<u>BERING STRAIT NORSEMAN II 2021 MOORING CRUISE REPORT</u>

Research Vessel Norseman II, Norseman Maritime Charters

Nome-Nome, 7th July to 17th July 2021

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Funding from NSF Arctic Observing Network Program PLR-1758565

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Trace Metal/Nutrient Sampling:
Laramie Jensen, Randi Bundy, Ryan McCabe, UW
Glider:
Hank Statscewich, University of Alaska Fairbanks (UAF)

Research vessel Norseman II during 2019 Nome on-load [Credit: Woodgate].

As part of the Bering Strait project funded by NSF-AON (Arctic Observing Network), in July 2021 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 of the expedition were:

1) recovery of 6 moorings carrying physical oceanographic (Woodgate & Peralta Ferriz) and whale acoustic (Stafford) instrumentation. These moorings were deployed in the Bering Strait region in 2019 and 2020 from the Norseman II. The funding for the physical oceanographic components of these moorings comes from NSF-AON.

2) deployment of 3 moorings in the Bering Strait region, carrying physical oceanographic (Woodgate & Peralta-Ferriz) and whale acoustic (Stafford) instrumentation. The funding for the physical oceanographic components of these moorings comes from NSF-AON.

3) collection of trace metal/nutrient water samples using a pumped system at selected CTD casts (Jensen)

4) a set of CTD sections studying water properties in the region (Woodgate & Peralta-Ferriz)

5) collection of accompanying ship's underway data, viz. surface water temperature and salinity, ADCP velocity data and meteorological data (Woodgate & Peralta-Ferriz),

6) deployment of a glider (Statscewich).

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

As a Covid precaution, the science team quarantined in Fairbanks for 10 days prior to the cruise and transferred to the ship via a private air charter flight

<u>Key Statistics:</u>

6 moorings recovered, 3 moorings deployed,
276 CTD casts on 14 CTD lines,
trace metal/nutrient water samples taken on 41 stations,
1 glider deployed

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].

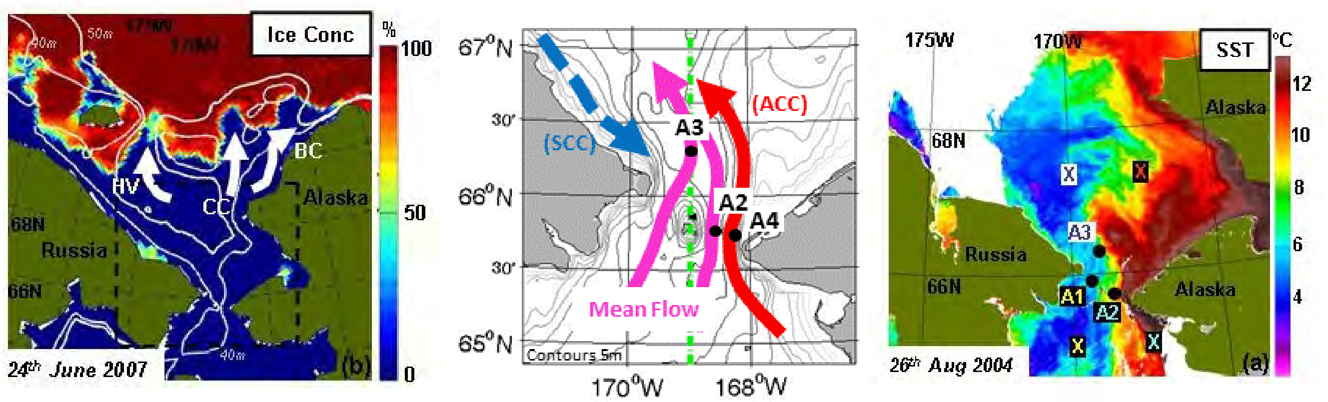

Figure 1: (Left) *Chukchi Sea ice concentration (AMSR-E) with schematic topography. White arrows mark three main water pathways melting back the ice edge [Woodgate et al., 2010].*
(Middle) *Detail of the Bering Strait, with schematic flows and mooring locations (black dots – A2, A3, A4). The main northward 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).

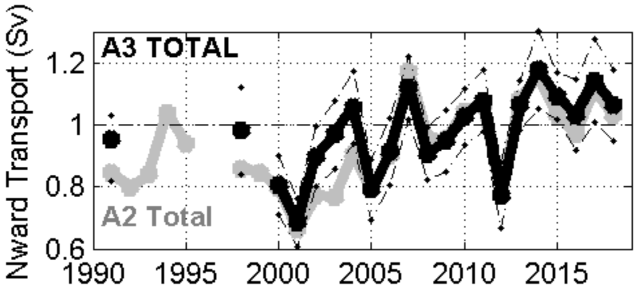

***Figure 2:** Annual mean (x-axis, time in years) of Bering Strait mooring data from 1991 to 2018, showing transport for the whole strait, as estimated from A2 (grey) or A3 (black).*

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-2022.

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).

