are photographed to record biofouling and other issues.

Action items: Be sure to add pear-link to the chain between float and ADCP. Prepare loops of line for threading through chain/shackles to provide a lifting point. High A-frame or crane very helpful for recovery. Also helpful to review mooring movies at start of cruise. Bring extra tires for the recovered floats.

The A-frame of the Norseman II is atypically high (~ 26ft less block attachments). While this is extremely useful in fair weather, it allows for swinging of the load in rougher seas. **Action item: Continue to use tag line options for recovery in rougher weather.**

Good visibility (at least ~1nm) is required for mooring recoveries since the mooring may delay releasing due to biofouling, or the mooring may require dragging, as in previous years. Given the proximity of A3 to the US-Russian border, small boat operations may also be necessary during a dragging operation to prevent the surfaced mooring drifting out of US waters. For these reasons, it was decided typically not to commence a new mooring operation after 5pm local time. **Action item: Continue to include weather days in the cruise plan; plan also for small boat operations (including sending a battery powered release unit), considering especially if small boat operations could be used in fog. Assess causes of foggy conditions, in order to predict best strategy for finding workable visibility.**

In 2023, all three moorings were successfully recovered. A4-22 required dragging. A3-22 had been again dragged from its deployed position by ice and it was necessary to triangulate on the mooring, but once found it released without dragging being necessary. In these waters we have discovered we can send commands to and get clear responses from a release at around 12km, and using the enable command (on a release that replies to enable), the deck set can detect some response from almost 10nm (note that is a 2 way travel time of 20s). A2-22 released perfectly.

Recovery operations went smoothly. The dragging of A4-22 parted iscat from the line (resulting in the wire rope being deformed into a tight spiral) and so the iscat was recovered before the main mooring.

This cruise also used a portable multibeam system (Norbit) to search for mooring A2-21 which was unable to be found last year. Full details of that (unfortunately unsuccessful) search are given below.

Biofouling was light on the 2023 moorings, as expected from instrumentation deployed in September (post bloom) and recovered in July (pre bloom). The ADCP heads and salinity cells were clear, and growth on floatation was very light. Both instruments of the miscat on A3-22 were recovered, showing success of the redesign to make the first loss the supporting float and not the SBE37. **Action item: Redesign all iscats in this style.**

Mooring deployments were done through the aft A-frame, using the A-frame hooks for lifting. The height of the Norseman II A-frame was extremely advantageous for these deployments. Lacking such an A-frame, alternative ships might consider lifting the mooring with the crane, rather than the A-frame. The mooring was assembled completely within the A-frame. The ship positioned to steam slowly (~1 to 2knots) into the wind/current, starting between 500m and 600m from the mooring site. **Action item: This distance (greater distance in strong current) works well.** At the start of the deployment, the iscat was deployed by hand and allowed to stream behind the boat, which steamed at ~ 2knots, fast enough to maintain headway and to trail the mooring behind the ship, but not so fast as to damage the equipment being towed or pull equipment off the deck. **Action item: Feed the iscat tether unwound to the person spooling it off the deck.** The first pick (from one of the hooks of the aft A-frame) was positioned below the ADCP, except in the case of A4, where the first pick was below the top float. The second pick (from the other hook of the aft A-frame) was lower down on the mooring allowing all the mooring except the anchor to come off the deck during the lift. Then, the A-frame boomed out to lower these instruments into the water. Tag lines were used to control the instruments in the air. **Action item: use deck cleats to fair tag lines. Be sure to position the lift point on the float so it does not cause the float to roll off.** The first pick was released by a mechanical quick release, which was then repositioned to lift the anchor. (Previous years have shown that if the first pick was insufficiently high, the releases would still be on deck when the first package was in the water. The releases would then slip off the deck inelegantly. It was found that a higher lift of the instruments, and using both hooks of the A-frame, allowed the releases also to be lifted from the deck and then hang nicely behind the ship once the ADCP was placed in the water.) The anchor was lifted into the water just prior to arriving at the site. Positioning of this final pick very close to the anchor prevents the releases being pulled back over the lip of the ship when the anchor is lifted. **Action item: Make final pick as close as possible to the anchor.** When the ship arrived on site, the anchor was dropped using the mechanical quick release. Positions were taken from a hand-held GPS on the upper aft deck, some 5m from the drop point of the mooring. **Action item: Continue to bring own GPS unit. Note that due to mooring fall back, actual mooring position may be ~ 10m from this position in the opposite direction to the steaming direction during recovery.** This information is noted on the mooring diagrams.

A team of 4-5 crew did the deployments, with one person on the A-frame, 3 on the "dog runs' assisting the instruments up into the air, and other members of the crew/science team assisting with tending the tag lines during lifting.

Action items: design pick points into the moorings for recover; continue to put 2 rings on the anchors for tag lines. Consider using chain, not line for the moorings (saves on splicing and gives extra pick points); Compute the best pick point, such that the releases are lifted free of the deck, rather than slipped over the edge. Add pick points to the mooring diagrams. Review the videos of mooring deployments before the operation.

Deployment Instrumentation issues: This year, to avoid needing a long preparation period in Nome, much of the instrumentation was started in Seattle and shipped on delayed start. (Note SBE37IM will not accept a delayed start longer than 30 days.) Exceptions were the biotopics instruments (SUNA, Wetlabs and ODOs) which have less battery endurance and so were started in Nome.

Iscat housings and tethers were assembled in Seattle, and ADCPs incorporated into the ADCP frames, leaving the only assembly work to be done in Nome/at sea the placing of the floats on the ADCP frames and the testing of the releases. **Action item: Consider in future if starting instruments in Seattle is a safe way of saving time in Nome. Note that releases could also be deck checked ashore to save time at sea.**

Recovered Data and Instrumentation issues: Data recovery on the moorings was very good.

- ISCAT SBE37IMS AND LOGGERS:

Three iscats/miscat were deployed on the recovered moorings.

All SBE37s were recovered from moorings A3-22 and A4-22, but the SBE37 iscat on A2-22 was lost on the 27th Jun 2023.

While all moorings returned logger records, only that of A2-22 (where the SBE37 was lost) was of good quality. Investigation showed that the couplers on A3-22 and A4-22 were functioning poorly. **Action item: instigate check of all couplers in Seattle; do final coupler test before deployment, bring spare couplers to cover any last minute failures. Continue to use Lithium battery on miscat in the future. Redesign iscat float set up to minise instrument loss.**

Preliminary results (before any correction for biofouling or post cruise calibration) are plotted below.

- *ADCPs:* The three recovered ADCPs were running on recovery and gave complete data records. These instruments were deployed with lithium batteries (and no external battery pack) and a conservative recording schedule and were expected to last the two years. The ice track records have been roughly investigated, and show the large ice keel which moved A3. **Action item: Check the sea ice data.**

Preliminary results are plotted below.

- *SBEs:* A SBE16 was recovered from each mooring. None of these instruments were pumped. All instruments were running on recovery and returned full data records. Note that with these older instruments, it is easy to download only part of the data. **Action items: Revise checksheet to ensure all data are downloaded. Send for calibration.**

Preliminary results (before any correction for biofouling or post cruise calibration) are plotted below.

- Biooptics instrumentation (SUNA, Wetlabs, ODOs). All biotoptic instruments were running on recovery and returned complete data records. Only minor issues have been identified to date, viz:

- Wetlabs 1260 on A3 could only be downloaded using a real serial port.

- SUNA instruments (1918 and 1920) are both reading identically zero for humidity. Action item: Refer this to the manufacturer.
- ODO 244-44 did not have a completely clear memory before deployment – 1 record from the tests remained uncleared. The seabird data conversion record takes this first record as the start time and then set subsequent timestamps as the number of records from this point. Thus, the timestamps on the record are offset. To correct the record, it is necessary to subtract 62.665 days from the timestamp.

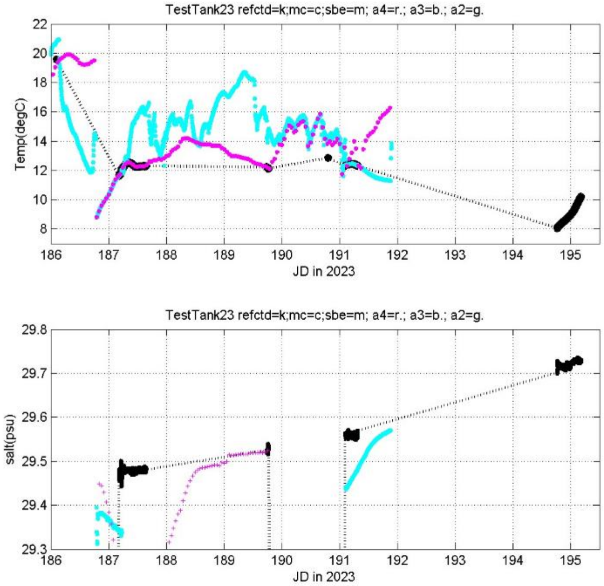
Post recovery tank calibrations: As an addition calibration test, uncleaned post-recovery SBE instruments were placed, for various periods after recovery in a large-plastic bin filled with salt water in conjunction with three recently calibrated SBE instruments:

- SBE19 #924, borrowed from the APL equipment pool and last calibrated in Jan/Feb 2018
- SBE37-24435, brought as a mooring spare and newly calibrated
- SBE37IM-24308, brought as a mooring spare and newly calibrated.

The intent was to ascertain to what extent cleaning after recovery changes the readings on the SBE instruments. The preliminary test with this system was in 2016, and had significant limitations, likely relating to the instruments being horizontal, trapping air bubbles or biofouling, or coming out of the water on the rolling ship, or possibly due to interactions between instruments. This year, as in 2017 and 2018 and 2019 and 2021, the tank was designed to a) allow all instruments to be vertical and b) to include a pump to circulate water within the tank.

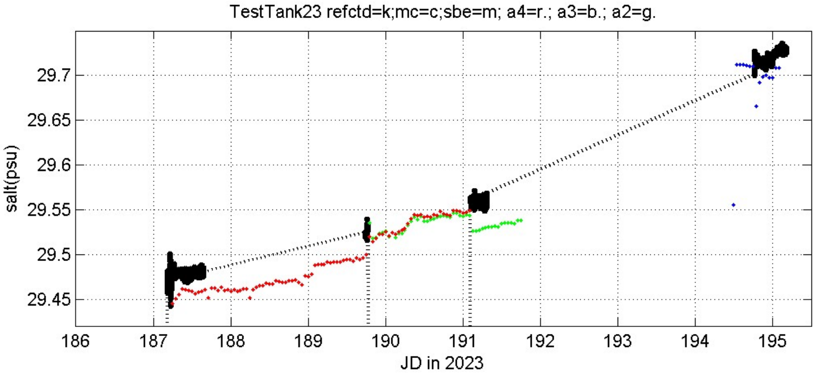
Once instruments were recovered from the moorings, they were placed in the tank for various periods of several hours, such as to obtain at least 6 readings. Since recovered instrumentation was recording either hourly (SBE16or37) or every 5min (SBE37IM), this allows a good comparison with the calibration CTD, set at 5 second data, and somewhat with the SBE16 recording hourly and SBE37IM recording every 5min. . Instruments were then cleaned and placed again in the tank for at least another 6 readings. The instruments will next be returned to the manufacturer for post cruise calibration. **Action item: Keep CTD upright. Do test before and after cleaning. Use both mooring spares**. **Track CTD time (only ~ 28hrs per battery set). Check CTD pump is working.**

This year, many problems were encountered with the system. The SBE19-CTD was intermittent in its operation, likely due to the switch being knocked as the instrument were moved in the tank. Even between newly calibrated instruments, only poor agreement was found.

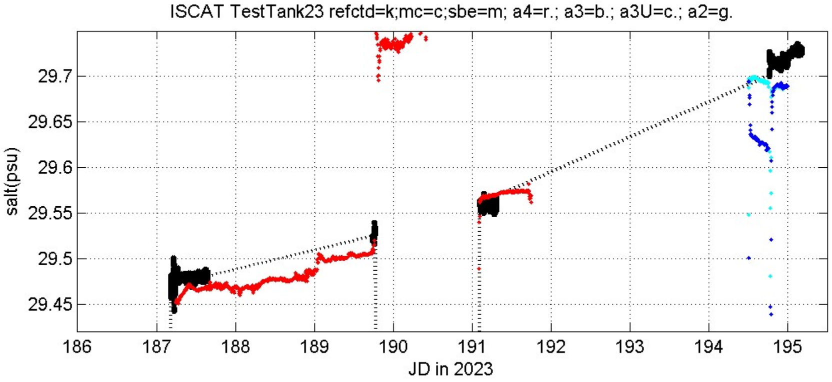


Comparison of references: SBE19 (black), SBE37(Magenta), SBE37IM (cyan).

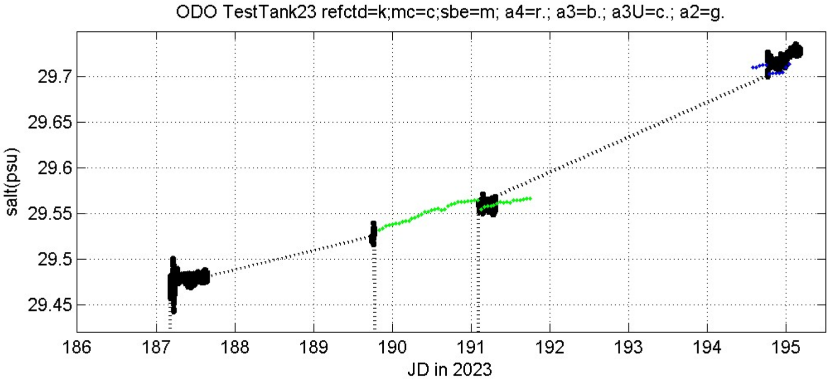
Comparing instrument type (plots below, color indicates mooring -A4 as red, A2 as green, A3 as blue, with the SBE19 reference (black) allows us only to conclude that no large offsets of salinity were evident:



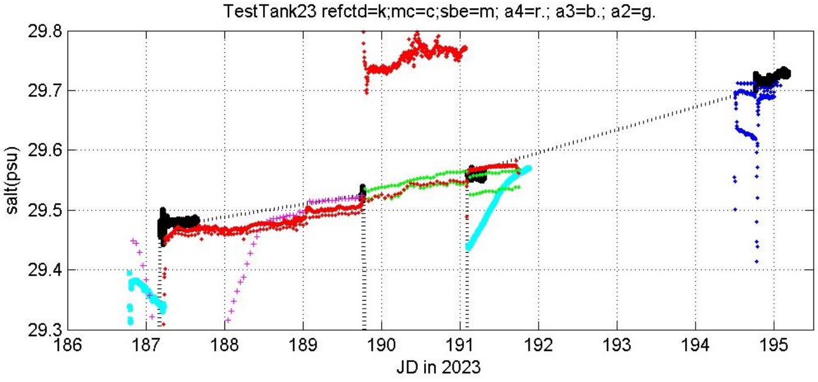
Recovered SBEs.
Although frequent poor agreement with SBE19, good agreement with each other.and with SBE19 at some times, especially A3, blue).



Recovered ISCATS:



Recovered ODOs:



All instrumentation

Action item: Redesign test tank.

March 2024 notes with post-cruise calibrations:
Post cruise calibrations were obtained for SBE16s, SBE37Ims, and SBE37ODO.

SALINITY DRIFT:
In line with the light biofouling, only small changes in salinity (<0.0145psu, see summary table below) were found. Thus, the test tank plots, although for the pre-cruise calibrations, may be taken as representative of the post calibrations also. Agreement between instruments at times of presumed water column homogeneity was also extremely good – generally better than 0.01psu, much better than the manufacturer's specifications (equivalent to 0.05psu for SBE16, and 0.008psu for SBE37). Deployment and recovery CTDs also generally gave good agreement, although it is important to remember this is a poor test – even recently calibrated instruments can not agree with these casts due to changes in time or space (as illustrated by the -0.135psu difference for A4-22 iscat. Given the good correspondence between instruments, we conclude the winter freezing temperatures being 0.01-0.02degC below the surface freezing temperature is not an issue for concern.
In summary. all salinity records are considered to be within manufacturer's specifications, although two minor issues should be noted:
a) A2-22 SBE has a period of likely blocked salinity from JD275 to JD279. A more reliable record could be obtained from the A2-22 SBE ODO for this period.
b) A2-33 SBE appears to be about 0.03 psu too fresh, but note this is within manufacturer's specifications.

OXYGEN DRIFT:
Post-pre calibration differences for the two ODOs were ~0.2ml/l or ~3%. Comparison of the final data (interpolated between pre and post cruise calibration) gives remarkably good agreement to OX1 sensor of the deployment CTDs (max diff 0.02ml/l or 0.12%), and agreement to within specifications to OX2.
In summary. all oxygen records are considered to be within manufacturer's specifications, or better.
Also, the Ox1 sensor on the CTD is deemed to be more reliable.

Note that ODO pressure sensors (strain gauge) show a significant drift throughout the deployments, however, this is likely instrument drift as this is not seen in the higher quality digiquartz sensors on the SBE16s.

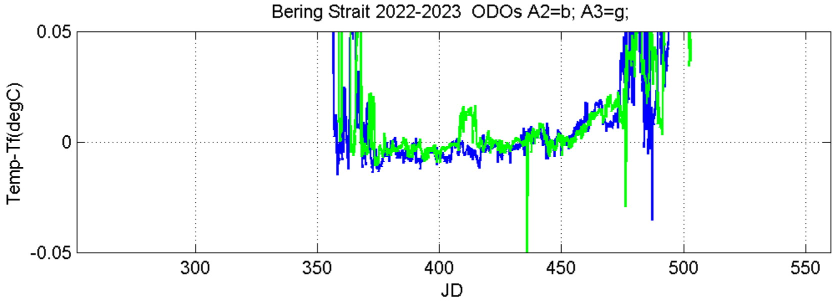
WETLABS POST-CRUISE ISSUES:

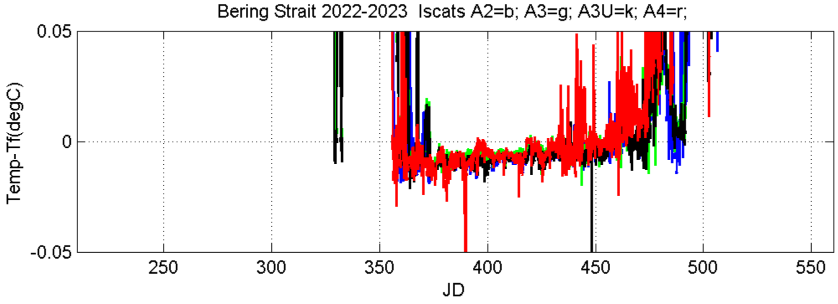
SUMMARY OF FINAL DATA FOR OX AND SALINITY:

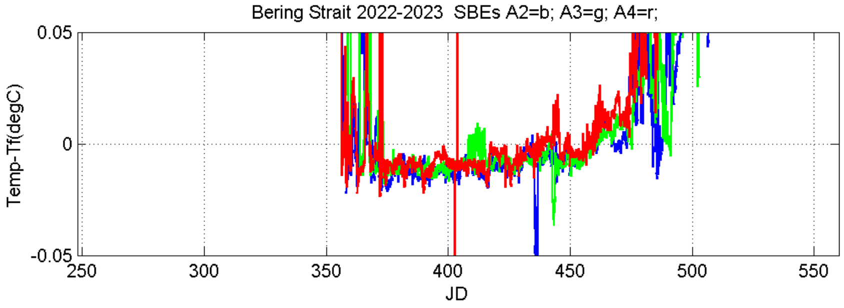
	A2-22 SBE	**A2-22 ODO**	**A2-22ISC**	**A3-22 SBE**	**A3-22 ODO**	**A3-22 ISCAT**	**A3-22 U-ISC**	**A4-22 SBE**	**A4-22 ISC**
Note	SBE16 1226	SBE37 24443	LOST	SBE16 1225	SBE37 24444	SBE37 24297	SBE37 20935	SBE16 2341	SBE37 24300
SAcc (psu)	0.05	0.008		0.05	0.008	0.008	0.008	0.05	0.008
1)ppp (psu) Ps-pr	NA	0.0055		0.0104	0.0121	0.0145	0.0129	0.0092	-0.0084
2) TT									
CTDD	0.001	0.019		-0.006	-0.008	0.006	-0.024	-0.04	-0.135
CTDR	-0.02	-0.016						0.001	0.001
4) Yr+1									
5) Iscat	JD275.75 to JD279 Clogged. JD279-311 0.1 too fresh, then ok	Agree with iscat better than 0.01		0.02 to 0.05 fresher than odo & iscats 0.03 mostly	Better than 0.01 to iscats			Agree better than 0.01	Agree better than 0.01
6)Moor									
7)Tfrz degC	-0.02	-0.01	-0.02	-0.02	-0.01	-0.02	-0.02	-0.02	-0.02
CONC	JD275 to JD279 use ODO?	In spec	In spec	0.03 too fresh But in specs	In spec	In spec	In spec	In spec	In spec
		A2-22 ODO			**A3-22 ODO**				
		SBE37 24443			SBE37 24444				
		Max of 0.07ml/L or 2%			Max of 0.07ml/L or 2%				
Ox ppp Ps-pr		0.208ml/l 2.55%			0.2465ml/l 3.00%				
CTDD (ox1)		0.006ml/l 0.12%			0.02ml/l 0.1%				
CTDR (ox1)		0.005ml/l 0.02%							
CONC		To CTD Ox1, VVgood 0.006ml/l 0.12%			To CTD Ox 1 0.02ml/l 0.1%				

Comparisons to freezing point:

Check against Tfreeze … all same ..


Bering Strait 2022-2023 ODOs A2=b; A3=g;

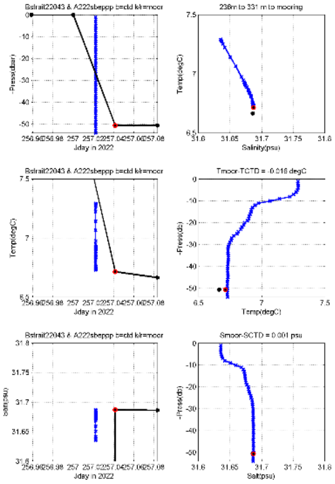

Bering Strait 2022-2023 Iscats A2=b; A3=g; A3U=k; A4=r;


Bering Strait 2022-2023 SBEs A2=b; A3=g; A4=r;

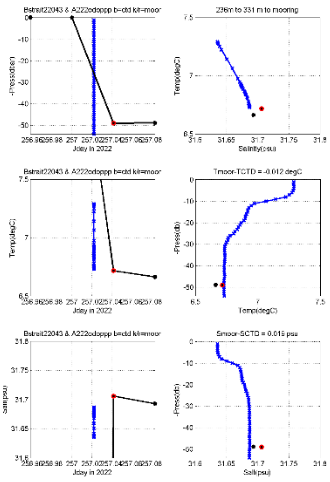
Comparison to CTD casts:

To 2022 (Deployment):

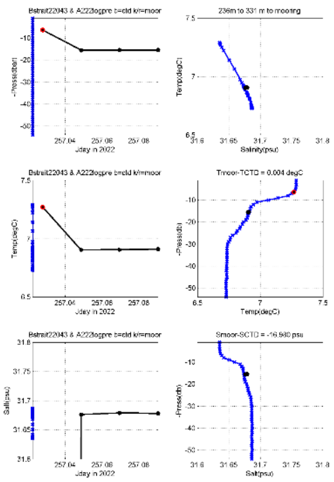
A2- sbe



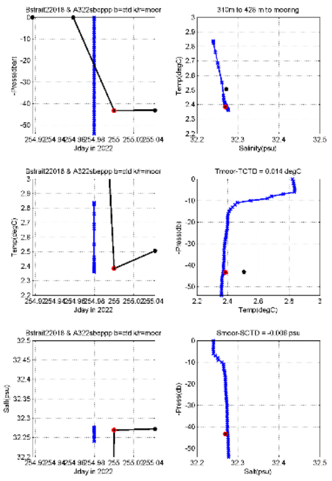
A2-odo



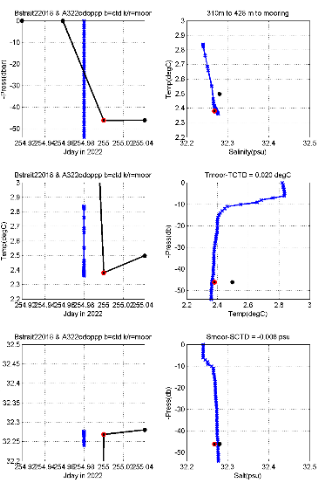
A2-logger



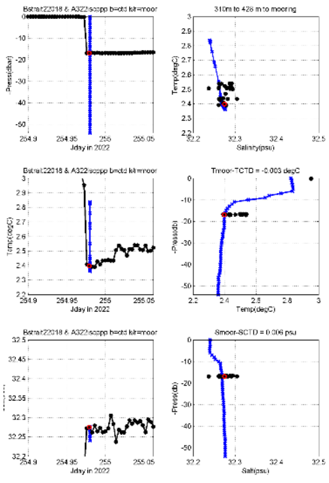
A3-sbe



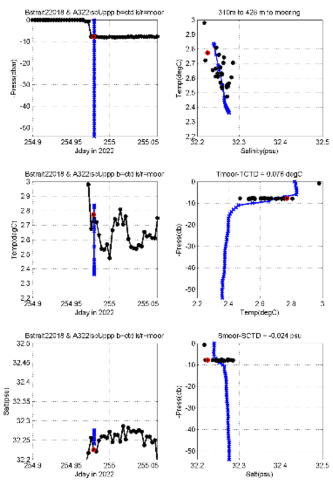
A3-odo



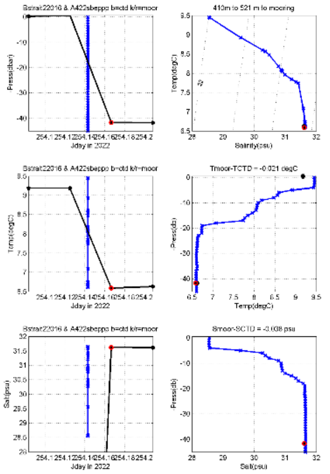
A3loweriscat



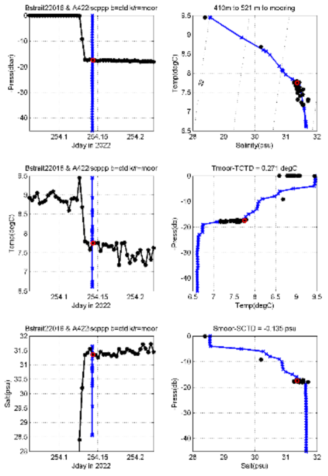
A3upperiscat



A4-sbe



A4iscat

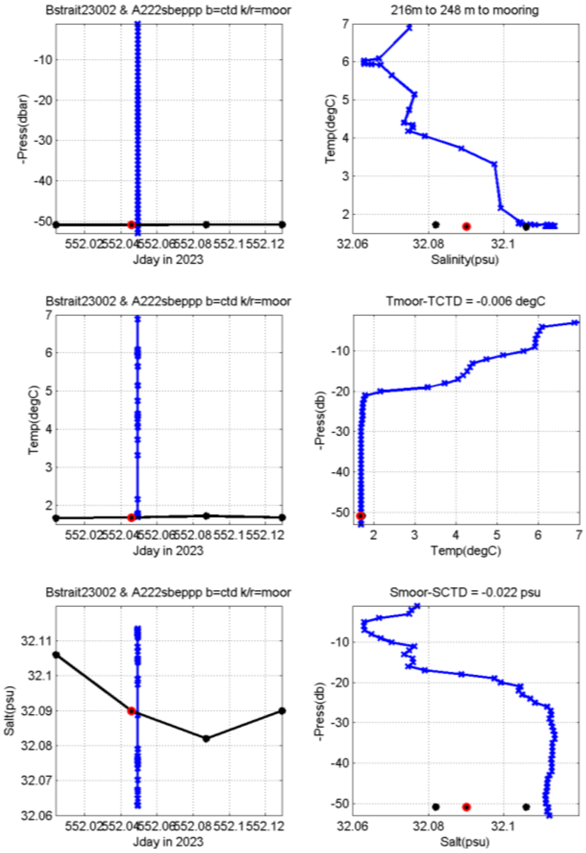


At iscat depth, far too much variability to be reliable.

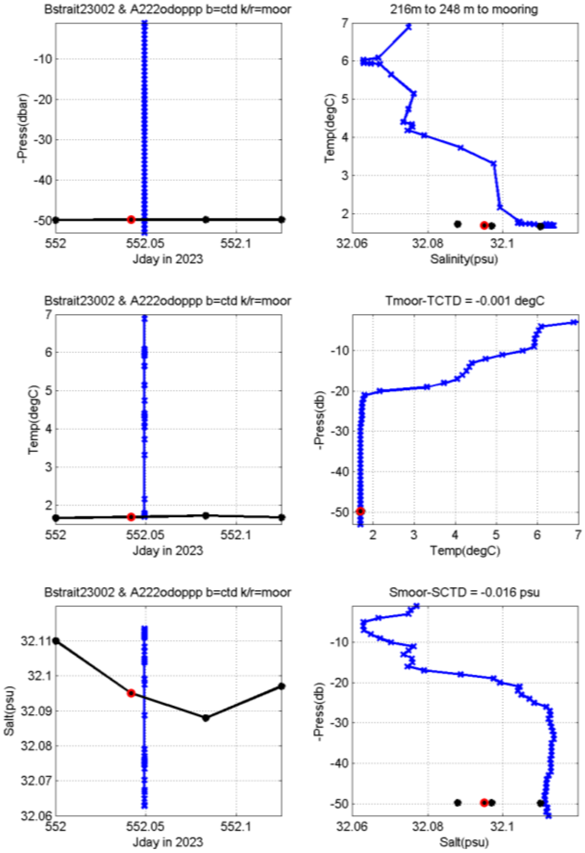
Even at seabird/odo depth inconclusive really.

Pre recovery:

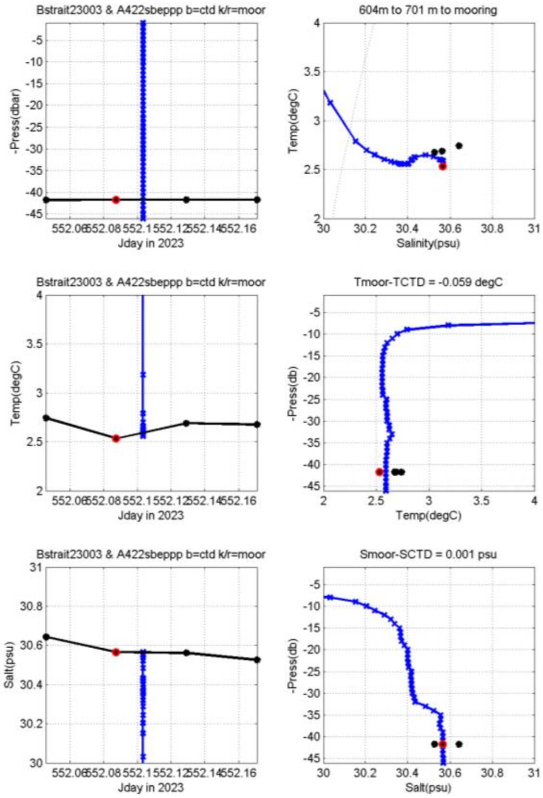
A2 – SBE

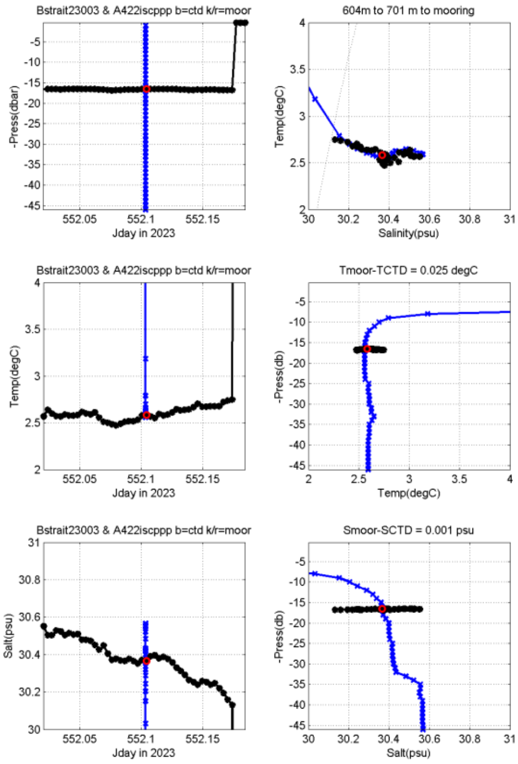


A2-ODO



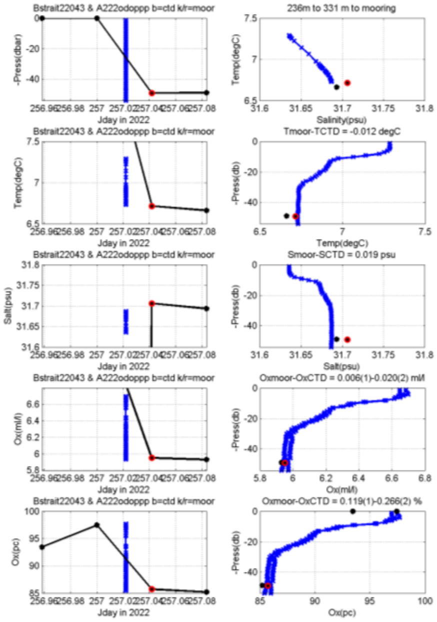
Both are too fresh (SBE (0.022psu) by more than ODO (0.016psu).. but not much difference



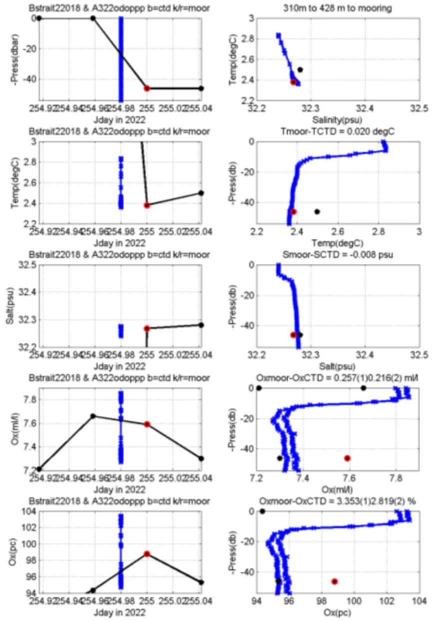


ODOs and CTD Oxygen

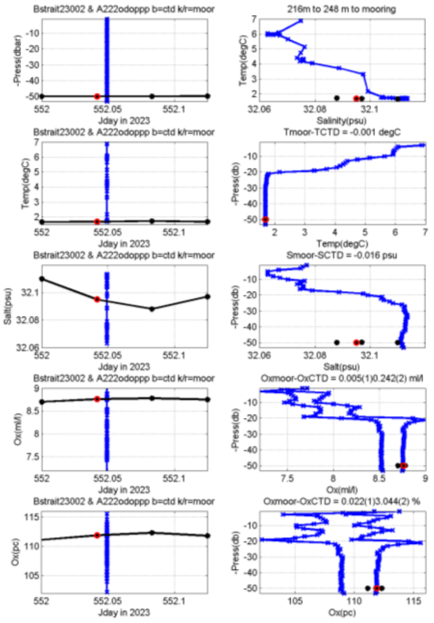
A2-22 in 2022
Looks good, ox1 better
0.006ml/l, 0.1% !!



A3-22 in 2022
First bad, but could be air
Second O1ml0.02, O2ml0.06ml
Second O1pc 0.1%, Ox2pc 0.7%

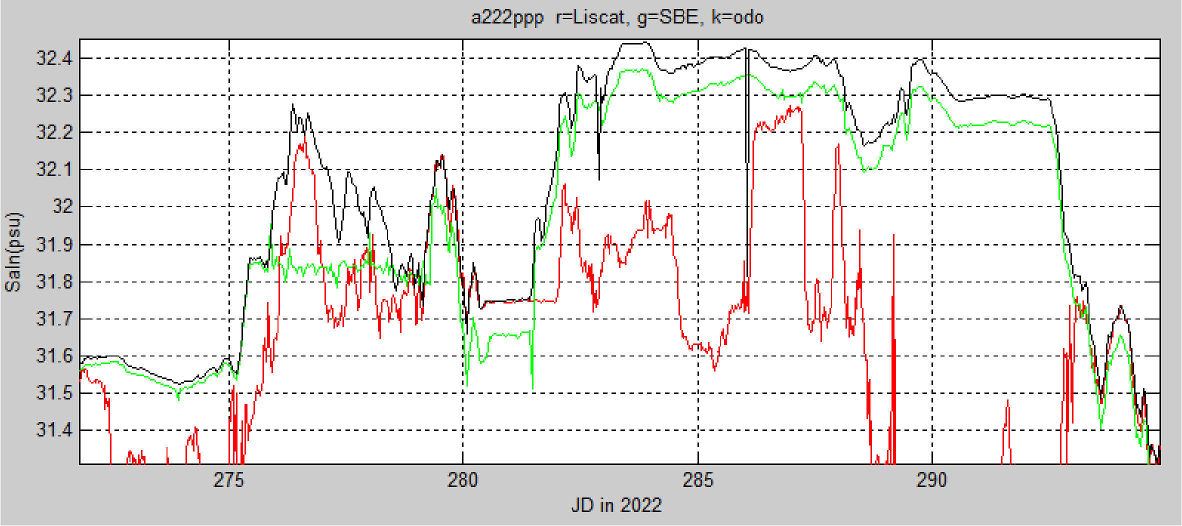


A2-22 in 2023
Looks good, ox1 better
0.005ml/l, 0.02%!!



```
%********SUMMARY CAL CASTS*** run Mar2024 with postcals *****
%Mooring  CTDYr CTDNum DISTSt&E(m) Press(db)  Mooring-CTD for
%                                                       T(degC)   S(psu)  Ox1mll  Ox2mll   Ox1pc   Ox2pc
% -- DEPLOYMENTs
A222sbeppp Bstrait22   043      236  331          50.7     -0.016    0.001
A222odoppp Bstrait22   043      236  331          49.0    - 0.012     0.019
A222odoppp Bstrait22   043      236  331          49.0    - 0.012     0.019    0.006   -0.020    0.119   -0.266
A222logpre Bstrait22   043      236  331          6.4       0.004  -16.980
A322sbeppp Bstrait22   018      310  428          43.3      0.014   - 0.006
A322odoppp Bstrait22   018      310  428          46.2      0.020   - 0.008
A322odoppp Bstrait22   018      310  428          46.2      0.020   - 0.008    0.257    0.216    3.353    2.819
A322iscppp Bstrait22   018      310  428          16.9    - 0.003     0.006
A322iscUppp Bstrait22  018      310  428           7.8      0.076    -0.024
A422sbeppp Bstrait22    016     410  521          41.7    - 0.021    -0.038
A422iscppp Bstrait22   016      410  521          17.4      0.271   - 0.135
%
% -- RECOVERY - SBEs
A222sbeppp Bstrait23   002      216  248          50.9    - 0.006   - 0.022
A222odoppp Bstrait23    002      216  248         49.8    - 0.001   - 0.016
A222odoppp Bstrait23    002     216  248          49.8    - 0.001   - 0.016    0.005    0.242    0.022    3.044
A422sbeppp Bstrait23   003      604  701          41.7    - 0.059     0.001
A422iscppp Bstrait23   003      604  701          16.6      0.025     0.001
```

A222- suspected cell clogging event.



Other Recovered/Deployed Instrumentation: Other instruments on the moorings were recovered/deployed for other groups. These instruments are:

Recoveries: An ***Aural Marine Mammal Acoustic*** sensor on A3 was deployed by Kate Stafford, (UW). This instrument was cleaned and data storage returned to Seattle for analysis.

Deployment: ***Marine Mammal Acoustic*** only 1 sensor (placed on A3) was deployed this year. This instrument is deployed for Kate Stafford, UW.

Details of mooring positions and instrumentation are given below, along with schematics of the moorings, photos of the mooring fouling, and preliminary plots of the data as available.

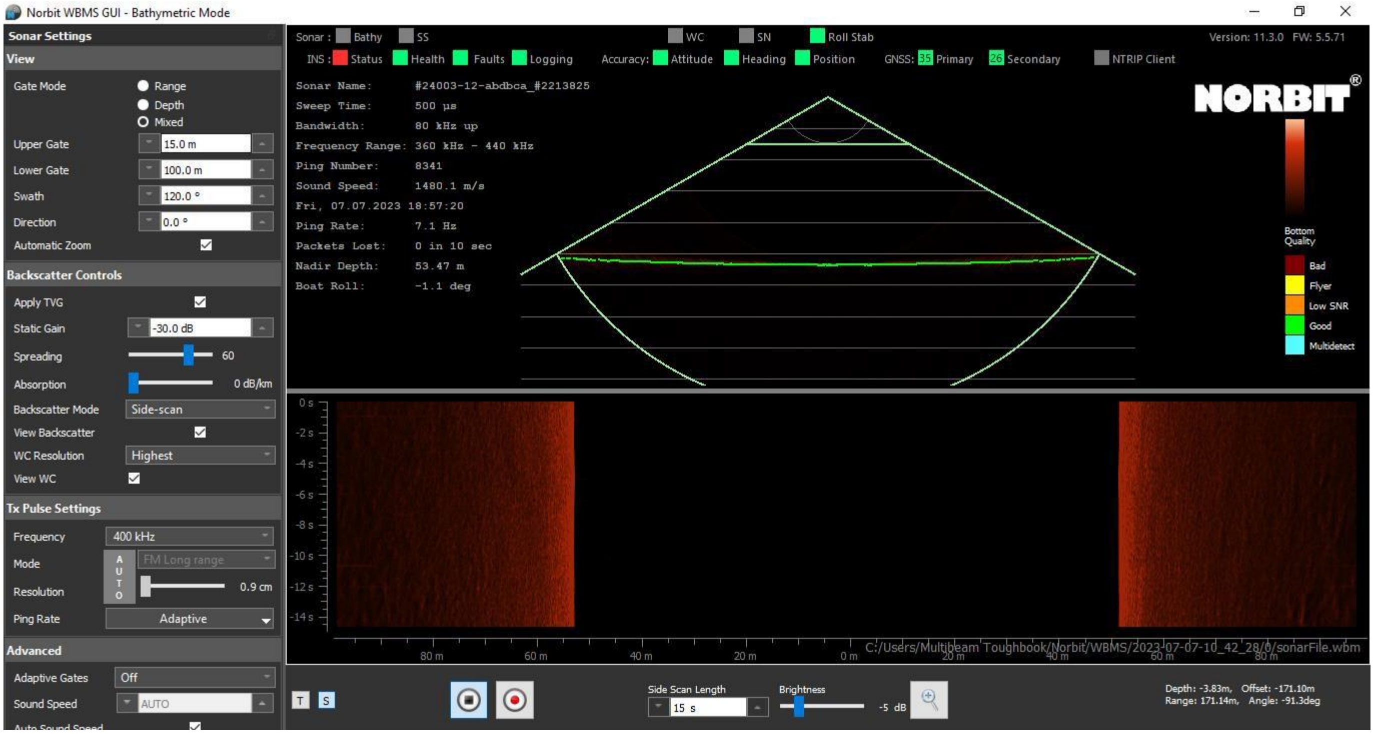
BERING STRAIT 2023 Multibeam Norbit Mooring Search

Our 2022 cruise failed to find mooring A2-21 despite many dragging operations at the deployment site and an acoustic survey of much of the southern Chukchi and some of the northern Bering. As a prior mooring had been dragged by ice, there was the possibility that the mooring was present in the region but with dual failed releases. Finding the mooring in this state with the equipment on the Norseman2 would require the ship to drive right over the top of the mooring, obviously a hopeless search strategy. Thus, in 2023 we thus borrowed a portable multibeam system which would allow a larger swath search of the region.

The Norbit iWBMS Turnkey Multibeam sonar system was borrowed from UW's Applied Physics Laboratory. The Norseman2 has, portside, a hingeable pole on which the system can be mounted. Instrument set up in Nome took approximately 4 hours. The sonar head was installed on the pole on the afternoon of the 4th July 2023. The Norbit requires two GPS antenna, which were mounted forward of the pivot pole, In-line with the ship's railing, so as to have a clear view of the sky. Cables were run through a midship access port into the main lab of the ship, where the laptop dedicated to the Norbit was set up. A brief test of the system was done in port in Nome once the system was installed (late afternoon).

To obtain calibrated data, it is necessary to run a heading alignment calibration. This was performed on the evening of the 4th July, during transit to the Strait, at a site on the shelf slope which was believed to house a ship wreck, (giving an opportunity of observing a sea floor feature). The calibration took ~4hrs, though with lessons learnt during the process, that could probably be done faster in future. In outline, the calibration has two phases, both of which involve driving figures of eight, (the first "tight", the second "lazy") so as to allow the system to quantify the antenna positions relative to the ship's turning. In each phase, continued pattern driving should reduce the heading error to an acceptable level. If that level is not reached within 30min, the calibration times out and one must start from the beginning again.
Try1 start: 919pm local, error down to 0.815 at 952pm and system timed out.
Try2 start 956pm local, error down to 0.528 at 1030pm and system timed out again
** Learnt it was better to drive FAST
Try3 start 1033pm local, error down to 0.487 at 1053pm which the system accepted, instructing then to drive a "lazy" figure of eight. That failed to get the error down and the calibration failed again at 1119pm.
Try 4, start 11:28pm, error down low enough by 11:46. For "lazy", kept at 5 knots and made the figure of 8 bigger, finding the error improved in the straight sections. At 12:05am, that calibration was accepted at 0.517deg error.
**** Learn: Drive fast and tight for the first stage**
Drive fast and Big for the second stage
There is option to allow for a bigger error.
As requested by the system, we then ran across and along slope sections, although it is unclear what this data would be useful for.

Next it was necessary (a) to find the settings required to see a mooring in the water and (b) to ascertain parameters (transit speed and swath separation) for a survey. On 5th July, we spent several hours experimenting with settings around the mooring A2-22 (which we found acoustically and on the ship's echosounder), with little convincing success. After a very thorough read of the manuals, on the 6th July we tried again with A3-23, finally finding settings where we could reliably see the mooring. Full settings are given below, but the vital ones appear to be:
- backscatter mode OFF (as snippet limits resolution to max 18kHz)
- water column resolution HIGH
- view water column ON.