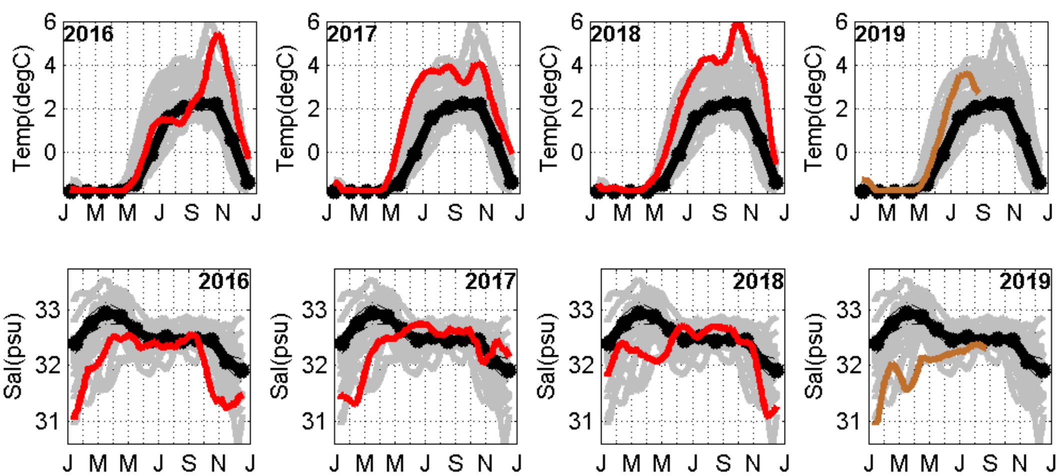

***Figure 3:** 30 day smoothed near-bottom A3 temperature **(top)** and salinity **(bottom)**, data for recent years **(columns)**, showing labeled year in color, climatology [Woodgate et al., 2005b] in black, and all prior years (1990-present) in grey. X-axis labels show month (J=January,etc.), [Woodgate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

2021 CRUISE SUMMARY:

Since in 2020 no Bering Strait mooring recoveries were done due to the Covid situation, we scheduled our 2021 Bering Strait mooring cruise for July, traditionally a time of few storms, and early in the season, in the hope of avoiding the need to drag for too many of the old moorings.

Even though the Covid vaccination program was well advanced in both Washington and Alaska, anti-Covid precautions were still required for the cruise, and the science team followed a strict pre cruise quarantine consisting of 14 days "Strict social Distancing" in Seattle, a pre flight test, a 10-day isolation quarantine in Fairbanks, another predeparture test, and then a charter flight (rather than a commercial flight) to Nome. The charter flight left Fairbanks early (~ 7:30am) on the first day of the cruise (7th July 2021), and under a special arrangement with Nome, the science team transferred directly to the ship from the airport, without entering the airport building.

To minimize contacts in Nome, science gear was also loaded in Homer (the home port of the ship), rather than Nome, with the ship leaving Homer for Nome on the 29th June 2021. The transit north was used to trouble shoot the underway systems. Three issues were encountered - the seawater intake system not transmitting data (which seemed to resolve itself), the aft GPS providing erroneous dates (this is the GPS week rollover error, and resolved by using a different GPS unit/post processing), and the meteorological package (new this year), not logging (a set up issue). The ship reached Nome on the 6th July and on the am of the 7th July performed a calibration of the meteorological sensors' compass just outside Nome, prior to the arrival of the science party.

The ship sailed from Nome shortly after everyone was on board. The transit to the strait was used to set up science gear, including repotting the CTD termination and doing a test CTD cast.

The 8th July provided good weather for the first day of recoveries. Four mooring recoveries (A2-20, A2-19, A4-20, A4-19) were completed smoothly, with pre-recovery CTD casts. All moorings released as planned with no dragging necessary. It proving too late in the day to transit to A3 in time for working, an underway section across the Alaskan Coastal Current was run while the A2 mooring was prepared for deployment. Mooring A2-20 was deployed, and a post-deployment CTD was taken. The ship then ran underway sections (to BS11, up to NBS10, west along NBS and then up to A3) until the next morning. In the preliminary part of this run, the trace metal/nutrient pumping system was set up and tested.

The 9th July again provided good weather for mooring recoveries. After pre-recovery CTD casts, mooring A3-20 was recovered smoothly. Mooring A3-19 required dragging, an operation which first brought aboard one of our prior anchors (in extremely good condition). The A3-19 mooring was sighted during this operation and safely recovered afterwards. Then mooring A3-21 was deployed, with its accompanying post deployment CTD cast, and the ship steam south running underway lines (S along the DL line, east along BS, west back along BS, east along BS again) to be at A4 for the morning. These underway sections should capture the movement of the ACC under a wind change from southward to northward winds.

During this transit, we became aware that the release system for the iscat had not been installed in the A3 mooring. Thus, to safeguard the most important mooring of our project, we postponed the deployment of A4 until A3 could be recovered, repaired and redeployed, an operation which required better weather than we currently had. Thus, on the 10th July, we instead ran the BS CTD line, with sampling for trace metals/nutrients, continuing N along the DL lines (no trace metals/nutrients) and the A3line (with trace metals/nutrients). This enabled us to return to A3 for the mooring operations at A3 on the morning of the 11th of July. From that operation, we steamed to A4, to deploy A4-21, and then returned north to continue our CTD survey, pausing around the A3 line that evening to deploy the glider.

Starting early on the 12th July, we CTDed (with trace metal/nutrient sampling) the CS line towards Point Hope, although poor weather forced us to suspend operations for ~ 4hrs after CS13, a cast we retook once the weather had calmed to test the continuity of the section. The PH line was started late that night, and run westward to NPH13 only, a time choice to allow timely completion of the other sections, the end location being chosen beyond a chlorophyll maximum found in prior years, but absent this year. Thus on the 13th July, we completed the shortened NPH line, ran the CD line east from CD14, and the LIS line westward with trace metal/nutrient sampling, and started the CCL line heading south towards the NPH line. The initial stations of the

LIS line found remarkably fresh water (~ 25psu) and some surface samples were taken for O18 analysis when back in Seattle.