Norbit WBMS GUI - Bathymetric Mode

Sonar Settings

View

Gate Mode: ○ Range ○ Depth ● Mixed
Upper Gate: 15.0 m
Lower Gate: 100.0 m
Swath: 120.0 °
Direction: 0.0 °
Automatic Zoom: ☑

Backscatter Controls

Apply TVG: ☑
Static Gain: -30.0 dB
Spreading: 60
Absorption: 0 dB/km
Backscatter Mode: Side-scan
View Backscatter: ☑
WC Resolution: Highest
View WC: ☑

Tx Pulse Settings

Frequency: 400 kHz
Mode: AUTO FM Long range
Resolution: 0.9 cm
Ping Rate: Adaptive

Advanced

Adaptive Gates: Off
Sound Speed: AUTO
Auto Sound Speed: ☑

```
Sonar Name:       #24003-12-abdbca_#2213825
Sweep Time:       500 µs
Bandwidth:        80 kHz up
Frequency Range:  360 kHz - 440 kHz
Ping Number:      8341
Sound Speed:      1480.1 m/s
Fri, 07.07.2023 18:57:20
Ping Rate:        7.1 Hz
Packets Lost:     0 in 10 sec
Nadir Depth:      53.47 m
Boat Roll:        -1.1 deg
```

Version: 11.3.0 FW: 5.5.71

C:/Users/Multibeam Toughbook/Norbit/WBMS/2023-07-07-10_42_28/0/sonarFile.wbm

Side Scan Length: 15 s
Brightness: -5 dB

Depth: -3.83m, Offset: -171.10m
Range: 171.14m, Angle: -91.3deg

This is the typical Norbit screen

-left = settings (see below)

-top middie ('the oyster') screen showing current returns, showing vertical section under the Norbit (which is the peak of the triangle). Sloping horizontal lines are the edges of the swath. Upper horizontal white line is the minimum range gate (set to avoid noise from the surface). Curved white line going off bottom of panel is the maximum range gate. Green, slightly rough horizontal line is the image of the bottom. Thus**, a mooring appears in this panel as a vertical line, at a horizontal position according to its location under the Norbit,** (see red circled blips in picture below).

- bottom middle – scrolled history. Brown areas show sea floor features, and the black area center is a representation of the water column. Thus a seafloor feature extending both sides of the Norbit would appear cut in half by the black water column area. A mooring might be identified in this by the anchor appearing as a very small blimp in the brown area. But if is far better seen as a brown vertical dash in the black area

Sighting of a mooring was best done by seeing the image appear in the oyster area. At the ship's speeds used (see below), the image in this area was only present for about 1 or maybe 2 seconds (increasing in intensity and then fading away). Once the mooring was identified in the oyster area, its presence could be confirmed by looking at the bottom brown plot, where a vertical dash in the black area (about 1/20th of height of the panel) would appear and move down the screen for about 30s before disappearing.

To reliably see a mooring, it was thus essential to never take your eyes off the screen. Thus, in the search we completed, we ran a 24hr watch system with 2 teams of three people, and 1 floater. The Norbit image was mirrored onto the second screen usually used for the CTD. At any time, two of the watch were sat in front of these two screens, while the third watch member provided support (food, drink, sanity, music, etc,) At intervals (typically 30min-1hr, or whenever anyone was tired),team members would swap around.

Final settings determined to work for seeing our moorings: X = means activated

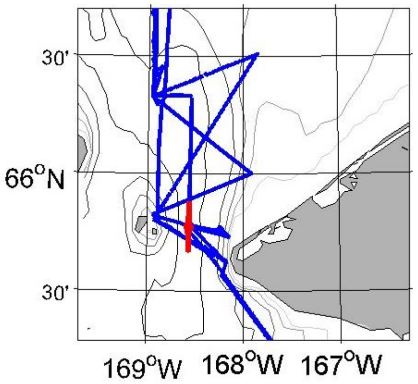
VIEW		ADVANCED
Gate Mode – Mixed		Adaptive Gates – Manual - normal
Upper Gate – 15		Sound Speed – Off
Lower Gate – 100		Auto Sound Speed – X
Swath – 120		Stabilization – X Roll
Direction – 0		Pulse Amplitude – 15
Automatic Zoom – X		Beam Distribution - Equiangular 512
BACKSCATTER CONTROLS		Sonar Tilt - 0
Apply TVG – X		Multidetect - X
Static Gain - -30		CONNECTION
Spreading – 60		Server Status – Server started
Absorption – 0		Port - 7000
Backscatter Mode - Sidescan		Auto Start - X
View Backscatter – X		Force Push – [ ]
WC Resolution – Highest		ExportS7K Real Time - X
View WC - X		
TX PULSE SETTINGS		
Frequency – 400 KHz		
Mode – Auto- full range		
Resolution – 0.9cm		
Auto Mode – X		
Ping Rate - Adaptive		

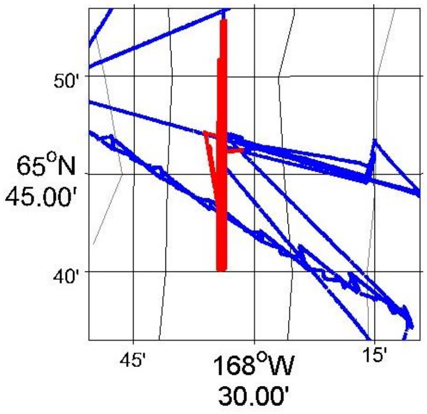
Static Gain at -154 also worked

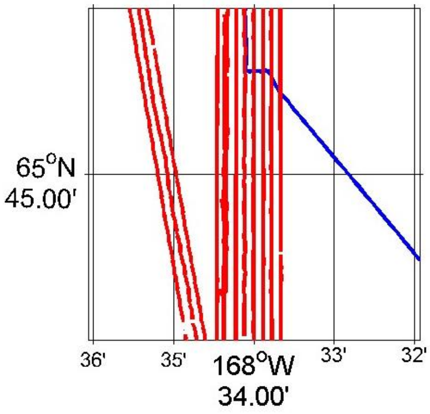
Having obtained reliable imaging of the mooring, it was then necessary to determine a search pattern. Repeated passes over A3-23 lead us to conclude a line spacing of 70m was reliably able to detect a mooring in the region. (Note that the Norbit was off the center of the ship, however keeping track of this was deemed too open to error, and thus 70m was chosen as a conservative estimate.

Ship speed was another concern. The original intent was 2-3knots, but maintaining ship heading at these speeds was very difficult without moving in and out of gear, a maneuver which put noise into the Norbit data. To address this issue, the ship used a trolling motor, which allowed them to stay in gear at much slower speeds. After trials, around 5-6knot was deemed an acceptable speed, being better at covering area while still slow enough to identify the mooring. .

On Friday 7th July around 1015am, we started the survey of the search area. Initially we swept out an area of 1km around the mooring site, and then ran a search grid extending 500m east west and 9-12.6nm north south. Studies of past data show the flow direction to be strongly confined to the north south direction.







This survey lasted almost 24hrs, until 9am on Saturday 8th July. While mooring A2-22 (left in the water as a calibration point) was reliably identified during this survey, no other reliable targets were found.

After recovery of A2-22, while A2-23 was being prepared for deployment, a few more survey lines were run, near the ‘maybe’ point, a site where a promising signal had been seen on the ship’s echosounder the previous year, but again no sign was found of the mooring.

To conclude the search, we sent the release codes for the missing A2-21, unsurprisingly without any reply. Thus, A2-23 was deployed and re moved to CTD operations.

CONCLUSIONS: Although the missing mooring A2-21 was not found, once calibrated and correctly set up, the Norbit system worked well. We are confident that, had the mooring been in the region searched, we would have found it.

BERING STRAIT 2023 MOORING POSITIONS AND INSTRUMENTATION

ID	LATITUDE (N) (WGS-84)	LONGITUDE (W) (WGS-84)	WATER DEPTH /m (corrected)	INST.
2022-2023 Moorings (i.e. recoveries)				
A2-22	65 46.850	168 34.103	56	ISCAT, ADCP, SBE37ODO, FLNTUSB, SUNA SBE16
A4-22	65 44.743	168 15.781	49	ISCAT, ADCP, SBE16, FLNTUSB
A3-22	66 19.628	168 56.930	58	MISCAT, ADCP with SBE16, SBE37ODO, FLNTUSB, SUNA new MMR

ID	LATITUDE (N) (WGS-84)	LONGITUDE (W) (WGS-84)	WATER DEPTH /m (corrected)	INST.
2023 Mooring Deployments				
A2-23	65 46.864	168 34.062	56	ISCAT, ADCP, SBE37ODO, FLNTUSB, SUNA SBE16
A4-23	65 44.761	168 15.756	49	ISCAT, ADCP, SBE16, FLNTUSB
A3-23	66 19.600	168 56.944	58	MISCAT, ADCP with SBE16, SBE37ODO, FLNTUSB, SUNA new MMR

ADCP = RDI Acoustic Doppler Current Profiler
ISCAT = near-surface Seabird TS sensor in trawl resistant housing, with near-bottom data logger
MISCAT = ISCAT with two near-surface sensors (one at ~ 8m, one at ~ 16m)
SBE16 = Seabird CTD recorder, SBE37 = Seabird CTD recorder
MMR=Marine Mammal Recorder (new=new APL version)
SBE37ODO = Seabird CTD and dissolved oxygen recorder
FLNTUSB = Wetlabs fluorescence and turbidity recorder
SUNA = Seabird optical SUNA nitrate sensor

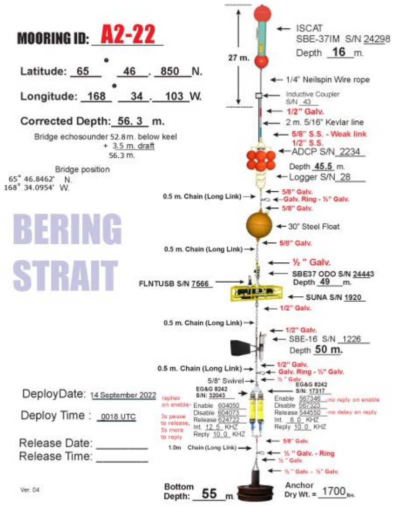
For 2022 deployments, water depths are assuming a ship's draft of 3.5m.
For 2023 deployments, water depths are assuming a ship's draft of 3m.

BERING STRAIT 2023 SCHEMATICS OF MOORING RECOVERIES AND DEPLOYMENTS

RECOVERED

DEPLOYED

= in the eastern channel of the Bering Strait



MOORING ID: A2-22

Latitude: 65° 46. 850 N.

Longitude: 168° 34. 103 W.

Corrected Depth: 56. 3 m.

Bridge echosounder 52.8 m. below keel
+ 3.5 m. draft
56.3 m.

Bridge position
65° 46.8462' N.
168° 34.0954' W.

DeployDate: 14 September 2022

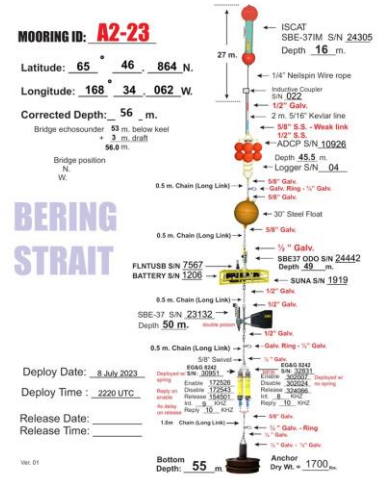
Deploy Time : 0018 UTC

Release Date: ________
Release Time: ________

Ver. 04

Bottom Depth: 55 m.

Anchor Dry Wt. = 1700 lbs.



MOORING ID: A2-23

Latitude: 65° 46. 864 N.

Longitude: 168° 34. 062 W.

Corrected Depth: 56 m.

Bridge echosounder 53 m. below keel
+ 3 m. draft
56.0 m.

Bridge position
N.
W.

Deploy Date: 8 July 2023

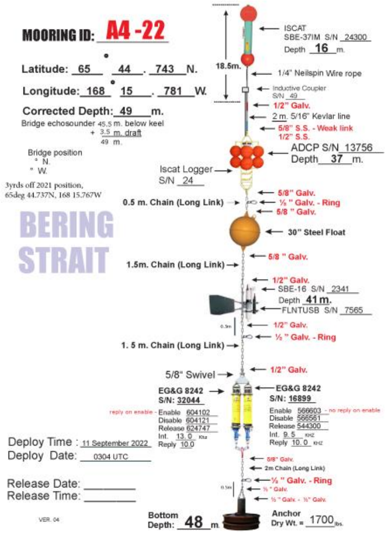
Deploy Time : 2220 UTC

Release Date: ________
Release Time: ________

Ver. 01

Bottom Depth: 55 m.

Anchor Dry Wt. = 1700 lbs.



MOORING ID: A4 -22

Latitude: 65° 44. 743 N.

Longitude: 168° 15. 781 W.

Corrected Depth: 49 m.

Bridge echosounder 45.5 m. below keel
+ 3.5 m. draft
49 m.

Bridge position
° N.
° W.

3yrds off 2021 position,
65deg 44.737N, 168 15.767W

Deploy Time : 11 September 2022

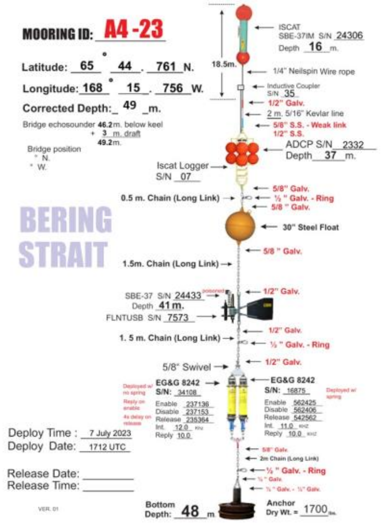
Deploy Date: 0304 UTC

Release Date: ________
Release Time: ________

VER. 04

Bottom Depth: 48 m.

Anchor Dry Wt. = 1700 lbs.



MOORING ID: A4 -23

Latitude: 65° 44. 761 N.

Longitude: 168° 15. 756 W.

Corrected Depth: 49 m.

Bridge echosounder 46.2 m. below keel
+ 3 m. draft
49.2 m.

Bridge position
° N.
° W.

Deploy Time : 7 July 2023

Deploy Date: 1712 UTC

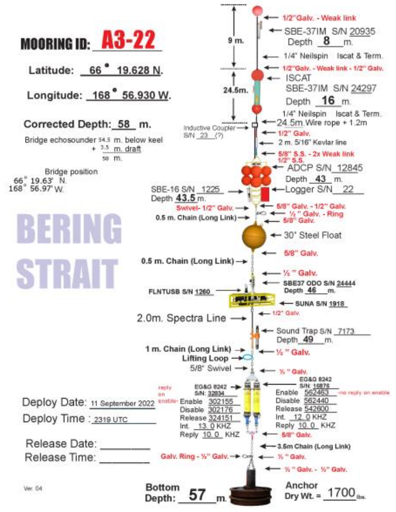
Release Date: ________
Release Time: ________

VER. 01

Bottom Depth: 48 m.

Anchor Dry Wt. = 1700 lbs.

= at the climate site, ~ 60km north of the Strait



MOORING ID: A3-22

Latitude: 66° 19.628 N.

Longitude: 168° 56.930 W.

Corrected Depth: 58 m.

Bridge echosounder 54.5 m. below keel
+ 3.5 m. draft
58 m.

Bridge position
66° 19.63' N.
168° 56.97' W.

Deploy Date: 11 September 2022

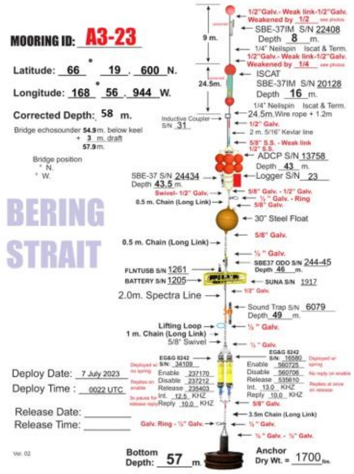
Deploy Time : 2319 UTC

Release Date: ________
Release Time: ________

Ver. 04

Bottom Depth: 57 m.

Anchor Dry Wt. = 1700 lbs.



MOORING ID: A3-23

Latitude: 66° 19. 600 N.

Longitude: 168° 56. 944 W.

Corrected Depth: 58 m.

Bridge echosounder 54.9 m. below keel
+ 3 m. draft
57.9 m.

Bridge position
° N.
° W.

Deploy Date: 7 July 2023

Deploy Time : 0022 UTC

Release Date: ________
Release Time: ________

Ver. 02

Bottom Depth: 57 m.

Anchor Dry Wt. = 1700 lbs.

BERING STRAIT 2023 RECOVERY PHOTOS

A4-22 (dragged)

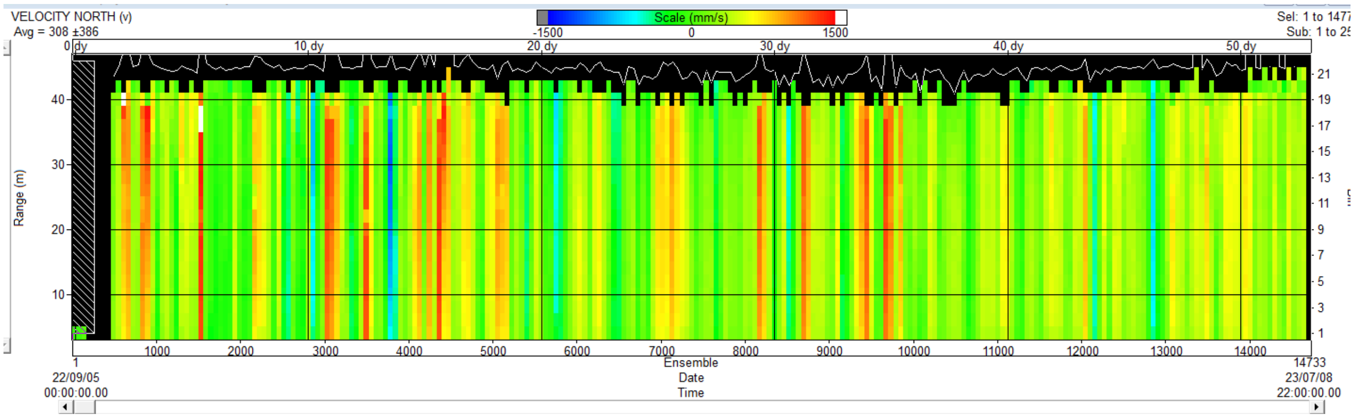
Iscat floating free after dragging. Coiled wire rope and marks show trawl wire ran up it, and pulled top iscat off

A2-22

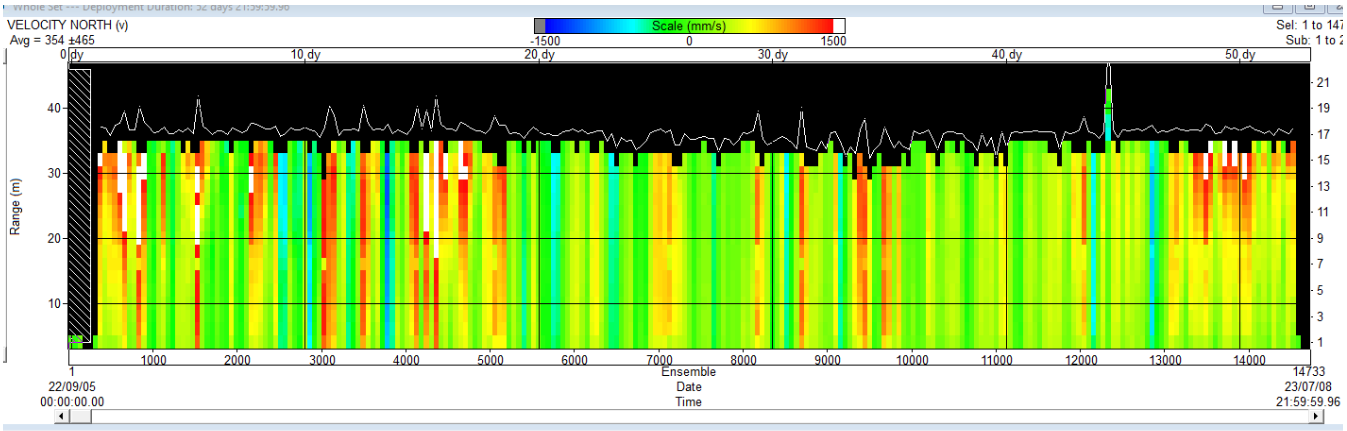
A3-22

NORTHWARD VELOCITY from Bering Strait 2022-2023 ADCPs

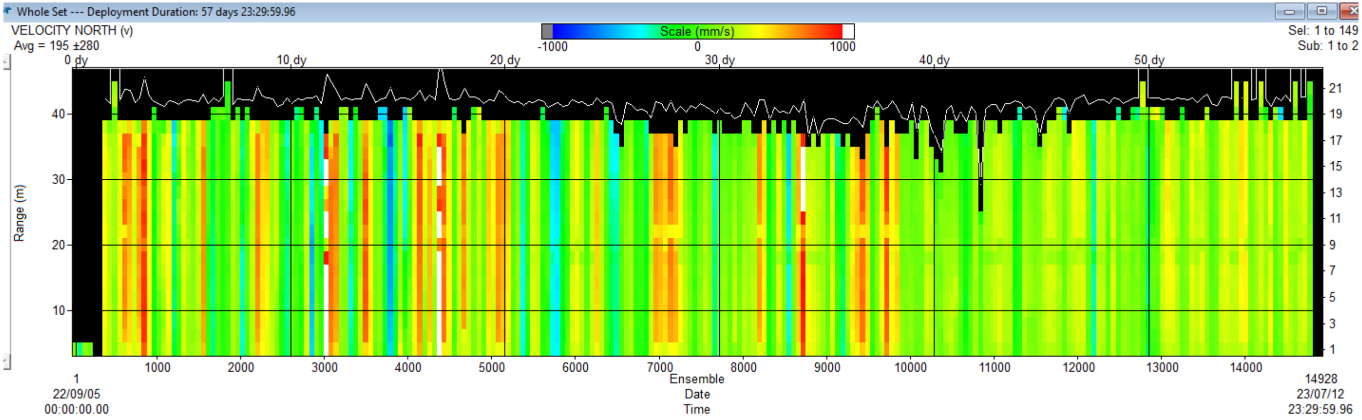
A2-22 2234



A4-22-13756

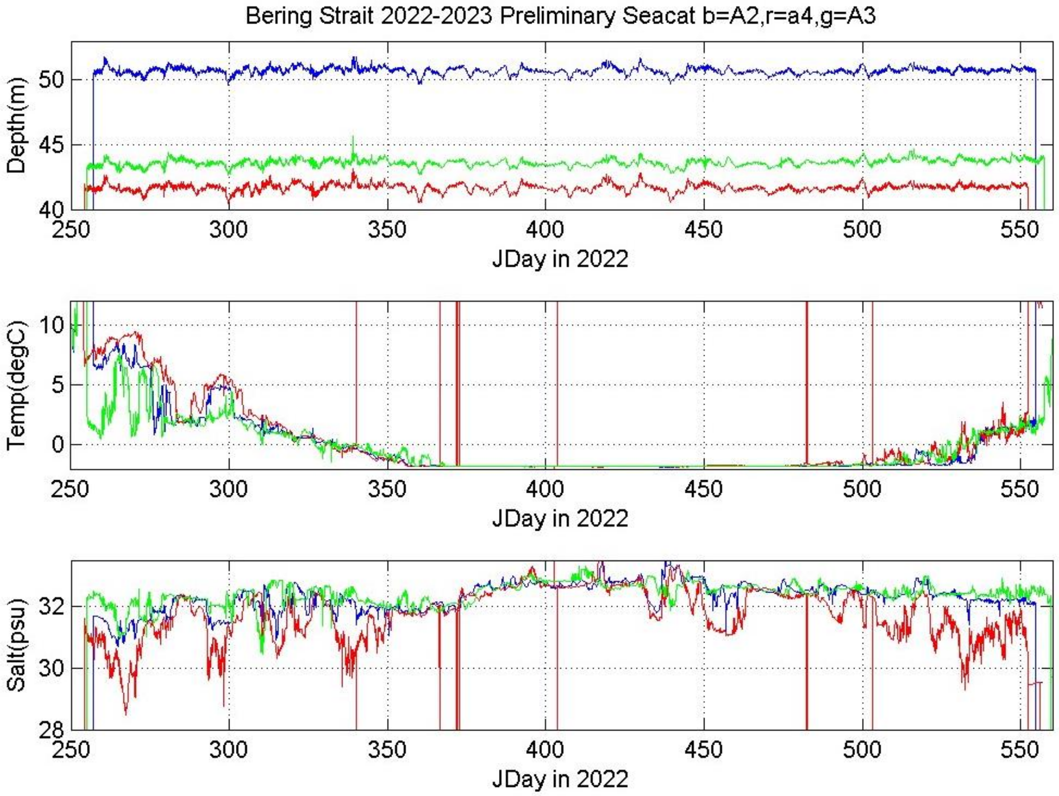


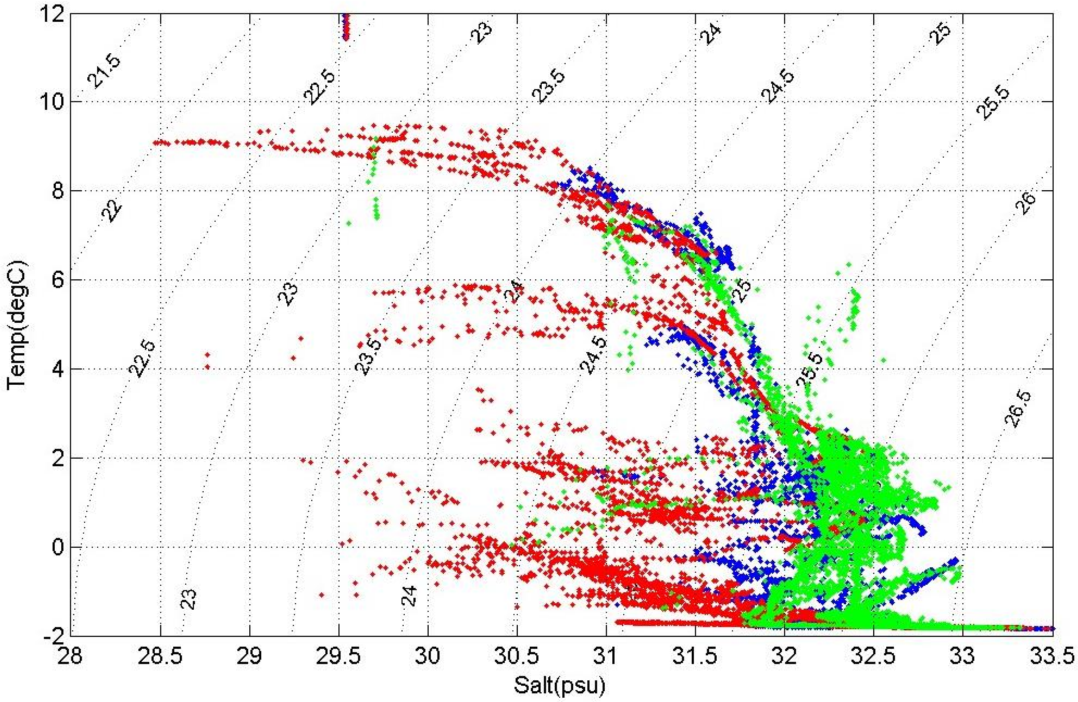
A3-22 12845 (Note different scale)



BERING STRAIT 2022-2023 SBE PRELIMINARY RESULTS (Ax22 data)

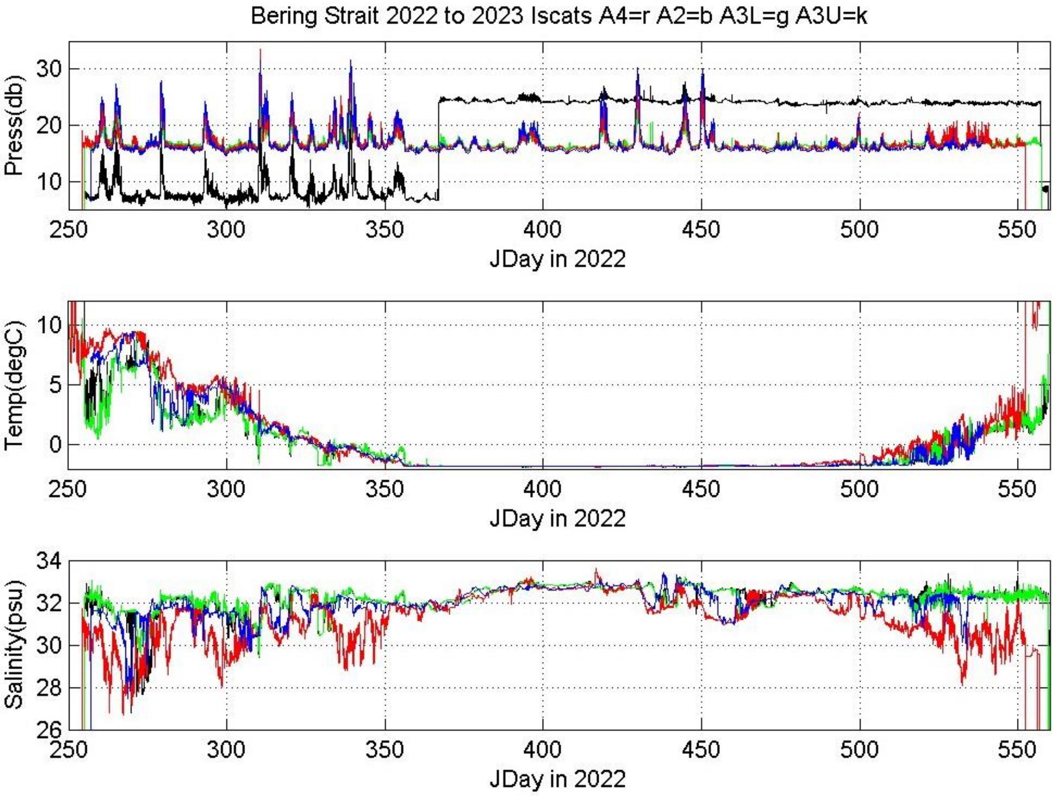
– all lower level TS Sensors

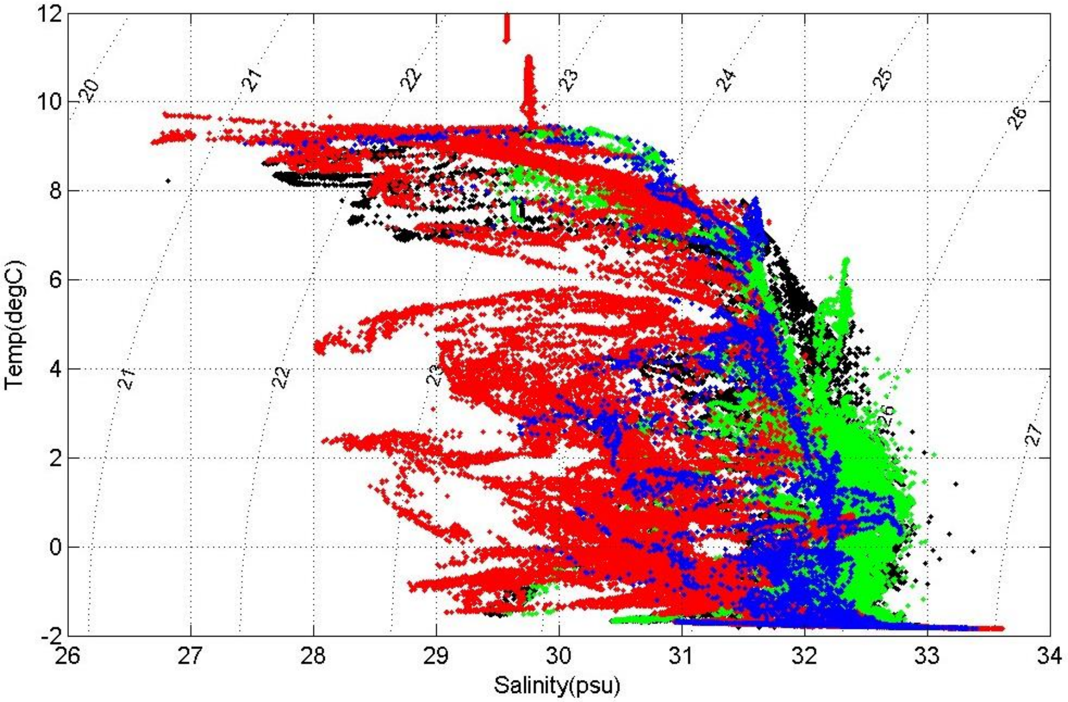




BERING STRAIT 2022-2023 ISCAT PRELIMINARY RESULTS

– all upper level TS Sensors



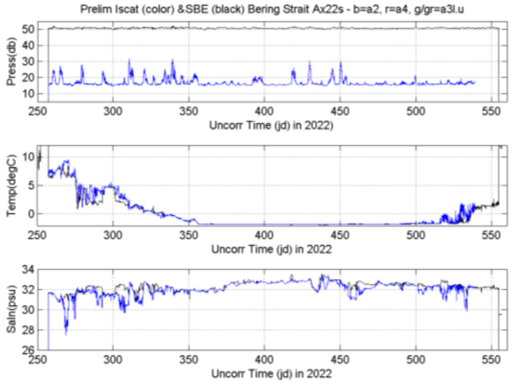


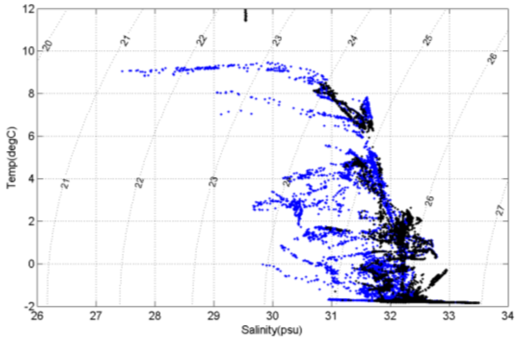
(includes testtank data)

BERING STRAIT 2022-2023 ISCAT and SBE PRELIMINARY RESULTS (Ax22data)

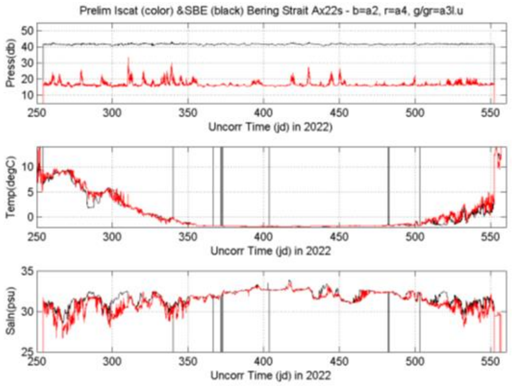
–upper and lower TS sensors by mooring

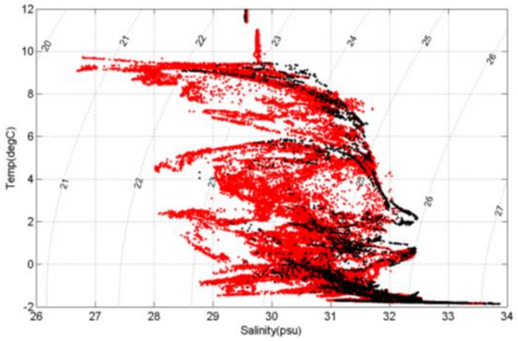
A2-21



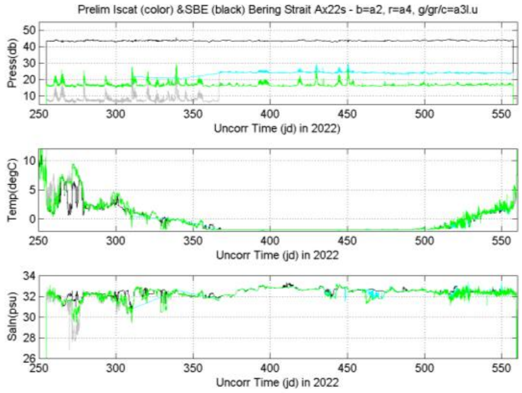


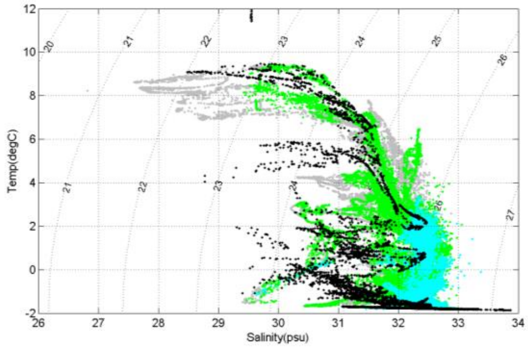
A4-21



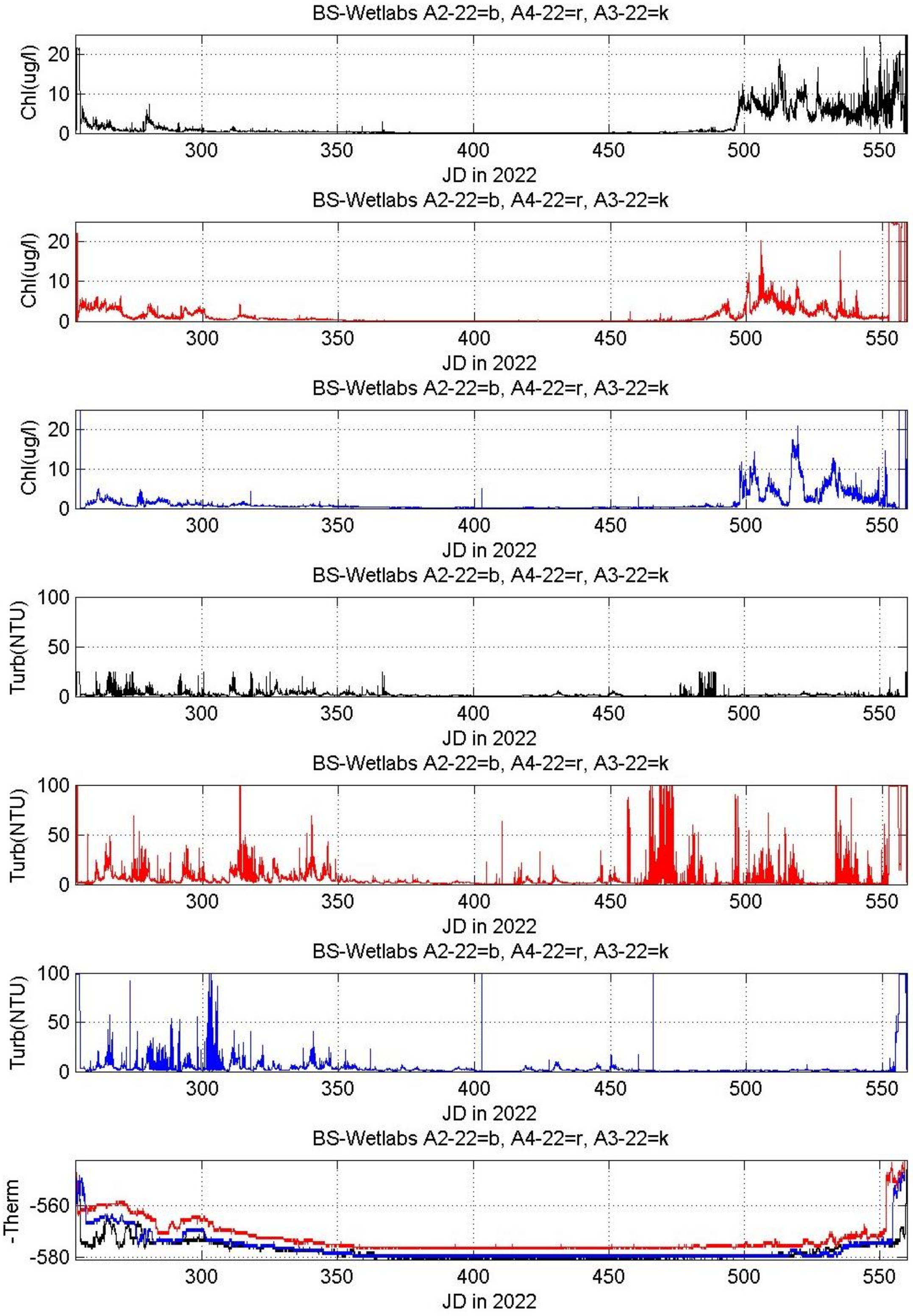


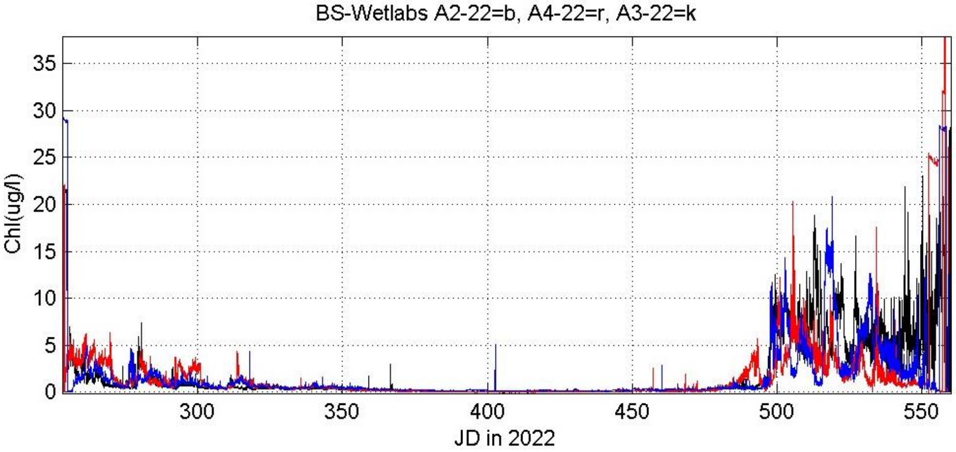
A3-21

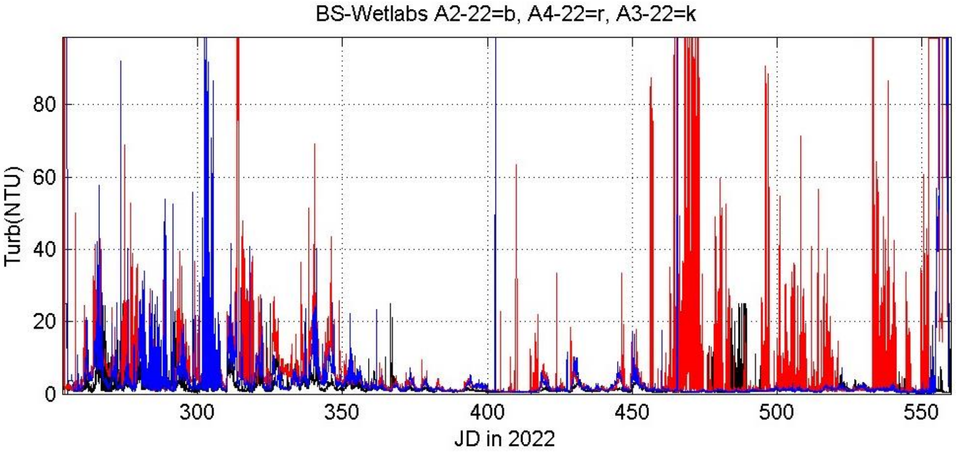


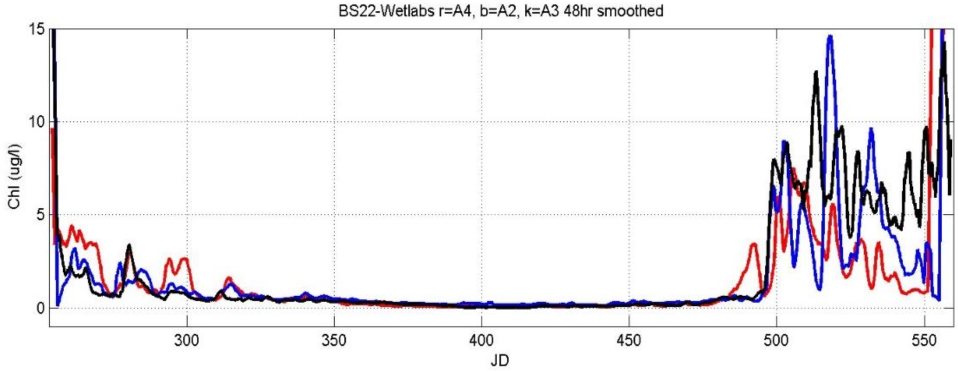


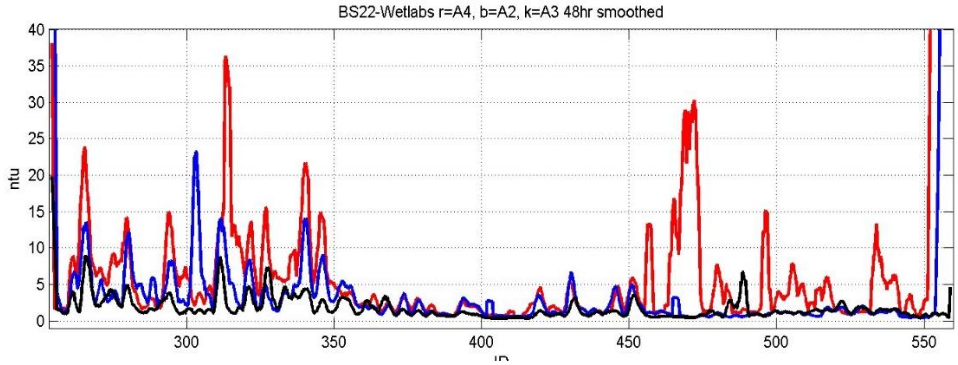
BERING STRAIT 2022-2023 WETLABS Chlorophyll (Fluorescence) and Turbdity PRELIMINARY RESULTS (Ax22data)



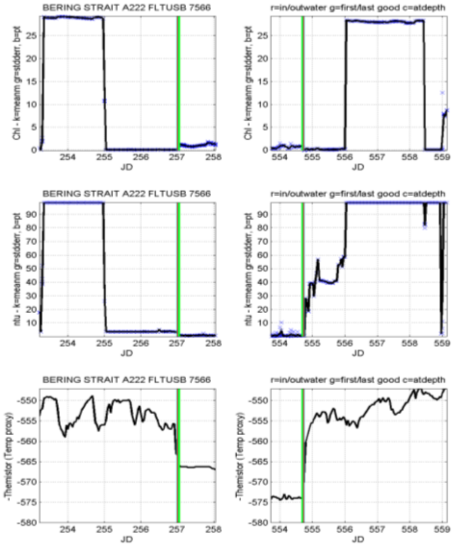

BS-Wetlabs A2-22=b, A4-22=r, A3-22=k
Chl(ug/l)
35
30
25
20
15
10
5
0
300
350
400
450
500
550
JD in 2022


BS-Wetlabs A2-22=b, A4-22=r, A3-22=k
Turb(NTU)
80
60
40
20
0
300
350
400
450
500
550
JD in 2022


BS22-Wetlabs r=A4, b=A2, k=A3 48hr smoothed
Chl (ug/l)
15
10
5
0
300
350
400
450
500
550
JD

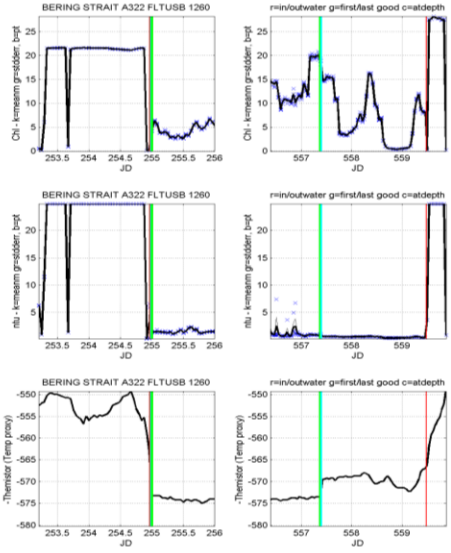

BS22-Wetlabs r=A4, b=A2, k=A3 48hr smoothed
ntu
40
35
30
25
20
15
10
5
0
300
350
400
450
500
550

And comparison of time before and after deployment (i.e., with cap on).


BERING STRAIT A222 FLTUSB 7566

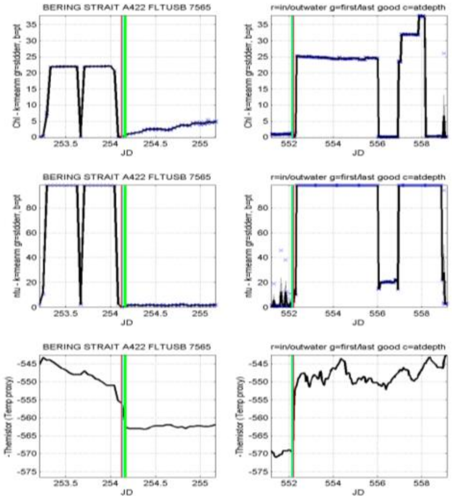
r=in/outwater g=first/last good c=atdepth

A2-22


BERING STRAIT A322 FLTUSB 1260

r=in/outwater g=first/last good c=atdepth

A3-22


BERING STRAIT A422 FLTUSB 7565

r=in/outwater g=first/last good c=atdepth

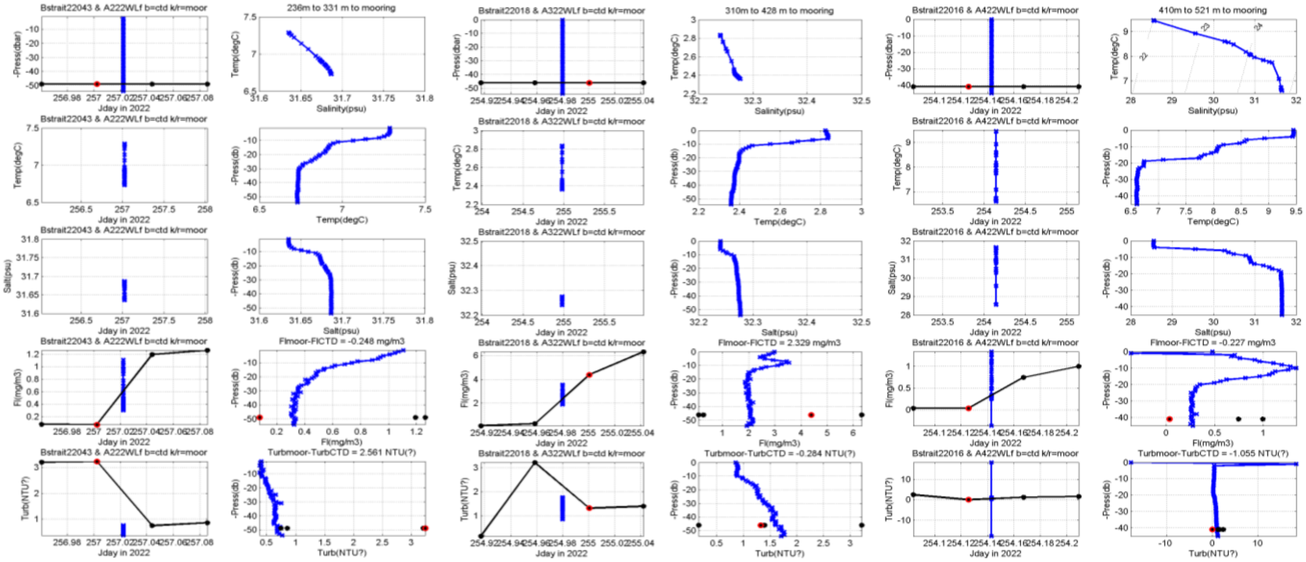
A4-22

Compare Mooring to CTD casts (units: Chlorophuyll, mg/m3, equivalent to ug/l); Turbidity, NTU)

A2 in 2022	**A3 in 2022**	**A4 in 2022**
Chl Mooring 1, CTD 0.3	Chl Mooring 4 , CTD 2	Chl Mooring 0.7 , CTD 0.2
Turb MATCH!! (0.7)	Turb v close 1.4 not 1.6	Turb Mooring 0 , CTD 1

Chl: Mooring HIGHER than CTD. Could be that CTD-Chl IS LOW …. But these are all small numbers -

Turb is remarkably close, with mooring LESS than CTD

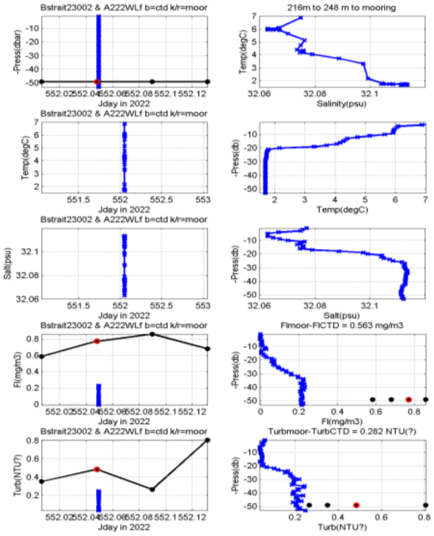


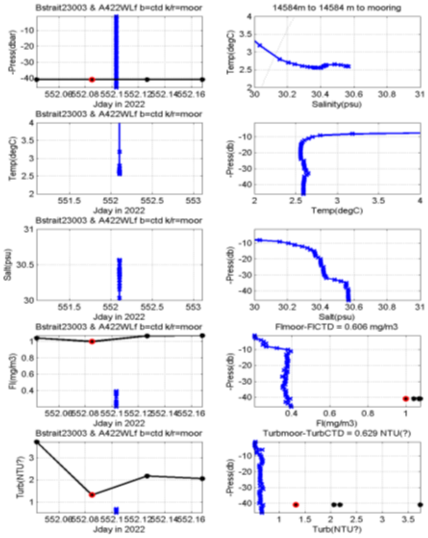
A2 in 2023	**A4 in 2023**
Chl Mooring 0.8 , CTD 0.2	Chl Mooring 1 , CTD 0.4
Turb Mooring 0.5 , CTD 0.2	Turb Mooring 1.4 , CTD 0.8

Chl Mooring HIGHER than CTD, Very similar to deployments, but not many data points

Could be that CTD-chl IS LOW …. But these are all small numbers

Turb now mooring is 0.5 higher … but that again is small numbers.





CONCLUDE: - Chl differences (Mooring to CTD) are very similar in deployment and recovery. (Diff 2ug/l) Is encouraging that drift might be small, and but these are all on small numbers and might not give a realistic view of the higher values. Mooring is both cases higher than CTD. (CTD has not been calibrated for a long time.)

- Suggests that Mooring Turb might have drifted to higher numbers (maybe as not so clean?). But delta only 0.3NTU (but in about 0.2-0.8NTUs).

CTD OPERATIONS (Whole Science Team)

As in previous years, in 2023 the moorings were supported by annual CTD sections. This year, these sections were run with a CTD rosette system to allow bottle samples to be taken. This is in addition to the separate pumped system was used to take trace metal and nutrient samples.

The CTD rosette system used on this cruise was loaned from APL-UW and, used the same instrumentation as in previous years, other than the altimeter was replaced with a SUNA nitrate sensor with external battery pack (which required the space of one of the bottles of the rosette). Serial numbers and calibration dates are given here. Note the system was sent for calibration some months before the cruise, however the xmlcon file used during the cruise did not capture the new oxygen calibrations. Sections plotted here have been postprocessed with the most recent calibrations, which are listed here:

one SBE9+ with pressure sensor
(SN26451 – calibration 17th June 2019 (Not calibrated pre cruise)
two SBE3 temperature sensors
(T1 = SN0843 – calibration 21st Dec 2022)
(T2 = SN0844 – calibration 21st Dec 2022)
two SBE4 conductivity sensors
(S1 = SN0484 – calibration 13th Dec 2022)
(S2 = SN0485 – calibration 14th Feb 2023)
two SBE43 oxygen sensors
(Ox1 = SN1753 – calibration 21st Feb 2023)
(Ox2 = SN1754 – calibration 21st Feb 2023)
one Wetlabs FLNTURT fluorescence/turbidity sensor (SN1622 – calibration 11th March 2010)
on SUNA nitrate sensor (SN1916 -new summer 2022, reference update pre cruise)
two Seabird pumps (believed to be SN50340, SN55236, but not confirmed)
one EG&G transponder (D-CAT SN31892, Interrogate: 11.0kHz, Reply: 13.5kHz)

The temperature, conductivity and oxygen probes were paired as last year, viz:

	Temperature	**Conductivity**	**Oxygen**	**Pump**
Primary	#843	#484	#1753	SN NA
Secondary	#844	#485	#1754	SN NA

With the rosette system, the sensors are mounted horizontally below the rosette. Care must be taken that they are installed the correct way around as the rosette frame is not symmetric, and only in one orientation are the sensors protected by the cage. **Action item Check mounting before shipping from Seattle**.

The CTD was connected to a conducting wire winch on the ship. This winch (Rapp Hydema NW, SOW 160 5000m capacity, with 3 conductor 0.322”diameter wire), was new on the Norseman II in 2014. Chris Siani, APL, assisted with wiring and CTD tests of this system while the ship was in Seattle in April 2014. In 2022, we found the termination had been changed by the prior cruise. We reterminated, but the test cast failed however, and eventually this was traced to a leak in the termination. A second retermination was successful. In 2023, no retermination was necessary. **Action item: Bring several termination kits.**

The winch was connected to an SBE11 deckbox, which in turn was linked via serial ports and USB-serial connectors to a dedicated PC, running the software package Seasave v7. Data were recorded in standard hexadecimal SBE format, incorporating NMEA GPS input from the Norseman II. **Action item: Check which GPS used, and that the date is not subject to the roll over error.**

An event log (copied attached at the end of this report) was maintained on the CTD computer, including comments on data quality and other issues. The log, the data files, and a screen dump of the end-of-cast Seasave image were copied to a thumb drive as a backup after each cast.

The CTD console was set on the port side of the interior lab. The package was deployed through the aft A-frame using a special block supplied by the ship. Although a Pentagon ULT unit had been mounted inside by the CTD console for lowering and raising the CTD, in practice, the winch driving was done by a crew member on deck, directed by the CTD operator using radio commands. This was deemed more efficient given the shortness of the casts (50m or less).

As in previous years, in 2023 the crew operated the winch from a remote console on the deck by the A-frame. The lowering (and raising) rate we seek is ~30 or 40m/min. There is no readout of winch speed at the remote console and winch drivers had to estimate speed either from the sound of the winch or from feedback from the scientist in the lab. **Action item: Be sure to calibrate in winch speed early in the cruise, preferably with some scale on the winch so the speed is consistent between operators. Update ship's winch so as to provide a speed readout by the remote console. Also, train CTD driver to check winch speed on read-out beside CTD console both for lowering and raising.**

For the casts done during mooring operations, the CTD was hand-carried forward after each cast to the port-forward corner of the aft-deck, to clear the aft-deck for mooring work. Once all the mooring work was complete, the CTD package was kept on the aft deck.

Once mooring work was complete, CTD operations were run 24hrs, using a team (per watch) of 1 science team member driving the CTD, and up to 3 personnel (2 ship, 1 science) on deck - one (ship's crew) driving the winch, one ship's crew on starboard side of deck, one scientist on port side of deck. Since the aft doors were open so as to not lift the CTD too high, all personnel on deck wore harnesses and were attached to the "dog runs" overhead wires. **Action item: Consider if rosette could be lifted over the rail rather than work with aft doors open**. For this cruise, weather did not require tag lines to be used.

The efficiency of the crew made for very speedy CTD operations, and combined with the fast winch speed, resulted in commendably fast times for running line, though significantly slower than using the non-rosette system. If pumped samples were to be taken, this operation followed on immediately after the CTD cast without the ship repositioning. **Action item: Make sure the CTD is recovered and out of the water before the pump system is deployed, otherwise ship's manoeuvrability is compromised**.

Prior to each cast the turbidity sensor was cleaned by rinsing with soapy water and freshwater and wiping. **Action item: Bring syringe with better fit for flushing the CTD cell.**

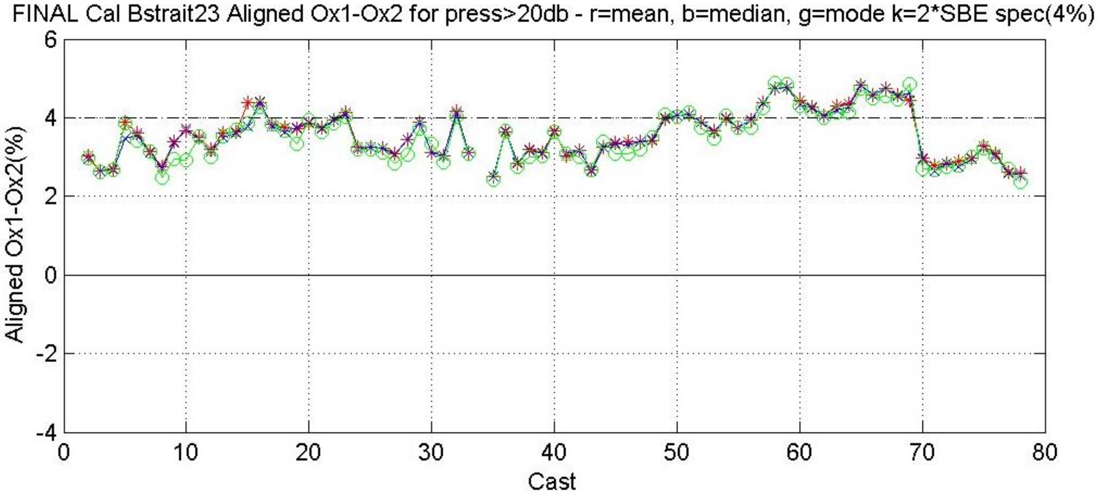
Ship's draft was estimated at 2m, and this should be taken into account in viewing the data. Also given that sea states were often significant and the altimeter on the CTD (which usually rarely functioned) was not used this year, some casts stop 5m-6m above the bottom.

As in 2022, a SUNA nitrate sensor was added to the CTD package. As this requires significant current on start up, it was powered by an external, rechargeable battery, as per a design from Seth Danielson. When the CTD powers on, this activates a relay in the external battery which turns on power to the SUNA. Two battery packs were constructed so one could be charging while one was in use. **Action item: Add charging information here**. The SUNA returned a voltage to SeaSave, which gives a rough estimate of nitrate. Proper calibration of this data stream is still required. **Action item: Process SUNA data once CTD data final.** Plots in this report use preprocessed SUNA data.

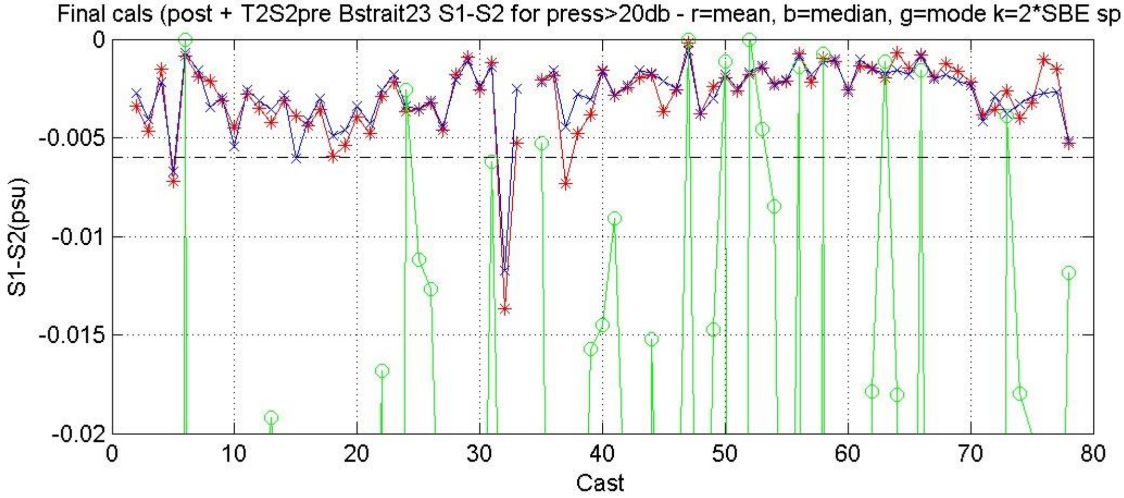
Overall, CTD data this year are exceedingly clean, although the following issues were encountered:

Cast1: - has poor data, but was only for bottle firing check rather than the cast itself
Cast 8: - was yoyoed on the upcast
Cast 16: - problems with S2
Cast 73: - partial dropout of SUNA data.

Note that the raw cruise data was using the old calibrations resulting in significant differences (6-8%) between O1 and O2. This discrepancy is reduced to mostly within the manufacturer's specification when the correct calibration files are used.



Differences between salinity sensors was also within manufacturer's specifications.



Oxygen align was found to be best with 2 as in previous years.

Processing details (given below) are as in previous years, with the addition of the corrections of the SUNA data. (section 9.5).

Details of processing steps (File name are altered to reflect 2023, rather than 2022)

Overview:

Start with files from SeaSave for each cast, i.e.,
Bstrait22nnnn.hex and Bstrait22nnnn.hdr

Then run through 9 steps (8 of them with SBEDataProcessing program from Seabird).

001_DatCnvBStrait2022_allvarswithSUNA
Start matlab tests
002_DatCnvBStrait2022_CTDforprocesswithSUNA_FINAL
003_FilterBStrait2022_CTDforprocesswithSUNA_FINAL
Copy files to testoxalign

In main

004_AlignCTDBStrait2022_CTDforprocessOx2withSUNA_FINAL
005_CellTMBStrait2022_CTDforprocess_FINAL
006_LoopEditBStrait2022_CTDforprocess7m4m18p5mndp_FINAL
Check soak with matlab
007_DeriveCTDBStrait2022_CTDprocess_FINAL

In testoxalign

004_AlignCTDBStrait2022_CTDforprocessOx3withSUNA_FINAL
(change advance in data set up and file name)
004_AlignCTDBStrait2022_CTDforprocessOx4withSUNA_FINAL
004_AlignCTDBStrait2022_CTDforprocessOx5withSUNA_FINAL
005_CellTMBStrait2022_CTDforprocess_FINAL
006_LoopEditBStrait2022_CTDforprocess7m4m18p5mndp_FINAL
007_DeriveCTDBStrait2022_CTDprocess_FINAL
Run matlab tests to decide on ox aligns.

In main, once ox aligns set, next

008_W_FilterCTDBStrait2022_CTDforprocess_MF17_FINAL

If available, run the SUNA postprocessing, which takes the output from W-Filter and corrects the SUNA data from the raw recorded in Seasave, to the UCI corrected version.

Finally run the bin averages.

009_BinAvgBStrait2022_CTDforprocess_FINAL
009_BinAvgUBStrait2022_CTDforprocess_FINAL
Run matlab tests to check data

This completes the CTD data processing.

Finally, extract bottle data information and merge with bottle data (in matlab)

Full details of 2023 processing (file names updated to reflect current year)

=== 1) First make up a file to be used for quick plotting. This contains all variables, but is not corrected in any way.

IN SBEDATA PROCESSING, RUN: DATA CONVERSION

(PSA file for this = 001_DatCnvBStrait2022_allvars.psa)

Inputs are: BStrait22nnnn.hex and BStrait22nnnn.hdr

*In FILE SETUP
-- CHECK box on match instrument to configuration file
-- Choose input file (should be .HEX) and directory
-- Name append .rw1
-- Choose output directory
*In DATA SETUP
-- Convert data from:UP and downcast *(Last year we just did down as we were firing no bottles. Here we do both, noting that upcasts may differ because of water being swept up with the CTD.)*
-- Create file types: data (.CNV) only *** NOW Cast and bottle data ... *** USING .BL File
...—Merge Header file
-- Select output variables... for 2019 we use
-- 1) Pressure, Digiquartz (db)
-- 2) Temperature (ITS-90, degC)
-- 3) Temperature,2 (ITS-90, degC)
-- 4) Conductivity (S/m)
-- 5) Conductivity, 2 (S/m)
-- 6) Oxygen raw, SBE 43 (Volts)
-- 7) Oxygen, SBE 43 (saturation)
-- 8) Oxygen raw, SBE 43, 2(Volts)
-- 9) Oxygen, SBE 43, 2(saturation)
-- 10) Fluorescence WET Labs WET star (mg/m^3)
-- 11) Upoly 0, FLNTURT
12) Scan Count % This was done in 2018, but not recorded in the write up
-- 13) Salinity, Practical (PSU)
-- 14) Salinity, Practical, 2 (PSU)
-- 15) Time, NMEA (seconds)
-- 16) Latitude (deg)
-- 17) Longitude (deg)
-- 18) Altimeter (m) *** NOW USER POLY 2 FOR APPROXIMATE SUNA DATA
-- 19) Pump Status
-- Source for start time in output .cnv header: Select NMEA time
*In MISCELLANEOUS
-- Keep all defaults. Note the Oxygen is Window size (2s), Apply Tau Correction, Apply Hysteresis.
But now we want
A) to replace Alt with SUNA ...in col 18
b) to do bottle file also. ... so ---- do bottle and data
--- source is bl file

THIS GIVES files called: BStrait22nnn.rw1.cnv

=== 2) Do first basic quality control by plotting everything in Matlab

Matlab master code = **testplotsBStrait2018RW.m** which calls subroutine **CTDQCpump.m**

Inputs are: BStrait18nnn.rw1.cnv

Checks here include:
--- that the pump comes on
--- that the altimeter is working
--- that T1=T2, S1=S2 and Ox1=Ox2
--- preliminary identification of spikes and other issues.

=== 3) Now work through the 7 steps (002-009)of SBEDataConversion. Start by applying the calibrations to get the converted files, but this time excluding all the derived variables.
IN SBEDATA PROCESSING, RUN: DATA CONVERSION
(PSA file for this = DatCnvBStrait2022_CTDforprocess.psa)
Inputs are: BStrait22nnnn.hex and BStrait22nnnn.hdr

*In FILE SETUP
-- CHECK box on match instrument to configuration file ** Do not check box, as using postcal/precal file
-- Choose input file (should be .HEX) and directory
-- Name append NONE
-- Choose output directory
*In DATA SETUP
-- Convert data from:UP and downcast *(Last year as here, we do both, noting that upcasts may differ because of water being swept up with the CTD.) *** ADD WiTH BOTTLES AND ** ADD .BT FILE*
-- Create file types: data (.CNV) only
...—Merge Header file
-- Select output variables... for 2018 we use
-- 1) Pressure, Digiquartz (db)
-- 2) Temperature (ITS-90, degC)
-- 3) Temperature,2 (ITS-90, degC)
-- 4) Conductivity (S/m)
-- 5) Conductivity, 2 (S/m)
-- 6) Oxygen raw, SBE 43 (Volts)
-- 7) Oxygen raw, SBE 43, 2(Volts)
-- 8) Fluorescence WET Labs WET star (mg/m^3)
-- 9) Upoly 0, FLNTURT
-- 10) Scan Count
-- 11) Time, NMEA (seconds)
-- 12) Latitude (deg)
-- 13) Longitude (deg)
-- 14) Altimeter (m) ** REPLACE WITH SUNA (UPoly2)
-- 15) Pump Status
** 16) BOTTLES FIRED
-- Source for start time in output .cnv header: Select NMEA time
*In MISCELLANEOUS
-- Keep all defaults. Note the Oxygen is Window size (2s), Apply Tau Correction, Apply Hysteresis.

THIS GIVES files called: BStrait22nnnn.cnv and BStrait22nnn..ros

=== 4) Second step of SBEDataProcessing. Apply a time filtering to the data.

This step allows us to time-filter (i.e., smooth) the data. Routine allows us to select two filters, A and B. In 2014, we used A = 0.5 sec and B=0.15 sec, but in 2015 this appeared to remove too much variability.
Manual for the SBE9plus suggests to not filter Temperature and Conductivity, but to filter pressure at 0.15s. So set A=0, and B=0.15 and then only filter pressure *(this is now the same as 2015, but different to 2014).*

Note these filters should be applied to the raw data (e.g., Ox voltage, Conductivities), not the derived data (e.g., salinity, oxygen saturation, etc).

IN SBEDATA PROCESSING, RUN: FILTER
(PSA file for this = FilterBStrait2022_CTDforprocess.psa)
**** Could filter SUNA here, but decide not to, as SUNA data will be processed properly separately**
Note that bottle data will be reextracted later.

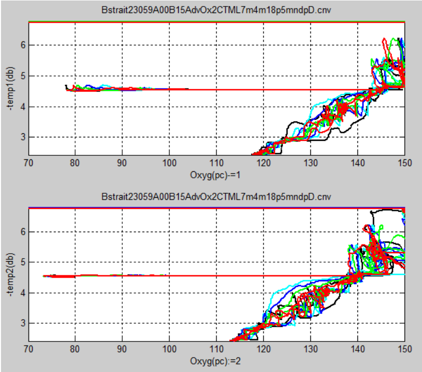
Inputs are: BStrait22nnnn.cnv
*In DATA SETUP
-- Lowpass filter A(sec): 0.0 *(was 0.5 in 2014, but this seemed too smooth in 2015, so used 0, as here)*
-- Lowpass filter B(sec): 0.15 *(This is as per the manual for SBE9plus)*
--> SPECIFY FILTERS
-- Pressure: Lowpass filter B
-- Temperature: None
-- Temperature, 2: None
-- Conductivity: None
-- Conductivity,2: None
-- Oxygen raw: None
-- Oxygen raw,2: None
-- All others: None ... including SUNA
*In FILE SETUP
-- Name append = A00B15 *... this indicates data was filtered (Note: makes only small changes to the data)*
THIS GIVES files called: BStrait22nnnnA00B15.cnv

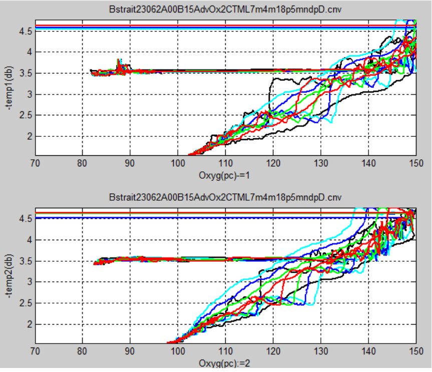
=== 5) Third step of SBEDataProcessing. Align the timeseries in time.

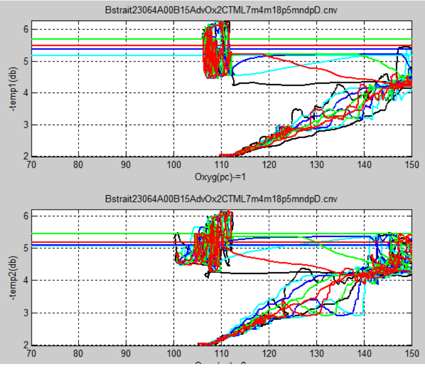
This step is to compensate for the delay between the water passing the various sensors in the pumped pathway. For the SBE9plus, the manuals suggest that
- the temperature advance relative to pressure =0
- that the salinity advance relative to pressure is 0.073s, but this advance is set in the SBE11plus by factory settings, and thus for this program we use conductivity advance =0. ***Action item: Check this is what is set in the SBE11 plus.***
- that the oxygen advance should be between +2and +5. This should be done on the Oxygen voltage.

IN SBEDATA PROCESSING, RUN: ALIGN
(PSA file for this = AlignCTDBStrait2022_CTDforprocessOx2.psa)
Inputs are: BStrait22nnnnA00B15.cnv
*In DATA SETUP
--> Enter Advance values
-- Oxygen: 2 *(as recommended in SBE9+ manual (2 to 5), and tests suggest in 2014 and 2015)*
-- All others: 0
*In FILE SETUP
-- Append added = AdvOx5
THIS GIVES files called: BStrait22nnnnA00B15AdvOx2.cnv

So, of these, it is suggested we investigate the various oxygen options. This we run this step with various values for the oxygen advance (2-5) and, by plotting oxygen against temperature, see which advance value gives the most consistent reading comparing the up and down casts.
This is using the precals: R=2,g=3,b=4,c=5







Previous years have segregated casts into which colors are good. Here 2 is the best (red) and will use that, as in prior years, though not 2020. Note the CTD is mounted horizontal this year.

Finally conclude:
- at this stage will use Ox1, as it shows slightly less spread than Ox2.
- alignment is generally best at +2.
- recognize that up and down casts may differ by 5%-10% .
- agreement between sensors ~ 1%, well within manufacturer's specs (twice 2% saturation)

=== 6) Fourth step of SBEDataProcessing. Correct for thermal mass of the cell

This is a standard SBE correction to compensate for thermal mass of the cell. Assumes the pump is at 3000 rpm. ***Action Item: Check this.*** Then manual suggests for SBE9+ Alpha=0.03, 1/beta=7.
IN SBEDATA PROCESSING, RUN: CELL THERMAL MASS
(PSA file for this = CellTMBStrait2022_CTDforprocess.psa)
Inputs are: BStrait22nnnnA00B15AdvOx2.cnv
*In DATA SETUP (correct both Primary and Secondary values)
-- Thermal anomaly amplitude [alpha]: 0.03 *(suggested for SBE9+)*
-- Thermal anomaly time constant [1/beta]: 7 *(suggested for SBE9+)*
*In FILE SETUP
-- Append added = CTM
THIS GIVES files called: BStrait22nnnnA00B15AdvOx2CTM.cnv

== 7) Fifth step of SBEDataProcessing. Remove pressure loops from the casts.

This step is to take out pressure looping, stalls in lowering, and the surface soak. To run this, you must have filtered the pressure first (as we did above). This does not remove any data, it just marks looped data with a bad data flag of -99e-26.
In 2015, we instigated a 5m depth for the initial surface soak, returning after that soak to the surface to start the downcast. Thus the used values were L5m2m6m (soak, min, max) and were used including deck pressure, and that seemed to work well with this routine. Prior years just used a 2m soak depth and that might be less successful with this routine.
In 2016 the soak was about 4m .. checks show this works with this routine and these settings.
In 2017, soak is about 7m, but sometimes much deeper. Previous settings (L5m2m6m) did not work well with this data set. After investigation, we learn the following:
- likely best not to include the deck pressure as offset - our system is never on while in air, and thus this will just introduce a non-intuitive offset.

- the max must be deeper than the deepest soak, yet shallower than the maximum depth of the shallowest cast. In 2017, the shallowest casts were (Cast1 and 2, tests, and thus not considered; 113(19.6m), 114(19.6m), 115(19.5m), 117(18.7m). Our deepest soaks were cast 20(18.25m), cast 31(16m). Thus, we set max to be 18.5m
- the min must be deep enough to separate the going-in-the-water oscillations from the soak. 2m and 3m were found to be too shallow in 2017, but by inspection 4m works well.
Finally settings for 2017 were thus: 7m soak, min 4m, max 18.5m. (Note if you specify max and min, the program is not supposed to use soak depth at all.)
In2018 these settings gave a good result and were used without further testing.
In 2021, 2022 and 2023, we again adopted these settings

IN SBEDATA PROCESSING, RUN: LOOP EDIT
(PSA file for this = LoopEditBStrait2022_CTDforprocess.psa)
Inputs are: BStrait22nnnnA00B15AdvOx2CTM.cnv
Must run filter on pressure first. Flag surface soak with -9.99e-26 ..
*In DATA SETUP
-- Minimum ctd velocity (m/s) = 0.25
--> Check box Remove Surface soak
-- Surface soak depth (m) = 7
-- Minimum soak depth (m) = 4
-- Maximum soak depth (m) = 18.5
--> UNCheck box Use deck pressure as pressure offset
--> Check box Exclude scans marked bad
*In FILE SETUP
-- Append added = L7m4m18p5mndp
THIS GIVES files called: BStrait22nnnnA00B15AdvOx2CTM L7m4m18p5mndp.cnv

=== 8) Sixth step of SBEDataProcessing. Derive the parameters you want.
This step takes the raw data and calculates derived parameters, such as salinity, density, oxygen values, etc.
IN SBEDATA PROCESSING, RUN: DERIVE
(PSA file for this = DeriveCTDBStrait2022_CTDforprocess.psa)
Inputs are: BStrait22nnnnA00B15AdvOx2CTML7m4m18p5mndp.cnv
-- CHECK box on match instrument to configuration file (Prior notes says to check this box, however, in 2016 this crashed if the box was checked, so instead uncheck the box, **BUT MUST MAKE SURE IS USING A CURRENT CALIBRATION FILE**). If ever change sensors during cruise, will have to do something different here. Check these files to make sure the .con files are consistent.
** FOR 2022 - FINAL, use the combined post/pre XML file
*In DATA SETUP
--> Select derived variables... add:
-- Salinity (psu)
-- Salinity,2 (psu)
-- Salinity difference
-- Sigma theta (kg/m3)
-- Sigma theta,2 (kg/m3)
-- Sigma theta difference
-- Oxygen, SBE 43 (ml/l)
-- Oxygen, SBE 43 (saturation)
-- Oxygen, SBE 43, 2 (ml/l)
-- Oxygen, SBE 43, 2 (saturation)
*In FILE SETUP

-- Append added = D

THIS GIVES files called: BStrait22nnnnA00B15AdvOx2CTM L7m4m18p5mndp D.cnv

Could stop here, and use these files, but to be more useful want to have Bin averages and despike, and the combination of the two of those processes. So, first look at the despiking options. SBEDataProcessing includes a file called "Wild Edit", but the manual describes that as "not the faint of heart" and says much trial and error is necessary to get good results. Thus, instead use something more automatic, Window Filter.

=== 9) Twelfth step of SBEDataProcessing. Use Window Filter to despike.

This is an attempt at automatic despiking. If just try so smooth over a spike, you will flatten it, but the bad data will still remain. Here we make one basic attempt, as outlined in the manual. This takes a window of data points, and for each window, replaces the central (?) point with the median of all the points. In some way thus, this is smoothing over the data points, but one that neglects extreme values. Their example suggests 17 points, and we have used that. Sampling rate is 24Hz. Drop rate is ~ 1m/s. So this is roughly equivalent to smoothing at 0.7 sec, or 70cm.

IN SBEDATA PROCESSING, RUN: WINDOW FILTER

(PSA file for this = W_FilterCTDBStrait2022_CTDforprocess_MF17.psa)

Inputs are: BStrait22nnnnA00B15AdvOx2CTM L7m4m18p5mndp D.cnv

*In DATA SETUP

--> Select Exclude scans marked bad

--> Specify Window Filters:

Type: Median   Parameters: 17

For variables: Temp1, Temp2, Cond1, Cond2, Oxraw1, Oxraw2, Fluorescence, Upoly (Turbidity/Transmissivity), Latitude, Longitude, Salinity1, Salinity2, Density1, Density2, Ox1ml/l, Ox1%, Ox2ml/l, Ox2%,Upoly2(rawSUNA)

-- Append added = MF17

THIS GIVES files called: BStrait22nnnnA00B15AdvOx2CTM L7m4m18p5mndpDMF17.cnv

=== 9.5) SUNA postprocessing. During profiling, the SUNA returns a voltage to Seasave which can be plotted at a nominal calibration. Final corrected SUNA data are however obtained directly from the SUNA instrument, where data are stored internally at higher resolution allowing for postprocessing. The steps of that post processing are given briefly here, with full details below. Data processing has been checked against bottle samples, with the final agreement of SUNA data to the bottle samples being ~0.6uM, somewhat better than the manufacturer's specifications of 2uM.

SUNA processing summary:

** Very important to ensure SUNA clock is correct to NMEA time

Pre deployment,

- run SUNA reference update
- run test runs of DI water, standard solution (ours made up at UW to 20uM), and DI water again

Post-deployment

- run test runs of DI water, standard solution (ours made up at UW to 20uM), and DI water again
- run SUNA reference update

Use matlab routines to create from the final CTD data a file of temperature and salinity data on timestamps matching the SUNA data that was recorded internally on the SUNA

Run the Seabird UCI program to correct SUNA data for temperature and salinity, using both the pre-deployment reference update and the post-deployment reference update. The resultant timeseries will differ by a constant.

Linearly interpolate (by record number) between the pre and the post cal. (Test against bottle data show this product has an RMS error to the bottle data of 1.1uM)

Calculate offsets of these data to the pre and post DI water and standard runs.
Linearly interpolate that error (by record number) to obtain final data set. (Test against bottle data show this product has an RMS error to the bottle data of 0.6uM.
Use matlab routine to update .cnv files with corrected SUNA data.

=== 10) Seventh step of SBEDataProcessing. Bin average all the data.

All data files prior to this have been the 24Hz data up and down casts. Here we separate out the downcasts only, exclude the data marked bad by loop edit, and create 1m bin averages. We chose here to create a surface sample, however often the number of scans in that sample is small and in any case surface stirring by the ship must also be considered.

IN SBEDATA PROCESSING, RUN: BIN AVERAGE
(PSA file for this = BinAvgBStrait2022_CTDforprocess.psa)
Inputs are: BStrait22nnnnA00B15AdvOx2CTM L7m4m18p5mndp.cnv &
BStrait22nnnnA00B15AdvOx2CTM L7m4m18p5mndpDMF17.cnv
Or if the SUNA correction has been done
Bstrait23078A00B15AdvOx2CTML7m4m18p5mndpDMF17corSUNA.cnv

*In DATA SETUP
-- Bin type = Pressure
-- Bin size = 1
--> Select Exclude scans marked bad
→ Select include number of scans per bin
-- Scans to skip over = 0
-- Cast to process = **Downcast**
-> Include surface bin 0,1,0
*In FILE SETUP
-- Append added = BADCS010

THIS GIVES files called: BStrait22nnnnA00B15AdvOx2CTM L7m4m18p5mndp DMF17BADCS010.cnv
Or Bstrait23002A00B15AdvOx2CTML7m4m18p5mndpDMF17corSUNABADCS010.cnv

==== 11) Eighth step ... do Bin average up also.
THIS GIVES files called: BStrait22nnnnA00B15AdvOx2CTM L7m4m18p5mndp DMF17BADCS010.cnv
In 2022 this marks the end of the CTD pre processing.

==== Note on Bottle processing:

- during cast, **seasave** writes **.bl** file, which has bottle fire scan number, and that plus 36 (1.5s)
- **seabird dataconversion**, creates a **.ros** file from .bl .. (option of how long for averaging bottle (2s)
  This is extracted lines from .cnv for 2s after bottle files
- **bottle summary**, ..takes the .ros file and makes a **.btl** using 49 scans per bottle
  Options: Select all averaged variables
  Apply Tau correction

So one could extract bottle information from either:
- the bottle summary (Advantage: Standard. Disadvantage: Does not include correction)
- or from a separate program which extracts the same data from the final calibrated data.

We opt to do the second, in matlab, allowing us to easily combined the bottle information with the nutrient (and where taken, salinity) sample data into one ascii file.

SUMMARY OF 2023 CTD SUNA processing - 11th Nov 2023

AT SEA Suna 1916

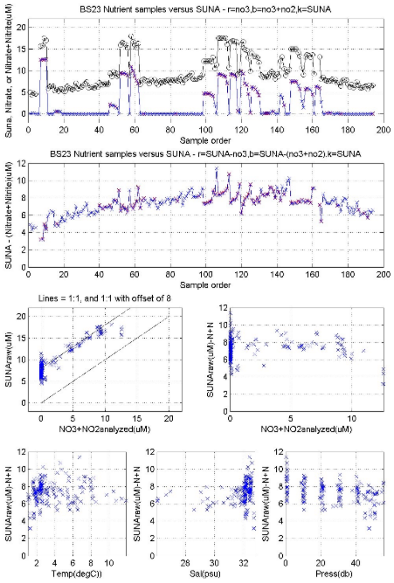
- deployed on profiling SBE 9-11 CTD
- using a custom battery set up, modelled on that used by Seth Danielson,
    - power up voltage from SBE9 switches on power to SUNA from independent battery
    - prevents large current draw required for SUNA overpowering CTD
- preliminary data are recorded in Seasave .. however
    - this uses just a nominal calibration and a linear fit to voltage
    - has some data dropouts, possibly due to water in the connector?
- raw data are recorded at full resolution on the SUNA itself
    - **** VERY IMPORTANT to ensure SUNA is on NMEA TIME ****

- pre and post cruise, run SUNA checks including:
    - **updating the reference spectra using DI water ** VERY IMPORTANT****
    - **running a standard solution (made at UW to ~20uM concentration ** VERY IMPORTANT ****

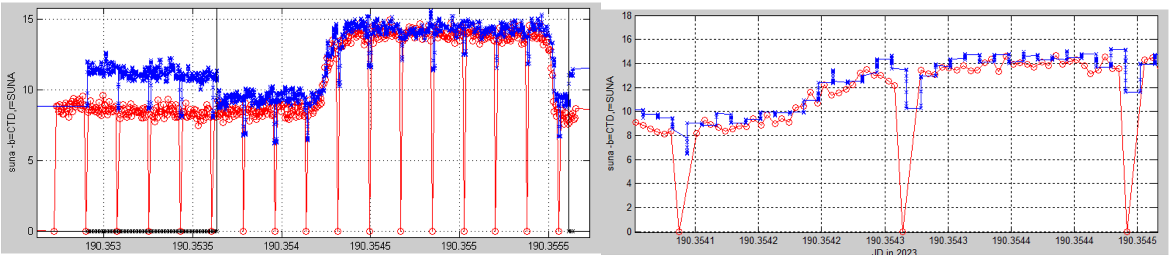
- water samples taken at standard depths, during cruise and analysed for standard nutrients
    - SUNA is recording Nitrate+Nitrite.

PROCESSING

- comparison of the CTD SUNA to bottles shows
    - significant differences CTD SUNA ~ 8uM too high
    - strong correlation to bottle data.
    - difference changing in time
    - no clear relationship of difference to T, S or P



- raw SUNA data (i.e. that stored on the SUNA) is
    - very similar to the CTD SUNA in value
    - starts before the CTD SUNA
      (SUNA powers on while CTD waking up)
    - stops after CTD SUNA
      (CTD recording stopped before power off)
    - has the zeros every 30 frames
    - these zeros appear as noise in CTD SUNA
    - shows clocks are well aligned.

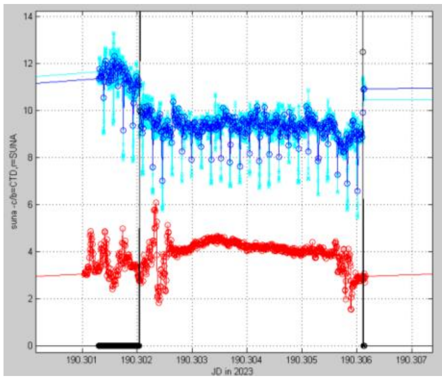


- SUNA requires TS correction, so use CTD data to make that file
    - want TS interpolated to all times the SUNA is on
    - note there is dubious TS data before the pumps come on, but that will be removed later

- To run correction in UCI needs:
    - raw SUNA data
    - TS file
    - package file (an instrument specific file, only changing when the instrument is repaired)
    - REFERENCE FILE - we have two … before (here I) and after (here J) cruise.
    - RUN TS correction in UCI for both reference files.

Learn:

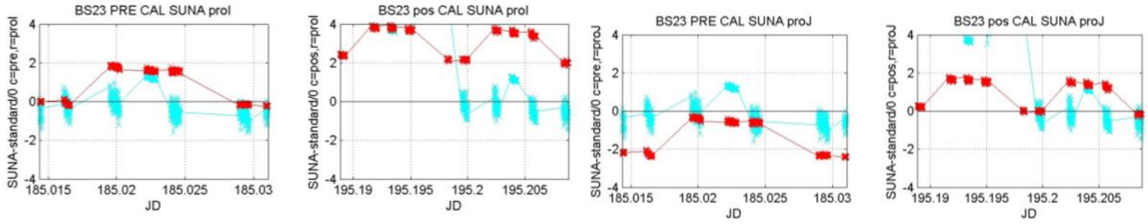
- for FRESHWATER (the standards we run), this correction is NOT a function of temperature
  (i.e. don't have to be concerned about measuring temperature of standard)
- for rest, can make a very LARGE difference (about 5uM)
- this introduces noise, related to sharp TS gradients.
  Possibly this is due to minor timing mismatches?
  Assume we can smooth this out later.



NOW compare corrected data to standards and to the bottles:

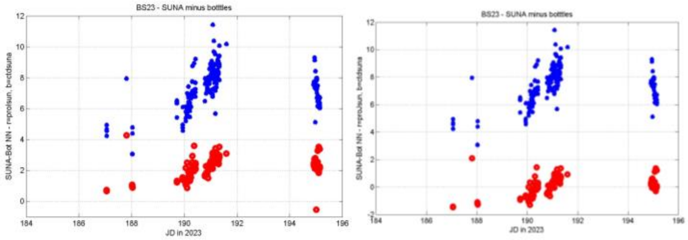
- run with pre cruise calibration (here I) and post cruise (J)
- find these differ only by a constant!
- TS correction has made BIG difference, in unexpected ways.