On the 14th July we repeated the NPH line (this time in full) and the CS line (this time in almost calm). A dead grey whale was spotted around station CS14.5 and reported to NOAA. In the teeth of a poor forecast, we started working south along the CCL line and DL lines late that evening. The bad weather predicted arrived on the 15th July, breaking off CTD operations after cast DL16.5. To retain a chance of repeating the BS line, we continued S into the high winds, attaining the lee of the Diomede islands around 11pm. During the night, we transited back and forward around the north and east sides of Little Diomede hiding from weather.

Early on the 16th July (~0630 ship time), we started the final run of the BS line with trace metal/nutrient sampling, although the winds were still strong (from the south). A small easing of the wind allowed us to accomplish the section, and half the stations on the SBSnn line before turning for Nome around 8:30pm ship time.

As in 2019, the transit to Nome was slowed by strong currents (possibly tidal), but the ship made Nome by around 8am, and was able to tie up alongside a barge, over which the science team was able to disembark gear (for Air Cargo). The science team left the ship around 1045am, catching the lunch time flight back to Anchorage and then onto Seattle. The ship left Nome around 1130 to transit to Homer, arriving in Homer on the 25th July.

Other than the missing weak link on the moorings (also missed on A2, though that could not be recovered and replaced), the cruise went exceptionally smoothly. It is remarkable that only one dragging operation was necessary, although this is in part due to the cruise being so early in the year. The 2019 moorings were deployed in September, after the main summer growing season and thus really only had one summer (2020) in which to biofoul. The 2020 mooring recoveries were remarkably clean. After some teething problems, the CTD operations went smoothly, recording 276 casts. The retermination of the cable was something we were prepared for, but not expecting. The first 10 CTD casts were missing the TS ducting on the CTD, causing a mismatch between T and C data. However as these were calibration casts of the deeper layer (where the timing mismatch was not critical) no special processing has been done to correct for this. Due to driver inattention, the CTD touched bottom on cast 222, but without damage or data loss other than on the oxygen upcast. Vent plugs caused the usual problems, though their impact on the data is minimal due to vigilance of the CTD driver and deck crew, to ensure regular and timely cleaning. The trace metal/nutrient pumping, a first for this cruise, went extremely smoothly, collecting data on 41 stations (33 separate locations). Unresolved issues remain with the meteorological data (new system this year), which we suspect may be reading high on wind speeds, and erroneously on temperature. This requires further investigation. Issues with the Aft-GPS date remained unresolved for the cruise - the aft A-frame GPS was repositioned to the aft rail, but CTD and other systems logged instead the forward GPS data which was correct.

Over all, a set of 14 CTD lines were taken, mostly under northward wind conditions, but through various wind strengths. For full station coverage, see map and listings below. Preliminary results are given in the various sections.

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 both runnings 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. **Pumped samples for trace metals/nutrients were taken on both runnings of this line in 2021.**

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.

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, and extended by 6.6nm to map the transition to shallower water**. Run with trace metal/nutrient sampling.**

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.**

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.

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.

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**

Re-run of NPH (this time from CCL to the east), and CS lines

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), 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.

Re-run of BS line with trace metal/nutrient sampling

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).

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

After A2 deployment, west to BS11, then NE to NSB10, back west along the NBS line and then N to A3

See maps for details of these lines.

Prior lines not taken on this cruise:

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

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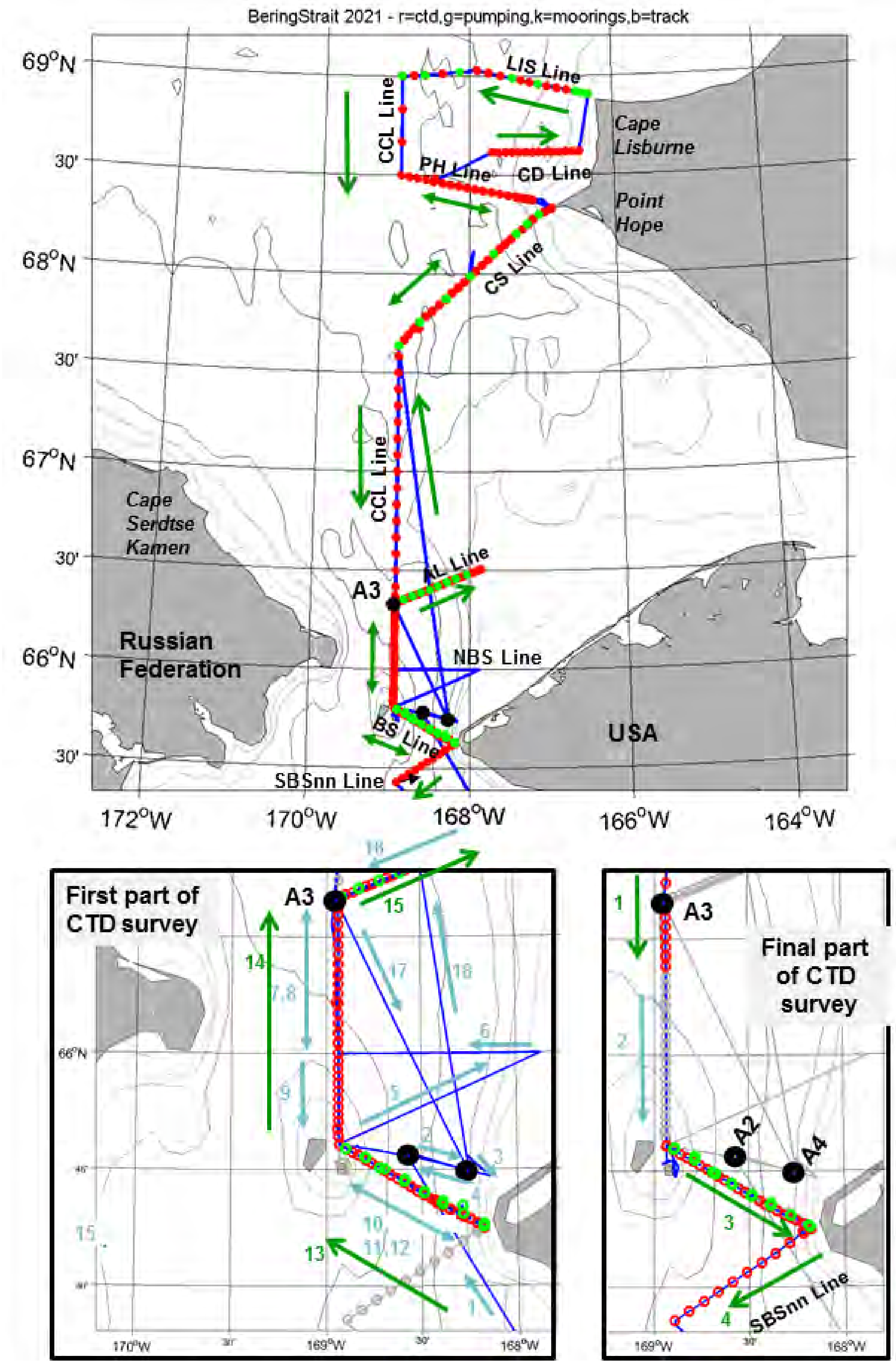
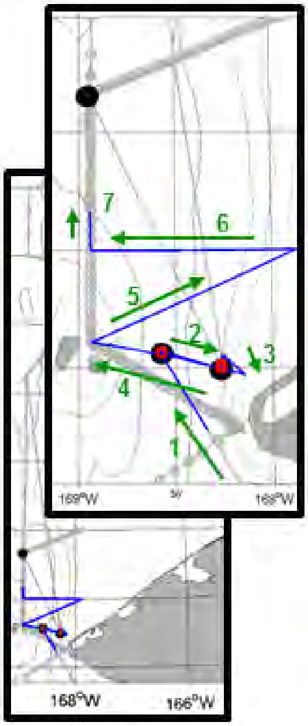
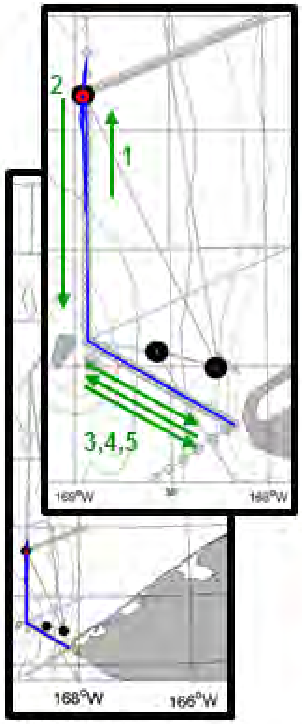
BERING STRAIT 2021 CRUISE MAP: *Ship-track, blue. Mooring sites, black. CTD stations, without (red) and with (green) trace metal/nutrient sampling, Consecutively numbered arrows show direction of travel (on this figure, green marking CTDing lines, cyan marking transit). Depth contours every 10m from IBCAO (International Bathymetric Chart of the Arctic Ocean [Jakobsson et al., 2000]. Lower panels give detail of strait region at the start (left) and end (right) of the cruise. (See next page for daily detail.)*

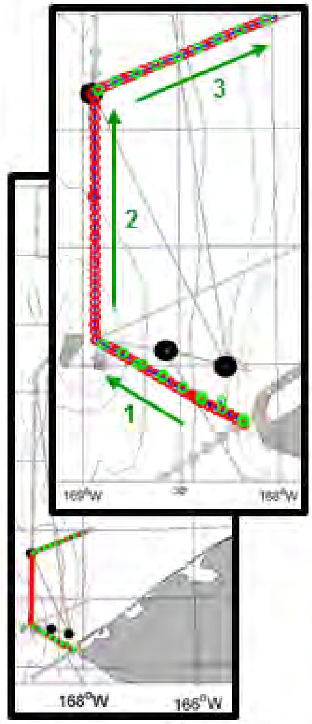




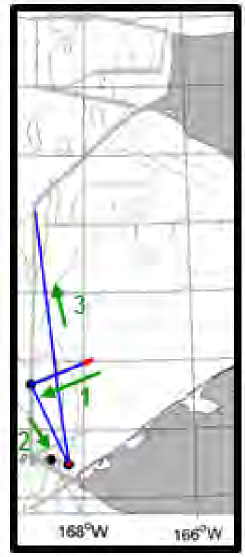
Day 2 *(local time)*
0500 8th Jul 2021
- 0500 9th Jul 2021