Standards:

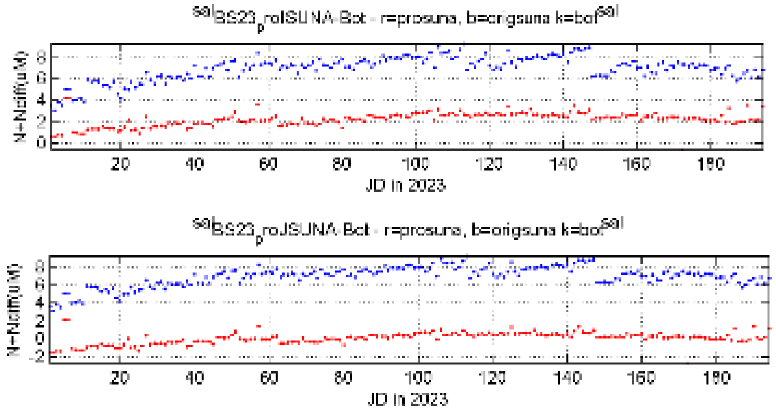


- light blue, pre TS; Red, with TS correction; Left to Right (I Pre, I post, J Pre, J post)

Bottles:



- blue, pre TS; Red, with TS correction; left I, right J. Above with JD, below with Record number



TOP is I .. error from 0 to 2
Below is I … error from -2 to 0

So decide to linearly interpolate in time between pre (I) and post (J).

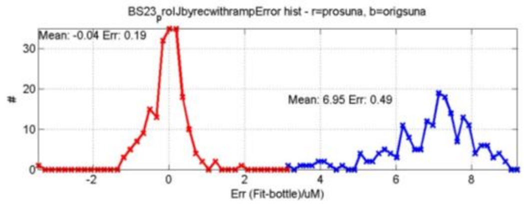
- could do **by time on (so record number**) **or by Julian day (time**)
  - BY JD has significant fits of error to
    - (a) nitrate (0.028/uM … so 10uM would be 0.28uM diff
    - (b) salinity(0.099/psu … so 6psu chance would be 0.6uM
    - But neither look particularly good, so leave them.
  - BY rec – does not have these fits.
  - both are on average ¬1uM more the precals, the bottle data and the post cals.
    - (to cals, typically zero is correct, SUNA ~2uM greater than standard)
  - can remove that residual offset either with constant offset, or ramping from pre to post
    - (difference here negligible … so why NOT do ramp?)
  - Finally compute remaining error to cals and bottles, as MEAN, STD and RMS

What	**Err to precal**	**Err to bottles**	**Err to postcal**
Orig	-0.06 (std 0.8) rms0.79	6.9 (std 1.1) rms7.04	2.12 (std2.4)rms3.19
proI	0.9 (std 0.9) rms1.26	2.23 (std 0.65) rms 2.32	3.1 (std 0.7)rms3.22
proJ	-1.3 (std0.9) rms 1.55	0.06 (std 0.65) rms 0.65	1.0 (std 0.7) rms 1.21
proIJbyrec	0.9 (std 0.9) rms 1.25	0.91 (std 0.60) rms 1.09	1.0 (std 0.7) rms 1.22
proJIbyJD	0.9 (std 0.9) rms 1.26	0.83 (std 0.67) rms 1.07	1.0 (std 0.7) rms 1.21
proIJbyrecwith constoffset	-0.05 (std 0.89) rms 0.89	-0.03 (std 0.60) rms 0.60	0.05 (std 0.73) rms 0.73
proIDbyJDwith constoffset	-0.04 (std 0.89) rms 0.89	-0.11 (std 0.67) rms 0.68	0.04 (std 0.73) rms 0.73
proIJbyrecwith ramp	0.00 (std 0.89) rms 0.89	-0.04 (std 0.61) rms 0.61	0.00 (std 0.73) rms 0.73
proIJbyJDwith ramp	0.00 (std 0.89) rms 0.89)	-0.12 (std 0.68) rms 0.69	0.00 (std 0.73) rms 0.73

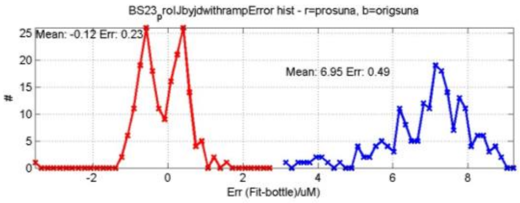
.

- look at histogram of errors:

This by record with ramp



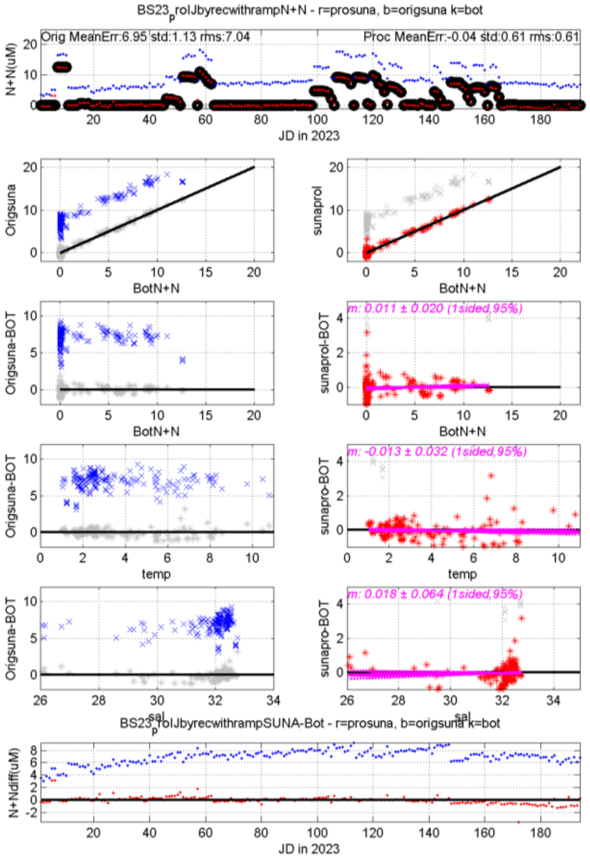
This by JD with ramp

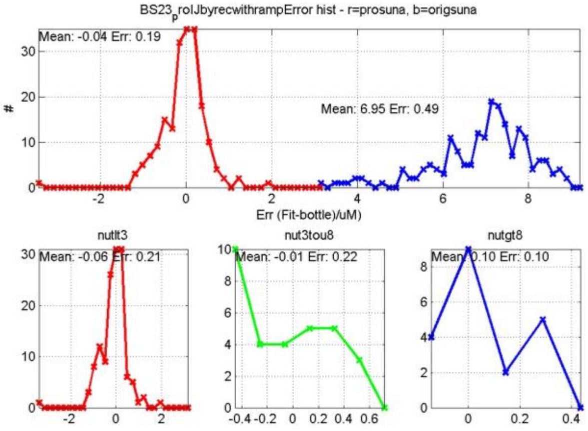


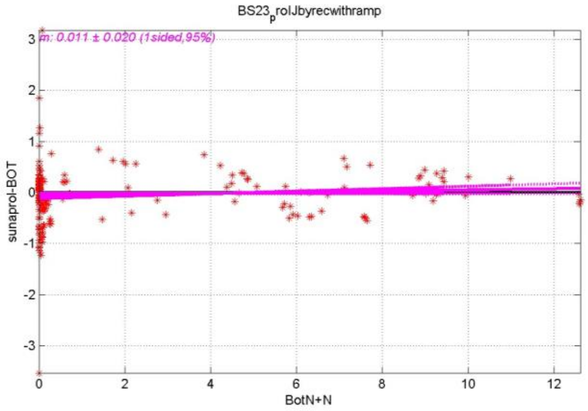
Conclude:

- using just pre and post cals, rms error about 1.3uM to standard, 1.1uM to bottles
- once have taken off the offset (const or ramp), BY REC gives slightly better fit (0.6uMrms)
  - And has more normal error distribution.
- find that largest errors are at zero nitrate values (Mean -0.06plusminus0.2), but
  - Many values almost 1uM, and extremes are almost 3uM.
- **Conclude with all these corrections, final error rms is about 0.6uM.**

**- could have got same numeric result just by using the pre and post standard runs,
But have the satisfaction of knowing how good the reference updates were
(and how much we are correcting beyond that with the standard).**







From here

- read in .cnv files, correct SUNA and write back out
- replot .. find
  - less noisy
  - some data below zero – obviously not negative, just within errors.

BERING STRAIT 2022 CTD OPERATION NOTES from end of cruise

0. Coming onto station
    - pre fill Event Log (Excel file)
    - In Seasave
        - Real time data, Start, Begin archiving data immediately
        - Select Output Data File Name: Bstrait21nnn.hex, *** NOTE NAME 17, not 2017
        - Start
        - fill in header
            - Ship: Norseman 2, Station name (e.g., BS24), Operator
    - then WAIT
    - **Driver to Deck:** "**clean wetlabs sensor**"
    - **Deck to Driver:** "**sensor cleaned**"
    - **Driver to Deck:** "**Are all bottles primed?**"
    - **Deck to Driver:** "**Bottles are primed**"

1. On station confirmed from bridge "**on station**",
    - **Driver to deck**, "**Ready to Deploy**"

    CTD in the water (**Deck to Driver**: "**CTD in water and at 5m**") (**Driver: double click radio**)
    - Power on CTD Deck Unit, check get readout of "10" (01<u>10</u>)
    - OK on SeaSave header, wait until SeaSave gray windows close
    - Real-time Control, Pump on (to turn pump on manually)
    - Fill out rest of Event log (Excel file) for deployment (including time).
    - Driver to deck, "**Please note wave height(m), clear or fog, and depth lose sight of ctd**"
    - WAIT until –"11", "Pump on", Data ok (incl S and position), check #'s agree
    - check target depth ~ water depth under keel
    - **Driver to Deck**: "**return to surface and go down to xxx meters**" (GET SURFACE WIRE OUT)
    - **Deck to Driver**: "**Going down**"
    - Check lower speed (want 30/40 m/min) on winch readout

3. CTD lowers
    - watch pressure ... *(resist temptation to analyze the cast on the way down) .. focus only on the pressure*
    - **Driver to Deck**: "**3 2 1 stop**" for target depth
    - **Deck to Driver**: "**CTD stopped**" (GET BOTTOM WIRE OUT)
    - wait ~2sec or if want bottom bottle, wait 10s, and fire bottle(s)
    - **Driver to Deck**: "**Come to surface/ come up xxm**" AND CHECK CTD COMES UP

4. CTD comes up
    - if firing bottles,

    Driver to Deck: "**3 2 1 stop**" for target depth, WAIT 10S, fire bottle, **Driver to Deck**: "**Come up xxm"**

    If time, ** COMPARE SENSOR PAIRS - decide if data good enough to leave

    When at surface (**Deck to Driver: "At surface"**) (**Driver: double click radio**)
    - real time control – Pump off
    - real time data – STOP
    - Power off CTD Deck Unit
    - **Driver to deck**: "**Recover CTD and proceed to next station/stay on station for pumping**"
    - OR IF may have to recast .. add "**We have CTD issues, do not leave after this cast"**
    - fill in Event Log for up cast (including time), while
    - **Deck to Driver** "**CTD recovered SUNA off, bottle issues**, **wave height, fog, depth seeing ctd**."

    THEN
    - screen dump to paint (Alt-print screen, Cntrl V, save as BStrait21nnn.png); F12 (save as);
    - QUIT paint.
    - Copy the 4 files (.hex, .hdr, .xmlcon, .png) to USB Backup file directory

(Start event log for next cast)

**CHANGE SUNA BATTERY AT 500min (about 50 casts)

Deck responsibilities every cast:

- checking sensor cleaned and bottles correctly primed, including
  caps correctly position, spigots out and vent plugs tight.
- checking depth of surface soak
- watch wire (out aft is ok, under ship is not, far to side near ship not)
- keep winch operator focused
- count CTD as it goes down, listen for 3 2 1 stop and make sure winch stops

- At Bottom, make sure winch comes UP (e.g., watch wheel)
- Watch for tape on way up,

- Observe and report surface issues (e.g., broke surface, ask for repeat soak if out of water for more than 4 sec)
- report - clarity of water (max range at which you can see CTD in m)
  - fog
  - wave height if exciting
- report bottle issues once CTD is on deck.
- report if jelly fish remains on salinity cells

- make sure secure on deck.
- every 50 casts, check all CTD bolts

- do water sampling as required
- report any bottle problems (e.g. leaking).
- if bottle is leaking, do not sample from it unless it is the surface bottle.

BERING STRAIT 2023 CTD LINES

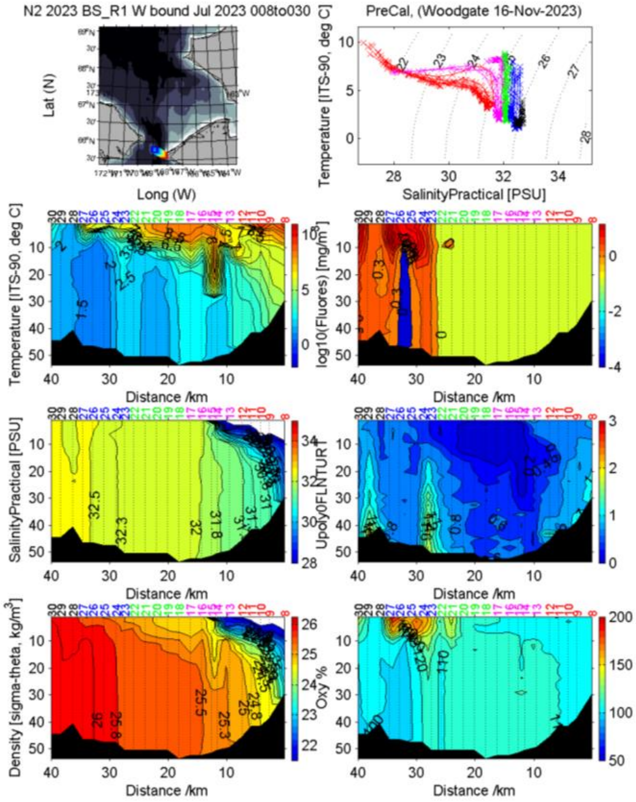
Four CTD lines, including a rerunning of the BS line (at lower resolution due to time/weather constraints) were run on the cruise.

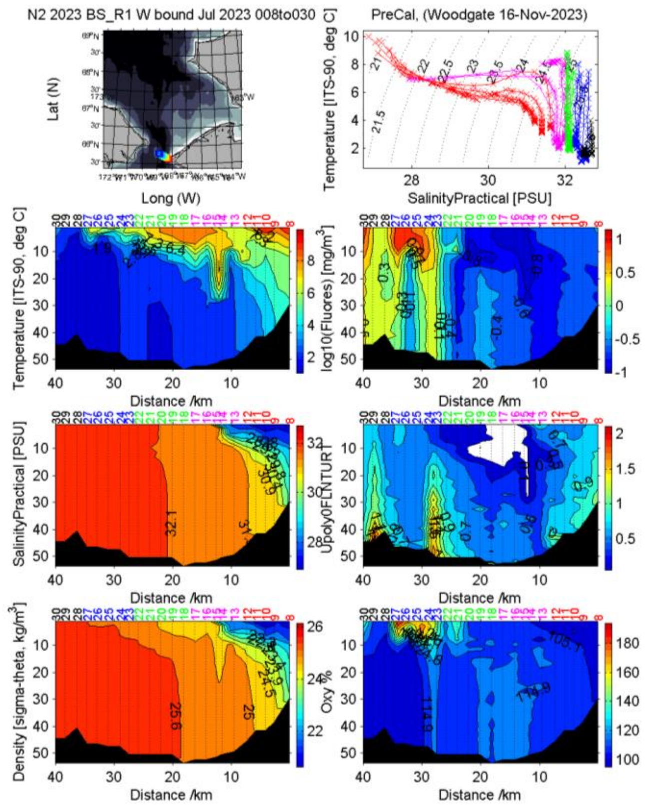
Sections were plotted using code from An Nguyen from the final processed data, using also corrected SUNA data, and the quality control procedures outlined above to give 1m bin averages for plotting.

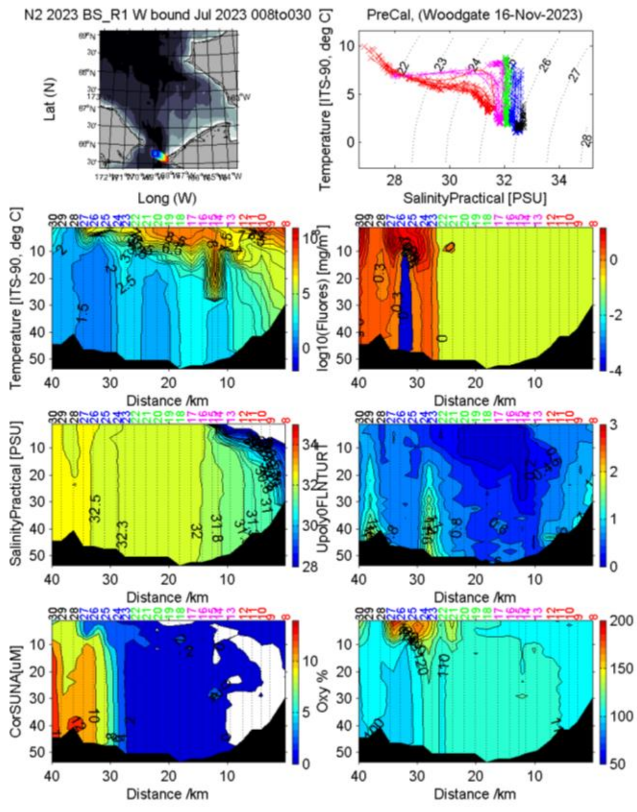
The plots below give all sections on the same scales (left) and on a scale for that section (right), presented in order of data acquisition. Note that:
- this uses the S1 and Ox1 data,
- typically stops 2 to 3+ m above the bottom.

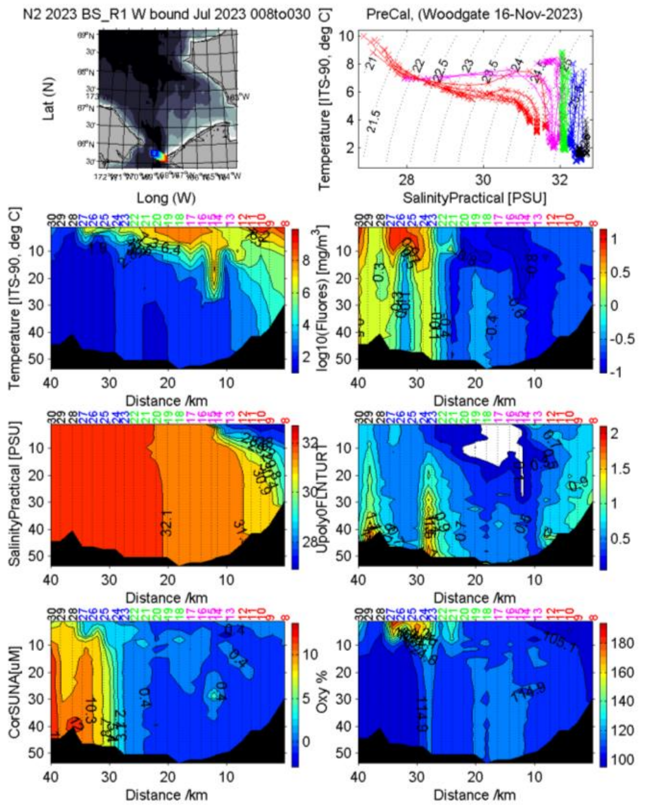
For full positions and times see event log and data file headers.

1) Bering Strait line (BS) – first running, Westward

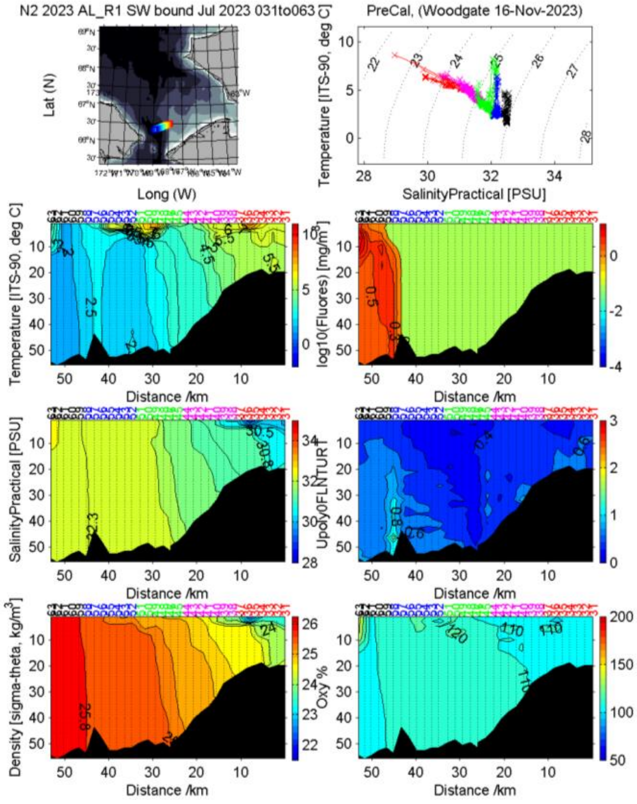


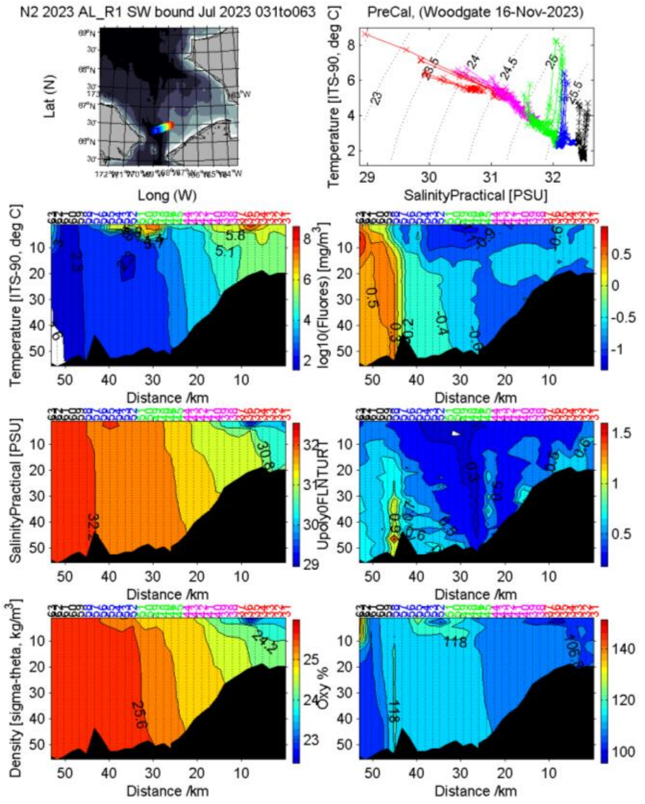


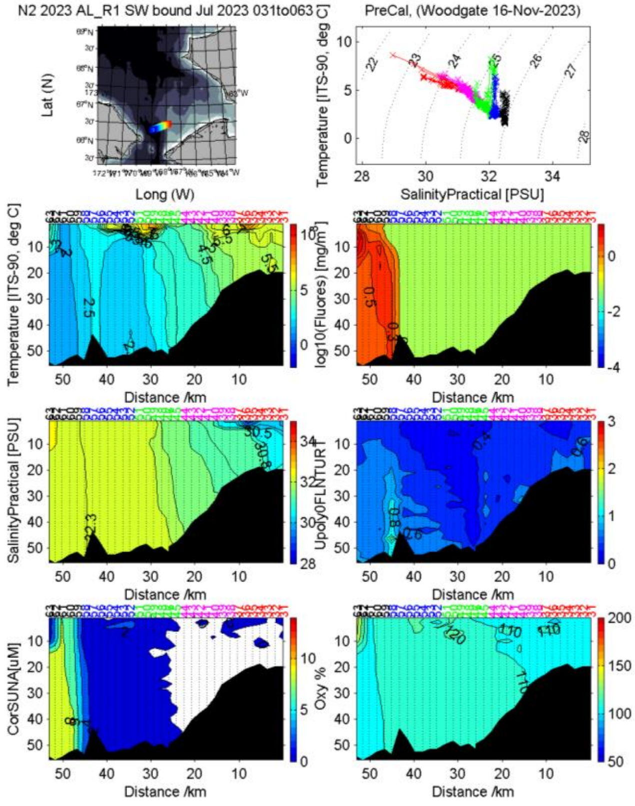


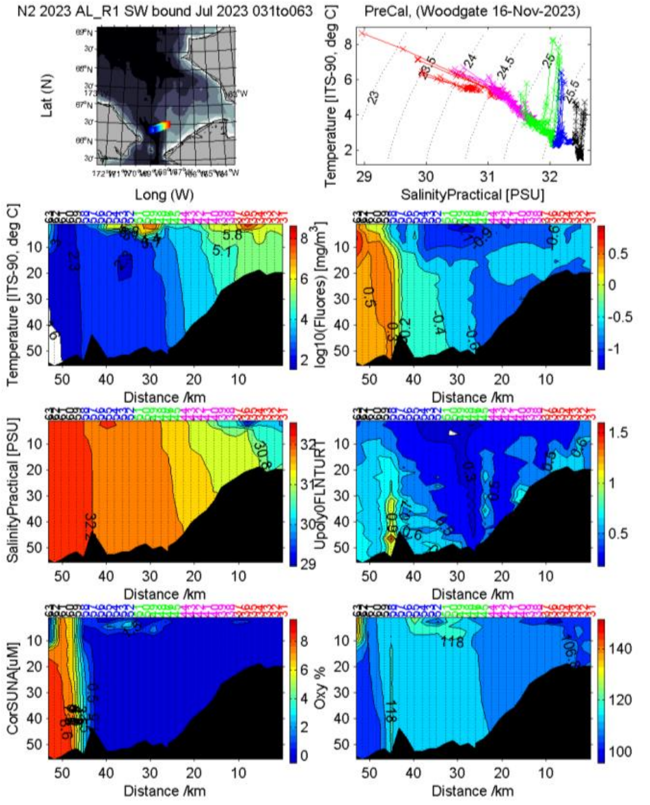


2) A3 line (AL) – run Southwestward

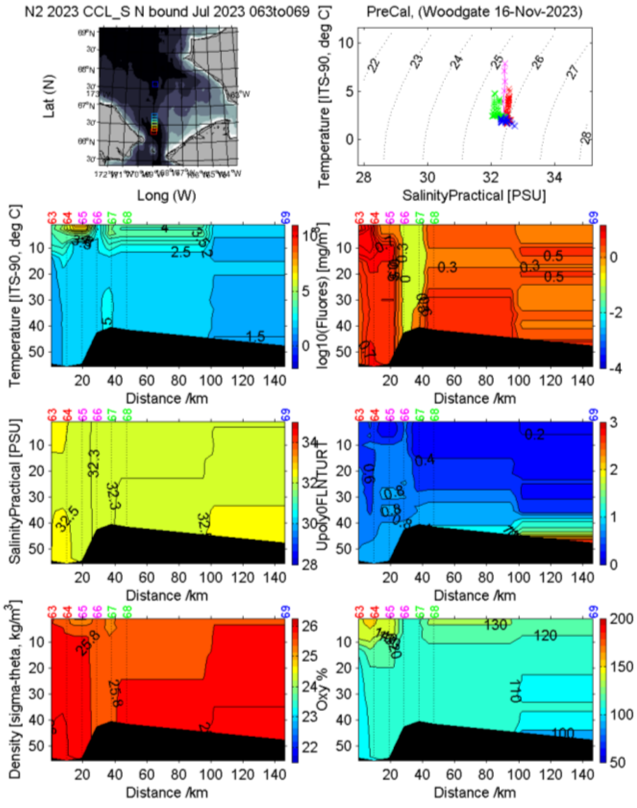


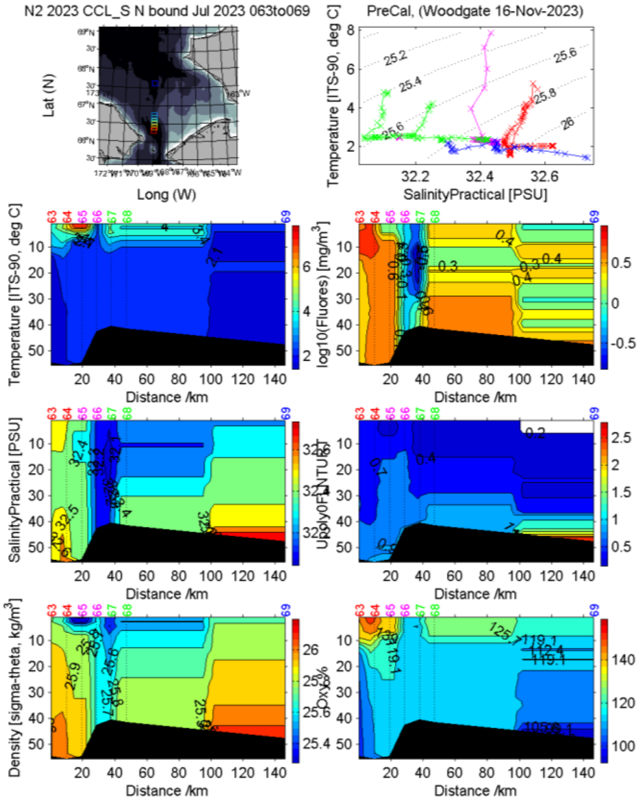


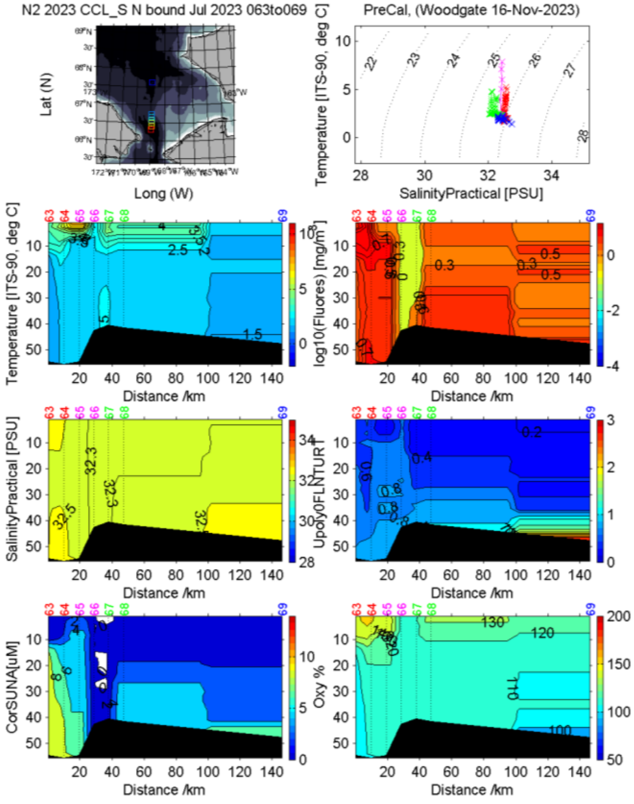


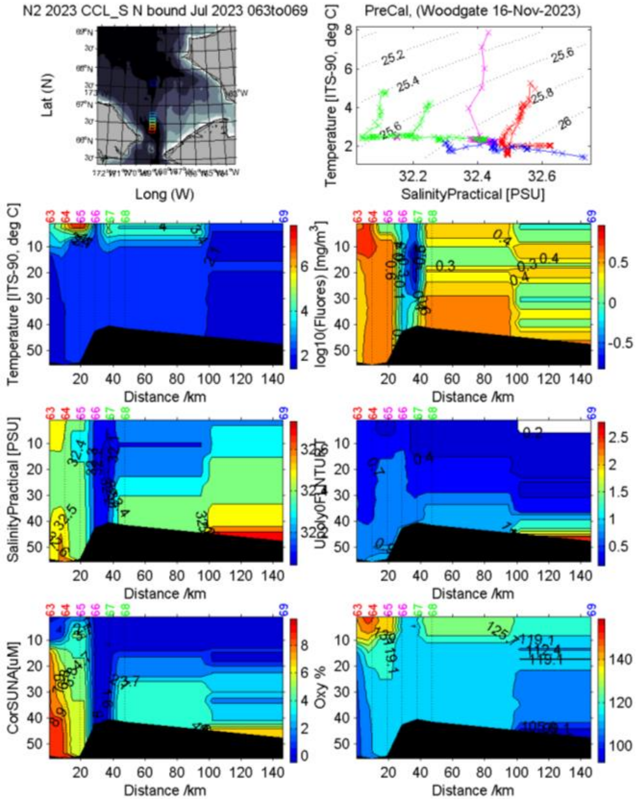


3) Chukchi Central line Middle part – run Northward

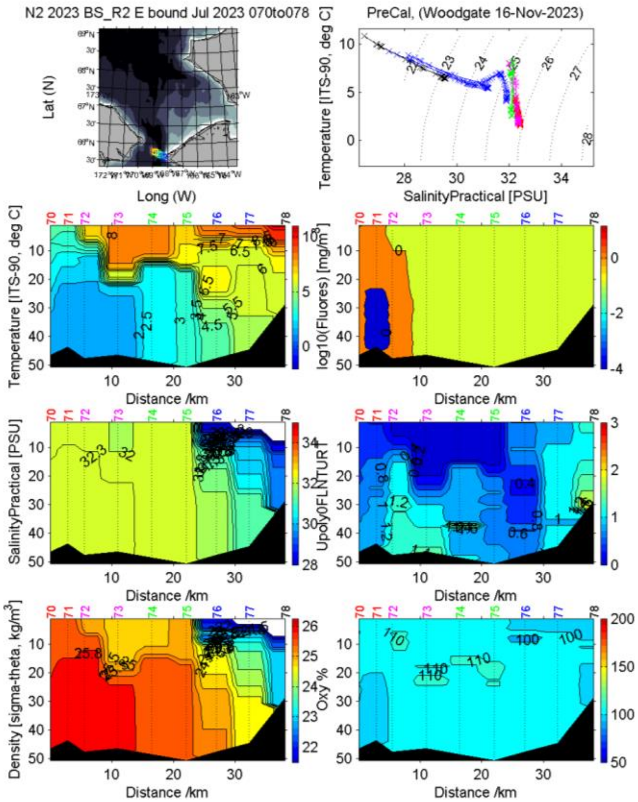


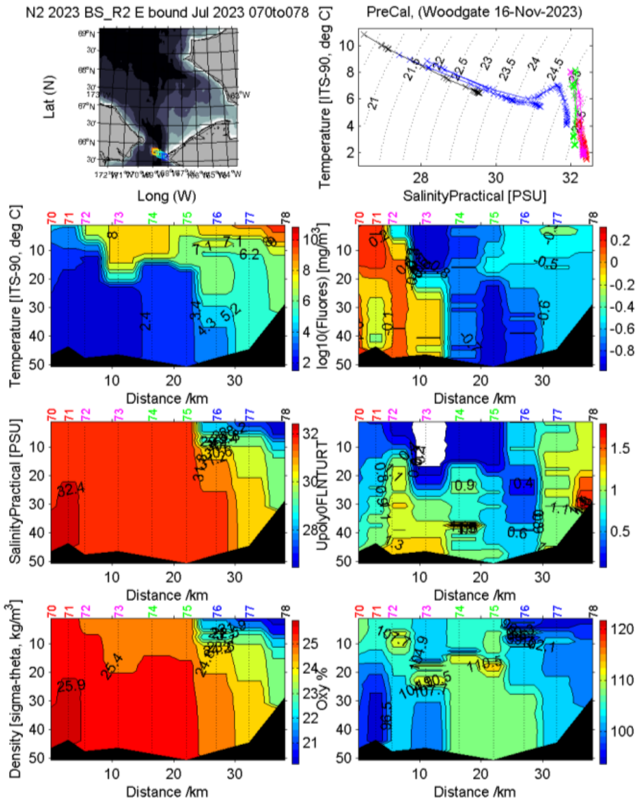


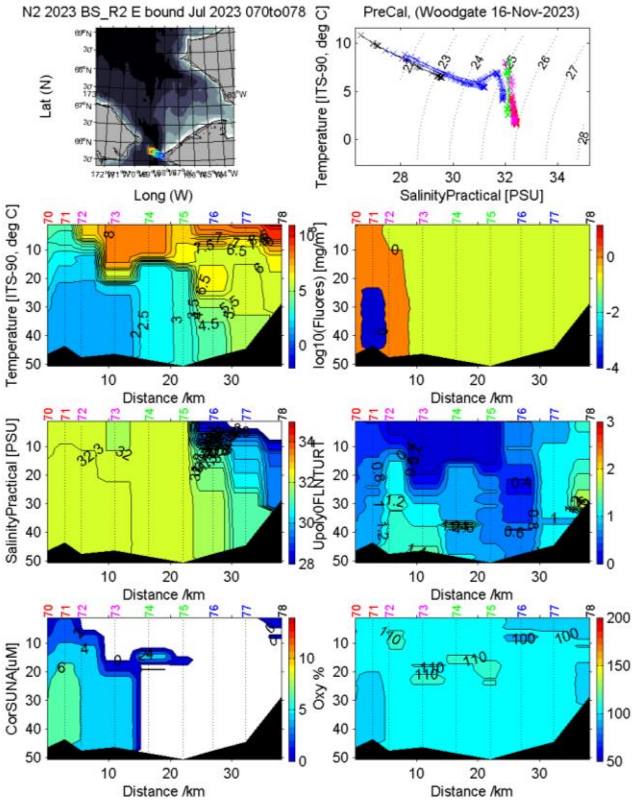


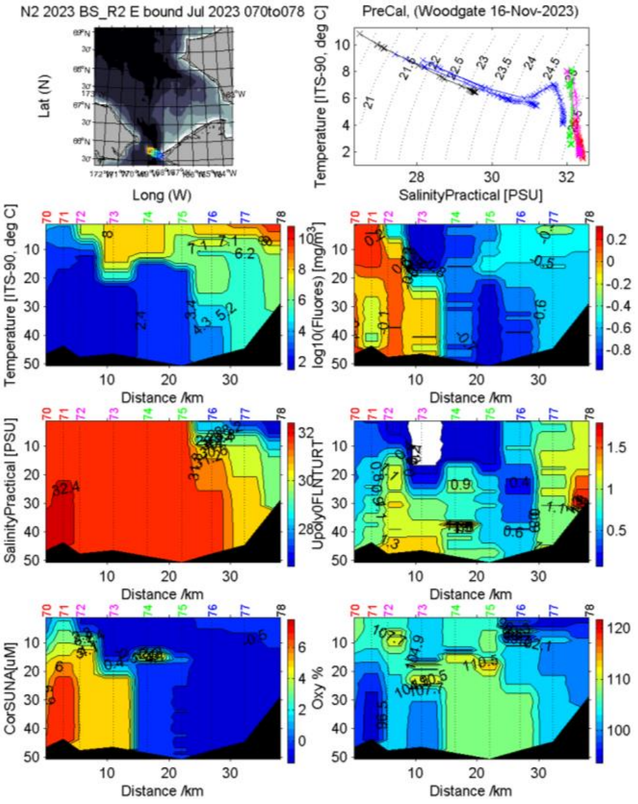


4) Bering Strait line (BS) – second running (low resolution), Eastward



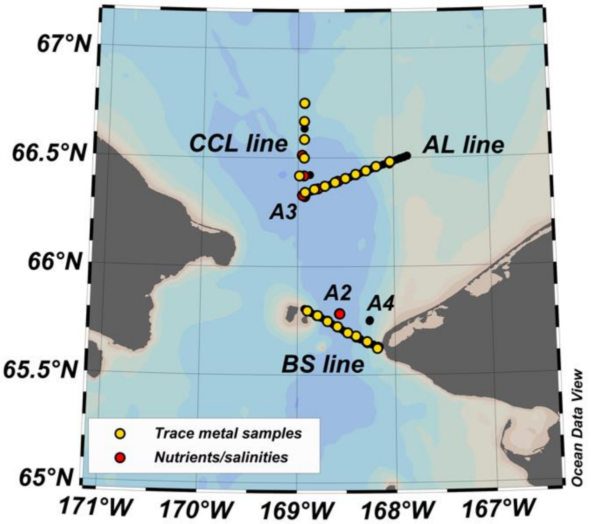






BERING STRAIT 2023 TRACE METAL AND NUTRIENT PUMPING REPORT (Jensen)

Quick summary: 30 Stations sampled for trace metals and nutrients (yellow dots in map below), 63 trace metal samples and 64 nutrient samples collected at the surface (5m) and bottom (variable depending on bottom depth), including one set of TM duplicates and two sets of nutrient duplicates.



Background: The objective of this sampling is to take high quality/high resolution trace metal (iron, zinc, nickel, copper, cadmium, manganese, lead) and macronutrient (nitrate, phosphate, silicate) samples alongside the CTD and mooring temperature and salinity sampling. Trace metals (found in small or trace concentrations, ~10^{-9}mol/L) may be useful in deciphering water mass circulation or provenance. Many, like iron, are biologically important for phytoplankton in the surface waters. Importantly, the Bering and Chukchi shelves provide a large source of these trace metals to the Western Arctic Ocean.

Moreover, the inventory of these trace metals appears to increase moving from the North Pacific/Bering Sea through the Bering Strait and onto the Chukchi Shelf. Sources for these metals are primarily sediment resuspension (export of organic matter to the sediments release trace metals through diagenesis or non-reductive dissolution) or riverine input. Freshwater intrusions (salinity <30) were observed throughout the CTD transects close to the Alaskan Coast (lines BS and AL). Rivers may act as a source or diluent for metals and nutrients. Variations in temperature and salinity indicate the presence of multiple water masses observed along the CTD lines sampled. The major objective of this high resolution sampling is to assess if or to what extent trace metals and nutrients vary across these different water masses feeding into the Bering Strait. Trace metals could be used to trace water mass movement further north where currents are complicated by bathymetric features and become more difficult to track.

Pump sampling of trace metals: Sampling was done using a trace metal clean PTFE double diaphragm pump (Wilden, see picture below) with a max flow capacity at 56 liters/minute at 125 psi air supply. Tubing both in and out of the water was Grainger 1/2in OD (polyethylene) connected to the pump with PVDF 1/2in compression fittings (all acid cleaned prior to the cruise). Tubing was cut to ~70m and marked with tape up to 60m from the surface and attached to 3/8in Nylon line. An 8lb kettleball weight was attached directly to the Nylon rope and a RBR Concerto[3] CTD was lashed to the rope with Dynacon line (see figure). Thus the tubing sat approximately 1m above the kettleball weight.

Air was supplied by the ship service air connection on the starboard side and pressure was ultimately controlled using an air regulator (see picture) before entering the pump. Pumping at max capacity, pump was cleared in 60-70 seconds, estimated by introducing a bubble before each cast to mark “new water” being sampled. Thus, before each surface and deep sample the pump was flushed for at least 80 seconds at max capacity/speed.

Larger capacity Acropaks were used (Acropak-1500 0.2 μm filter) again this year instead of the Acropak-200 used in 2021. These filters did not clog (although two were used – BB and CC- over the total filtering time to assuage sample contamination) and thus there was very little pressure on the pump and tubing. Additionally, the same acid clean Masterflex L/S 24 tubing implemented in 2022 was used rather than the C-flex tubing from 2021 that has a thinner outer diameter and thus “wears out” more easily in response to any back pressure. Both the filtered and unfiltered flow were attached to the main Grainger tubing via a plastic wye split and the

Masterflex tubing connection was reinforced by zipties. Flow between the filtered and unfiltered tubing was controlled by plastic snap clamps. After flushing the system, flow was reduced to ~60 psi via the regulator to comply with the pressure ratings on the filter and alleviate back pressure.

Filtered samples (trace metals and nutrients) were filtered directly into 250 mL (TMs) and 60 mL (nuts) Nalgene bottles (pre-cleaned) following 2-3 10% volume rinses as water budget allowed. Samples were bagged in two poly bags. Nutrient samples were placed in -20°C freezer inside another poly bag within 4 hours of sampling. Trace metal samples were double bagged in poly bags in increments of 12. Nutrient samples remained frozen until they could be analyzed in the Marine Chemistry Lab at the University of Washington. Trace metal samples were all acidified to pH 1.8 using 500 μL of Optima HCl (12M) under a Class 100 laminar flow hood (OSB 443) on 08/02/23. Note that volume was estimated for incomplete samples (clearly less than 250 mL volume) and acidification volume was adjusted accordingly (ie if only 50 mL of seawater was collected, 100 μL of Optima HCl was used).

Issues encountered during sampling and possible modifications:

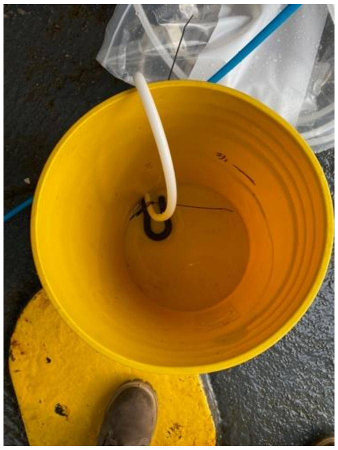
New in 2023:

- **Hauling in the apparatus:** One 8lb weight plus the 1.5 kg (3.3 lbs) RBR CTD was about at the limit for one person to haul in comfortably and repeatedly However, sometimes the weight was not enough to get the tubing down to desired depth.
    - **In the future:** Use of a snatch block attached to the overhang on the aft deck could help gain leverage when deploying and recovering the pumping system.
- **Ease of sampling:** The past three years have yielded successful and rapid sample collection. However, it would be easier to sample with a few simple additions such as a filter rig/filter holder that could be secured on deck and hold the filter and unfiltered lines in place. This would allow sampling with both hands and less potential contamination of samples (dropping filter, using "dirty" hand to turn the pump on and off, etc.).
    - **In the future:** Build a filter rig or modify existing rigs such as the "SBE Stand" used by PI Woodgate to hold instruments during mooring data download or calibration. Ideally, a slot for the 1500 Acropak and potentially a space for the unfiltered flow to be secured. Pressure through the pump causes tubes to wiggle or bounce and this would help that situation.
- **Flow recirculation between filtered and unfiltered lines:** During sampling, the wye split allowed for flow to recirculate between the filtered and unfiltered tubing, i.e. the pulses of water back-flowed into the wye split and into the other side. To minimize the chance that water that touched the "dirty" unfiltered tube came into contact with the clean tubing and filter, the clamp was placed directly below the wye split. This way, the flow recirculation.
    - **In the future:** Continue to clamp conservatively. Also, ensure that all tubing is acid washed prior to field sampling.