Day 3 *(local time)*
0500 9th Jul 2021
- 0500 10th Jul 2021

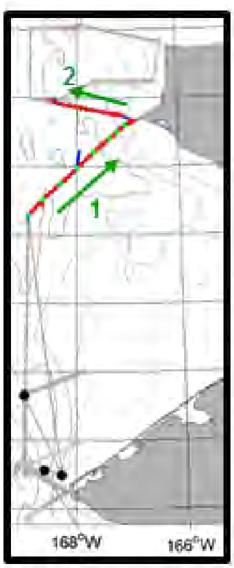


Day 4 *(local time)*
0500 10th Jul 2021
- 0500 11th Jul 2021



Day 5 *(local time)*
0500 11th Jul 2021
- 0500 12th Jul 2021

Bering Strait 2021 Mooring Cruise Norseman II



Day 6 *(local time)*
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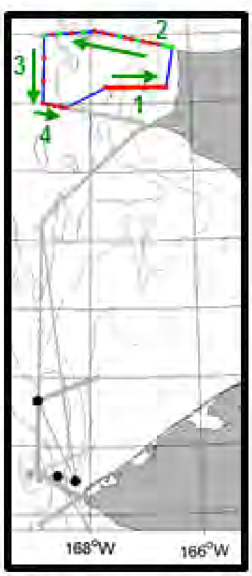
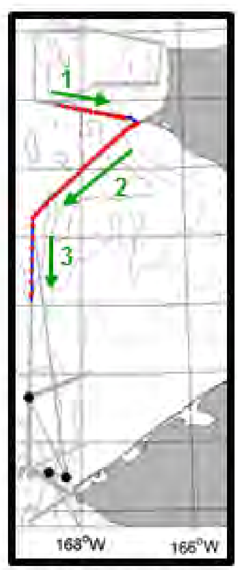
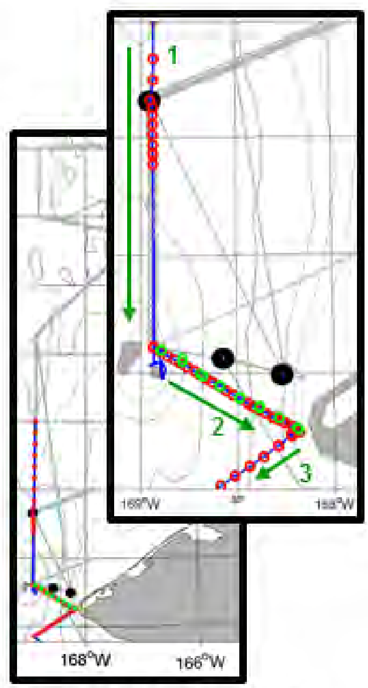
- 0500 13th Jul 2021



Day 7 *(local time)*
0500 12th Jul 2021
- 0500 14th Jul 2021



Day 8 *(local time)*
0500 14th Jul 2021
- 0500 15th Jul 2021



Day 9 &10 *(local time)*
0500 15th Jul 2021
- 0500 17th Jul 2021

BERING STRAIT 2021 SCIENCE PARTICIPANTS

On Shore:

1. Rebecca Woodgate	UW	*Chief Scientist and UW PI*
2. Cecilia Peralta-Ferriz	UW	*Co-Chief Scientist and UW Co-PI*

On board:

1. Jim Johnson (M)	UW	*UW lead and chief mooring technician*
2. John Guthrie (M)	UW	*UW research scientist*
3. Laramie Jensen (F)	UW	*UW postdoc & lead of trace metal/nutrient sampling*
4. Katy Christensen (F)	UW	*UW graduate student & lead of CTD measurements*
5. Robert Daniels (M)	UW	*UW mooring technician*

UW – University of Washington, US

Cabin Allocations:

Main deck (Cabin 4) - Jim Johnson
Lower deck, starboard aft (Cabin 7) - Laramie Jensen & Katy Christensen
Lower deck, port aft (Cabin 8) - John Guthrie
Lower deck, starboard forward (Cabin 5) - Robert Daniels

BERING STRAIT 2021 NORSEMAN II CREW

1. Mike Hastings (M)	SVA	*Captain*
2. Pat Murphy (M)	SVA	*Mate*
3. Jim Wells (M)	SVA	*Boson*
4. Dan Hill (M)	SVA	*Cook*
5. Bryce Walker (M)	SVA	*Asst. Cook*
6. Kevin Duff (M)	SVA	*Engineer*
7. Mike Leiffeste (M)	SVA	*AB*
8. Nathanial Charbonneau (M)	SVA	*AB*

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

Ship contract arranged by:

CPS Polar Field Services, partner of Battelle ARO
Anna Schemper, anna@polarfield.com

BERING STRAIT 2021 CRUISE SCHEDULE (Times: Alaskan Daylight Time (UTC-8), 24hr format)
(Wind directions are wind source .. so S Wind = wind from South)