Consistent since 2021:

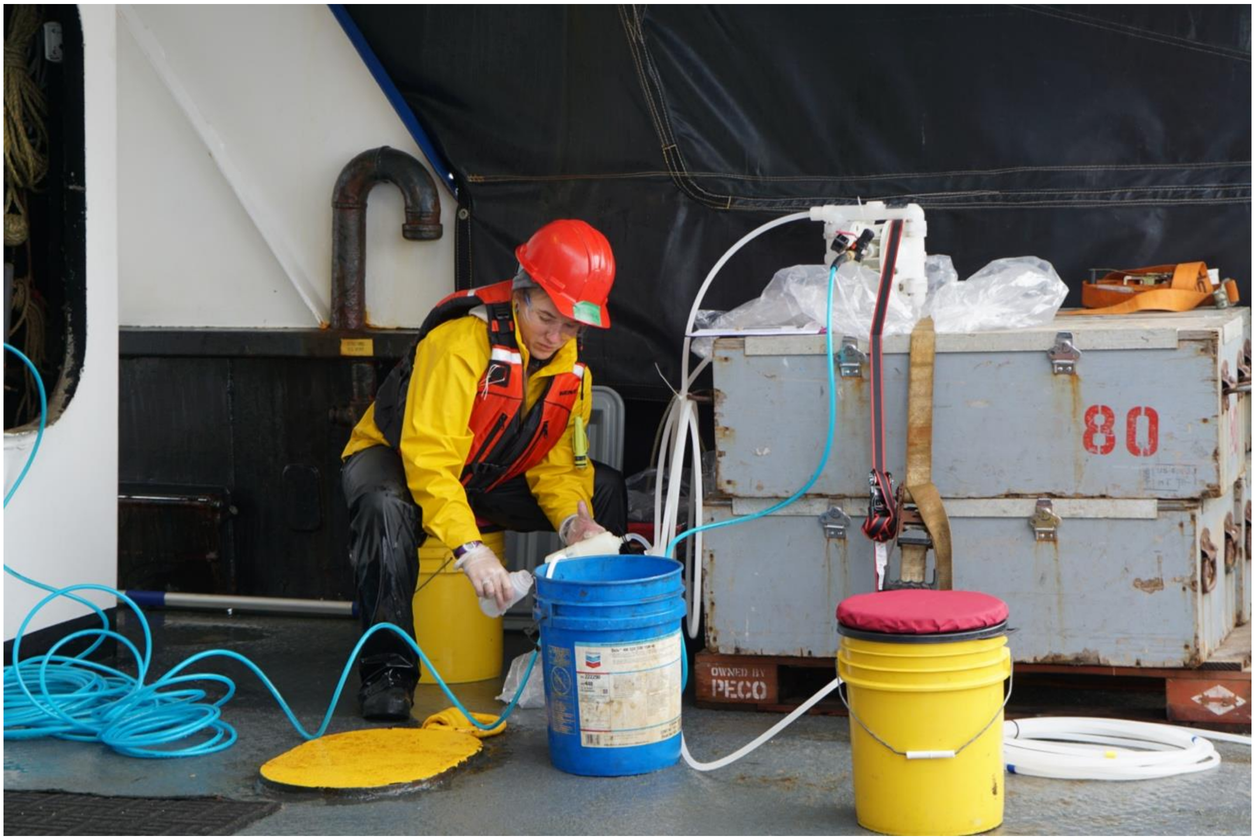
- **Back pressure on filters**: As described above, the max pressure output of 125 psi from the Whilden pump was too strong for the Acropak capsule filters.
    - **Solution(s) at sea:** Reduced pressure to ~80 psi when actively sampling. Also, only slightly closed the unfiltered tubing so that some pressure was relieved that way. Tubing was reinforced with zipties rather than plastic hose clamps. Larger capacity filters were used this year (1500 vs 200) and this was a prodigious solution for backpressure due to clogging. Stronger tubing (Masterflex L/S 24) were also used to great effect.

- **End of tubing staying clean:** The ship's crew did an excellent job of making sure the end of the tubing attached to the Nylon rope did not hit the side of the ship upon recovery. However, this meant that when recovering the weight/CTD/end of the tubing one must lean out over the side of the ship and not use the ship railing as a counterbalance.
    - **In the future:** Results from 2021 suggest very minimal contamination of samples, so end of tubing is likely not a major contamination source if it stays clean during sampling effort.
- **Trace metal cleanliness:** Ideally, sampling would be done in a clean, positive pressure environment. Occasionally, filter apparatus and sample bottles were exposed to seaspray, water on the deck, surfaces inside the ship, or ungloved hands.
    - **Solutions at sea:** Using plastic bags and gloves as much as possible to protect samples from potential contamination.
    - **In the future:** Trying to set up an small environment on the ship where samples could be re-bagged or sorted in a clean way. Even better, creating a way for the entire sampling process to be done indoors in a clean space. Some ideas for this include having the tubing go through a window or other opening and sampling into the sink in a small "bubble" environment.



View of coiled rope and tubing with tape markings (left) and mini RBR CTD (red, white, black). Bucket used to collect unfiltered flow during flushing with shackle attached to restrict the "bouncing" of the white C-flex tubing that occurs due to the pump pressure.

Close up of pump with air regulator and air hose (blue) sitting on the mooring release pallets. It was necessary to use a ratchet strap to stabilize the pump so it did not move during sampling. Plastic bags were used as an extra precaution against contamination.


View of trace metal pump sampling on deck, 2023. PC: K. Christensen.


Trace metal tubing (far right) attached <1m above RBR CTD (middle) and ~2m from weight (far left).

Table of Bering Strait 2023 Trace Metal and related Nutrient sampling

Station	Cast	Latitude	Longitude	Depth	Sampling date	Nutrient sample	TM sample
#	#	(degN)	(degW)	m	(UTC)	#	#
BS22	1	65.623	168.180	5	7/9/23	7064	BS22 surf
BS22	1	65.623	168.180	25	7/9/23	7065	BS22 bot
BS20.5	2	65.649	168.280	5	7/9/23	7066	BS20.5 surf
BS20.5	2	65.660	168.292	40	7/9/23	7067	BS20.5 bot
BS19	3	65.676	168.395	5	7/9/23	7068	BS19 surf
BS19	3	65.683	168.400	45	7/9/23	7069	BS19 bot
BS17.5	4	65.695	168.483	5	7/9/23	7070	BS17.5 surf
BS17.5	4	65.695	168.483	45	7/9/23	7071	BS17.5 bot
BS16	5	65.723	168.589	5	7/9/23	7072	BS16 surf
BS16	5	65.723	168.589	45	7/9/23	7073	BS16 bot
BS14.5	6	65.747	168.691	5	7/9/23	7074	BS14.5 surf
BS14.5	6	65.747	168.691	45	7/9/23	7075	BS14.5 bot
BS13	7	65.775	168.793	5	7/9/23	7076	BS13 surf
BS13	7	65.775	168.793	45	7/9/23	7077	BS13 bot
BS11.5	8	65.796	168.899	5	7/9/23	7078	BS11.5 surf
BS11.5	8	65.796	168.899	40	7/9/23	7079	BS11.5 bot
AL25	9	66.480	168.032	5	7/9/23	7080	AL25 surf
AL25	9	66.481	168.034	20	7/9/23	7081	AL25 bot
AL23	10	66.459	168.172	5	7/9/23	7082	AL23 surf
AL23	10	66.461	168.185	25	7/9/23	7083	AL23 bot
AL21.5	11	66.441	168.285	5	7/9/23	7084	AL21.5 surf
AL21.5	11	66.441	168.285	35	7/9/23	7085	AL21.5 bot
AL20	12	66.425	168.394	5	7/9/23	7086	AL20 surf
AL20	12	66.425	168.394	45	7/9/23	7087	AL20 bot
AL18.5	13	66.406	168.501	5	7/9/23	7088	AL18.5 surf 1
AL18.5	13	66.406	168.501	5	7/9/23	7089	AL18.5 surf 2
AL18.5	13	66.406	168.501	45	7/9/23	7090	AL18.5 bot 1
AL18.5	13	66.406	168.501	45	7/9/23	7091	AL18.5 bot 2
AL17	14	66.387	168.610	5	7/10/23	7092	AL17 surf
AL17	14	66.387	168.610	50	7/10/23	7093	AL17 bot
AL15.5	15	66.370	168.717	5	7/10/23	7094	AL15.5 surf
AL15.5	15	66.370	168.717	45	7/10/23	7095	AL15.5 bot
AL14	16	66.354	168.825	5	7/10/23	7096	AL14 surf
AL14	16	66.357	168.828	50	7/10/23	7097	AL14 bot 1
AL14	16	66.357	168.828	50	7/10/23	7098	AL14 bot 2
AL12.5	17	66.334	168.925	5	7/10/23	7099	AL12.5 surf
AL12.5	17	66.350	168.925	45	7/10/23	7100	AL12.5 bot

CCL5	18	66.418	168.985	5	7/10/23	7101	CCL5 surf
CCL5	18	66.418	168.985	50	7/10/23	7102	CCL5 bot
CCL6	19	66.500	168.934	5	7/10/23	7103	CCL6 surf
CCL6	19	66.500	168.934	45	7/10/23	7104	CCL6 bot
CCL7	20	66.584	168.934	5	7/10/23	7105	CCL7 surf
CCL7	20	66.584	168.934	40	7/10/23	7106	CCL bot
CCL8	21	66.667	168.934	5	7/10/23	7107	CCL8 surf
CCL8	21	66.667	168.934	40	7/10/23	7108	CCL8 bot
CCL8.5	22	66.751	168.933	5	7/10/23	7109	CCL8.5 surf
CCL8.5	22	66.751	168.933	35	7/10/23	7110	CCL8.5 bot
BS11.5	23	65.799	168.897	5	7/13/23	7111	BS11.5_R surf
BS11.5	23	65.799	168.897	40	7/13/23	7112	BS11.5_R bot
BS11.5	23	65.799	168.897	40	7/13/23	7113	BS11.5_R bot
BS13	24	65.774	168.793	5	7/13/23	7114	BS13_R surf
BS13	24	65.774	168.793	40	7/13/23	7115	BS13_R bot
BS14.5	25	65.749	168.692	5	7/13/23	7116	BS14.5_R surf
BS14.5	25	65.749	168.692	40	7/13/23	7117	BS14.5_R bot
BS16	26	65.723	168.589	5	7/14/23	7118	BS16_R surf
BS16	26	65.723	168.589	40	7/14/23	7119	BS16_R bot
BS17.5	27	65.698	168.488	5	7/14/23	7120	BS17.5_R surf
BS17.5	27	65.698	168.488	45	7/14/23	7121	BS17.5_R bot
BS19	28	65.678	168.397	5	7/14/23	7122	BS19_R surf
BS19	28	65.678	168.397	45	7/14/23	7123	BS19_R bot
BS20.5	29	65.656	168.291	5	7/14/23	7124	BS20.5_R surf
BS20.5	29	65.656	168.291	40	7/14/23	7125	BS20.5_R bot
BS22	30	65.630	168.181	5	7/14/23	7126	BS22_R surf
BS22	30	65.630	168.181	25	7/14/23	7127	BS22_R bot

(While we expect position information in this table to be correct, the definitive version of positions, times and names is in the Cruise Event log, included at the end of this report.)

BERING STRAIT 2023 CTD WATER SAMPLING REPORT

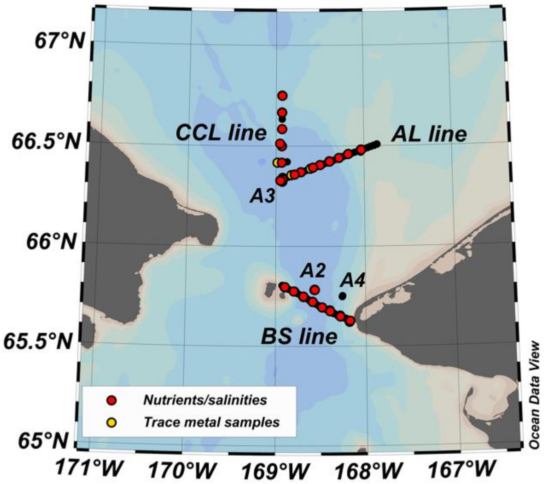
Water sampling (nutrients and salinity samples):

Woodgate, Peralta Ferriz & Jensen

Overview: Under a new NSF grant (supporting field work from 2022-20126). Water sampling from the rosette become part of our at-sea work. Sampling is for:

1) nutrients (nitrate, nitrite, ammonium, silicate, and phosphate), both for ascertain conditions during the cruise, and for checking of our new SUNA nitrate sensors on the moorings and the CTD).

2) salinities. In 2022, salinity samples were taken to check bottle firing protocols. That investigation indicated that a 10s wait was sufficient to allow for bottle flushing. In 2023, salinity samples were taken only at the start, middle, and end of the cruise, to check calibration of the CTD sensors. See salinity report below.



Map of nutrient, salinity, and trace metal samples taken in 2023. Black dots indicate CTD casts without water sampling.

In addition, during transit in 2023, white clumps floating in surface water (jokingly nicknamed whale vomit and henceforth labeled as WV1,2, etc.) were observed and sampled by surface bucket both for nutrients (filtered) and (unfiltered) for later identification (see report below)

Locations of water samples in 2023 are shown on the map above. A total of **194 nutrient samples, including duplicates (both filtered and unfiltered), and 6 salinity samples** were taken in 2023. These stations also overlapped with trace metal pumping stations for comparison between "pumped" nutrients and "bottle" nutrients . The nutrient samples were from **35 casts on 4 major lines (BS, BSrepeat, Al and CCL**) and one surface bucket sample.

Rosette Operations: A 12-position rosette fitted with 11 x 1.5L Niskin bottles (position 6 remained open to accommodate the SUNA sensor) was deployed from the back deck with the doors open during deployment and recovery. The CTD was deployed with a deck team of 2 or 3 – one winch driver from the ship and up to two catchers (both clipped onto safety lines) - one catcher from the ship, and one catcher from the science party.

Bottles were fired after waiting 10s at the desired depth. Up to six standard depths (every 10m plus bottom) were chosen for bottles (e.g., for 54m bottom depth, bottles were fired at 54m, 40m, 30m, 20m, 10m, and 0m (surface)). To allow for leaking bottles, two bottles were fired at each depth if sufficient bottles were available. For full 6 depth cast, as only 11 bottles were on the rosette, only 1 bottle was fired at the surface, since a bucket could be used to collect a surface sample if the surface bottle was unusable. This was used on one occasion. On 6 other occasions (see header of final data file), the surface bottle was found to be leaking. However it was sampled anyhow, since it could only be contaminated with surface water.

Nutrient sampling and analysis: Upon recovery bottles were checked for signs of leaking from the bottom and by opening the outlet without loosening the gas valve to ensure that the bottle was airtight (NB, before shipping to the cruise this year, all o-rings were replaced and bottles were tested). A 50 or 60 CC plastic syringe was then rinsed with water from the desired bottle three times and fitted with an Anodisc 0.45um syringe filter (luer lock) including a 0.45um, 25mm cellulose acetate syringe filter Sterlitech filter (as in 2022). A 60 mL HDPE sample bottle and lid were rinsed three times with filtered water (~5-10 mL) and filled to approximately 45 mL. Immediately upon collection, samples were double bagged in sets of 5 and put into a -22degC freezer upright. After they were frozen, samples were combined into larger bags and transported in a cooler back to Seattle as hand luggage, and transferred to UW Marine Chemistry Lab freezers on 1st August 2023, to be analyzed to JGOFS protocols. As the samples were in the transit cooler for nearly 25hrs, they were found to be slightly thawed on arrival in Seattle. However, results from 2022 shows that thawing for up to 76 hours did not degrade the data of filtered samples beyond the analysis errors, and thus we assume the much shorter thawing in 2023 does not affect the data, other than perhaps the unfiltered samples.

Samples were analyzed for nutrients (Phosphate (PO4), Silicate (SO4), Nitrate (NO3), Nitrite (NO2) and ammonia (NH4)) in late August 2023 (25th-29th) by the UW Marine Chemistry Lab, https://www.ocean.washington.edu/story/Marine_Chemistry_Laboratory using a Seal Analytical AA3, following protocols of the WOCE Hydrographic Program, UNESCO, 1994, Protocols for the joint global ocean flux study (JGOFS) core measurements. Vol. 29.

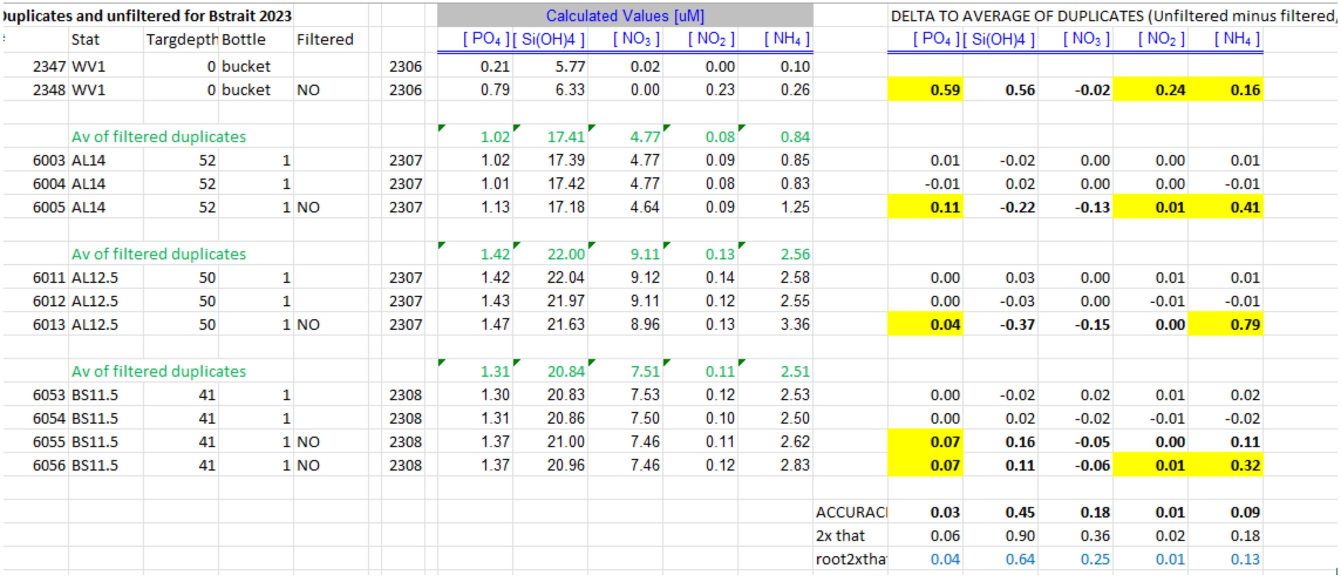
Minimum Detection Limits are: 0.03uM(PO4), 0.45uM(SO4), 0.18uM(NO3), 0.01uM(NO2), 0.09uM(NH4)

A full nutrient sample list is given below. This includes four sets of duplicates (including 5 unfiltered samples), viz:

Cast WV1 at surface - 2347 (filtered) and 2348 (unfiltered)
Cast 59, AL14 at bottom - 6003 and 6004 (filtered) and 6005 (unfiltered)
Cast 62, AL12.5 at bottom - 6011 and 6012 (filtered) and 6013 (unfiltered)
Cast 70, BS11.5 at bottom - 6053 and 6054 (filtered) and 6055 and 6056 (unfiltered)

Results from Duplicates:

Summary of results from duplicates is given here. (yellow=greater than analysis error)



uplicates and unfiltered for Bstrait 2023						Calculated Values [uM]						DELTA TO AVERAGE OF DUPLICATES (Unfiltered minus filtered,				
	Stat	Targdepth	Bottle	Filtered		[PO_4]	[Si(OH)4]	[NO_3]	[NO_2]	[NH_4]		[PO_4]	[Si(OH)4]	[NO_3]	[NO_2]	[NH_4]
2347	WV1	0	bucket		2306	0.21	5.77	0.02	0.00	0.10						
2348	WV1	0	bucket	NO	2306	0.79	6.33	0.00	0.23	0.26		**0.59**	**0.56**	**-0.02**	**0.24**	**0.16**
	Av of filtered duplicates					1.02	17.41	4.77	0.08	0.84						
6003	AL14	52	1		2307	1.02	17.39	4.77	0.09	0.85		0.01	-0.02	0.00	0.00	0.01
6004	AL14	52	1		2307	1.01	17.42	4.77	0.08	0.83		-0.01	0.02	0.00	0.00	-0.01
6005	AL14	52	1	NO	2307	1.13	17.18	4.64	0.09	1.25		**0.11**	**-0.22**	**-0.13**	**0.01**	**0.41**
	Av of filtered duplicates					1.42	22.00	9.11	0.13	2.56						
6011	AL12.5	50	1		2307	1.42	22.04	9.12	0.14	2.58		0.00	0.03	0.00	0.01	0.01
6012	AL12.5	50	1		2307	1.43	21.97	9.11	0.12	2.55		0.00	-0.03	0.00	-0.01	-0.01
6013	AL12.5	50	1	NO	2307	1.47	21.63	8.96	0.13	3.36		**0.04**	**-0.37**	**-0.15**	**0.00**	**0.79**
	Av of filtered duplicates					1.31	20.84	7.51	0.11	2.51						
6053	BS11.5	41	1		2308	1.30	20.83	7.53	0.12	2.53		0.00	-0.02	0.02	0.01	0.02
6054	BS11.5	41	1		2308	1.31	20.86	7.50	0.10	2.50		0.00	0.02	-0.02	-0.01	-0.02
6055	BS11.5	41	1	NO	2308	1.37	21.00	7.46	0.11	2.62		**0.07**	**0.16**	**-0.05**	**0.00**	**0.11**
6056	BS11.5	41	1	NO	2308	1.37	20.96	7.46	0.12	2.83		**0.07**	**0.11**	**-0.06**	**0.01**	**0.32**
											ACCURACI	**0.03**	**0.45**	**0.18**	**0.01**	**0.09**
											2x that	0.06	0.90	0.36	0.02	0.18
											root2xtha	0.04	0.64	0.25	0.01	0.13

Conclude:

1a) Filtered Duplicates agree to within analysis accuracies, mostly by better than instrument accuracies (apart from nitrite,which is at instrument accuracy).

1b) Unfiltered duplicates (only 1 pair) agree with each other to within analysis accuracies, apart from in NH4.

2) Compared to filtered, unfiltered are:

..HIGHER in PO4
.. HIGHER in NO2 and NH4
.. Silicate change less than error (and some positive, some negative)
.. Nitrate change less than error (though always negative)

This is consistent with cell degradation (releases Po4 and lower forms of N)

4) Filtering does make a significant difference to some results, so filtering is necessary.

Note these changes are NOT the same as last year (though both year show increase in P), which again suggests filtering is necessary for interannual comparison.

LIST OF BERING STRAIT 2023 **APL** NUTRIENT SAMPLES.

Station	**Sampling date (M/D/Yr)**	**Latitude**	**Longitude**	**Cast**	**Niskin bottle**	**Target Depth**	**Nutrient sample**
#	**UTC**	**(degN)**	**(degW)**	**#**	**#**	**(db)**	**#**
A2-22	7/6/23	65.784	168.567	2	1	50	2337
A2-22	7/6/23	65.784	168.567	2	2	50	2338
A2-22	7/6/23	65.784	168.567	2	3	48	2339
A2-22	7/6/23	65.784	168.567	2	4	48	2340
WV 1	7/6/23	66.323	168.929		Bucket	0	2347
WV 1	7/6/23	66.323	168.929		Bucket	0	2346**
WV 1	7/6/23	66.323	168.929		Bucket	0	2348*
A3-23	7/7/23	66.328	168.953	4	1	47	2341
A3-23	7/7/23	66.328	168.953	4	2	47	2342
A3-23	7/7/23	66.328	168.953	4	3	45	2343
A3-23	7/7/23	66.328	168.953	4	4	45	2344
A2-22	7/8/23	65.782	168.568	6	1	50	2345
A2-22	7/8/23	65.782	168.568	6	2	50	2349
A2-22	7/8/23	65.782	168.568	6	3	48	2350
A2-22	7/8/23	65.782	168.568	6	4	48	2351
A2-23	7/8/23	65.623	168.565	7	1	50	2352
A2-23	7/8/23	65.623	168.565	7	2	50	2353
A2-23	7/8/23	65.623	168.565	7	3	48	2354
A2-23	7/8/23	65.623	168.565	7	4	48	2355
BS22	7/9/23	65.623	168.565	8	1	30	2356
BS22	7/9/23	65.623	168.565	8	3	20	2357
BS22	7/9/23	65.623	168.565	8	5	10	2358
BS22	7/9/23	65.623	168.565	8	9	0	2359
BS20.5	7/9/23	65.649	168.281	11	1	44	2360
BS20.5	7/9/23	65.649	168.281	11	3	30	2361
BS20.5	7/9/23	65.649	168.281	11	5	20	2362
BS20.5	7/9/23	65.649	168.281	11	8	10	2363
BS20.5	7/9/23	65.649	168.281	11	10	0	2364
BS19	7/9/23	65.676	168.395	14	1	50	2365
BS19	7/9/23	65.676	168.395	14	3	40	2366
BS19	7/9/23	65.676	168.395	14	5	30	2367
BS19	7/9/23	65.676	168.395	14	8	20	2368
BS19	7/9/23	65.676	168.395	14	10	10	1281
BS19	7/9/23	65.676	168.395	14	12	0	1282
BS17.5	7/9/23	65.695	168.483	17	1	50	1283
BS17.5	7/9/23	65.695	168.483	17	3	40	1284
BS17.5	7/9/23	65.695	168.483	17	5	30	1285

BS17.5	7/9/23	65.695	168.483	17	8	20	1286
BS17.5	7/9/23	65.695	168.483	17	10	10	1287
BS17.5	7/9/23	65.695	168.483	17	12	0	1288
BS16	7/9/23	65.722	168.590	20	1	50	1289
BS16	7/9/23	65.722	168.590	20	3	40	1290
BS16	7/9/23	65.722	168.590	20	5	30	1291
BS16	7/9/23	65.722	168.590	20	8	20	1292
BS16	7/9/23	65.722	168.590	20	10	10	1293
BS16	7/9/23	65.722	168.590	20	12	0	1294
BS14.5	7/9/23	65.749	168.691	23	1	50	1295
BS14.5	7/9/23	65.749	168.691	23	3	40	1296
BS14.5	7/9/23	65.749	168.691	23	5	30	1297
BS14.5	7/9/23	65.749	168.691	23	8	20	1298
BS14.5	7/9/23	65.749	168.691	23	10	10	1299
BS14.5	7/9/23	65.749	168.691	23	12	0	1300
BS13	7/9/23	65.775	168.798	26	1	50	1301
BS13	7/9/23	65.775	168.798	26	3	40	1302
BS13	7/9/23	65.775	168.798	26	5	30	1303
BS13	7/9/23	65.775	168.798	26	8	20	1304
BS13	7/9/23	65.775	168.798	26	10	10	1305
BS13	7/9/23	65.775	168.798	26	12	0	1306
BS11.5	7/9/23	65.797	168.896	29	1	45	1307
BS11.5	7/9/23	65.797	168.896	29	3	30	1308
BS11.5	7/9/23	65.797	168.896	29	5	20	1309
BS11.5	7/9/23	65.797	168.896	29	8	10	1310
BS11.5	7/9/23	65.797	168.896	29	10	0	1311
AL25	7/9/23	66.480	168.032	36	1	22	1312
AL25	7/9/23	66.480	168.032	36	3	10	1313
AL25	7/9/23	66.480	168.032	36	5	0	1314
AL23	7/9/23	66.459	168.180	40	1	33	1315
AL23	7/9/23	66.459	168.180	40	3	20	1316
AL23	7/9/23	66.459	168.180	40	5	10	1317
AL23	7/9/23	66.459	168.180	40	8	0	1318
AL21.5	7/9/23	66.441	168.285	43	1	43	1319
AL21.5	7/9/23	66.441	168.285	43	3	30	1320
AL21.5	7/9/23	66.441	168.285	43	5	20	1321
AL21.5	7/9/23	66.441	168.285	43	8	10	1322
AL21.5	7/9/23	66.441	168.285	43	10	0	1323
AL20	7/9/23	66.423	168.393	47	1	49	1324
AL20	7/9/23	66.423	168.393	47	3	40	1325
AL20	7/9/23	66.423	168.393	47	7	30	1326

AL20	7/9/23	66.423	168.393	47	8	20	1327
AL20	7/9/23	66.423	168.393	47	10	10	1328
AL20	7/9/23	66.423	168.393	47	12	0	1329
AL18.5	7/9/23	66.406	168.502	50	1	52	1330
AL18.5	7/9/23	66.406	168.502	50	3	40	1331
AL18.5	7/9/23	66.406	168.502	50	5	30	1332
AL18.5	7/9/23	66.406	168.502	50	8	20	1333
AL18.5	7/9/23	66.406	168.502	50	10	10	1334
AL18.5	7/9/23	66.406	168.502	50	12	0	1335
AL17	7/9/23	66.387	168.610	54	1	54	1336
AL17	7/9/23	66.387	168.610	54	3	40	1337
AL17	7/9/23	66.387	168.610	54	5	30	1338
AL17	7/9/23	66.387	168.610	54	8	20	1339
AL17	7/9/23	66.387	168.610	54	10	10	1340
AL17	7/9/23	66.387	168.610	54	12	0	1341
AL15.5	7/10/23	66.370	168.718	56	1	50	1342
AL15.5	7/10/23	66.370	168.718	56	3	40	1343
AL15.5	7/10/23	66.370	168.718	56	5	30	1344
AL15.5	7/10/23	66.370	168.718	56	8	20	6000
AL15.5	7/10/23	66.370	168.718	56	10	10	6001
AL15.5	7/10/23	66.370	168.718	56	12	0	6002
AL14	7/10/23	66.358	168.790	59	1	52	6003
AL14	7/10/23	66.358	168.790	59	1	52	6004
AL14	7/10/23	66.358	168.790	59	1	52	6005*
AL14	7/10/23	66.358	168.790	59	3	40	6010
AL14	7/10/23	66.358	168.790	59	5	30	6006
AL14	7/10/23	66.358	168.790	59	8	20	6007
AL14	7/10/23	66.358	168.790	59	10	10	6008
AL14	7/10/23	66.358	168.790	59	12	0	6009
AL12.5	7/10/23	66.334	168.923	62	1	50	6011
AL12.5	7/10/23	66.334	168.923	62	1	50	6012
AL12.5	7/10/23	66.334	168.923	62	1	50	6013*
AL12.5	7/10/23	66.334	168.923	62	3	40	6014
~~AL12.5~~	~~7/10/23~~	~~66.334~~	~~168.923~~	~~62~~	~~5~~	~~30~~	~~6015~~ *(bottle not filled)*
AL12.5	7/10/23	66.333	168.923	62	8	20	6016
AL12.5	7/10/23	66.333	168.923	62	10	10	6017
AL12.5	7/10/23	66.333	168.923	62	Bucket	0	6018
A3	7/10/23	66.327	168.950	63	1	50	6019
A3	7/10/23	66.327	168.950	63	3	40	6020
A3	7/10/23	66.327	168.950	63	5	30	6021

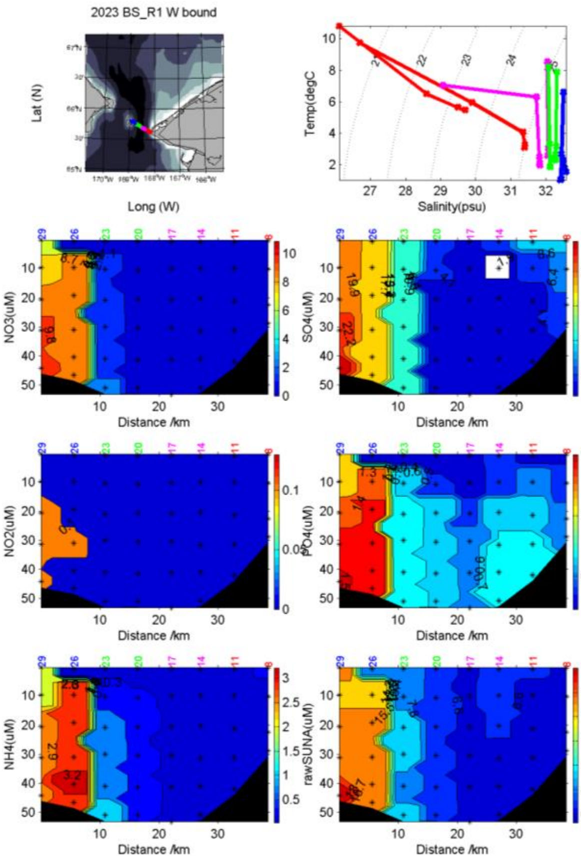
A3	7/10/23	66.327	168.950	63	8	20	6022
A3	7/10/23	66.327	168.950	63	10	10	6023
A3	7/10/23	66.327	168.950	63	12	0	6024
CCL5	7/10/23	66.418	168.935	64	1	50	6025
CCL5	7/10/23	66.418	168.935	64	3	40	6026
CCL5	7/10/23	66.418	168.935	64	5	30	6027
CCL5	7/10/23	66.418	168.935	64	8	20	6028
CCL5	7/10/23	66.418	168.935	64	10	10	6029
CCL5	7/10/23	66.418	168.935	64	12	0	6030
CCL6	7/10/23	66.500	168.934	65	1	50	6031
CCL6	7/10/23	66.500	168.934	65	3	40	6032
CCL6	7/10/23	66.500	168.934	65	5	30	6033
CCL6	7/10/23	66.500	168.934	65	8	20	6034
CCL6	7/10/23	66.500	168.934	65	10	10	6035
CCL6	7/10/23	66.500	168.934	65	12	0	6036
CCL7	7/10/23	66.584	168.934	66	1	40	6037
CCL7	7/10/23	66.584	168.934	66	3	30	6038
CCL7	7/10/23	66.584	168.934	66	5	20	6039
CCL7	7/10/23	66.584	168.934	66	8	10	6040
CCL7	7/10/23	66.584	168.934	66	10	0	6041
CCL8	7/10/23	66.666	168.933	67	1	40	6042
CCL8	7/10/23	66.666	168.933	67	3	30	6043
CCL8	7/10/23	66.666	168.933	67	5	20	6044
CCL8	7/10/23	66.666	168.933	67	8	10	6045
CCL8	7/10/23	66.666	168.933	67	10	0	6046
CCL8.5	7/10/23	66.750	168.931	68	1	40	6047
CCL8.5	7/10/23	66.750	168.931	68	3	30	6048
CCL8.5	7/10/23	66.750	168.931	68	5	20	6049
CCL8.5	7/10/23	66.750	168.931	68	8	10	6050
CCL8.5	7/10/23	66.750	168.931	68	10	0	6051
CCL14	7/10/23	67.635	168.933	69	1	0	6052
WV 2	7/11/23	66.512	168.955		Bucket	0	3264**
BS11.5	7/13/23	65.797	168.898	70	1	41	6053
BS11.5	7/13/23	65.797	168.898	70	1	41	6054
BS11.5	7/13/23	65.797	168.898	70	1	41	6055*
BS11.5	7/13/23	65.797	168.898	70	1	41	6056*
BS11.5	7/13/23	65.797	168.898	70	3	30	6057
BS11.5	7/13/23	65.797	168.898	70	5	20	6058
BS11.5	7/13/23	65.797	168.898	70	7	10	6059
BS11.5	7/13/23	65.797	168.898	70	10	0	6060
BS13	7/13/23	65.774	168.793	72	1	50	6061

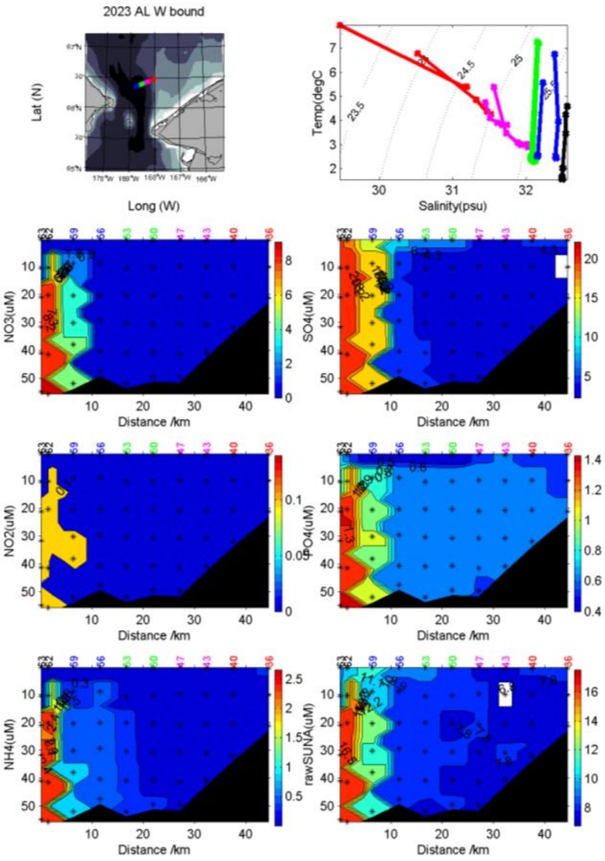
BS13	7/13/23	65.774	168.793	72	3	40	6062
BS13	7/13/23	65.774	168.793	72	5	30	6063
BS13	7/13/23	65.774	168.793	72	8	20	3111
BS13	7/13/23	65.774	168.793	72	10	10	3113
BS13	7/13/23	65.774	168.793	72	12	0	3115
BS14.5	7/13/23	65.746	168.692	73	1	50	3116
BS14.5	7/13/23	65.746	168.692	73	3	40	3117
BS14.5	7/13/23	65.746	168.692	73	5	30	3118
BS14.5	7/13/23	65.746	168.692	73	8	20	3120
BS14.5	7/13/23	65.746	168.692	73	10	10	3121
BS14.5	7/13/23	65.746	168.692	73	12	0	3122
BS16	7/14/23	65.723	168.589	74	1	50	3123
BS16	7/14/23	65.723	168.589	74	3	40	3124
BS16	7/14/23	65.723	168.589	74	5	30	3125
BS16	7/14/23	65.723	168.589	74	9	20	3134
BS16	7/14/23	65.723	168.589	74	10	10	3136
BS16	7/14/23	65.723	168.589	74	12	0	3202
BS17.5	7/14/23	65.698	168.486	75	1	50	3203
BS17.5	7/14/23	65.698	168.486	75	3	40	3204
BS17.5	7/14/23	65.698	168.486	75	5	30	3205
BS17.5	7/14/23	65.698	168.486	75	9	20	3206
BS17.5	7/14/23	65.698	168.486	75	10	10	3207
BS17.5	7/14/23	65.698	168.486	75	12	0	3208
BS19	7/14/23	65.671	168.391	76	1	50	3209
BS19	7/14/23	65.671	168.391	76	3	40	3210
BS19	7/14/23	65.671	168.391	76	5	30	3211
BS19	7/14/23	65.671	168.391	76	8	20	3212
BS19	7/14/23	65.671	168.391	76	10	10	3213
BS19	7/14/23	65.671	168.391	76	12	0	3214
BS20.5	7/14/23	65.651	168.287	77	1	44	3215
BS20.5	7/14/23	65.651	168.287	77	3	30	3216
BS20.5	7/14/23	65.651	168.287	77	5	20	3217
BS20.5	7/14/23	65.651	168.287	77	8	10	3218
BS20.5	7/14/23	65.651	168.287	77	11	0	3219
BS22	7/14/23	65.626	168.177	78	1	30	3226
BS22	7/14/23	65.626	168.177	78	3	20	3227
BS22	7/14/23	65.626	168.177	78	5	10	3228
BS22	7/14/23	65.626	168.177	78	8	0	3229

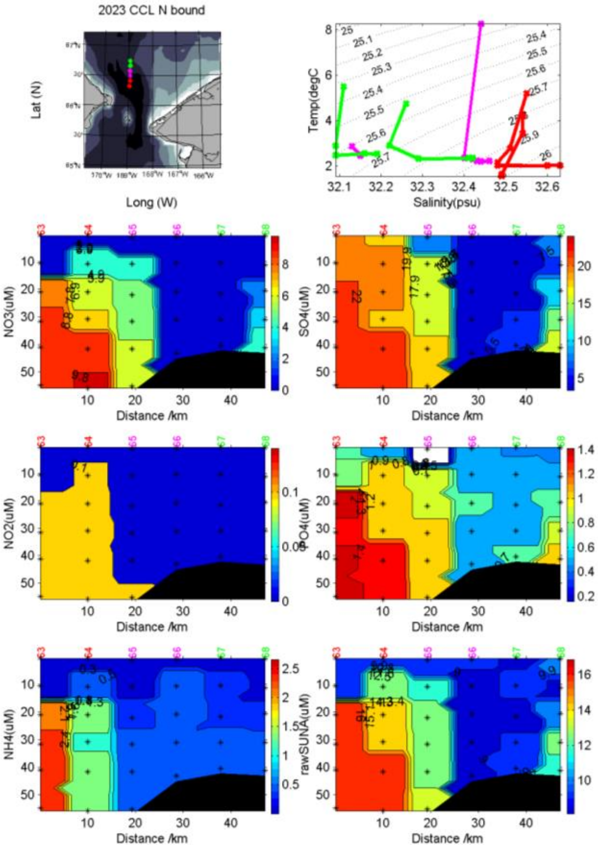
*unfiltered **unfiltered & unfrozen

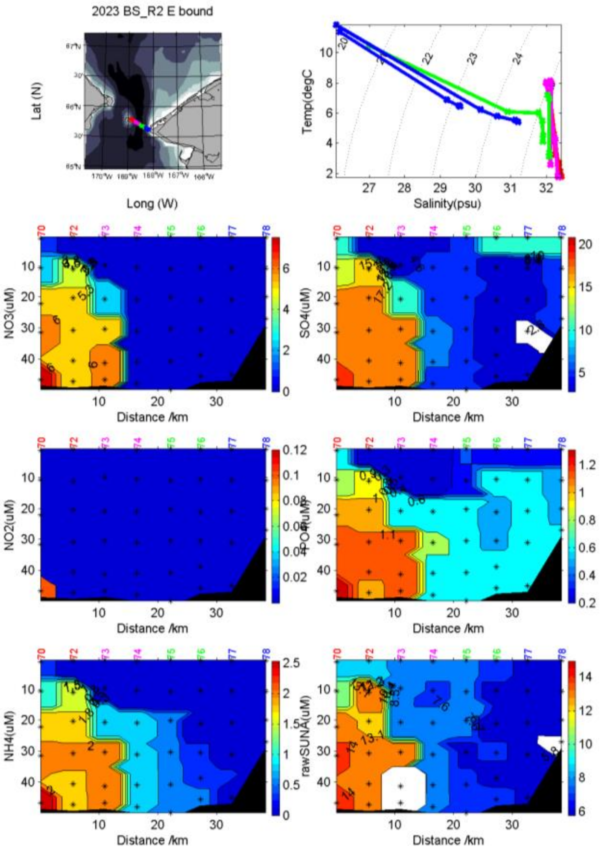
(While we expect position information in this table to be correct, the definitive version of positions, times and names is in the Cruise Event log, included at the end of this report.)

BS2023 Nutrients by section, (own scales)

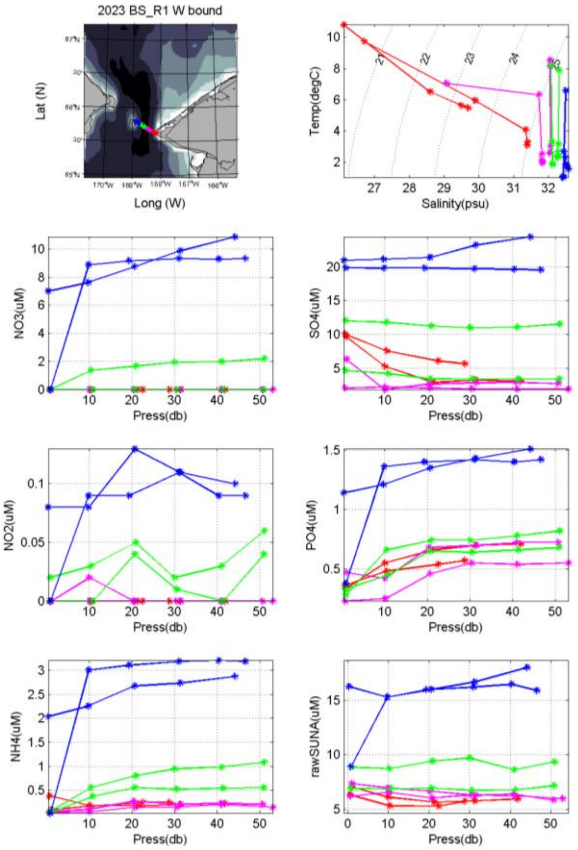


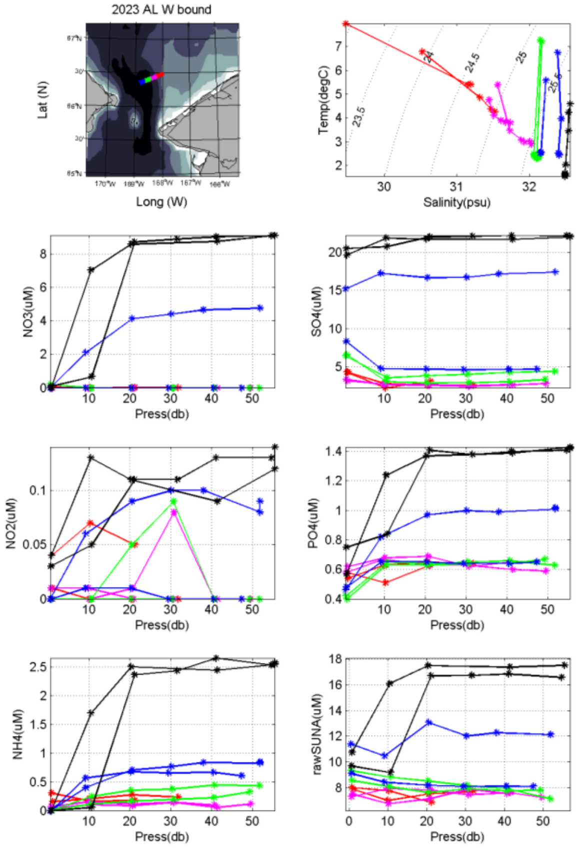


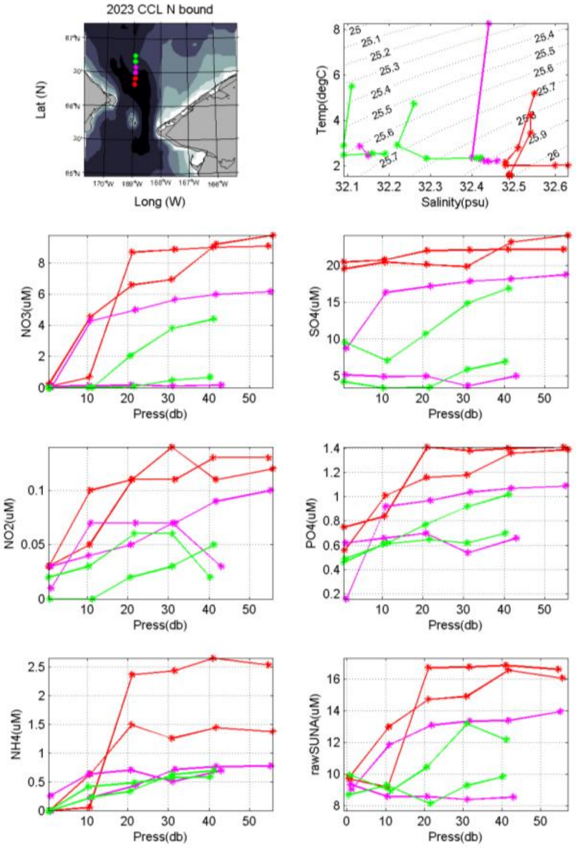


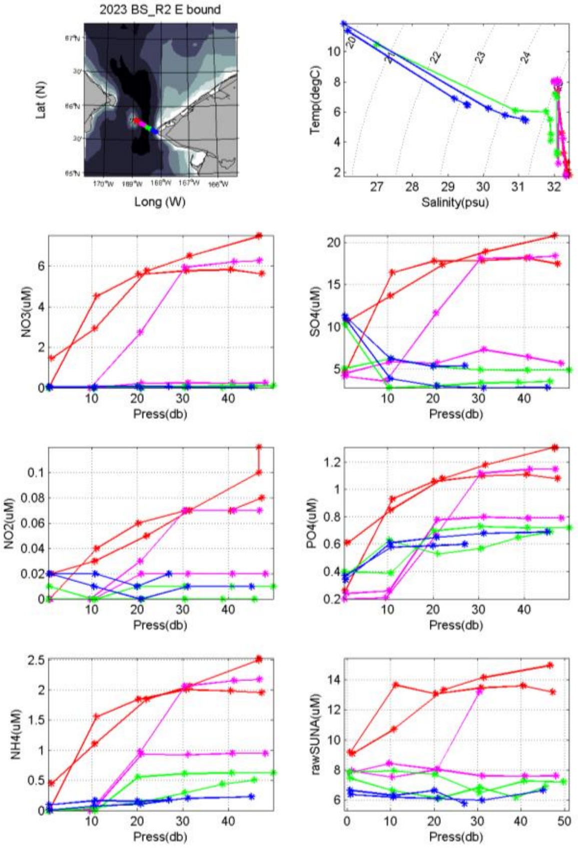


BS2023 Nutrients by section, versus depth

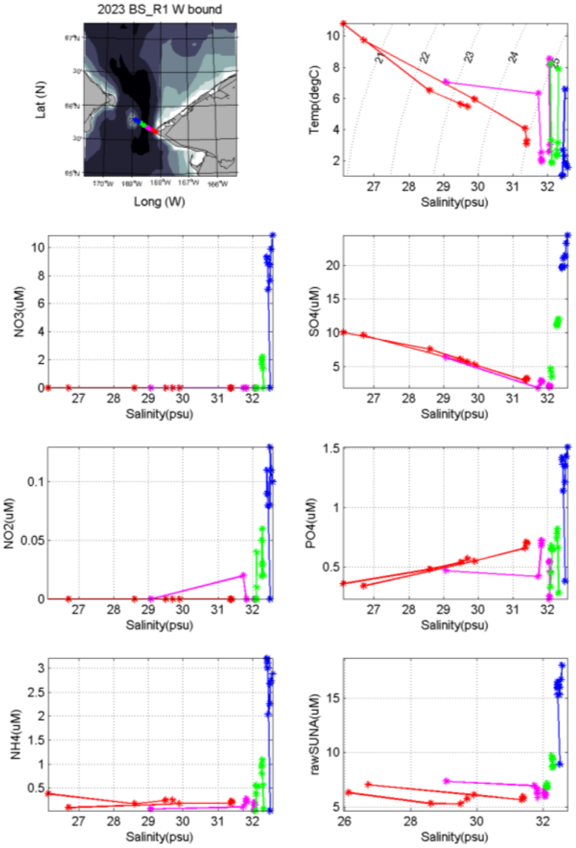


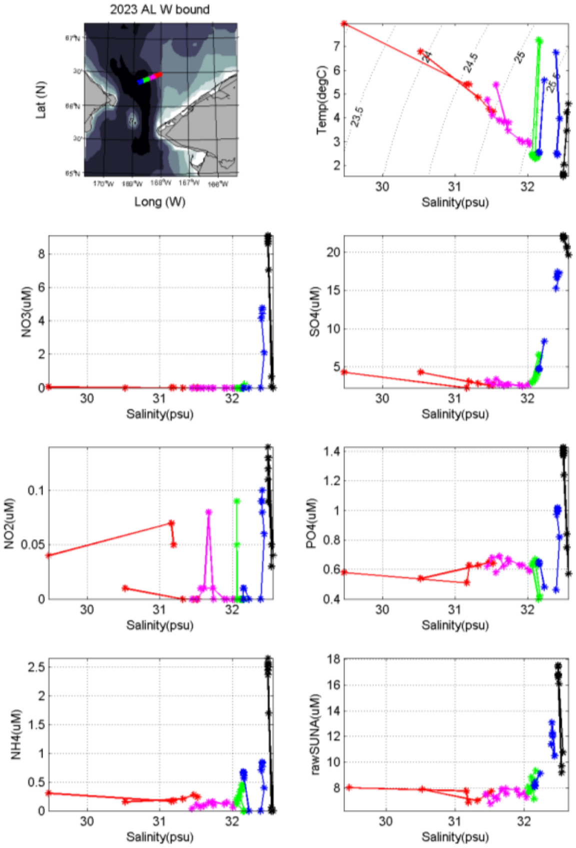


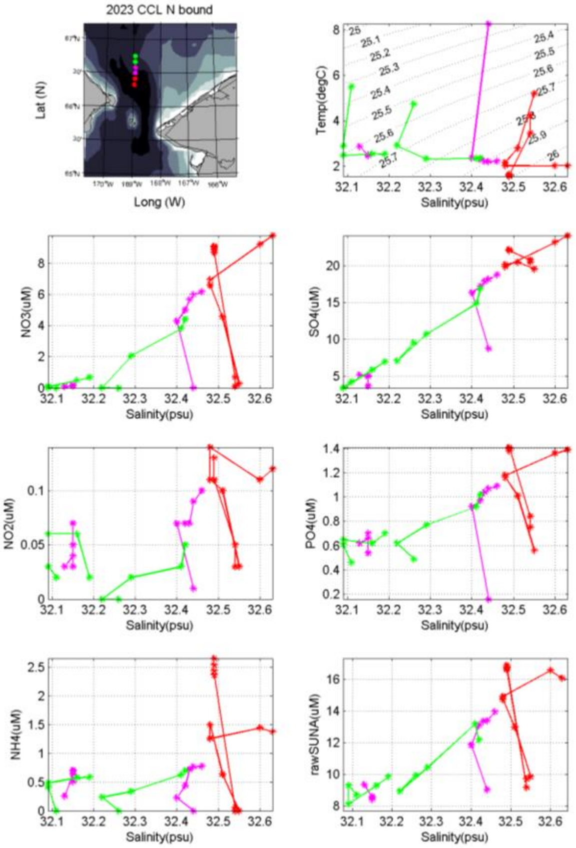


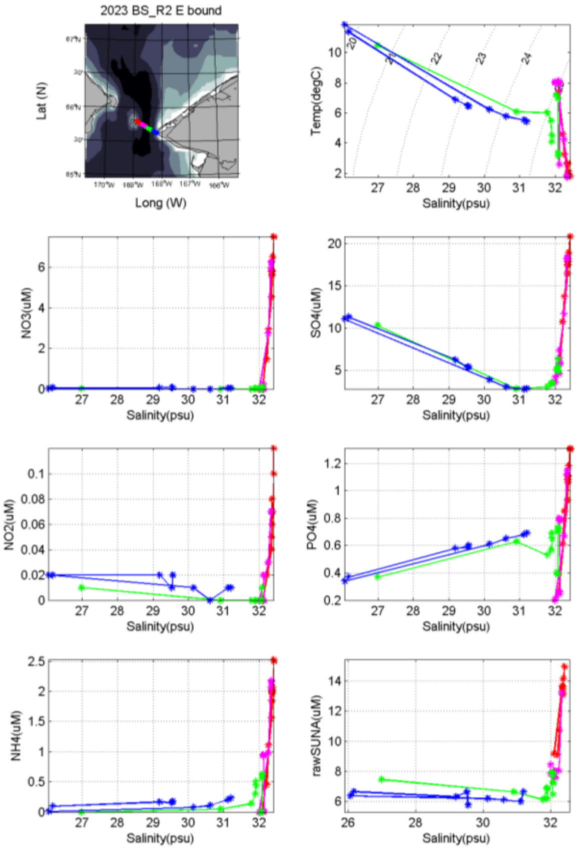


BS2023 Nutrients by section, versus salinity

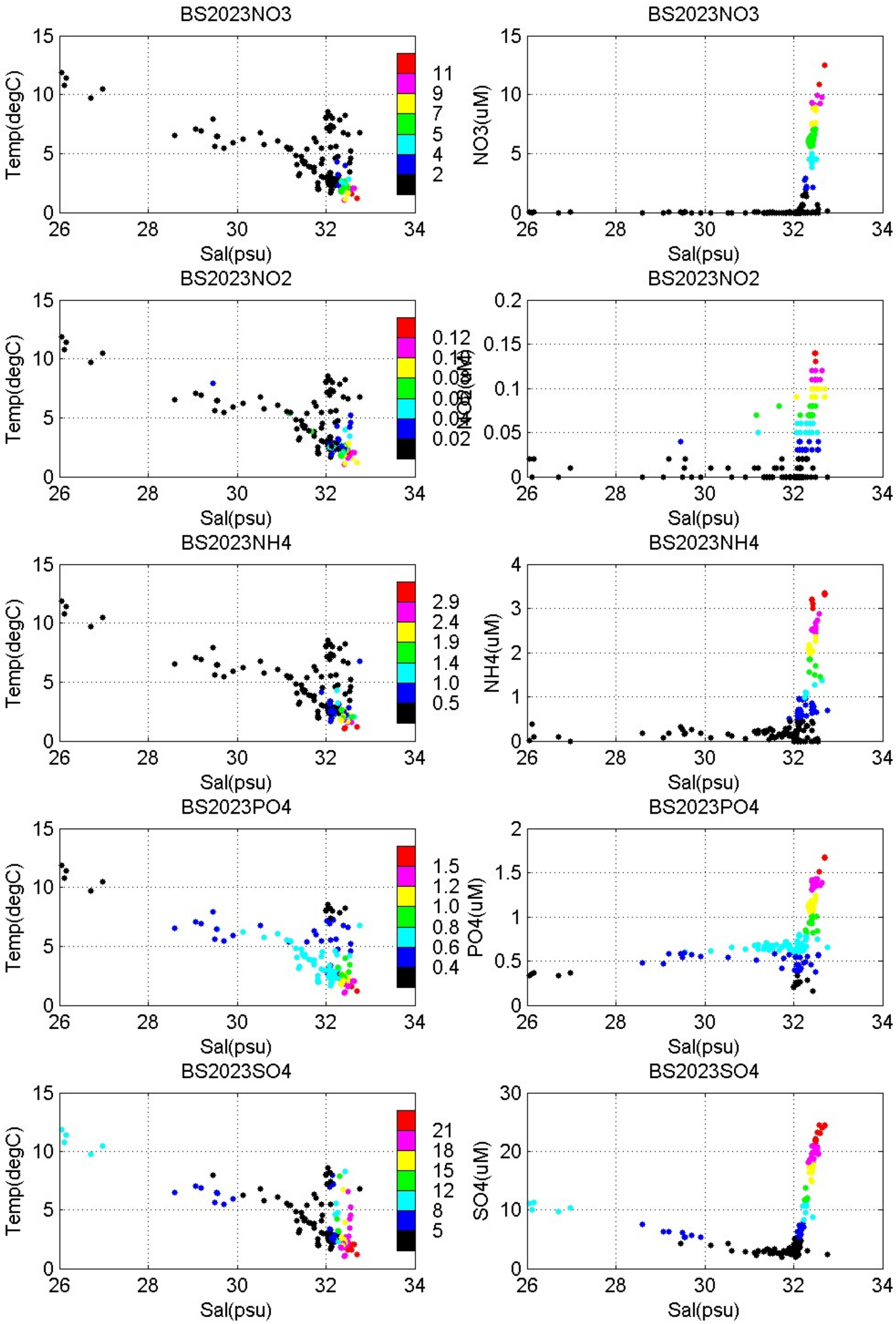




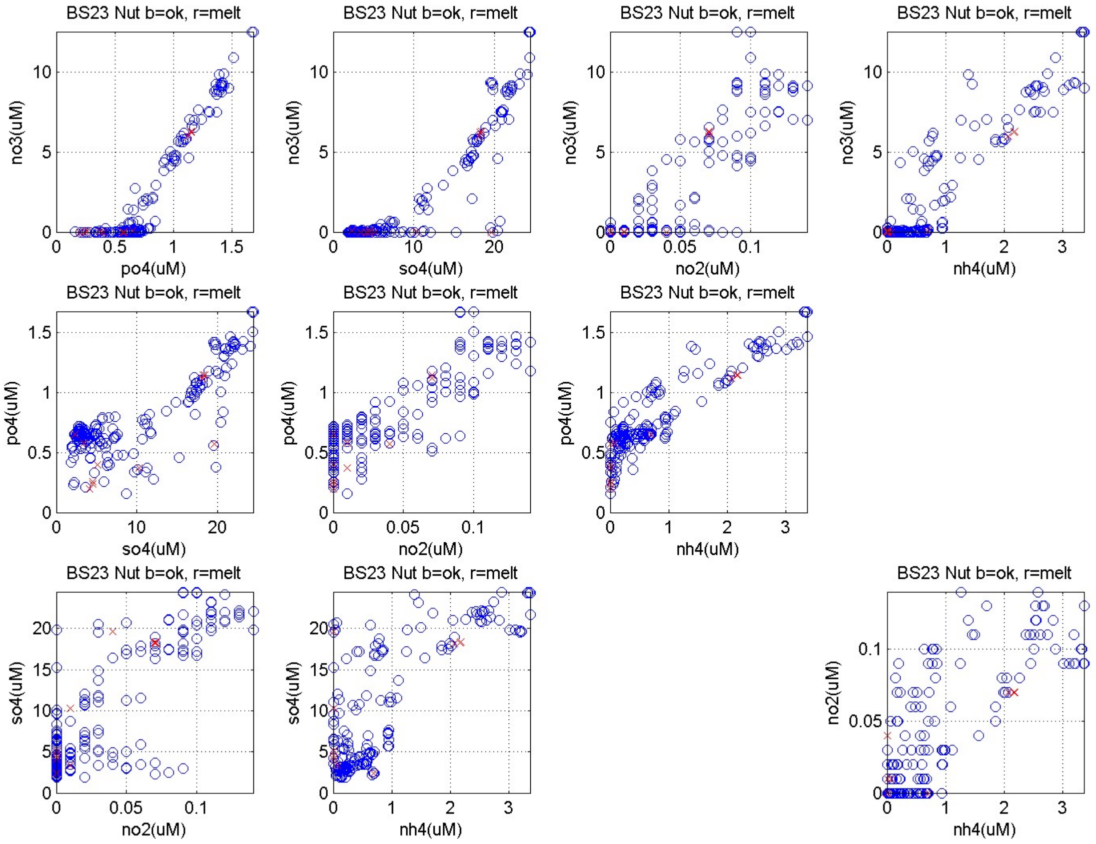




BS2023 Nutrients in TS space (all cruise)



BS2023 Nutrients ratios (all cruise)



Bering Strait 2023 Salinity sampling:

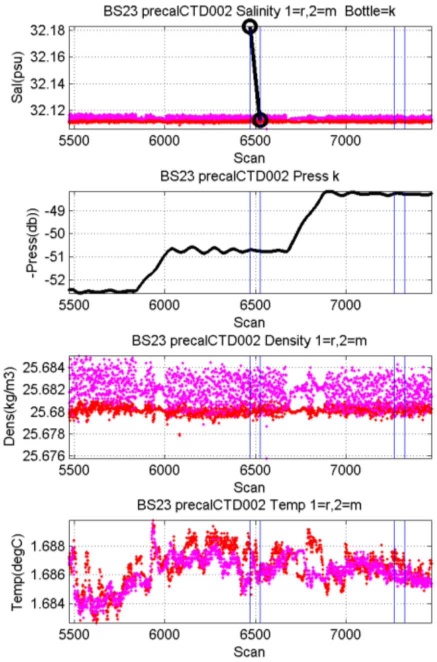
In 2023, salinity samples were taken to check the calibration of the CTD sensors. Three pairs of samples were taken, (6 samples total). 2 at the start of the cruise, 2 in the middle of the cruise, and 2 at the end of the cruise. In each case, they were taken from the most homogeneous layer found (typically bottom). Samples were collected in glass bottles to WOCE standards (3 rinses of bottle and cap), and returned to the UW Marine Chemistry Lab, where they were analyzed as per UNESCO (1994) JGOFS standards, with resultant accuracy of 0.002psu.

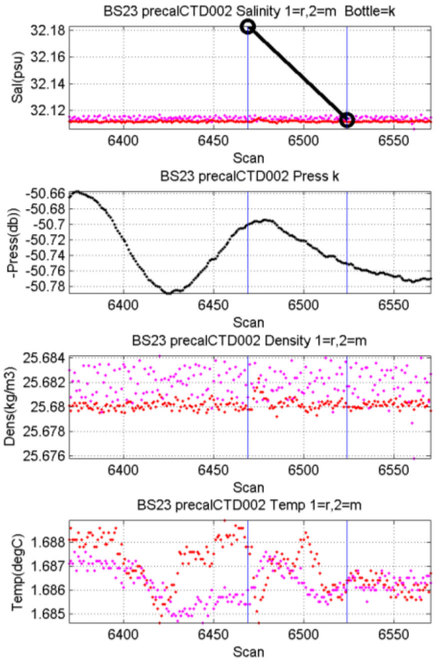
LIST OF 2023 SALINITY SAMPLES

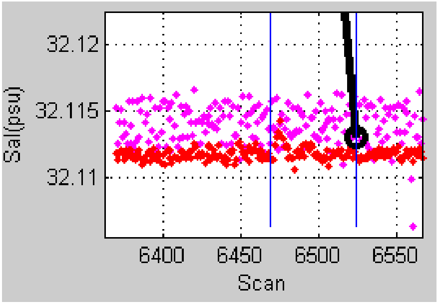
Date 2023	GMT	Station	Cast	Latitude (N)	Longitude (W)	Bottle #	Target Depth (db)	Sample #	Analyzed Salinity (psu)
July	0111	A2-22Rec5	2	65.784	168.567	1	50 (bottom)	121	32.183
6th	0118		2	65.784	168.567	2	50 (bottom)	122	32.113
July	2142	Al20recast	47	66.423	168.393	2	49 (bottom)	123	32.033
9th	2150		47	66.423	168.393	2	49 (bottom)	124	32.034
July	2155	BS11.5	70	65.799	168.898	2	47 (bottom)	125	32.422
13th	2202		70	65.799	168.898	2	47 (bottom)	126	32.422

The manufacturer's accuracy for the CTD is 0.003psu. Comparison of the bottle data to the CTD (below) show:
1) CTD sensor S1 has noise of about 0.001psu. CTD sensor S2 has noise of about 0.005psu, or less.
2) With one exception, bottle data agree with CTD data to 0.001psu or better.
3) The exception (sample 121) has a salinity greater than the rest of the cast, indicating likely contamination of the bottle.

CAST 2:



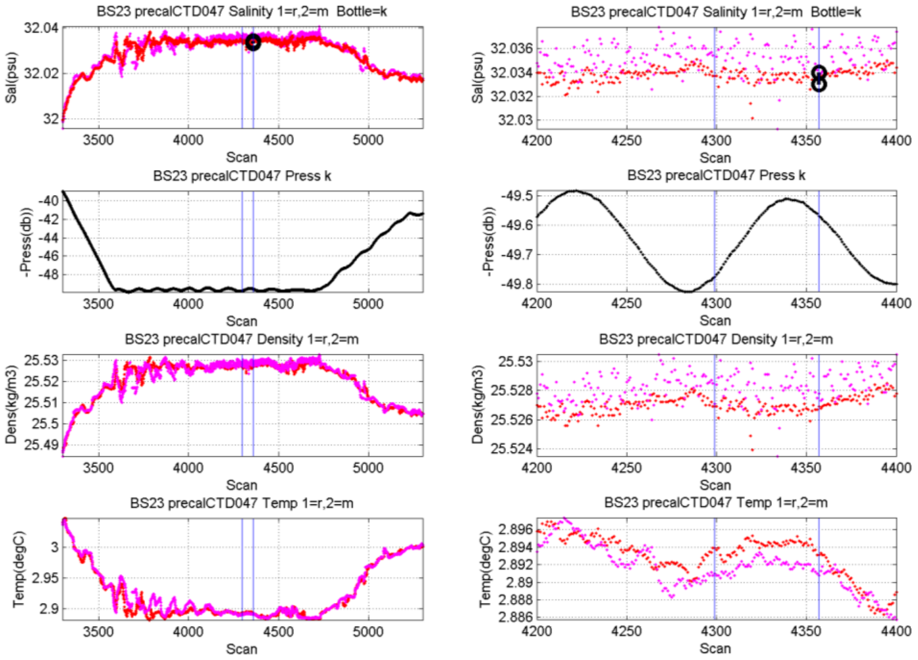




Bottles differ by 0.06psu

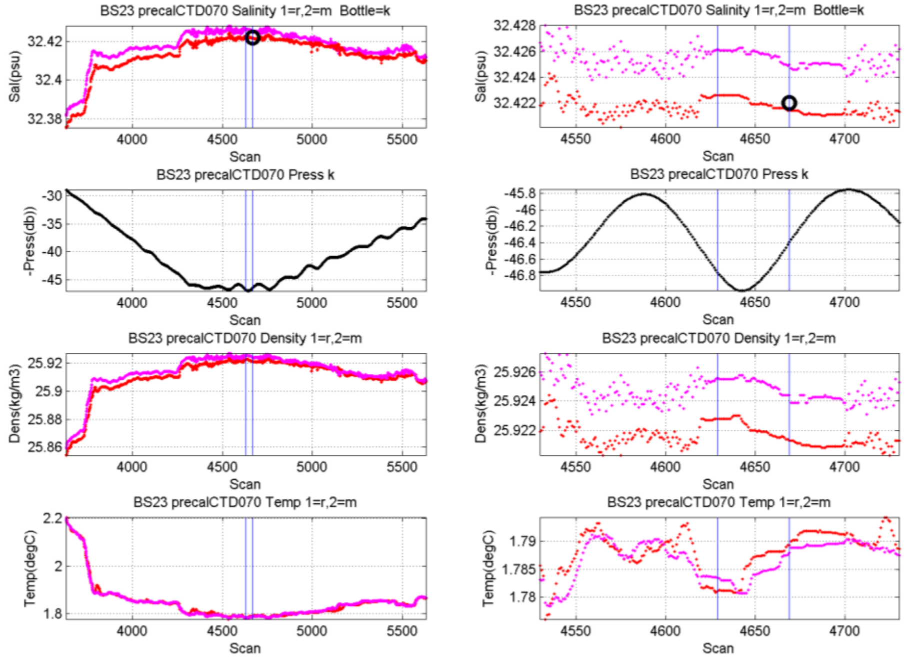
S1 stable to 0.001psu,
S2 stable only to 0.005psu
Bottle 0.001psu saltier than S1

CAST 47:



Bottles agree to 0.001psu
Bottle agree with S1 to 0.001psu
S1 and S2 diff by 0.002psu

CAST 70:

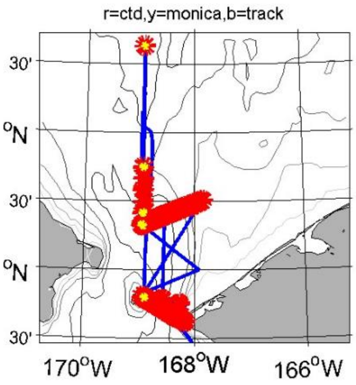


Bottles agree to < 0.001psu
Bottles to S1 agree by < 0.0005psu
S1 and S2 agree to 0.003psu

We conclude:

- CTD S1 sensor is preferred (as less noise) and better match to bottle data (0.001psu)
- both sensors are within manufacturer's specifications
- this technique (duplicate bottles at the start, middle and end of the cruise) should be continued in future years to test for problems with the CTD salinity sensors (as have been experienced in previous years.

BERING STRAIT 2023 Microplastic Sampling for Monica Orellena



UW PI Monica Orellena requested we take water samples for her for an investigative study into microplastics. She asked that we targeted surface waters, preferably near ice (unfortunately we found no sea ice) or in the higher nutrient Anadyr waters. Medium was added to these samples to guard against starvation before the samples could reach Seattle. These samples were kept in a cooler and hand transported back to UW immediately after the cruise.

Samples were taken at 6 locations (see map, note WV1 and cast 63 are close to each other).

In the following tables, times are GMT. Subtract 8hrs to get to local time.
Samples were taken either by surface bucket or from the top bottle of the CTD rosette.
Filtered samples were also taken for nutrients at the same locations

#	Day July 2023	Time (GMT)	Location	Cast number (if applic)	Latitude (N)	Longitude (E)	Echosounder Reading (m) (add 3m for Bottom depth)	Collection method Niskin # or TS information if Bucket	Nutrient bottle number
1	6th	1913	WV1 (near A3)	Bucket	66.32	168.93	54.8	Tintake= 6.80degC S=32.76psu	2347(filtered) 2348(unfiltered)
2	10th	0332	A3	63	66.32803	168.9504	55.0	CTD #12	6024
3	10th	0420	CCL5	64	66.41773	168.935	55.6	CTD #12	6030
4	10th	0802	CCL8.5	68	66.75088	168.9328	41.7	CTD #10	6051
5	10th	1417	CCL14	69	67.63448	168.933	49.2	CTD #1	6052
6	13th	2155	BS11.5	70	65.79855	168.8971	46.5	CTD #10	6060

BERING STRAIT 2023 Opportunistic water sampling

During the cruise, unusual white material was observed floating in the surface of the water, and at two locations (jokingly named WV (Whale Vomit)1 and 2) a surface bucket was taken to obtain water samples for identification of the material. The first location was also sampled for nutrients and the microplastic investigation. Below are a log of the samples and some photographs.

Bering Strait 2023 unusual floating white material two bucket sample information.
ID samples are unfiltered. Water depth are given as Echosounder reading – add 3m for true water depth

#	Day (July 2023)	Time (GMT)	Location	Bottle # for ID	Latitude (N)	Longitude (E)	Water Depth (m)	Underway TS	Other samples taken
WV1	6th	1913 (1113 local)	WV1 0.5nm SE of A3	2346	66deg 19.36'N (66.32)	168deg 55.74'W (168.93)	54.8	T2(intake) = 6.80degC S=32.76psu	**Nutrients:** 2347 (filtered) 2348 (unfiltered) **Monica:** 1=WV1
WV2	11th	1755 (0955 local)	WV2 11.2nM N of A3, Near CCL 6 Cast 65	3264	66deg 30.72'N (66.51)	168deg 57.30'W (168.96)	55.2	T2(intake) =4.4degC S=32.2psu	

Samples were returned to Seattle, and investigated by Dr Monica Orellena, who preliminary identified the material as 'marine snow'. The white material had disintegrated by the time this investigation took place (Sept 2023), however at that time, the samples had "quite a bit of dissolved carbohydrates, … which are known to be produced by phytoplankton under stress (run out of nutrients for example) and released as foam into the sea water." This is common at the end of blooms, if, for example, the cells have run out of the silica needed to make their cell walls. Another common stress could be attack from viruses.

Note that as per data present above, waters in this region were depleted to ~zero nitrate, with low or zero nitrite and ammonia readings. Silicate values were, however, comparatively high (~15uM).

Note too that in 2004 a seemingly different white floating material was discovered in the Central Chukchi on our Alpha Helix cruise (see [*Woodgate*, 2004]). In contrast to the 2023 material, which had no clear spatial form, the 2004 material resembled grains of rice and were later tentatively identified as dead copepods by Jeff Napp (NOAA) in Nov 2004, viz:

"*Yes, I finally had a few quiet minutes to sit at the 'scope. Most of what I saw was fragments of copepods (plus a couple of bird feathers). There were a few almost intact exoskeletons with oil droplets inside. One or two of the almost intact ones had enough of their anatomy remaining that I could tell they were females. Given the size of what was there, I am guessing these were Neocalanus plumchrus or Neocalanus flemingerii. The abundant waxy substance is most likely from their depot lipids. They store both wax esters and triacylglycerols for energy during the winter when they stop feeding and spawn 600 - 1200 m. The triacylglycerols are usually used first before the wax esters.*

I will send you a reprint of an article about exoskeletons from the Oyashio/Kuroshio confluence. I'm not sure of the next step. Your material is suggestive of vertical transport of females from great depth, well before the time of spawning. It might make an interesting journal note. Alternatively we could wait for more information if you think you can find a similar patch next year I could prepare you with preservatives for both the lipid and the little beasties.. (2004 photos reproduced here for ease of access.)

Top 3 photos =- 2023 station WV1 (photos by Katie Kohlmanm UW)

Below – photo of 2023 WV2 (by Katy Christensen, UW)

From Woodgate, 2004 cruise report:

HX290 - 2004
Sat 4th Sept ca 0800 local
(1600GMT)
between CCL6 and CCL7
ca. 66 30.16N, 168 57.63W
5.16deg C, 30.43 psu
this, surface trapped, soapy to the touch, granular yet soft,
also dead seabirds, bottles, other rubbish

.. some present in water for ca.30nm
south (until NBS line and 2 stations into NBS line)

BERING STRAIT 2023 UNDERWAY DATA REPORT – Woodgate (UW)

**March2024 – Underway TSG calibrations were performed using 2016 calibration. New calibration of sensors, Nov/Dec 2023, show a post cruise change, which suggests data recorded here are ~0.05psu too fresh.*

Underway CTD, ADCP and some meteorological data were collected during the cruise using the Norseman II's ship-based systems. These systems are set up by the Norseman II crew at the start of the cruise. **Action item: Pre-cruise, develop checksheets for the setup of these instruments to ensure settings are as desired. Check the setups as soon as the ship leaves port.**

ADCP: This year, as last year, we collected data from the Norseman II's Teledyne RD Instruments 300kHz Workhorse Mariner ADCP (SN 19355), which is equipped with high accuracy bottom tracking. The ADCP is mounted 3m below the water line. This system was operational for the cruise, running with 1m bins and bottom track. The following file types are available for processing (file information copied from http://po.msrc.sunysb.edu/SBI/Healy_ADCPs.htm)

*.ENR – raw binary ADCP data which contains every ping
*.ENS – Binary ADCP data after the data has been preliminarily screened for backscatter and correlation
*.ENX - Binary ADCP data after screening and rotation to earth coordinates
*.STA - Binary ADCP ensemble data that has been averaged into short term averages
*.LTA - Binary ADCP ensemble data that has been averaged into long term averages
*.N1R - Raw NMEA ASCII data from the primary navigation source
*.N2R - Raw NMEA ASCII data from the secondary navigation source, if available, and which should include Ashtech heading data
*.NMS - Binary screened and averaged navigation data
*.VMO - This ASCII file is a copy of the *.ini options file that was used during the data collection
*.LOG - ASCII file containing a log of any errors the ADCP detected during the session

Preliminary data plots will be added to this report once available. Bottom track data was logging during this deployment. **Action item: Ensure that bottom tracking is turned on. Process ADCP data.** Note also that since heading information is given by the ship's GPS position, it is not necessary to correct for magnetic declination. **Action item: Check prior data for magnetic declination issue.**

MET DATA: The Norseman2 had South Central Radar install a new Meteorological sensor package in 2021, as the previous sensors failed. The new version is an Airmar 220WX instrument Weather caster 153 (https://www.airmar.com/weather-description.html?id=153, https://www.airmar.com/uploads/InstallGuide/17-461-01.pdf) running WeatherCaster 3 software. Trouble shooting of these sensors in 2021 (and comparison to ERA, JRA and NCEP data) concluded that the unit was reading:

- too high for wind speed (by about 2m/s on average, i.e., about 4 knots)
- too low for temperature (by about 2degC on average)
- too low for pressure (by ~ 2hPa).

These differences are all greater than the stated accuracy of the sensor https://www.airmar.com/weather-description.html?id=153 (0.5m/s for speed; 1.1degC for temperature, 0.5hPa for pressure).

Note the instrument calculates true wind direction and speed (and this is not reproducible exactly from relative wind and ship heading. In 2021, a compass calibration was performed off Nome in less than ideal conditions, and this may have contributed to the errors in the 2021 data. For 2022, a better calibration was performed pre cruise, in suitable conditions. It is not clear if the system has been calibrated subsequently. It is possible thus that the 2023 data are of higher quality than in 2021 but this should be confirmed with comparison to the model wind products: Note that the temperature and wind chill temperature reported remain identical, which is clearly erroneous. **Action item: Repeat comparison to ERA, JRA and NCEP wind data.**

As can be seen in the plots below, winds were light (and somewhat confused) for the start of the cruise, but resolved to higher speeds and initially southward, and then northward towards the end of the cruise. Wind direction should be taken into account when considering the hydrographic sections. **Action item: Add wind direction to the CTD sections. .**

UNDERWAY TEMPERATURE AND CONDUCTIVITY DATA: The Norseman II used an Seabird SBE21 temperature conductivity sensor mounted 3.4m below the water line (slightly to port of the ship's ADCP, in the center of the ship) to collect underway data throughout the cruise, also logging position information and depth. A separate temperature sensor (SBE38) is placed closer to the intake to measure the temperature (recorded as temperature 2) before it is warmed by the ship. **Action item: Ensure depth is always logged in this file.** An hourly watch was kept on these data to ensure no loss of data. **Action item: Continue hourly monitoring of underway data while at sea. Check the temperature and salinity data to the CTD casts.**

The calibration file used was the December 2016 calibration. **Action item: Ensure the most recent calibration is used in the field.** Data were logged every 3 seconds.

Preliminary plots of the underway temperature and salinity data are given below

.

Note the NMEA data string logged by the underway temperature and salinity SB21 shows the same GPS roll over error that was present in 2021. This means that the raw data dates start from 19th Nov 2003, rather than 5th July 2023. It is only the date that is in error. The time is correct. The date is corrected in post processing. **Action item: Correct this problem with the GPS**

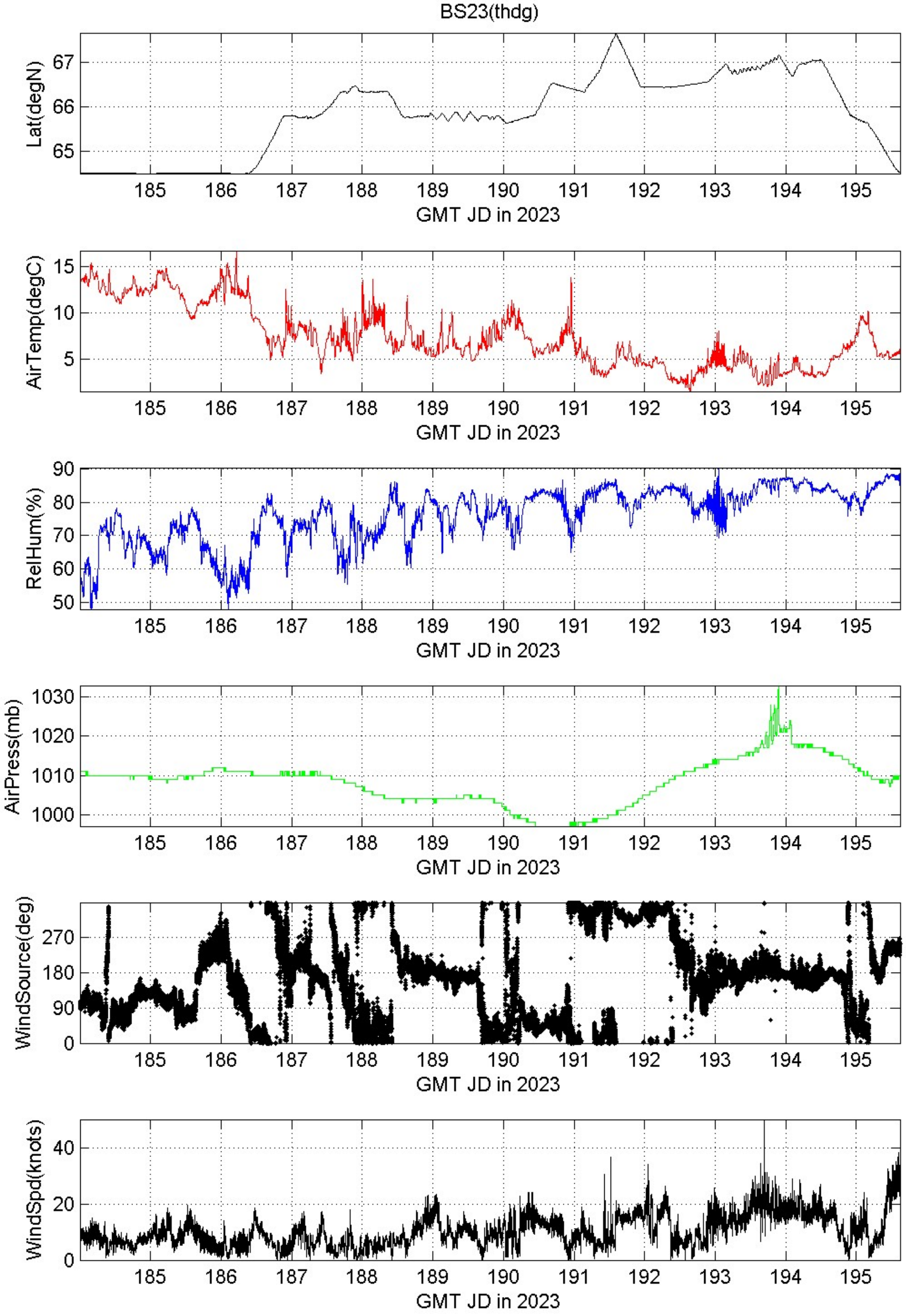
Note also that at the start of the cruise, some valves had been erroneously shut in the underway system resulting in the isolation of the seachest. This was identified by a large divergence of temperature between the intake temperature and the seachest temperature (this difference is ~0.1degC when functioning correctly). This was identified and corrected on 6th July 2023, around 06:16GMT (5th July 2023, around 22:15 local). Prior to this time only intake temperature is meaningful. **Action item: Check delta T at start of cruise**

It is very important to remember when interpreting these data, that they are taken over the many days of the cruise, and the oceanographic conditions change significantly during this time, as is evidenced by the plots of the various crossings of the Bering Strait also shown below. **Action item: Examine surface salinities and temperatures, especially in conjunction with prior data.**

For dates and times, see cruise schedule at start of report.

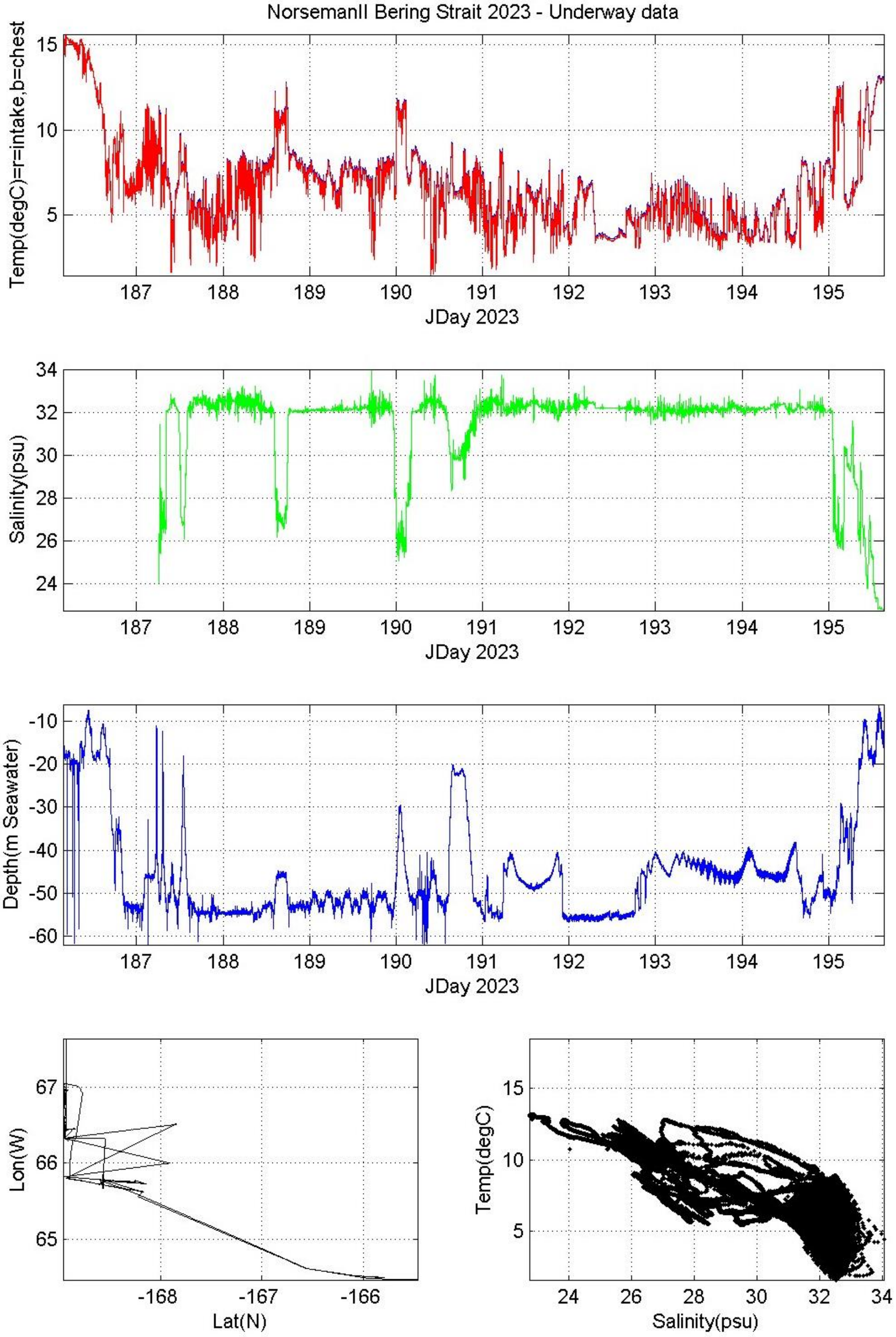
BERING STRAIT 2023 METEOROLOGICAL DATA PLOTS

Stated accuracy of the sensor https://www.airmar.com/weather-description.html?id=153 (0.5m/s for speed; 1.1degC for temperature, 0.5hPa for pressure), but 2021 analysis suggests these accuracies are over optimistic. Note the instrument calculates true wind direction and speed (and this is not reproducible exactly from relative wind and ship heading



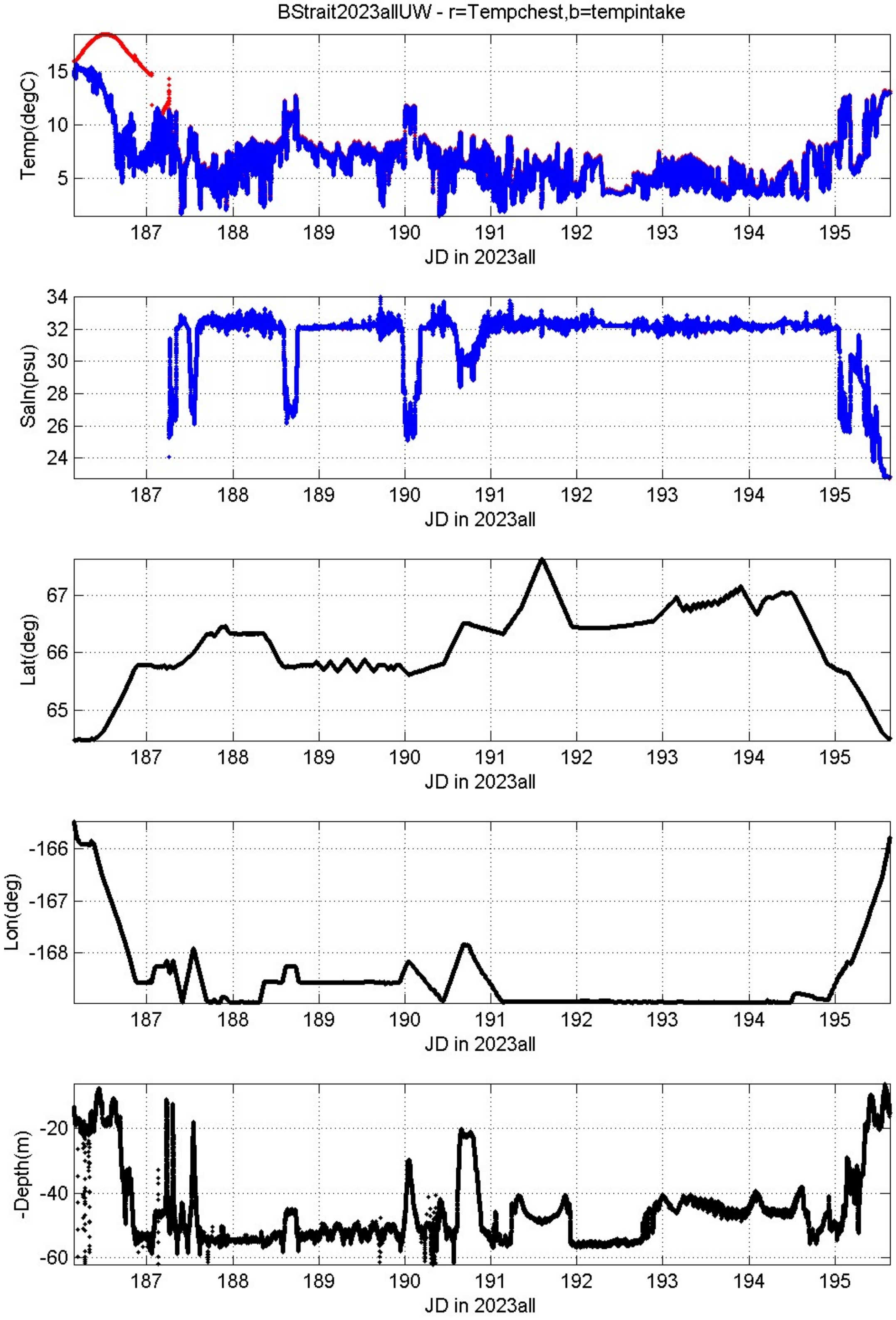
BERING STRAIT 2023 UNDERWAY TEMPERATURE SALINITY DATA

See write up. Salinity data prior to 6th July 0615GMT (5th July 2023, 2215 local) are erroneous and have been excluded from this plot.