Mid May 2021	*Shipment of container of UW equipment to Homer*
Mid June 2021	*Loading of gear in Homer*
Sat 12th June 2021	*UW Science team start period of "Strict Social Distancing" in Seattle*
Wed 23rd June 2021	*UW Science team do PCR Covid test in Seattle*
Sat 26th June 2021	*UW Science team fly commercial to Fairbanks* *and start 10-day quarantine at Wedgewood Resort, Fairbanks*
Tuesday 29th June 2021	*Norseman2 leaves Homer (~ 0300UTC)*
Wednesday 30th June 2021	*Norseman2 at Takli Island* *Tests of underway systems during this transit*
Thurs 1st July 2021	*UW Science team do PCR Covid test in Fairbanks*
Friday 2nd July 2021	*Norseman2 passes Aleutian Chain east of Unimak Island (1200)*
Sunday 4th July 2021	*Norseman2 passes S of Nunivak Island (~0735)* *Norseman2 passes N of Nunivak Island (~1530)*
Monday 5th July2021	*Two of UW Science team retest as test results not back* *Finally all test results (including duplicates) return negative* *Norseman2 passes St Lawrence Island (~1800)*
Tuesday 6th July 2021	*Norseman2 reaches Nome Harbor (~1800) and then waits outside*

Wednesday 7th July 2021	*~ 0800 Norseman2 performs Met system calibration off Nome* *~ 1130 returns to Harbor for onload of personnel* *UW Science team fly private charter to Nome (~0730-1030),* **UW science team board Norseman2 in Nome ~ 1130** Safety briefings, Sail ~ 1445 Set up underway, reterminate CTD cable, do test CTD cast.
Thurs 8th July 2021 *(JD 189)*	Arrive on site A2 ~ 0630 From 0803 do **pre recovery CTDs at A2** 0829 Start **A2-20 recovery**, all on deck 0843 0909 Start, all on deck 0925 Steam to A4

From 1110 do **pre recovery CTDs at A4**
1217 Start **A4-20 recovery**, all on deck 1231
1257 Start **A4-19 recovery**, all on deck 1310
Start towards A3, then replan as too far for working today
Steam towards Alaskan Coast to map ACC
Return towards A2, setting up deployment
1654 Start **A2-21 deployment** run, drop Anchor 1659
1726 **A2-21 post deployment CTD cast**
Steam towards DL1, with trace metal/nutrient (TMN) pumping test
Steam underway lines over night (to NBS10, to NBS1, to A3)

Fri 9th July 2021 (*JD 190*)
Arrive on site A3 ~ 0715
From 0811 do **pre recovery CTDs at A3**
0905 Start **A3-20 recovery**, all on deck 0917
0940 Start **A3-19 recovery**, required dragging, all on deck 1101
Prepare A3-21 deployment
1600 Start **A3-21 deployment**, drop Anchor 1605
1620 **A3-21 post deployment CTD cast**
Prepare A2-21 deployment while steaming South overnight
Steam S along DL to DL1,
Steam SE along BS to BS22
Steam NW along NS to BS11
Steam SE along BS to BS22
During this transit, discover problem with A3-21 deployment

Sat 10th July 2021 *(JD191)*
0752 Start **CTDing BS line (from BS22 to NW) with TMN pumping**
    1438 finish BS line at BS11, steam to DL1
1445 Start **CTDing DL line (from DL1 to N)**
    2043 finish DL line at DL19.5, steam to A3
2051 Start **CTDing AL line (from A3 to NE) with TMN pumping**

Sun 11th July 2021 (*JD192)*
0541 finish AL line at CL27.5, steam to A3 (foggy)
0859 Start **A3-21 recovery,** all on deck 0914
Prepare A3-21 redeployment
1012 Start **A3-21 deployment**, drop Anchor 1019
Steam to A4, preparing A4-21 deployment
1517 Start **A4-21 deployment**, drop Anchor 1518
1529 **A4-21 post deployment CTD cast**
Steam towards CS10, preparing glider on transit
2121 Stop to **deploy glider** at ~ 66 32.93N, 168 32.72W
2149 Continue on to CS10

Mon 12th July 2021 *(JD193)*
0526 Start **CTDing CS line (CS10US to NW) with TMN pumping**
    1055 Break off CTDing at CS13 due to bad weather
    1625 Restart CTDing at CS13 as weather improves
    2223 finish CS line at CS19, steam to NPH1
2312 Start **CTDing NPH line (from NPH1 to NW)**

Tues 13th July 2021 *(JD194)*
    0444 finish NPH line at NPH13, steam to CD14
0709 Start **CTDing CD line (from CD14 to E)**

1123 finish CD line at CD1, steam to LIS1
1327 Start **CTDing LIS line (LIS1, to NW) with TMN pumping +O18**
2242 finish LIS line at CCL22n, steam to CCL21
2242 Continue **CTDing CCL line S**

Wed 14th July 2021 *(JD195)*
0301 Start **CTDing NPH line (from CCL19 to SE)**
1020 finish NPH line at NPH1, steam to CS19
1118 Start CTDing **CS line (from CS19 to SW)**
2202 finish CS line at CS10.
2202 Continue **CTDing CCL/DL line S, including A3**

Thurs 15th July 2021 *(JD196)*
1519 break off DL line at DL16.5 due to bad weather
Make headway south to the Diomedes
2306 arrive near Little Diomede, run arcs around NW side of island

Friday 16th July 2021 *(JD197)*
0635 Start CTDing **BS line (from BS11 to SE) with TMN pumping**
1424 finish BS line at BS22
1424 Continue **CTDing SBSnn line (from BS11 to SW), halves only**
2027 finish SBSnn line at SBSnn10.5
2027 Turn for Nome

Sat 17th July 2021 *(JD198)*
~0800 Tie up in Nome alongside barge, send CTD to AirCargo
1045 UW Science party leave ship.
1130 Norseman2 leaves Nome for Homer
1255 UW Science party fly from Nome,
arriving back in Seattle ~2100PDT

Sunday 25th July 2021
~0620 Norseman2 docks in Homer.