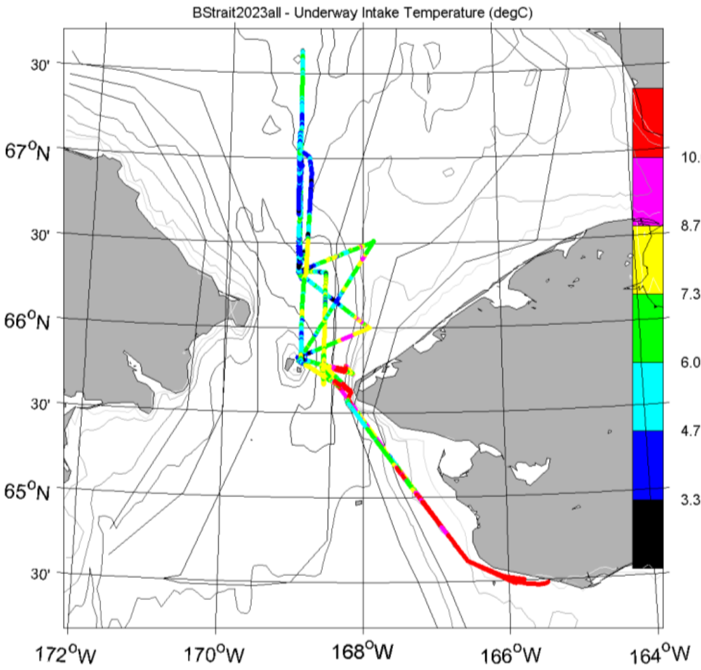
BERING STRAIT 2023 UNDERWAY TEMPERATURE SALINITY DATA (continued)

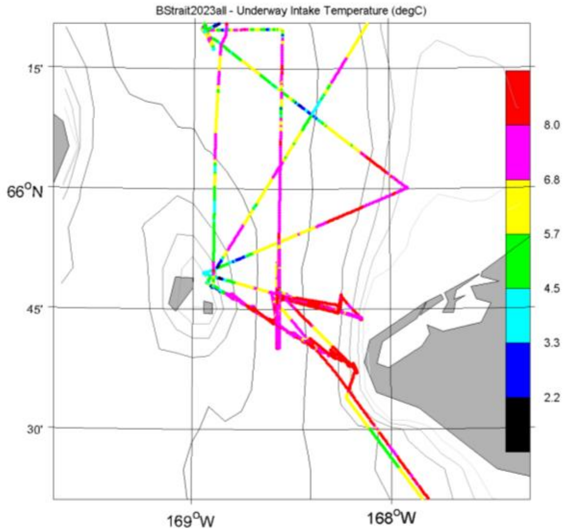
See write up. (Seachest was isolated from intake until 6th July 0615GMT (5th July 2023, 2215 local), hence chest temperature is much higher than intake temperature.

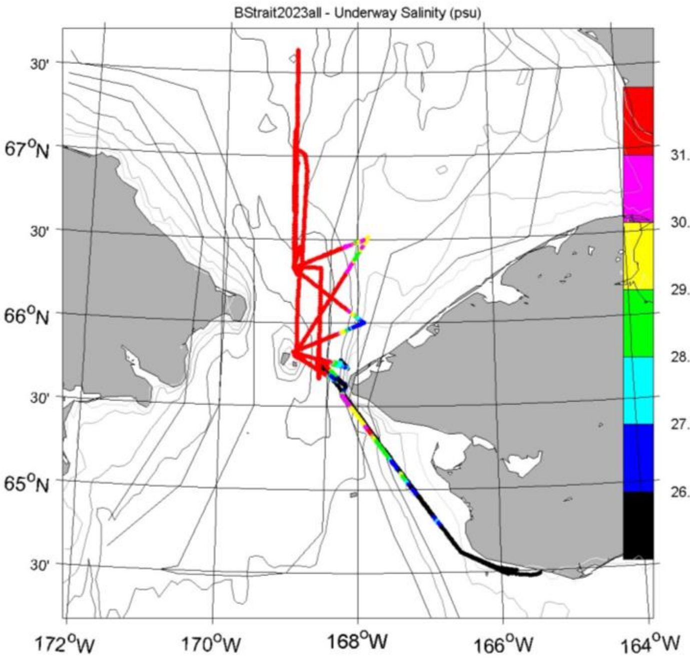


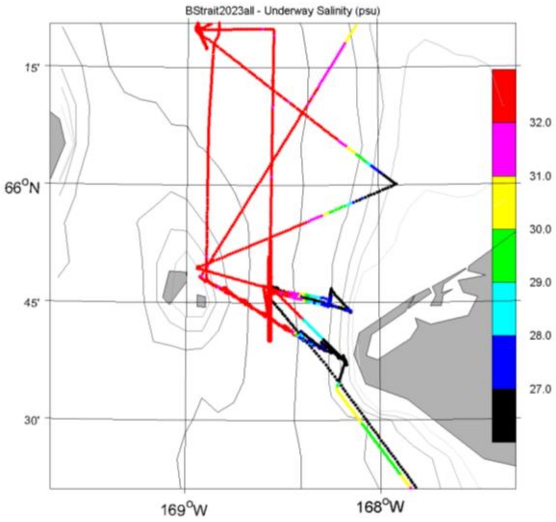
BERING STRAIT 2023 UNDERWAY TEMPERATURE SALINITY DATA (continued)

(Note multiple runnings of the Bering Strait (and other) lines are masked in these plots.)


BStrait2023all - Underway Intake Temperature (degC)


BStrait2023all - Underway Intake Temperature (degC)

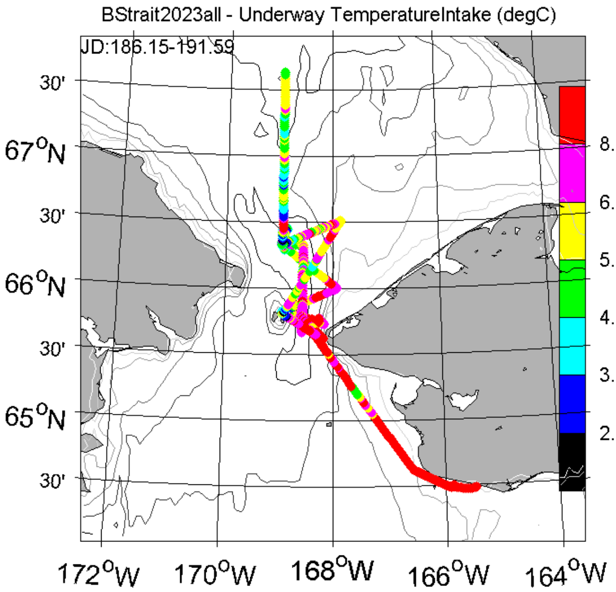

BStrait2023all - Underway Salinity (psu)

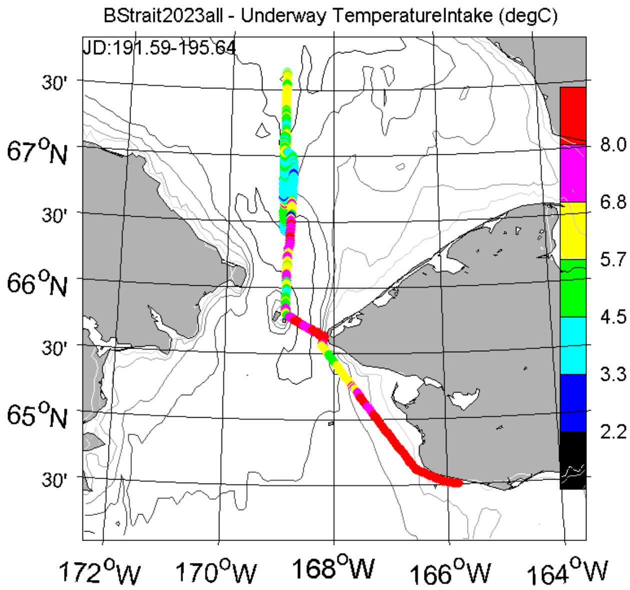

BStrait2023all - Underway Salinity (psu)

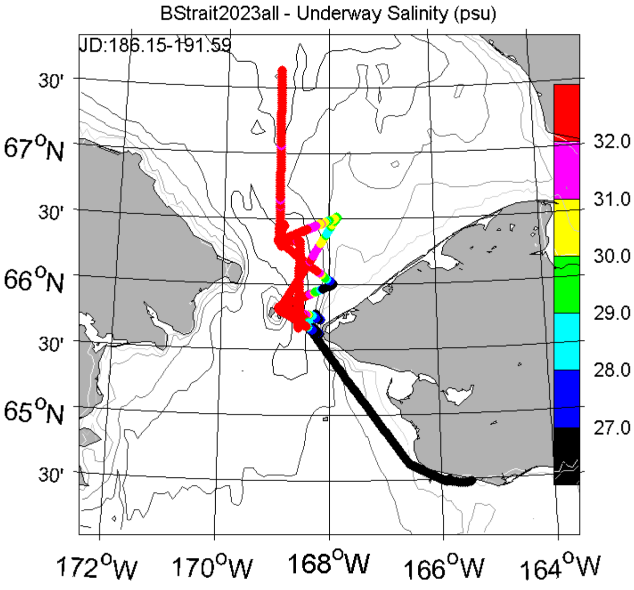
BERING STRAIT 2023 UNDERWAY TEMPERATURE SALINITY DATA (continued)

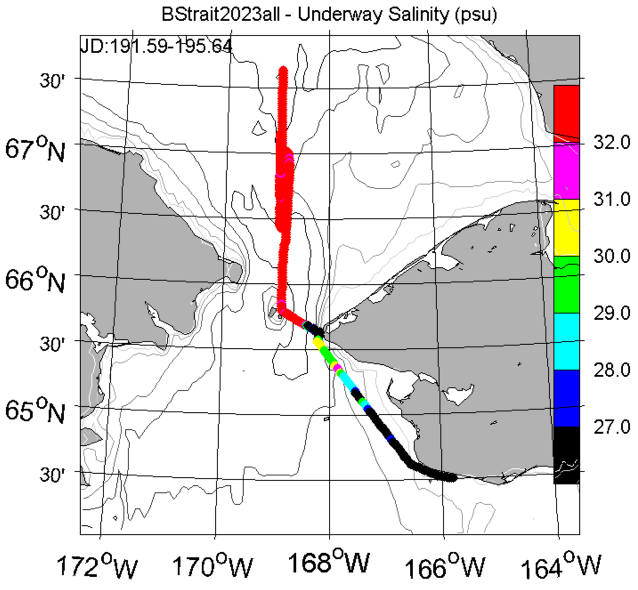
First Half

Second half


BStrait2023all - Underway TemperatureIntake (degC)


BStrait2023all - Underway TemperatureIntake (degC)

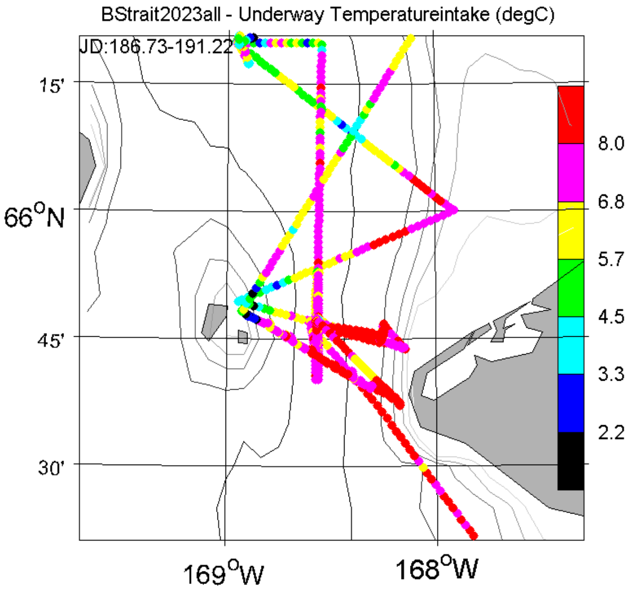

BStrait2023all - Underway Salinity (psu)

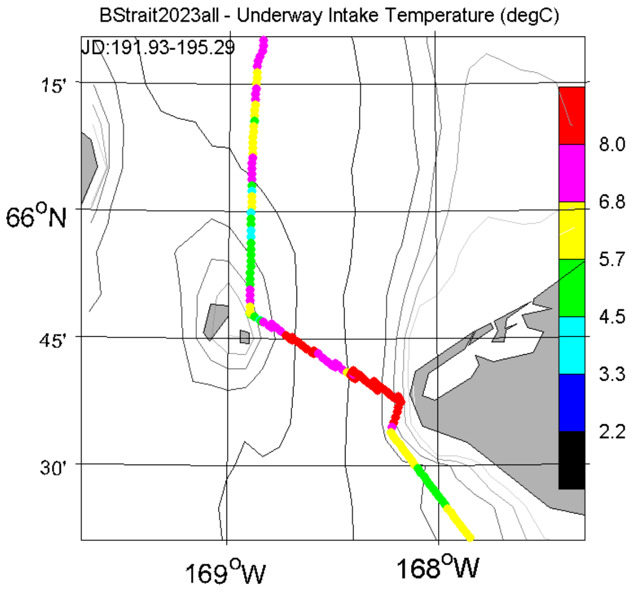

BStrait2023all - Underway Salinity (psu)

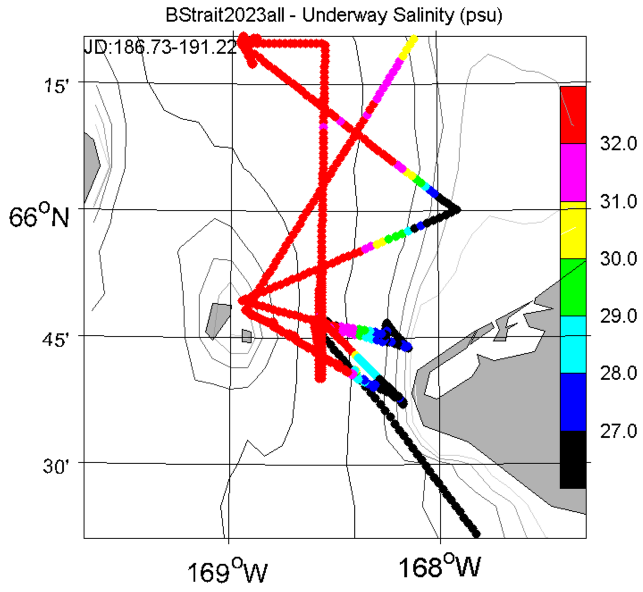
BERING STRAIT 2023 UNDERWAY TEMPERATURE SALINITY DATA (continued)

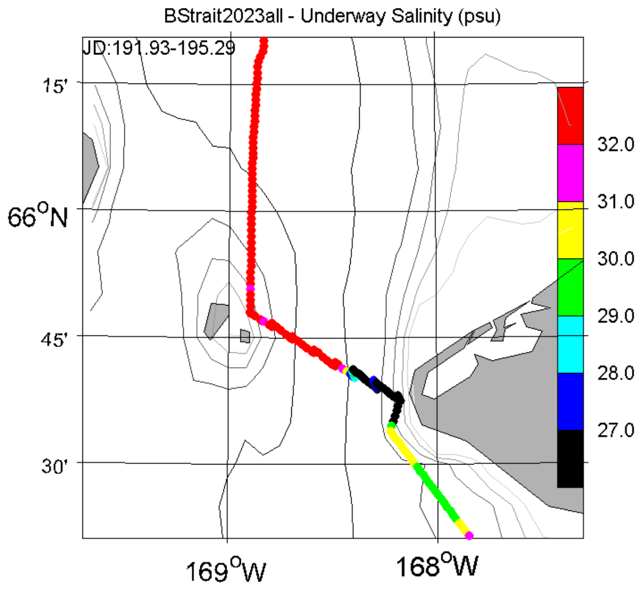
Focus on the strait only

First Half **Second half**









BERING STRAIT 2023 MARINE MAMMAL REPORT –

This year, there was no marine mammal observer on the cruise.   However, breaching whales (at least two, possibly 4), thought to be Humpbacks, were observed in the Bering Strait at 65 44.24F, 168 9.7W at 2130 local, 5th July 2023 (i.e.. 0530GMT 6th July 2023).

BERING STRAIT 2022 TARGET CTD POSITIONS

```
%=============================================================
% Stations for BStrait Mooring Cruise 2023 NorsemanII
%=============================================================
% Vers: 7th June 2023
%
% US-Russian convention line is at 168deg 58.7'W.
% All stations in this file are in US waters.
% (Let me know if any points are too close to border for you.)
%
% Time estimates are based on the 2013 NorsemanII cruise.
%=============================================================
% INCLUDING NEW LINES FROM 2017 CRUISE, viz
% - higher res DL north
% - higher res A3L
% - higher res SBS
% - LIS redone to avoid cable at LIS9
%=============================================================
% *****   MOORING POSITIONS *****
%=============================================================
% In likely order of servicing, i.e.,
% - recoveries from east to west in strait, then northern site;
% - deployments northern site, the west to east in strait.
% == 4 moorings to recover
% == 3 moorings to deploy
%-----------------------------------------
% RECOVERIES of moorings deployed in 2021
%-----------------------------------------
%NAME       Lat(N)        Long (W)      Water   Top
%           deg min        deg min      depth   Float
% A2-21    65  46.849     168  34.089    57m     16m
% this is original position, but it is almost certainly not here
%-----------------------------------------
% RECOVERIES of moorings deployed in 2022
%-----------------------------------------
%NAME       Lat(N)        Long (W)      Water   Top
%           deg min        deg min      depth   Float
% A3-22    66  19.628     168  56.930    58m      8m
% A2-22    65  46.850     168  34.103    56m     16m
% A4-22    65  44.743     168  15.781    49m     16m
%--------------------------------
% DEPLOYMENTS for this 2023 cruise
%--------------------------------
% Target same as 2012 positions.
%NAME      Lat(N)       Long (W)     Water
%         deg min       deg min      depth
% A3-23   66  19.61     168  57.05    58m
% A2-23   65  46.86     168  34.07    56m
% A4-23   65  44.75     168  15.77    49m
```

```
%
%-----------------------
% INTERMOORING DISTANCES
%-----------------------
% A2 - A4 ~ 8nm
%------------
% To A3 from
%------------
%   A2  - 34nm
%   A4  - 39nm
%-------------
% To Nome from
%-------------
%   A4 - 120nm
%   CS1 - 200-220nm
%=========================================================
%
%=========================================================
% *****   HISTORIC CTD SECTIONS *****
%=========================================================
% There are 14 historic CTD lines here.
% These are the same positions as suggested in 2017, with
% the addition of 3 lines run in 2017 and the moving of
% one line (a change also made on the 2017 cruise).
% We may not have time for all of these, in which case
% we will do a subset.  But I've included
% them all, so you have the positions in advance.
% If operations/science dictate, then there
% might be different lines proposed while at sea.
%
% Some lines are given here at a high resolution and low
% resolution.  Time permitting we will run lines at high
% resolution.
%
% Naming is based on historic data.
% "+net" also refers to historic operations and
% is not relevant for this cruise.
% "no bottles" refers to historic operations and
% is not relevant for this cruise.
%
% On this cruise we will take CTD bottles
% a) for nutrients on lines BS, DI and AL lines only, and only on the
% first running.  These stations are marked *NUT22

% b) for salinity on approx 6 stations, to be decided in real time
% c) for delta O18, to be decided in real time

% Additionally, at ~32 stations on the BS, AL, CS and LIS lines,
% after some casts, we will take trace metal samples using the
% hand lowered pumped system. These stations are marked *PUMP22
```

```
% Known Hazards are indicated.
%
% Stay a safe distance (300m?) from all deployed
% moorings.
%
% Except for around moorings or for mooring work,
% within 200m is ok for positions.
%
%
%=================================================================
% BS = Bering Strait Line (US portion)
%=================================================================
% - 15 stations
% - station spacing generally ~ 2nm
% Distances: - BS11-BS22 21.7nm
%            - BS22-BS24  3.1nm
% Total length 24.8nm
%--
% Time from NorsemanII, 6 hrs running W, 5 hrs running E
% Time from Khromov 10.5hrs
%-------------------------------------------------
% Lat (N) Long (W)   Lat (N)     Long (W)    Name
%                 deg min     deg   min
%-------------------------------------------------
% LOW RESOLUTION VERSION
%-------------------------------------------------
  65.805  168.933   65  48.31   168  55.96  % BS11
  65.788  168.860   65  47.26   168  51.62  % BS12
  65.772  168.794   65  46.33   168  47.64  % BS13
  65.755  168.721   65  45.28   168  43.29  % BS14
  65.739  168.663   65  44.35   168  39.80  % BS15
  65.722  168.591   65  43.29   168  35.46  % BS16 + net
  65.704  168.521   65  42.23   168  31.28  % BS17
  65.695  168.486   65  41.70   168  29.16  % BS17S
  65.686  168.449   65  41.18   168  26.94  % BS18
  65.672  168.391   65  40.35   168  23.44  % BS19
  65.655  168.318   65  39.29   168  19.09  % BS20
  65.642  168.250   65  38.53   168  14.97  % BS21
  65.625  168.177   65  37.48   168  10.63  % BS22 + net
  65.599  168.161   65  35.96   168   9.66  % BS23
  65.582  168.117   65  34.91   168   7.00  % BS24
%-------------------------------------------------
% HIGH RESOLUTION VERSION (with nutrient sampling plan)
%-------------------------------------------------
%65.805          168.933          65        48.31     168       55.96     %         BS11
65.797  168.897          65        47.79     168       53.79     %         BS11.5 *NUT22 *PUMP22
65.788  168.86  65       47.26     168       51.62     %         BS12
65.780  168.827          65        46.8      168       49.63     %         BS12.5
65.772  168.794          65        46.33     168       47.64     %         BS13      *NUT22 *PUMP22
```

```
65.764  168.758         65      45.81   168     45.47   %       BS13.5
65.755  168.721         65      45.28   168     43.29   %       BS14
65.747  168.692         65      44.82   168     41.55   %       BS14.5 *NUT22 *PUMP22
65.739  168.663         65      44.35   168     39.8    %       BS15
65.731  168.627         65      43.82   168     37.63   %       BS15.5
65.722  168.591         65      43.29   168     35.46   %       BS16      *NUT22 *PUMP22
65.713  168.556         65      42.76   168     33.37   %       BS16.5
65.704  168.521         65      42.23   168     31.28   %       BS17
65.695  168.486         65      41.7    168     29.16   %       BS17.5 *NUT22 *PUMP22
65.686  168.449         65      41.18   168     26.94   %       BS18
65.679  168.42  65      40.77   168     25.19   %       BS18.5
65.672  168.391         65      40.35   168     23.44   %       BS19      *NUT22 *PUMP22
65.664  168.355         65      39.82   168     21.27   %       BS19.5
65.655  168.318         65      39.29   168     19.09   %       BS20
65.649  168.284         65      38.91   168     17.03   %       BS20.5 *NUT22 *PUMP22
65.642  168.25  65      38.53   168     14.97   %       BS21
65.634  168.214         65      38.01   168     12.8    %       BS21.5
65.625  168.177         65      37.48   168     10.63   %       BS22      *NUT22 *PUMP22
65.599  168.161         65      35.96   168     9.66    %       BS23
65.582  168.117         65      34.91   168     7       %       BS24
%
%
%==================================================================
% DL = Diomede Line (US only, 1nm east of border)
%==================================================================
% This line is to map eddying area north of the Diomedes
% - 19 stations
% - station spacing ~ 1nm in South,
%                ~ 2.5nm in north
% Distance: - DL1 to DL19  28.7nm
%--
% Time from NorsemanII - 5.5 hrs running N; 9hrs running S
% Time from Khromov to DL19 ~10hrs
%--------------------------------------------------
%    Lat (N)     Long (W)     Name
%    deg min      deg   min
%--------------------------------------------------
% LOW RESOLUTION VERSION
%--------------------------------------------------
0 0  65   49.28   168   56.2  % DL1  *NUT22
0 0  65   50.26   168   56.2  % DL2
0 0  65   51.23   168   56.2  % DL3
0 0  65   52.21   168   56.2  % DL4  *NUT22 + net
0 0  65   53.18   168   56.2  % DL5 - no bottles
0 0  65   54.15   168   56.2  % DL6
0 0  65   55.13   168   56.2  % DL7  *NUT22 - no bottles
0 0  65   56.10   168   56.2  % DL8
0 0  65   57.08   168   56.2  % DL9 - no bottles
0 0  65   58.05   168   56.2  % DL10 *NUT22
0 0  65   59.03   168   56.2  % DL11- no bottles
```

```
0 0  66   0.00   168  56.2  % DL12
%-----
0 0  66   2.55   168  56.2  % DL13- no bottles
0 0  66   5.10   168  56.2  % DL14
0 0  66   7.65   168  56.2  % DL15- no bottles
0 0  66  10.19   168  56.2  % DL16
0 0  66  12.74   168  56.2  % DL17- no bottles
0 0  66  15.29   168  56.2  % DL18
0 0  66  17.84   168  56.2  % DL19- no bottles
%-------------------------------------------------
% HIGH RESOLUTION VERSION (with nutrient sampling plan)
%-------------------------------------------------
0 0  65  49.28   168  56.2  % DL1  *NUT22
0 0  65  50.26   168  56.2  % DL2
0 0  65  51.23   168  56.2  % DL3
0 0  65  52.21   168  56.2  % DL4  *NUT22 + net
0 0  65  53.18   168  56.2  % DL5 - no bottles
0 0  65  54.15   168  56.2  % DL6
0 0  65  55.13   168  56.2  % DL7  *NUT22 - no bottles
0 0  65  56.10   168  56.2  % DL8
0 0  65  57.08   168  56.2  % DL9 - no bottles
0 0  65  58.05   168  56.2  % DL10 *NUT22
0 0  65  59.03   168  56.2  % DL11- no bottles
0 0  66   0.00   168  56.2  % DL12
%--
0 0  66   1.28   168  56.2  % DL12.5  *NUT22
0 0  66   2.55   168  56.2  % DL13
0 0  66   3.83   168  56.2  % DL13.5
0 0  66   5.10   168  56.2  % DL14    *NUT22
0 0  66   6.38   168  56.2  % DL14.5
0 0  66   7.65   168  56.2  % DL15
0 0  66   8.92   168  56.2  % DL15.5  *NUT22
0 0  66  10.19   168  56.2  % DL16
0 0  66  11.47   168  56.2  % DL16.5
0 0  66  12.74   168  56.2  % DL17    *NUT22
0 0  66  14.02   168  56.2  % DL17.5
0 0  66  15.29   168  56.2  % DL18
0 0  66  16.57   168  56.2  % DL18.5  *NUT22
0 0  66  17.84   168  56.2  % DL19
0 0  66  18.73   168  56.2  % DL19.5
% Ending at A3
 0 0  66  19.61   168  57.05  % A3mooring  *NUT22
% *** Adjust this first position to be safe distance (300m?) from A3 mooring
%
%
%=================================================================
% DL A and B lines (Diomede A and B lines)
%=================================================================
% These lines, with DL, form a grid to map
% eddying N of the Diomedes.
```

```
% - each line 12 stations
% - station spacing ~ 1nm
% Distances: - each line ~ 11nm
%--
% Estimate for NorsmanII for each line ~3.5hrs
% Time from Khromov for each line ~5hrs
%----------------------------------------
%    Lat (N)      Long (W)     Name
%    deg min       deg   min
% Northbound leg
0 0   65   49.30    168   52.2  % DLa 1
0 0   65   50.27    168   52.2  % DLa 2
0 0   65   51.25    168   52.2  % DLa 3
0 0   65   52.22    168   52.2  % DLa 4
0 0   65   53.19    168   52.2  % DLa 5
0 0   65   54.16    168   52.2  % DLa 6
0 0   65   55.14    168   52.2  % DLa 7
0 0   65   56.11    168   52.2  % DLa 8
0 0   65   57.08    168   52.2  % DLa 9
0 0   65   58.05    168   52.2  % DLa 10
0 0   65   59.03    168   52.2  % DLa 11
0 0   66    0.00   168   52.2  % DLa 12
% Southbound leg
0 0   66    0.00   168   48.2  % DLb 12
0 0   65   59.03    168   48.2  % DLb 11
0 0   65   58.05    168   48.2  % DLb 10
0 0   65   57.08    168   48.2  % DLb 9
0 0   65   56.11    168   48.2  % DLb 8
0 0   65   55.14    168   48.2  % DLb 7
0 0   65   54.16    168   48.2  % DLb 6
0 0   65   53.19    168   48.2  % DLb 5
0 0   65   52.22    168   48.2  % DLb 4
0 0   65   51.25    168   48.2  % DLb 3
0 0   65   50.27    168   48.2  % DLb 2
0 0   65   49.30    168   48.2  % DLb 1
%
%
%==============================================================
% AL = A3 Line (US portion)
%==============================================================
% Hazards on this line:
% == First station on this line is at mooring A3-17, so exact
% position needs to be altered to be a safe distance (300m?)
% from mooring A3-17 site.
%----------------------------------------------------
% - 13 stations including cast at A3mooring site
% - station spacing ~ 1.9nm
% Distance: - A3 to AL24 = 22.2nm
% --
% Time from NorsemanII ~5.5hrs
```

```
% Time from Khromov ~9hrs
%----------------------------------------------------
% Lat (N) Long (W)   Lat (N)      Long (W)     Name
%                 deg min      deg   min
%-------------------------------------------------
% LOW RESOLUTION VERSION
%-------------------------------------------------
  66.327  168.951   66  19.61    168   57.05  % A3-17
% *** Adjust this first position to be safe distance (300m?) from A3-17
  66.340  168.895   66  20.39    168   53.71  % AL13
  66.352  168.823   66  21.09    168   49.40  % AL14
  66.363  168.752   66  21.80    168   45.09  % AL15
  66.375  168.680   66  22.51    168   40.78  % AL16
  66.387  168.608   66  23.21    168   36.47  % AL17 + net
  66.399  168.536   66  23.92    168   32.16  % AL18
  66.410  168.464   66  24.63    168   27.84  % AL19
  66.422  168.392   66  25.33    168   23.53  % AL20
  66.434  168.320   66  26.04    168   19.22  % AL21
  66.446  168.249   66  26.75    168   14.91  % AL22 + net
  66.458  168.177   66  27.45    168   10.60  % AL23
  66.469  168.105   66  28.16    168    6.29  % AL24
%-------------------------------------------------
% HIGH RESOLUTION VERSION (with nutrient sampling plan)
%-------------------------------------------------
  66.3270  168.9510   66   19.6100  168   57.0500    % A3 mooring
% *** Adjust this first position to be safe distance (300) from A3 mooring
  66.3335  168.9230   66   20.0000  168   55.3800    % new AL12.5  *NUT22 *PUMP22
  66.3400  168.8950   66   20.3900  168   53.7100    % AL13
  66.3460  168.8590   66   20.7400  168   51.5550    % new AL13.5
  66.3520  168.8230   66   21.0900  168   49.4000    % AL14        *NUT22 *PUMP22
  66.3575  168.7875   66   21.4450  168   47.2450    % new AL14.5
  66.3630  168.7520   66   21.8000  168   45.0900    % AL15
  66.3690  168.7160   66   22.1550  168   42.9350    % new AL15.5  *NUT22 *PUMP22
  66.3750  168.6800   66   22.5100  168   40.7800    % AL16
  66.3810  168.6440   66   22.8600  168   38.6250    % new AL16.5
  66.3870  168.6080   66   23.2100  168   36.4700    % AL17        *NUT22 *PUMP22
  66.3940  168.5657   66   23.6400  168   33.9400    % new AL17.5  % AND MOVED OFF Q CABLE
  66.3990  168.5360   66   23.9200  168   32.1600    % AL18
  66.4045  168.5000   66   24.2750  168   30.0000    % new AL18.5  *NUT22 *PUMP22
  66.4100  168.4640   66   24.6300  168   27.8400    % AL19
  66.4160  168.4280   66   24.9800  168   25.6850    % new AL19.5
  66.4220  168.3920   66   25.3300  168   23.5300    % AL20        *NUT22 *PUMP22
  66.4280  168.3560   66   25.6850  168   21.3750    % new AL20.5
  66.4340  168.3200   66   26.0400  168   19.2200    % AL21
  66.4400  168.2845   66   26.3950  168   17.0650    % new AL21.5  *NUT22 *PUMP22
  66.4460  168.2490   66   26.7500  168   14.9100    % AL22
  66.4520  168.2130   66   27.1000  168   12.7550    % new AL22.5
  66.4580  168.1770   66   27.4500  168   10.6000    % AL23        *NUT22 *PUMP22
  66.4635  168.1410   66   27.8050  168    8.4450   % new AL23.5
  66.4690  168.1050   66   28.1600  168    6.2900   % AL24
```

```
  66.4745  168.0690  66  28.5150  168   4.1350   % new AL24.5
  66.4800  168.0330  66  28.8700  168   1.9800   % AL25       *NUT22 *PUMP22
  66.4855  167.9970  66  29.2250  167  59.8200   % new AL25.5
  66.4910  167.9610  66  29.5800  167  57.6650   % AL26
  66.4965  167.9250  66  29.9350  167  55.5100   % new AL26.5
  66.5020  167.8890  66  30.2900  167  53.3550   % AL27
  66.5075  167.8530  66  30.6450  167  51.2000   % new AL27.5
%
%
%=================================================================
% AS = from AL to CS Line
%=================================================================
% Across-topography line linking Al line with CS
% - 20 stations (counting first of CS line)
% - station spacing
%      AS1-7 at ~ 4nm spacing.
%      AS7-14 at 2nm spacing,
%      A14 to end 4nm
% Distances: - AS1 to CS10 64.7nm
%--
% Time from Khromov (12casts, odds+2&18) ~11hrs
% Estimate for NorsmanII 20 casts ~ 12hrs
% Estimate for Khromov 20 casts ~ 14hrs
%-------------------------------------------
%    Lat (N)       Long (W)      Name
%    deg min        deg   min
0 0   66   41.47    167   38.86   % AS 1
0 0   66   45.01    167   43.78   % AS 2-no bottles
0 0   66   48.55    167   48.70   % AS 3
0 0   66   52.09    167   53.62   % AS 4-no bottles
0 0   66   55.63    167   58.55   % AS 5
0 0   66   59.17    168    3.47   % AS 6-no bottles
0 0   67    2.71    168    8.39   % AS 7
%                  (2nm spacing over slope)
0 0   67    4.48    168   10.85   % AS 8-no bottles
0 0   67    6.25    168   13.31   % AS 9
0 0   67    8.02    168   15.77   % AS 10-no bottles
0 0   67    9.78    168   18.23   % AS 11
0 0   67   11.55    168   20.69   % AS 12-no bottles
0 0   67   13.32    168   23.15   % AS 13
0 0   67   16.86    168   28.07   % AS 14
%                  (back to 4nm spacing)
0 0   67   20.40    168   32.99   % AS 15-no bottles
0 0   67   23.94    168   37.92   % AS 16
0 0   67   27.48    168   42.84   % AS 17-no bottles
0 0   67   31.02    168   47.76   % AS 18
0 0   67   34.56    168   52.68   % AS 19-no bottles
0 0   67   38.10    168   56.00   % CS10US
%
%
```

```
%=================================================================
% SAS = S extension of AS line
%=================================================================
% Adding another 8 stations at 4nm spacing south
% from AS1 to the coast.
%--
% Estimate for NorsemanII 8 casts ~ 4hrs
% Not run yet
%-------------------------------------------
%    Lat (N)       Long (W)      Name
%    deg min       deg   min
0 0   66   37.91    167   34.00   % SAS 1
0 0   66   34.35    167   29.14   % SAS 2
0 0   66   30.79    167   24.29   % SAS 3
0 0   66   27.23    167   19.43   % SAS 4
0 0   66   23.68    167   14.57   % SAS 5
0 0   66   20.12    167    9.72   % SAS 6
0 0   66   16.56    167    4.86   % SAS 7
0 0   66   13.00    167    0.00   % SAS 8
%
%
%=================================================================
% CS = Cape Serdtse Kamen to Point Hope Line (US portion)
%=================================================================
% Hazards on this line:
% == Final station CS19 is shallow.  Check on
% modern charts to see if deep enough for NorsemanII.
% (this station was too shallow for the Khromov, but
% was ok for the NorsemanII in 2013).
% == NOAA mooring at:
%         67 54.712N, 168 11.628W
%---------------------------------------------------------
% - 16 or 17 stations
% - station spacing ~ 5nm in the central Chukchi,
%                 ~ 2.2nm near the coast
% Distances: - CS10US to CS18 60.8nm
%          - CS18 to CS19    2.2nm
%--
% Time from NorsemanII (toCS19) ~ 10.5 hrs
% Time from Khromov (toCS18) ~12hrs
%---------------------------------------------------------
%    Lat (N)    Long (W)      Name
%    deg min    deg   min
%------------------------------------------------
% LOW RESOLUTION VERSION
%------------------------------------------------
0 0   67   38.1   168   56.0    % CS10US + net
0 0   67   41.7   168   48.1    % CS10.5  - no bottles
0 0   67   45.3   168   39.9    % CS11
0 0   67   48.9   168   29.4    % CS11.5  - no bottles
```

```
0 0   67   52.5   168   18.8    % CS12 + net
0 0   67   55.9   168    9.1    % CS12.5  - no bottles
0 0   67   59.3   167   59.4    % CS13
0 0   68    2.7   167   49.7    % CS13.5  - no bottles
0 0   68    6.1   167   39.9    % CS14 + net
0 0   68    9.1   167   30.7    % CS14.5  - no bottles
0 0   68   12.1   167   21.4    % CS15
0 0   68   13.6   167   16.8    % CS15.5  - no bottles
0 0   68   15.0   167   12.2    % CS16
0 0   68   16.6   167    7.6    % CS16.5  - no bottles
0 0   68   18.0   167    2.9    % CS17 + net
0 0   68   18.9   166   57.6    % CS18
0 0   68   19.9   166   52.3    % CS19 *** SHALLOW **
%             CS19 too shallow for Khromov.
%-----------------------------------------------
% HIGH RESOLUTION VERSION (with nutrient sampling plan)
%-----------------------------------------------
% - 27 stations
% - station spacing ~ 2.5nm in the central Chukch (0.25 stations)
%               ~ 2.2nm near the coast
% Distances: - CS10US to CS18 60.8nm
%         - CS18 to CS19    2.2nm
% Time from NorsemanII (toCS19) ~ 11hrs
%------------------------------------------------------
%    Lat (N)    Long (W)      Name
%    deg min     deg   min
0 0   67   38.1   168   56.0    % CS10US + net *PUMP22
0 0   67   39.9   168   52.0  % new CS10.25
0 0   67   41.7   168   48.1    % CS10.5  - no bottles
0 0   67   43.5   168   44.0  % new CS10.75
0 0   67   45.3   168   39.9    % CS11        *PUMP22
0 0   67   47.1   168   34.6  % new CS11.25
0 0   67   48.9   168   29.4    % CS11.5  - no bottles
0 0   67   50.7   168   24.1  % new CS11.75
0 0   67   52.5   168   18.8    % CS12 + net   *PUMP22
0 0   67   54.2   168   13.9  % new CS12.25
0 0   67   55.9   168    9.1    % CS12.5  - no bottles
0 0   67   57.6   168    4.2  % new CS12.75
0 0   67   59.3   167   59.4    % CS13        *PUMP22
0 0   68    1.0   167   54.5  % new CS13.25
0 0   68    2.7   167   49.7    % CS13.5  - no bottles
0 0   68    4.4   167   44.8  % new CS13.75
0 0   68    6.1   167   39.9    % CS14 + net   *PUMP22
0 0   68    7.6   167   35.3  % new CS14.25
0 0   68    9.1   167   30.7    % CS14.5  - no bottles
0 0   68   10.6   167   26.0  % new CS14.75
0 0   68   12.1   167   21.4    % CS15        *PUMP22
0 0   68   13.6   167   16.8    % CS15.5  - no bottles
0 0   68   15.0   167   12.2    % CS16        *PUMP22
0 0   68   16.6   167    7.6    % CS16.5  - no bottles
```

```
0 0   68   18.0   167    2.9    % CS17 + net   *PUMP22
0 0   68   18.9   166   57.6    % CS18
0 0   68   19.9   166   52.3    % CS19 *** SHALLOW ** %
%
%
%=====================================================================
% LIS = Cape Lisburne Line (redone to avoid Qcable at Lis9)
%=====================================================================
% - 18 stations (including first of CCL line)
% - station spacing ~ 2nm near coast,
%            ~ 3nm and ~ 5nm away from coast
% Distances: - LIS1 to CCL22 57.2nm
%--
% Time from NorsemanII, ~ 10hrs
% Time from Khromov ~11hrs
% (Times different now added stations)
%-------------------------------
%    Lat (N)       Long (W)     Name
%    deg min       deg   min
   0    0        68   54.40    166   19.80  % LIS 1 + net *PUMP22
   0    0        68   54.80    166   25.15  % LIS 2       *PUMP22
   0    0        68   55.20    166   30.51  % LIS 3       *PUMP22
   0    0        68   55.80    166   38.54  % LIS 4
   0    0        68   56.40    166   46.57  % LIS 5
   0    0        68   57.00    166   54.60  % LIS 6 + net
   0    0        68   57.60    167    1.95  % LIS 6.5 - no bottles *PUMP22
   0    0        68   58.20    167    9.30  % LIS 7
   0    0        68   58.80    167   16.65  % LIS 7.5 - no bottles
   0    0        68   59.40    167   24.00  % LIS 8       *PUMP22
   0    0        69   00.20    167   33.8   % NEW ** LIS 8.5
%DO NOT DO LIS 9
% 69    0.60    167   38.70  % LIS 9  ** on Q cable - do not do
%DO NOT DO LIS 9
   0    0        69    1.00    167   43.60  % NEW ** LIS 9.5
   0    0        69    1.80    167   53.40  % LIS 10 + net
   0    0        69    1.35    168    7.95  % LIS 11      *PUMP22
   0    0        69    0.90    168   22.50  % LIS 12
   0    0        69    0.45    168   37.05  % LIS 13      *PUMP22
   0    0        69    0.23    168   46.62  % LIS 14n + net
   0    0        69    0.00    168   56.00  % CCL22n % was 56.2  *PUMP22
%
%
%=====================================================================
% CCL = Chukchi Convention Line
%=====================================================================
% Hazards on this line:
% == First station on this line is the same as last station
% included in the LIS line above.  It does not need to be
% repeated.
% == Last station on this line is at mooring A3-14, so exact
```

```
% position needs to be altered to be a safe distance (300m?)
% from mooring A3-14 site.
% == There are 2 JAMSTEC moorings ~ 3nm east of station
% CCL16 on this line.  Those positions are:
% SCH13  68 2.002N   168 50.028W
% SCH13w 68 3.006N   168 50.003W
%--------------------------------------
% Line running from northern most point
% due south, ~ 1nm US side of conventionline
% - 20 stations (counting arriving at A3-14)
% - station spacing ~ 10nm until CCL8,
%     then reducing to ~5nm and ~2.5nm
% Distances: - CCL22 to A3-13 ~ 161nm
%--
% Time from NorsemanII, 21.5hrs
% Time from Khromov ~26hrs
%----------------------------------------
% MAIN LINE STARTS IN N WITH THESE
%----------------------------------------
%     Lat (N)      Long (W)     Name
%     deg   min     deg   min
0 0    69     0.0     168  56.0   % CCL22
0 0    68    50.0     168  56.0   % CCL21
0 0    68    40.0     168  56.0   % CCL20
0 0    68    30.0     168  56.0   % CCL19
0 0    68    20.0     168  56.0   % CCL18 + Net
0 0    68    10.0     168  56.0   % CCL17
0 0    68    00.0     168  56.0   % CCL16
0 0    67    50.0     168  56.0   % CCL15
0 0    67    38.1     168  56.0   % CCL14 (same as CS10US) + Net + Prod
%-------------------------------------------------
% THEN EITHER - LOW RESOLUTION VERSION
%-------------------------------------------------
0 0    67    30.0     168  56.0   % CCL13
0 0    67    20.0     168  56.0   % CCL12
0 0    67    10.0     168  56.0   % CCL11
0 0    67    00.0     168  56.0   % CCL10 + Net
0 0    66    50.0     168  56.0   % CCL9
0 0    66    40.0     168  56.0   % CCL8
%        - spacing now 5nm
0 0    66    35.0     168  56.0   % CCL7
0 0    66    30.0     168  56.0   % CCL6
0 0    66    25.0     168  56.0   % CCL5
%        - spacing now 2.5nm
0 0    66    22.3     168  56.0   % CCL4
0 0    66    19.61    168  57.05  % A3-17
% *** Adjust this position to be safe distance (300m?) from A3-17
%-------------------------------------------------
%  - OR HIGH RESOLUTION VERSION
% (halves from 8.5 to 13.5 are new)                    73nm ..
```

```
%-------------------------------------------------
0 0   67   35.0    168  56.0   % CCL13.5
0 0   67   30.0    168  56.0   % CCL13
0 0   67   25.0    168  56.0   % CCL12.5
0 0   67   20.0    168  56.0   % CCL12
0 0   67   15.0    168  56.0   % CCL11.5
0 0   67   10.0    168  56.0   % CCL11
0 0   67   05.0    168  56.0   % CCL10.5
0 0   67   00.0    168  56.0   % CCL10 + Net
0 0   66   55.0    168  56.0   % CCL9.5
0 0   66   50.0    168  56.0   % CCL9
0 0   66   45.0    168  56.0   % CCL8.5
0 0   66   40.0    168  56.0   % CCL8
%        - spacing now 5nm
0 0   66   35.0    168  56.0   % CCL7
0 0   66   30.0    168  56.0   % CCL6
0 0   66   25.0    168  56.0   % CCL5
%        - spacing now 2.5nm
0 0   66   22.3    168  56.0   % CCL4
0 0   66   19.61    168  57.05  % A3-17
% *** Adjust this position to be safe distance (300m?) from A3-17
%
%
%===============================================================
% MBSn = Mid Bering Strait line
%===============================================================
% Just north of the Bering Strait line
% - 14 stations
% - station spacing 1.7nm, less near coast
% Distance: - 21.0nm total
%--
% Time from Helix (8casts only) ~2.5hrs
% - Estimate NorsemanII (8 casts only) ~ 4hrs
% - Estimate NorsemanII (14 casts)  ~ 6hrs
% - Estimate Khromov (8casts only)~5.5hrs
% - Estimate Khromov (14casts) ~7hrs
%--------------------------------------
%     Lat (N)       Long (W)     Name
%     deg   min      deg   min
0 0   65   52.1    168  56.0   % MBSn1 % was 57.0
0 0   65   52.0    168  52.5   % MBSn1.5
0 0   65   51.9    168  49.1   % MBSn2
0 0   65   51.8    168  45.0   % MBSn2.5
0 0   65   51.7    168  40.9   % MBSn3
0 0   65   51.6    168  36.4   % MBSn3.5
0 0   65   51.5    168  31.9   % MBSn4 % was 51.6
0 0   65   51.4    168  27.5   % MBSn4.5
0 0   65   51.3    168  23.0   % MBSn5 % was 51.4
0 0   65   51.2    168  18.5   % MBSn5.5
0 0   65   51.1    168  13.9   % MBSn6
```

```
0 0    65    51.1    168  10.4   % MBSn6.5
0 0    65    51.0    168   6.9   % MBSn7
0 0    65    50.9    168   5.0   % MBSn8
%
%
%==============================================================
% NBS - North Bering Strait line
%==============================================================
% Hazards on this line:
% == Section crosses shallow waters.
% Beware of shallows from NBS9 and eastwards.
% (Helix diverted N to avoid shallows between
% stations NBS10 and NBS11)
% == Consider terminating line at NBS9
%----------------------------------------
% Another cross strait line, run previously
% at lower resolution (i.e. without the 0.5 stations).
% - stations 9 (NBS1-9) to 16 (NBS1-9 with 0.5s)
%    to 21 (full section, including shallows).
% - station spacing (with 0.5s) ~ 1.7nm
% Distance: - NBS1-9  25.8nm
%           - NBS1-14 44.1nm
%--
% Time from Helix to NBS9, 9 casts ~5.5hrs
% - Estimate for NorsemanII to NBS9, 9 casts, 6hrs
% - Estimate for NorsemanII to NBS9, 16 casts, 7.5hrs
% - Estimate Khromov to NBS9, 9 casts ~6.5hrs
% - Estimate Khromo to NBS9, 16 casts ~8hrs
% Time from Helix to NBS14, 14 casts ~8.5hrs
% - Estimate for NorsemanII to NBS14, 14 casts, 9hrs
% - Esimate for NorsemanII to NSB14, 21 casts, 10.5hrs
% - Estimate Khromov to NBS14, 14 casts ~10hrs
% - Estimate Khromov to NBS14, 21 casts ~13hrs
%------------------------------------------
%      Lat (N)       Long (W)     Name
%      deg   min      deg   min
0 0    66     0.0    168  56.0   % NBS1 % was 58.1
0 0    66     0.0    168  53.0   % NBS1.5
0 0    66     0.0    168  49.9   % NBS2
0 0    66     0.0    168  45.8   % NBS2.5
0 0    66     0.0    168  41.6   % NBS3
0 0    66     0.0    168  37.4   % NBS3.5
0 0    66     0.0    168  33.2   % NBS4
0 0    66     0.0    168  29.1   % NBS4.5
0 0    66     0.0    168  25.0   % NBS5
0 0    66     0.0    168  20.7   % NBS5.5
0 0    66     0.0    168  16.4   % NBS6
0 0    66     0.0    168  12.4   % NBS6.5
0 0    66     0.0    168   8.4  % NBS7
0 0    66     0.0    168   4.2  % NBS7.5
```

```
0 0    66     0.0     168   0.0   % NBS8 - 34m water
0 0    66     0.0     167  55.1   % NBS9 - 20m water
%  (consider terminating line here)
0 0    66     0.0     167  52.0   % NBS10 - 12m water
% (Helix diverted N to avoid shallows between these stations)
0 0    66     0.0     167  40.1   % NBS11 - 15m water
0 0    66     0.0     167  29.1   % NBS12 - 18m water
0 0    66     0.0     167  18.1   % NBS13 - 13m water
0 0    66     0.0     167  10.2   % NBS14 - 10m water
%
%
%==================================================================
% North North Bering Strait Line (NNBS)
%==================================================================
% A section across the ACC and main flow between
% the A3L line and the NBS line.
% With the 0.5s, at 1.76nm spacing
% 22.8nm length
%----------------------------------
% Run for the first time in 2015 - check water depths on
% the eastern (NNBS7.5) end)
% Dovetails with DL line.  NNBS1 is the same as DL16
% Now has one extra shallower station in the east NNBS8

 66.170 168.937   66   10.19 168   56.20  %NNBS1
 66.170 168.865   66   10.19 168   51.88  %NNBS1.5
 66.170 168.793   66   10.19 168   47.55  %NNBS2
 66.170 168.721   66   10.19 168   43.23  %NNBS2.5
 66.170 168.648   66   10.19 168   38.91  %NNBS3
 66.170 168.576   66   10.19 168   34.58  %NNBS3.5
 66.170 168.504   66   10.19 168   30.26  %NNBS4
 66.170 168.432   66   10.19 168   25.94  %NNBS4.5
 66.170 168.360   66   10.19 168   21.62  %NNBS5
 66.170 168.288   66   10.19 168   17.29  %NNBS5.5
 66.170 168.216   66   10.19 168   12.97  %NNBS6
 66.170 168.144   66   10.19 168    8.65  %NNBS6.5
 66.170 168.072   66   10.19 168    4.32  %NNBS7
 66.170 168.000   66   10.19 168    0.00  %NNBS7.5
 66.170 168.000   66   10.19 167   55.70  %NNBS8   *** NEW
%
%
%==================================================================
% NPH - North Point Hope Line
%==================================================================
%  Crossing from Point Hope to the ENE roughly.
% - 11 stations,
%     from 1-5 and 1.25nm spacing
%     for the rest of the line at 2.5nm
% - Distance 21nm
% - new in 2016
```

```
%   - ** CHECK DEPTH OF SHALLOWEST  NPH1
%
% Run from east (NPH1) to west (NPH11)
% - estimate 3hrs 15min
%--------------------------------------------
%    Lat (N)     Long (W)     Name
%    deg min      deg min
0 0   68  22.40    167  07.93   % NPH1
0 0   68  22.64    167  11.31   % NPH2
0 0   68  22.87    167  14.68   % NPH3
0 0   68  23.11    167  18.06   % NPH4
0 0   68  23.35    167  21.44   % NPH5
0 0   68  23.83    167  28.19   % NPH6
0 0   68  24.30    167  34.95   % NPH7
0 0   68  24.77    167  41.71   % NPH8
0 0   68  25.25    167  48.46   % NPH9
0 0   68  25.73    167  55.22   % NPH10
0 0   68  26.20    168  01.97   % NPH11
%-- with extension to the west (20nm, 8 stations, 4hrs)
0 0   68  26.68    168  08.72   % NPH11.5
0 0   68  27.15    168  15.47   % NPH12
0 0   68  27.63    168  22.23   % NPH12.5
0 0   68  28.10    168  28.98   % NPH13
0 0   68  28.58    168  35.74   % NPH13.5
0 0   68  29.05    168  42.49   % NPH14
0 0   68  29.53    168  49.25   % NPH14.5
0 0   68  30.00    168  56.00   % CCL19
%
%
%=================================================================
% CD- Cape Dyer
%=================================================================
%  Crossing east west, midway between Point Hope
% and Cape Lisburne (near Cape Dyer) and trying
% to avoid some topographic irregularites just
% N of the line on the charts.
% - originally 14 stations, 2nm spacing
% - Distance 26nm
% - new in 2016
%   - ** CHECK DEPTH OF SHALLOWEST  CD1
%--------------------------------------------
% extended to the west, by angling to meet CCL20
% at the Convention line.
% - Total distance 54nm, 27 stations
%    Lat (N)     Long (W)     Name
%    deg min      deg min
%--------------------------------------------
% STARTING FROM WEST EXTENSION
%--------------------------------------------
0 0   68  40.00    168  56.0   % CCL20
```

```
%**NEW
0 0   68  39.79    168  50.6   % CD27
0 0   68  39.57    168  45.3   % CD26
0 0   68  39.36    168  39.9   % CD25
0 0   68  39.14    168  34.6   % CD24
0 0   68  38.93    168  29.2   % CD23
0 0   68  38.71    168  23.9   % CD22
0 0   68  38.50    168  18.5   % CD21
0 0   68  38.29    168  13.1   % CD20
0 0   68  38.07    168   7.8   % CD19
0 0   68  37.86    168   2.4   % CD18
0 0   68  37.64    167  57.1   % CD17
0 0   68  37.43    167  51.7   % CD16
0 0   68  37.21    167  46.4   % CD15
%---------------------------------------
%*END OF NEW, carry on with orig stations
0 0   68  37.00    167  41.0   % CD14
0 0   68  37.00    167  35.5   % CD13
0 0   68  37.00    167  29.9   % CD12
0 0   68  37.00    167  24.4   % CD11
0 0   68  37.00    167  18.8   % CD10
0 0   68  37.00    167  13.3   % CD9
0 0   68  37.00    167   7.8   % CD8
0 0   68  37.00    167   2.2   % CD7
0 0   68  37.00    166  56.7   % CD6
0 0   68  37.00    166  51.2   % CD5
0 0   68  37.00    166  45.6   % CD4
0 0   68  37.00    166  40.1   % CD3
0 0   68  37.00    166  34.5   % CD2
0 0   68  37.00    166  29.0   % CD1
%
%
%==================================================================
%  NCD - North Cape Dyer Line
%==================================================================
%  2nm near the coast NCD1-16
%  2.5nm on out to CCL21 (which is NCD 26)
%-------------------------------------------------
% Length to CCL21 is 55.4nm
%-------------------------------------------------------------
% Lat(N)   Lon  (W)    Lat (N)       Lon (W)      NAME
% decdeg  decdeg    deg      min     deg   min
 68.753 166.422     68   45.20     166   25.30  %NCD1
 68.757 166.513     68   45.39     166   30.78  %NCD2
 68.760 166.604     68   45.59     166   36.26  %NCD3
 68.763 166.696     68   45.78     166   41.74  %NCD4
 68.766 166.787     68   45.97     166   47.22  %NCD5
 68.769 166.878     68   46.17     166   52.70  %NCD6
 68.773 166.970     68   46.36     166   58.18  %NCD7
 68.776 167.061     68   46.55     167    3.66  %NCD8
```

```
 68.779 167.152     68   46.75     167    9.14  %NCD9
 68.782 167.244     68   46.94     167   14.62  %NCD10
 68.786 167.335     68   47.13     167   20.10  %NCD11
 68.789 167.426     68   47.33     167   25.58  %NCD12
 68.792 167.518     68   47.52     167   31.06  %NCD13
 68.795 167.609     68   47.71     167   36.54  %NCD14
 68.798 167.700     68   47.91     167   42.02  %NCD15
 68.802 167.792     68   48.10     167   47.50  %NCD16  2nm up to here, 2.5nm after
 68.805 167.906     68   48.29     167   54.35 %NCD17
 68.808 168.020     68   48.48     168    1.20 %NCD18
 68.811 168.134     68   48.67     168    8.05 %NCD19
 68.814 168.248     68   48.86     168   14.90 %NCD20
 68.817 168.363     68   49.05     168   21.75 %NCD21
 68.821 168.477     68   49.24     168   28.60 %NCD22
 68.824 168.591     68   49.43     168   35.45 %NCD23
 68.827 168.705     68   49.62     168   42.30 %NCD24
 68.830 168.819     68   49.81     168   49.15 %NCD25
 68.833 168.933     68   50.00     168   56.00 %NCD26
%
%
%=================================================================
% - South Bering Strait section  (NOW REPLACED BY SBSnn)
%=================================================================
% First ran in 2014 and 2015 and then only partly
% Run in full in 2017
% To catch ACC before it enters the strait
%  - 22.5nm long
%  - 21 stations including halves
%-------------------------------------------------------------
% Lat(N)   Lon  (W)        Lat (N)       Lon (W)      NAME
% decdeg  decdeg       deg      min     deg   min
 65.5818  168.1167       65        34.91    168        7.00     % SBS1 = BS24
 65.5736  168.1571       65        34.42    168        9.43     %  SBS1.5
 65.5655  168.1975       65        33.93    168       11.85     % SBS2
 65.5573  168.2379       65        33.44    168       14.28     %  SBS2.5
 65.5491  168.2784       65        32.95    168       16.70     % SBS3
 65.5409  168.3188       65        32.45    168       19.13     %  SBS3.5
 65.5327  168.3592       65        31.96    168       21.55     % SBS4
 65.5245  168.3997       65        31.47    168       23.98     %  SBS4.5
 65.5163  168.4401       65        30.98    168       26.40     % SBS5
 65.5081  168.4805       65        30.49    168       28.83     %  SBS5.5
 65.5000  168.5209       65        30.00    168       31.26     % SBS6
 65.4918  168.5614       65        29.51    168       33.68     %  SBS6.5
 65.4836  168.6018       65        29.02    168       36.11     % SBS7
 65.4754  168.6422       65        28.52    168       38.53     %  SBS7.5
 65.4672  168.6826       65        28.03    168       40.96     % SBS8
 65.4590  168.7231       65        27.54    168       43.38     %  SBS8.5
 65.4508  168.7635       65        27.05    168       45.81     % SBS9
 65.4426  168.8039       65        26.56    168       48.24     %  SBS9.5
 65.4345  168.8444       65        26.07    168       50.66     % SBS10
```

```
 65.4263  168.8848       65        25.58    168       53.09    %  SBS10.5
 65.4181  168.9252       65        25.09    168       55.51    % SBS11
%
%
%=============================================================
% - South Bering Strait section  redone - SBSnn
%=============================================================
% First ran in 2014 and 2015 and then only partly
% Run in full in 2017
% Re aligned in 2019 to start from BS22
% 2019 stations slightly off this (SBSn)
% To catch ACC before it enters the strait
%  - 22.5nm long
%  - 21 stations including halves
%-------------------------------------------------------------
% Lat(N)   Lon  (W)    Lat (N)       Lon (W)     NAME
% decdeg  decdeg    deg     min     deg   min
 65.625 168.177     65   37.48    168   10.63 % SBSnn1 = BS22
 65.614 168.215     65   36.86    168   12.87 % SBSnn1.5
 65.604 168.252     65   36.24    168   15.12 % SBSnn2
 65.594 168.289     65   35.62    168   17.36 % SBSnn2.5
 65.583 168.327     65   35.00    168   19.61 % SBSnn3
 65.573 168.364     65   34.38    168   21.85 % SBSnn3.5
 65.563 168.402     65   33.76    168   24.09 % SBSnn4
 65.552 168.439     65   33.14    168   26.34 % SBSnn4.5
 65.542 168.476     65   32.52    168   28.58 % SBSnn5
 65.532 168.514     65   31.90    168   30.83 % SBSnn5.5
 65.521 168.551     65   31.29    168   33.07 % SBSnn6
 65.511 168.589     65   30.67    168   35.31 % SBSnn6.5
 65.501 168.626     65   30.05    168   37.56 % SBSnn7
 65.490 168.663     65   29.43    168   39.80 % SBSnn7.5
 65.480 168.701     65   28.81    168   42.05 % SBSnn8
 65.470 168.738     65   28.19    168   44.29 % SBSnn8.5
 65.459 168.776     65   27.57    168   46.53 % SBSnn9
 65.449 168.813     65   26.95    168   48.78 % SBSnn9.5
 65.439 168.850     65   26.33    168   51.02 % SBSnn10
 65.428 168.888     65   25.71    168   53.27 % SBSnn10.5
 65.418 168.925     65   25.09    168   55.51 % SBSnn11
%
```

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% Bering Strait 2023 NORSEMAN2 log CTD

%Date	**Time**	**1**	**Cast NO**	**wn(1),Up**	**Depth (m)**	**Lat (deg)**	**Lat (min)**	**Lon (deg)**	**Lon(min)**	**%**	**StationID**				**Windspeed**	**Winddir**	**Ope**	**Wave H (m)**	**Fog 0 = cle**	**Distanc (m)**	**Comments**
%Please fill in all data for every event (CTD/net tow)										%					knots						
%There should be one line for the beginning of the event and one line for the end										%											
%Date is GMT and has the format yyyymmdd										%											
%Time is GMT and has the format hhmm										%											
%Ty=Type: 1=CTD | 2=Net tow | 4=prod cast x | 5=LaramieTM | 6=CTD w Nuts | 7=CTD w Sal | 8=CTD w Sal + Nuts | 9=CTD +Monica sample |10=CTD w Nuts + Monica |11 =Surface bucket nuts+monica+bio| 12=ctd+nut+salt+monica | 13=surface bucket b																					
%#,Number is consecutive for that event type										%											
%In/out (I/O): 1=In / 2=Out										%											
%Dep=waterdepth(m) from Furuno readout by CTD which is depth below keel, keel is 3m (10ft)																					
%LatD and LatM are Latitude Degrees and Minute and are positive N										%											
%LonD and LonM are Longitude Degrees and Min and are positive W										%											
%St is the name of the station (Line ID then station number)										%											
% SS = CTD operator estimate of sea state (Beaufort Scale)																					
%WSp=wind speed in m/s; WD=Wind direction from bridge																					
%Op=CTD operator																					
% when 3 lines for NET, dep indicates wire out for net																					
% Altimeter = 0 if complete rubbish, 0.5 if some good readings, 1 if good both up and dowr																					
%Fill in any comments if needed.										%					KNOTS						
20140630	2035	1	**1**	1	17.3	64	43.774	166	41.009	%	dry test				3.4	217	atn				dry test to learn CTD driving
20140630	2045	1	**1**	2	17.1	64	44.855	166	43.033	%	dry test				4.6	214	atn			NEXT YEAR: m VISIBLE	
20140703	642	1	**20**	1	51.8	65	41.144	168	26.929	%	0.1				16.6	187	atn				
20140703	645	1	**20**	2	52.5	65	41.235	168	26.937	%	BS18				16.8	184	atn				BStrait14020.hdr file: put Station=BS20 by mistake, should be Station=BS18 as shown here in StationID

%%%%%%%%% STARTING HERE FOR 2023

AND GET A WIRE TO CLEAN PUMPS WHEN NEEDED

Changeat500min
SUNA BATTERY

SET LAPTOP TIME TO GMT

%Date	**Time**	**Type**	**Cast NO**	**Down(1),Up(2)**	**Depth (m)**	**Lat (deg)**	**Lat (min)**	**Lon (deg)**	**Lon(min)**	**%**	**StationID**	**SUNA bat s/n**	**Min SUNA on**	**Total time**	**Windspeed**	**Winddir**	**Operator**	**Wave H (m)**	**Clear(0) or Fog(1)**	**Water clarity (m)**	**Comments**
20230705	438	1	**1**	1	18.2	64	28.995	165	48.76	%	wettest001	5			9.5	147.2	KC	1	0	4	winch payout did not change at all, 5m soak at start was deeper (fixed tape mark for future), no leaky bottles
20230705	446	1	**1**	2	18.2	64	29.139	165	49.001	%	wettest001	5	8	8	9.4	150.4	KC	1	0	4	
20230706	111	8	**2**	1	53	65	46.957	168	34.138	%	A2_22_recovery	5			10.5	233.7	KC	0	0	15	took salinity and nutrient samples; did not recover mooring,only CTD cast
20230706	118	8	**2**	2	53.7	65	47.032	168	34.047	%	A2_22_recovery	5	7	15	11.4	234.4	KC	0	0	15	
20230706	229	1	**3**	1	45.9	65	44.983	168	15.553	%	A4_recovery	5			10.9	218.4	KK	0	0	4	
20230706	236	1	**3**	2	45.9	65	45.245	168	15.408	%	A4_recovery	5	7	22	10.5	210.1	KK	0	0	4	
20230706	1913	11	**1**	0	54.8	66	19.357	168	55.735	%	WV 1	-	-				RD	0	0	2	Surface nutrients and Monica's sample #1 - strange white particles in surface - samples taken from bucket
20230706	1913	11	**1**	0	54.8	66	19.357	168	55.735	%	WV 1	-	-				RD	0	0	2	Surface nutrients and Monica's sample #1 - strange white particles in surface - samples taken from bucket
20230707	33	6	**4**	1	54.8	66	19.698	168	56.994	%	A3_2023_deploy	5			3.6	354.6	KK	0	0	1	
20230707	40	6	**4**	2	54.8	66	19.707	168	57.162	%	A3_2023_deploy	5	7	29	5.7	248.3	KK	0	0	1	
20230707	1721	1	**5**	1	45.8	65	44.975	168	15.707	%	A4_23_deploy	5			2.1	17.3	KC	0	0	4	
20230707	1725	1	**5**	2	46	65	45.137	168	15.517	%	A4_23_deploy	5	4	33	2.9	26	KC	0	0	4	
20230708	1706	6	**6**	1	52.8	65	46.942	168	34.078	%	A2_22_recovery_true	5			2.5	63.9	KC	1	0	3	
20230708	1714	6	**6**	2	53.3	65	47.049	168	34.064	%	A2_22_recovery_true	5	8	41	3	65.4	KC	1	0	3	
20230708	2230	6	**7**	1	53.3	65	46.964	168	33.909	%	A2_23_deploy	5			11.3	38.2	KC	1	0	2	
20230708	2235	6	**7**	2	54.4	65	47.083	168	33.921	%	A2_23_deploy	5	5	46	11.2	37.1	KC	1	0	2	
20230709	116	6	**8**	1	30	65	37.4	168	10.495	%	BS22	5			2.8	225	ACP	1	0	1	
20230709	123	6	**8**	2	30	65	37.36	168	10.82	%	BS22	5					ACPF				
20230709	123	5	**1**	1	30	65	37.36	168	10.82	%	BS22										
20230709	9999	5	**1**	2	30	65	9999	9999	9999	%	BS22										
20230709	158	1	**9**	1	38.1	65	38.242	168	13.184	%	BS21.5	5			11	31.5	ACP	1	0	2	took longer to resolve xmlcom file - took one that was not the most updated one with NMEA feeding to PC directly
20230709	202	1	**9**	2	38.4	65	38.45	168	13.318	%	BS21.5	5	10	56	11	31.5	ACP	1	0	2	
20230709	216	1	**10**	1	40.8	65	38.58	168	15.03	%	BS21	5			13	37	ACP	1	0	2	
20230709	219	1	**10**	2	41.1	65	38.65	168	15.15	%	BS21	5	3	59	13	37	ACP	1	0	2	
20230709	229	6	**11**	1	44.3	65	38.948	168	16.845	%	BS20.5	5			11	48	RW	2	0	3	
20230709	237	6	**11**	2	44.7	65	39.181	168	17.03	%	bs20.5	5	8	67	19	69	RW	2	0	3	
20230709	237	5	**2**	1	44.3	65	39.181	168	17.03	%	BS20.5										
20230709	245	5	**2**	2	44.3	65	39.603	168	17.507	%	BS20.5										
20230709	301	1	**12**	1	46.6	65	39.254	168	18.834	%	BS20	5	6		5	168	RW	0.5	0	2	
20230709	307	1	**12**	2	47.1	65	39.413	168	18.871	%	BS20	5	6	73			RW				
20230709	320	1	**13**	1	49.1	65	39.866	168	21.32	%	BS19.5	5	5		16.3	85.2	JM				
20230709	325	1	**13**	2	49.2	65	40.023	168	21.323	%	BS19.5	5	5	78	11.9	110	JM	1	0	3	
20230709	340	6	**14**	1	50.3	65	40.253	168	23.564	%	BS19				16.9	107	JM				
20230709	346	6	**14**	2	51.4	65	40.539	168	23.727	%	BS19	5	6	84	13.4	130.3	JM	1	0	5	
20230709	346	5	**3**	1	51.4	65	40.539	168	23.727	%	BS19										
20230709	9999	5	**3**	2	9999	9999	9999	9999	9999	%	BS19										
20230709	415	1	**15**	1	51	65	40.654	168	24.839	%	BS18.5				7.6	207.5	JM				
20230709	420	1	**15**	2	51.3	65	40.759	168	24.84	%	BS18.5	5	6	89	10.9	210	JM	>1	0	10	

20230709	435	1	**16**	1	51.4	65	41.113	168	26.72 %	BS18				2.2	108.9	JM				
20230709	440	1	**16**	2	51.8	65	41.191	168	26.665 %	BS18	5	5	94	0.7	74.8	JM	1	0	10	Jellyfish sucked up, salinity measuring off.
20230709	454	6	**17**	1	52.2	65	41.59	168	29.109 %	BS17.5				2.8	325.7	JM				
20230709	501	6	**17**	2	51.9	65	41.702	168	28.984 %	BS17.5	5	7	101	1.7	356.2	JM	>1	0	10	
20230709	501	5	**4**	1	51.9	65	41.702	168	28.984 %	BS17.5										
20230709	9999	5	**4**	2	9999	9999	9999	9999	9999 %	BS17.5										
20230709	527	1	**18**	1	53.1	65	42.158	168	31.217 %	BS17				4	40.5	JM				
20230709	531	1	**18**	2	52	65	42.229	168	31.165 %	BS17	5	4	105	15.6	80.2	JM	>1	0	10	
20230709	544	1	**19**	1	50.5	65	42.759	168	33.292 %	BS16.5				14.4	94.5	JM				
20230709	550	1	**19**	2	50.3	65	42.809	168	33.266 %	BS16.5	5	6	111	12.7	107.7	JM	1	0	8	
20230709	604	6	**20**	1	50.1	65	43.32	168	35.406 %	BS16				14	92.6	JM				
20230709	612	6	**20**	2	50	65	43.405	168	35.359 %	BS16	5	8	119	10.8	81.1	JM	1	0	5	
20230709	612	5	**5**	1	50	65	43.405	168	35.359 %	BS16										
20230709	9999	5	**5**	2	9999	9999	9999	9999	9999 %	BS16										
20230709	638	1	**21**	1	50.2	65	43.864	168	37.556 %	BS15.5				12.4	88.4	JM				
20230709	642	1	**21**	2	50.2	65	43.93	168	37.563 %	BS15.5	5	4	123	13.4	81.9	JM	1	0	2	
20230709	656	1	**22**	1	50.2	65	44.336	168	39.179 %	BS15				12.5	75.2	JM				
20230709	701	1	**22**	2	50	65	44.404	168	39.691 %	BS15	5	5	128	15	57.5	JM	1	0	2	
20230709	713	6	**23**	1	50.1	65	44.83	168	41.512 %	BS14.5				12	47	JM				
20230709	721	6	**23**	2	50.2	65	44.94	168	41.45 %	BS14.5	5	8	136	15.3	50.7	JM	1	0	1	
20230709	721	5	**6**	1	50.2	65	44.94	168	41.45 %	BS14.5										
20230709	9999	5	**6**	2	9999	9999	9999	9999	9999 %	BS14.5										
20230709	810	1	**24**	1	50	65	45.29	168	43.11 %	BS14				18	54	ACP	2	0	1	
20230709	814	1	**24**	2	50	65	45.38	168	43.12 %	BS14	5	4	140	18	54	ACP	2	0	1	
20230709	828	1	**25**	1	51	65	45.86	168	45.45 %	BS13.5				16	59	ACP	2	0	1	
20230709	832	1	**25**	2	51	65	45.94	168	45.43 %	BS13.5	5	4	144	16	59	ACP	2	0	1	
20230709	846	6	**26**	1	50	65	46.35	168	47.59 %	BS13				15	58	ACP	2	0	1	
20230709	853	6	**26**	2	50	65	46.5	168	47.6 %	BS13	5	7	151	15	58	ACP	2	0	1	
20230709	853	5	**7**	1	50	65	46.5	168	47.6 %	BS13										
20230709	908	5	**7**	2	9999	9999	9999	9999	9999 %	BS13										
20230709	923	1	**27**	1	48	65	46.84	168	49.59 %	BS12.5				14	54	ACP	2	0	1	
20230709	927	1	**27**	2	48	65	46.89	168	49.55 %	BS12.5	5	4	155	15	84	ACP	2	0	1	
20230709	940	1	**28**	1	43.4	65	47.25	168	51.58 %	BS12				20	66	ACP	1	0	3	
20230709	944	1	**28**	2	43	65	47.23	168	51.64 %	BS12	5	4	159			ACPF				
20230709	1000	6	**29**	1	45	65	47.8	168	53.84 %	BS11.5				13	47	ACP	2	0	3	
20230709	1007	6	**29**	2	45	65	47.75	168	53.95 %	BS11.5	5	7	166			ACPF				
20230709	1007	5	**8**	1	45	65	47.75	168	53.95 %	BS11.5										
20230709	9999	5	**8**	2	9999	9999	9999	9999	9999 %	BS11.5										
20230709	1034	1	**30**	1	45	65	48.3	168	55.75 %	BS11				11	55	ACP	2	0	2	
20230709	1038	1	**30**	2	45	65	48.33	168	55.59 %	BS11	5	4	170	11	55	ACP	2	0	2	End of BS line
20230709	1745	1	**31**	1	22.1	66	30.472	167	51.08 %	AL27.5				14.8	42.5	KC	1	0	3	Start of AL line westbound
20230709	1748	1	**31**	2	22.1	66	30.487	167	51.133 %	AL27.5	5	3	173	13.1	39.1	KC	1	0	3	
20230709	1758	1	**32**	1	21.8	66	30.106	167	53.219 %	AL27				14.7	31.9	KC	1	0	3	
20230709	1801	1	**32**	2	21.9	66	30.124	167	53.301 %	AL27	5	3	176	16.1	55.6	KC	1	0	3	
20230709	1810	1	**33**	1	21.5	66	29.775	167	55.417 %	AL26.5				13.6	33.3	KC	1	0	3	
20230709	1813	1	**33**	2	21.6	66	29.803	167	55.55 %	AL26.5	5	3	179	13.5	55.1	KC	1	0	3	
20230709	1822	1	**34**	1	21.5	66	29.444	167	57.6 %	AL26				11.7	58.6	KC	1	0	4	
20230709	1825	1	**34**	2	21.5	66	29.468	167	57.644 %	AL26	5	3	182	14.4	13.9	KC	1	0	4	
20230709	1833	1	**35**	1	21.7	66	29.112	167	59.742 %	AL25.5				12.3	50.3	KC	1	0	4	
20230709	1836	1	**35**	2	21.7	66	29.152	167	59.787 %	AL25.5	5	3	185	13.5	56.4	KC	1	0	4	
20230709	1845	6	**36**	1	22.5	66	28.78	168	1.914 %	AL25				9.3	56.4	KC	1	0	4	
20230709	1850	6	**36**	2	22.6	66	28.82	168	1.949 %	AL25	5	5	190	13.1	43.6	KC	1	0	4	
20230709	1850	5	**9**	1	22.6	66	28.82	168	1.949 %	AL25										
20230709	1858	5	**9**	2	22.6	66	28.88	168	2.039 %	AL25										
20230709	1909	1	**37**	1	24.1	66	28.444	168	4.071 %	AL24.5				15.8	34.7	KC	1	0	4	
20230709	1911	1	**37**	2	24.2	66	28.473	168	4.122 %	AL24.5	5	2	192	16.1	44.3	KC	1	0	4	
20230709	1921	1	**38**	1	26.3	66	28.115	168	6.259 %	AL24				12.8	53	KC	1	0	4	
20230709	1923	1	**38**	2	26.3	66	28.127	168	2.296 %	AL24	5	2	194	10.8	58.1	KC	1	0	4	
20230709	1934	1	**39**	1	28.6	66	27.789	168	8.445 %	AL23.5				14.7	36.8	KC	1	0	4	
20230709	1937	1	**39**	2	28.7	66	27.828	168	8.56 %	AL23.5	5	3	197	15.4	66.8	KC	1	0	4	
20230709	1945	6	**40**	1	32.5	66	27.468	168	10.597 %	AL23				13.5	37.9	KC	1	0	4	
20230709	1951	6	**40**	2	32.7	66	27.531	168	10.804 %	AL23	5	6	203	15.4	57.1	KC	1	0	4	
20230709	1951	5	**10**	1	32.7	66	27.531	168	10.804 %	AL23										
20230709	9999	5	**10**	2	9999	9999	9999	9999	9999 %	AL23										
20230709	2016	1	**41**	1	36.6	66	27.12	168	12.8 %	AL22.5				11.3	80.1	KC	1	0	4	
20230709	2020	1	**41**	2	36.5	66	27.151	168	12.868 %	AL22.5	5	4	207	12.1	52.9	KC	1	0	4	
20230709	2028	1	**42**	1	39.9	66	26.75	168	14.93 %	AL22				12	56	RW	1	0	4	

20230709	2032	1	**42**	2	40	66	26.79	168	14.99 %	AL22	5	4	212	9	44	RW	1	0	4	
20230709	2041	6	**43**	1	42.9	66	26.39	168	17.03 %	AL21.5				7	53	RW	1	0	5	
20230709	2048	6	**43**	2	43	66	26.43	168	17.12 %	AL21.5	5	8	220	5	65	RW	1	0	5	
20230709	2048	5	**11**	1	43	66	26.43	168	17.12 %	AL21.5										
20230709	9999	5	**11**	2	43	66	26.5	168	17.34 %	AL21.5										
20230709	2108	1	**44**	1	47	66	26.028	168	19.157 %	AL21				4.2	41	KK	1	0	5	
20230709	2113	1	**44**	2	47	66	26.077	168	19.31 %	AL21	5	5	225	4.6	51	KK	1	0	5	
20230709	2122	1	**45**	1	50	66	25.652	168	21.315 %	AL20.5				3.5	99	KK	1	0	5	
20230709	2126	1	**45**	2	50	66	25.687	168	21.335 %	AL20.5	5	4	229	4.2	60	KK	1	0	5	
20230709	2136	1	**46**	1	51.6	66	25.324	168	52.57 %	AL20				2.8	114	KK	1	0	5	Came up without firing botles so recast to avoid yoyoing
20230709	2142	1	**46**	2	51.7	66	25.369	168	23.594 %	AL20						KK	1	0	5	
20230709	2142	8	**47**	1	51.7	66	25.369	168	23.594 %	AL20_recast				2.6	142	KK	1	0	5	sampled for salinity also
20230709	2150	8	**47**	2	51.6	66	25.49	168	23.635 %	AL20_recast	5	8	237	3.3	118	KK	1	0	5	bottle 12 leaking, but sampled anyhow
20230709	2150	5	**12**	1	51.6	66	25.49	168	23.635 %	AL20TM										
20230709	9999	5	**12**	2	9999	9999	9999	9999	9999 %	AL20TM										
20230709	2212	1	**48**	1	52	66	24.96	168	25.6 %	AL19.5						RW	1	0	5	
20230709	2216	1	**48**	2	51.8	66	24.9999	168	25.669 %	AL19.5	5	4	241	4.9	12.3	KK	1	0	5	
20230709	2227	1	**49**	1	52.9	66	24.6	168	27.878 %	AL19				4.2	43.2	KK	1	0	5	
20230709	2234	1	**49**	2	52.7	66	24.65	168	28.358 %	AL19	5	7	248	3.6	259	KK	1	0	5	
20230709	2241	6	**50**	1	52.6	66	24.257	168	29.934 %	AL18.5				2.3	64	KK	1	0	5	
20230709	2251	6	**50**	2	52.6	66	24.348	168	30.111 %	AL18.5	5	10	258	1.9	2.4	KK	1	0	5	
20230709	2251	5	**13**	1	52.6	66	24.348	168	30.111 %	AL18.5										
20230709	9999	5	**13**	2	9999	9999	9999	9999	9999 %	AL18.5										
20230709	2313	1	**51**	1	52.3	66	23.93	168	32.079 %	AL18				7.4	17.9	KK	1	0	6	
20230709	2320	1	**51**	2	52.3	66	23.91	168	32.333 %	AL18	5	7	265	10	359	KK	1	0	6	
20230709	2329	1	**52**	1	53.7	66	23.527	168	34.653 %	AL17.5				4.7	31.6	KK	1	0	6	
20230709	2336	1	**52**	2	53.9	66	23.577	168	34.787 %	AL17.5	5	7	272	5.7	20.2	KK	1	0	6	
20230709	2346	6	**53**	1	54.6	66	23.188	168	36.433 %	AL17				5.7	23.9	KK	1	0	5	
20230709	2357	6	**53**	2	54.7	66	23.245	168	36.6 %	AL17	5	11	283			KK	1	0	5	
20230709	2357	5	**14**	1	54.7	66	23.245	168	36.6 %	AL17TM										
20230709	9999	5	**14**	2	9999	9999	9999	9999	9999 %	AL17TM										
20230710	17	1	**54**	1	56	66	22.853	168	38.614 %	AL16.5				7.8	8.4	KK	1	0	6	
20230710	23	1	**54**	2	56.1	66	22.884	168	38.874 %	AL16.5	5	6	289	10.5	353	KK	1	0	6	
20230710	32	1	**55**	1	56.3	66	22.521	168	40.737 %	AL16				5	351	KK	1	0	3	
20230710	37	1	**55**	2	56.3	66	22.542	168	40.795 %	AL16	5	5	294	6	343	KK	1	0	3	
20230710	46	6	**56**	1	51	66	22.13	168	42.898 %	AL15.5				8	10	KK	1	0	5	
20230710	57	6	**56**	2	50.3	66	22.202	168	43.086 %	AL15.5	5	11	305	9	5	KK	1	0	5	
20230710	57	5	**15**	1	50.3	66	22.202	168	43.086 %	AL15.5TM										
20230710	9999	5	**15**	2	9999	9999	9999	9999	9999 %	AL15.5TM										
20230710	116	1	**57**	1	46.4	66	21.762	168	45.052 %	AL15				9		KK	1	1	5	
20230710	121	1	**57**	2	46.1	66	21.801	168	45.176 %	AL15	5	6	311	10	0.5	KK	1	1	5	
20230710	130	1	**58**	1	54.1	66	21.434	168	47.278 %	AL14.5				7	17	KK	1	1	4	
20230710	134	1	**58**	2	54	66	21.492	168	47.405 %	AL14.5	5	4	315	6	23	KK	1	1	4	
20230710	145	6	**59**	1	54.1	66	21.115	168	49.315 %	AL14				8.5	353	KK	1	1	3	duplicate and unfiltered nutrients from bottom bottle
20230710	154	6	**59**	2	54.1	66	21.255	168	49.494 %	AL14	5	9	324	6.4	348	KK	1	1	3	
20230710	154	5	**16**	1	54.1	66	21.255	168	49.494 %	AL14TM										
20230710	206	5	**16**	2	53.9	66	21.39	168	49.7 %	AL14TM										
20230710	217	1	**60**	1	53.4	66	20.752	168	51.515 %	AL13.5				3	330.1	JM	>1	1	2	
20230710	222	1	**60**	2	53.2	66	20.798	168	51.598 %	AL13.5	5	5	329	11.1	341.5	JM	>1	1	2	
20230710	233	1	**61**	1	55.1	66	20.389	168	53.662 %	AL13				11.5	345.6	JM	>1	1	2	
20230710	238	1	**61**	2	55.1	66	20.424	168	53.726 %	AL13	5	5	334	10	344.3	JM	>1	1	2	
20230710	247	6	**62**	1	55.1	66	19.986	168	55.346 %	AL12.5				15.7	342.5	JM	>1	1	2	Took surface sample from bucket - leaky bottle #12
20230710	255	6	**62**	2	55.1	66	20.01	168	55.505 %	AL12.5	5	8	342	10.7	345	JM	1		1	
20230710	255	5	**17**	1	55.1	66	20.01	168	55.505 %	AL12.5										
20230710	9999	5	**17**	2	55.1	66	9999	168	9999 %	AL12.5										
20230710	326	10	**63**	1	55.1	66	19.614	168	56.989 %	A3				9.5	342.6	JM	>1	1	2	Monica sample
20230710	332	10	**63**	2	55	66	19.682	168	57.024 %	A3	5	6	348	13.1	334.5	JM	>1	0	2	
20230710	412	10	**64**	1	55.4	66	24.964	168	55.978 %	CCL5				0	306.4	JM	>1	1	1	Monica sample
20230710	420	10	**64**	2	55.6	66	25.064	168	56.099 %	CCL5	5	8	356	7.7	323.6	JM	>1	1	1	
20230710	420	5	**18**	1	55.6	66	25.064	168	56.099 %	CCL5										
20230710	9999	5	**18**	2	9999	66	9999	168	9999 %	CCL5										
20230710	510	6	**65**	1	55.5	66	29.996	168	55.948 %	CCL6				9	327.1	JM	1	1	3	
20230710	517	6	**65**	2	55.2	66	29.982	168	56.03 %	CCL6	5	7	363	7.2	329.5	JM	1	1	3	
20230710	517	5	**19**	1	55.2	66	29.982	168	56.03 %	CCL6										
20230710	9999	5	**19**	2	9999	66	9999	168	9999 %	CCL6										
20230710	607	6	**66**	1	44.8	66	34.981	168	55.927 %	CCL7				9.7	330.8	JM	>1	1	1	
20230710	613	6	**66**	2	44.9	66	35.02	168	56.012 %	CCL7	5	6	369	8	333.6	JM	>1	1	1	

20230710	613	5	**20**	1	44.9	66	35.02	168	56.012	%	CCL7										
20230710	9999	5	**20**	2	9999	66	9999	168	9999	%	CCL7										
20230710	703	6	**67**	1	42.1	66	39.96	168	55.96	%	CCL8				6.4	41	JM	>1	1	8	
20230710	709	6	**67**	2	42.3	66	40.001	168	56.038	%	CCL8	5	6	375	6.6	25.1	JM	>1	1	8	
20230710	709	5	**21**	1	42.3	66	40.001	168	56.038	%	CCL8										
20230710	9999	5	**21**	2	9999	66	9999	168	9999	%	CCL8										
20230710	756	10	**68**	1	41.7	66	44.985	168	55.888	%	CCL8.5				5.7	349.5	JM	>1	0	1	Monica sample
20230710	802	10	**68**	2	41.7	66	45.053	168	55.967	%	CCL8.5	5	6	381	5.2	345.4	JM	>1	0	1	
20230710	802	5	**22**	1	41.7	66	45.053	168	55.967	%	CCL8.5										
20230710	9999	5	**22**	2	9999	66	9999	168	9999	%	CCL8.5										
20230710	1412	9	**69**	1	49.2	67	38.1	168	55.971	%	CCL14				17	343.1	KC	>1	0	5	last CTD and Monica sample and only surface bottle for nutrients, SUNA battery change at 0342 07/13 (12.2 V
20230710	1417	9	**69**	2	49.2	67	38.069	168	55.978	%	CCL14	5	5	386	13.4	330.5	KC	>1	0	5	
20230711	1755	13	**2**	0	55.2	66	30.723	168	57.298	%	WV2				9.8	240		0	0		WV2 in nutrient sample bottle #3264; white stuff in water
20230711	1809	13	**2**	0	55.2	66	30.723	168	57.298	%	WV2				9.8	240		0	0		WV2 in nutrient sample bottle #3264; white stuff in water
20230713	2155	12	**70**	1	46.5	65	47.841	168	53.854	%	BS11.5				14.8	159.4	KC	>1	0	3	Duplicate salinity, duplicate nutrients, duplicate unfiltered nutrients (bottom bottle), Monica sample (surface)
20230713	2202	12	**70**	2	46.5	65	47.913	168	53.827	%	BS11.5	22	7	7	6.5	87.1	KC	>1	0	3	
20230713	2202	5	**23**	1	46.5	65	47.913	168	53.827	%	BS11.5										
20230713	9999	5	**23**	2	9999	65	9999	168	9999	%	BS11.5										
20230713	2224	1	**71**	1	45.5	65	47.029	168	50.589	%	BS12.25				15.5	71	KC	>1	0	3	
20230713	2228	1	**71**	2	45.3	65	47.112	168	50.631	%	BS12.25	22	4	11	9.1	91.1	KC	>1	0	3	
20230713	2241	6	**72**	1	51.3	65	46.274	168	47.671	%	BS13				8.8	100.7	KC	>1	0	4	Bottle 12 leaked, but at surf so sampled still
20230713	2248	6	**72**	2	49.7	65	46.452	168	47.557	%	BS13	22	7	18	15.1	73.6	KC	>1	0	4	
20230713	2248	5	**24**	1	49.7	65	46.452	168	47.557	%	BS13										
20230713	9999	5	**24**	2	9999	65	9999	168	9999	%	BS13										
20230713	2320	6	**73**	1	49.8	65	44.755	168	41.589	%	BS14.5				15.8	100.1	KC	>1	0	10	Bottle 12 leaked, but at surf so sampled still
20230713	2328	6	**73**	2	50	65	44.936	168	41.542	%	BS14.5	22	8	14	8.3	77.5	KC	>1	0	10	
20230713	2328	5	**25**	1	50	65	44.936	168	41.542	%	BS14.5										
20230713	9999	5	**25**	2	9999	65	9999	168	9999	%	BS14.5										
20230714	0	6	**74**	1	49.8	65	43.249	168	35.391	%	BS16				6.4	45.8	KC	>1	0	10	Bottle 8 leaked, sampled 9 instead. Bottle 12 leaked, but at surf so sampled stil
20230714	7	6	**74**	2	49.7	65	43.406	168	35.361	%	BS16	22	7	21	10.7	30.3	KC	>1	0	10	
20230714	7	5	**26**	1	49.7	65	43.406	168	35.361	%	BS16										
20230714	9999	5	**26**	2	9999	65	9999	168	9999	%	BS16										
20230714	42	6	**75**	1	52.2	65	41.647	168	29.139	%	BS17.5				12.7	35.1	KC	>1	0	7	Bottle 8 leaked, sampled 9 instead. Bottle 12 leaked, but at surf so sampled stil
20230714	49	6	**75**	2	52	65	41.864	168	29.284	%	BS17.5	22	7	28	9	38.2	KC	>1	0	7	
20230714	49	5	**27**	1	52	65	41.864	168	29.284	%	BS17.5										
20230714	9999	5	**27**	2	9999	65	9999	168	9999	%	BS17.5										
20230714	126	6	**76**	1	50.2	65	40.276	168	23.45	%	BS19				18.1	128.1	KC	>1	0	3	Bottle 12 leaked, but at surf so sampled still
20230714	134	6	**76**	2	50.6	65	40.661	168	23.816	%	BS19	22	8	36	16.7	99	KC	>1	0	3	
20230714	134	5	**28**	1	50.6	65	40.661	168	23.816	%	BS19										
20230714	9999	5	**28**	2	9999	65	9999	168	9999	%	BS19										
20230714	230	6	**77**	1	44.7	65	39.043	168	17.2	%	BS20.5				21.5	88.3	KC	1	0	2	
20230714	236	6	**77**	2	45.5	65	39.342	168	17.453	%	BS20.5	22	6	42	17.9	88.5	KC	1	0	2	
20230714	236	5	**29**	1	45.5	65	39.342	168	17.453	%	BS20.5										
20230714	9999	5	**29**	2	9999	65	9999	168	9999	%	BS20.5										
20230714	328	6	**78**	1	30	65	37.587	168	10.592	%	BS22				19.5	28	KC	1	0	1	
20230714	333	6	**78**	2	30.5	65	37.804	168	10.836	%	BS22	22	5	47	15.5	31.1	KC	1	0	1	
20230714	333	5	**30**	1	30.5	65	37.804	168	10.836	%	BS22										
20230714	9999	5	**30**	2	9999	65	9999	168	9999	%	BS22										