<u>Bering Strait 2021 Mooring cruise TOTALS</u>

9.75 days at sea (away from Nome) 1445 7th July – 0800 17th July 2021
10 days on ship (including on/offload) 1130 7th July – 1045 17th July 2021

Moorings recovered: 6
Moorings deployed: 3
CTD casts: 276 (including 1 test cast) on 14 lines
Trace metal/nutrient Pumping stations: 41
Gliders deployed: 1

SCIENCE COMPONENTS OF CRUISE

The cruise comprised of the following science components:

- **Mooring operations** – 6 mooring recoveries, 3 mooring deployments (UW moorings)

- **CTD operations -** 276 casts on 14 lines (UW instrumentation, measuring temperature, conductivity, oxygen, fluorescence, and turbidity with pressure)

- **Water sampling for trace metals/nutrients** - 41 stations where samples taken with pumped system.

- **Opportunistic O18 sampling** - 2 samples taken at start of LIS line due to remarkably fresh waters.

- **Underway sampling** – ship-based equipment of 300kHz hull-mounted ADCP; SBE21 underway Temperature-Salinity recorder, an SBE38 temperature sensor, and some meteorological data (air temperature, pressure, humidity, wind direction and wind speed).

- **Moored Marine Mammal Observations (acoustic instruments on the moorings)**

All recovered A3 moorings and the deployed A3 mooring carried Marine Mammal Acoustic Recorders from Kate Stafford, UW.

- **Marine Mammal Glider Deployment** - one glider was deployed for PIs: Hank Statscewich and Seth Danielson (UAF),Kate Stafford (UW) and Mark Baumgartner (WHOI) as part of a project monitoring marine mammal calls in the western Chukchi.
http://dcs.whoi.edu/chukchi0721/chukchi0721_unit_595_html/chukchi0721_unit_595_summary.html

MOORING OPERATIONS (Johnson, 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. Six UW moorings were recovered on this cruise. These moorings (all in US waters – A2-19, A4-19, A3-19, and A2-20, A4-20, A3-20) were deployed from the Norseman II in September 2019 and 2020 respectively, with mooring funding from NSF-AON (PIs: Woodgate and Peralta-Ferriz, *PLR1758565*). Due to the Covid situation, the 2020 cruise sailed without a science party and thus no moorings were recovered that year.

Three UW moorings (A3-21, A2-21, A4-21) were deployed on this 2021 Norseman II cruise under funding from the same NSF-AON grant. 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 the 2019 and 2021 moorings also carried iscats (upper level temperature-salinity-pressure sensors in a trawl resistant housing designed to survive impact by ice keels). All recovered and deployed moorings also carried marine mammal acoustic recorders. The A3-19 and A3-21 moorings also carried the first prototypes of 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.

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.

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 and 2018 and 2019), an on-deck calibration tank was also used for recovered instruments. This is discussed below.

2021 Recoveries and Deployments: Given that 3 moorings had been in the water for almost 2 years, mooring recoveries were exceptionally smooth this year, with only one of the moorings requiring dragging.

For recoveries, 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 the all moorings, although our usual routine is to communicate and range with one release and then attempt to release the other release (to test both instruments), this year the same release was used for ranging and for release. This was successful at bringing the mooring to the surface on all moorings except for A3-19.

On A3-19, although both releases were activated (and confirmed release) the mooring did not surface, but ranges increases as the ship drifted away indicating the mooring was still connected to the anchor. Thus a dragging operation was initiated. Within ~ 30min of dragging the mooring was sighted on the surface, and the drag snagged an anchor, which was brought on board before the mooring could be recovered. On recovery, both releases were found to have released. Biofouling was present on the releases, and it is very possible that an unfortunately placed barnacle was the cause of holding the mooring down. **Action items: Investigate better biofouling paint. Ensure all releases are newly painted each year. Continue to use external springs**

In all cases, once the mooring was on the surface, the ship repositioned, 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 were 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 was 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 was 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, was recovered by hand at a convenient point in this operation, prior to recovery of most of the mooring. (This year, of the 4 iscat instruments that might have been present (only on the Ax19 moorings), the iscat was recovered only from A4-19.) Then the entire mooring was then elevated, using both hooks from the aft A-frame, and recovered onto deck. Recovery work was 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 were 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.**

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.**

Biofouling was heavy in the recoveries of the 2019 moorings, but light on the 2020 moorings. On A2-19 and A4-19 the ADCP heads were entirely covered with barnacles, and the A3-19 ADCP was almost entirely covered with barnacles. Salinity cells were only just clear on the Ax19 moorings. Bryozoan growth was limited - instead barnacles were plentiful. The releases had some biofouling, but significantly less than on the rest of the moorings.

In contrast to 2016, when significant damage (hypothesized ice damage) was found on the moorings, this year there was no clear evidence of mechanical damage to the mooring frames in general, although the protective case on the hydrophone of the A3--20 mooring was twisted off. Luckily the hydrophone itself appeared undamaged. It is unclear when this damage occurred. As A3-20 was recovered prior to the dragging operation on A3-19, it was not due to the dragging operation. The only other damage was the loss of the Iscats on A3-19 and A2-19. On A2-19 much (all?) of the iscat tether was recovered, suggesting the tether parted at the block below the iscat itself (though the block was not recovered).

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.

After the deployment of A2-21 and A3-21, it was discovered that the weak link had been omitted from the iscat systems. Without the weak link, the mooring might be dragged by ice. As A3 is near the EEZ line, this was deemed to be too great a risk, and the decision was taken to use the anchor we had recovered during dragging to redeploy A3-21 after a recovery. Thus the deployment of A4-21 was postponed (in case unexpected snags were encountered and equipment from that mooring was needed to complete the new A3-21) and CTD lines were run until the weather and light were possible for mooring recovery. Despite initial fog, the recovery and redeployment of A3-21 (with the weak link installed) went smoothly, and subsequently A4-21 was also safely deployed. This leaves A2-21 deployed without weak link. Typically, iscats are only lost from the moorings in ~ half of the deployments. Thus there is at least a 50% chance the mooring will not be snagged enough to drag it. **Action item: On recoveries in 2022 be aware that A2-21 may have moved position, and survey in the position before attempting recovery.**

Deployment Instrumentation issues: This year, because the cruise was only loading people in Nome, instrumentation was again started in Seattle and shipped to Homer set on delayed start. All instrument starts went smoothly, although it was discovered the SBE37IM would not accept a delayed start longer than 30 days ahead.

Iscat housings and tethers were assembled in Seattle, and ADCPs incorporated into the ADCP frames, leaving the only assembly work to be done 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 generally good, although with some challenges, as detailed below:

- ISCAT SBE37IMS AND LOGGERS: Of the 3 iscats/miscat deployed on the recovered moorings:
- from **A2-19**, the top SBE37 sensor was not recovered, but the logger recorded data until 13th May 2020 and continued to write files until 24th Jan 2021. On recovery the logger battery was dead. This is as expected from an iscat that has been dragged off the mooring.
- from **A4-19**, the top SBE37 sensor was recovered (the cell was only just clear) and the SBE37 ran until recovery. The logger however had recorded no data. Its clock was still correct and battery voltage was still high. **Action item: Investigate**
- from **A3-19,** the MISCAT system was not recovered. Both sensors were missing, but the logger returned some data on recovery - from deployment (7th Sept) to 11th Sept for the lower (~ 16m) sensor and longer to 15th Sept for the upper (~8m) sensor, although with increasing numbers of data gaps. Again the logger battery was dead, as expected once the SBE37IMs are lost. **Action item: Investigate, and run a wet test in Seattle.**
Preliminary results (before any correction for biofouling or post cruise calibration) are plotted below.

- ADCPs: Of the 6 ADCPs deployed on the recovered moorings, all were running on recovery and gave complete data records, including the 2 year deployments. 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 not yet been investigated. **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 with only minor problems, viz. spikes in 2341 on A2-19, and 1700 on A4-19 appears to have lost one data record sometime during the 2 year deployment. **Action items: Despike and investigate the instrument header to check the apparent missing record.**

Biofouling was extreme on the moorings that had been out for two years, and thus we expect significant salinity drift over the deployment, as is evident in the mismatch of freezing temperatures during the second winter (see plots below). The test tank is designed to elucidate the size of this drift, in conjunction with post deployment calibration. **Action item: Investigate drift. Check 0004, which appears to have gone from good agreement in the test tank to poor (0.3psu) agreement.**
Preliminary results (before any correction for biofouling or post cruise calibration) are plotted below.

Post recovery tank calibrations: As an addition calibration test, uncleaned post-recovery SBE instruments were placed, for various periods between 8th July 2021 (1715GMT) and 11th Sept July 2021 (~0250GMT) 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
- SBE16 # 0005, brought as a mooring spare and last calibrated in February 2020
- SB37IM #22408, brought as a mooring spare and last calibrated in September 2020

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, 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 (SBE16s) or every 5min (SBE37), this allows a good comparison with the calibration CTD, set at 5 second data, and the SBE37 recording every 5min. Instruments were then cleaned and placed again in the tank for at least another 6 readings. Note that at one point the water circulation pump in the test tank was found not to be working. It is unclear how long it was out of action. As the tank was not big enough for all instrumentation at one time, instruments were swapped in and out, and when not in the calibration tank or being cleaned, they were typically placed in a second “holding” tank so the cells did not dry out. The instruments will next be returned to the manufacturer for post cruise calibration.

Overall the methodology worked smoothly in 2021, although we found the SBE19 was consuming batteries at a much faster rate than expected, i.e., 7.75hrs for the first set of batteries, and 20hrs for the second.

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.

Preliminary results are shown below, relative to the SBE19 reference CTD. (At the time of writing, the records from the spare mooring instruments are not available for comparison, but these will be added to this document when it is updated with the post cruise calibrations.) **Action item: Add spare data** These records present some curious features:

1) The first soak of the 2020 SBEs show uniform agreement with the calibration CTD, as do most of the second soaks. However A420SBE becomes 0.3psu fresher than the calibration CTD after cleaning. **Action item: Investigate SBE16, SN0004.**

2) The first soaks of the 2019 SBEs show uniform freshness of 0.1-0.2psu compared to the calibration CTD. This is in line with previous results.

However, it is slightly concerning that

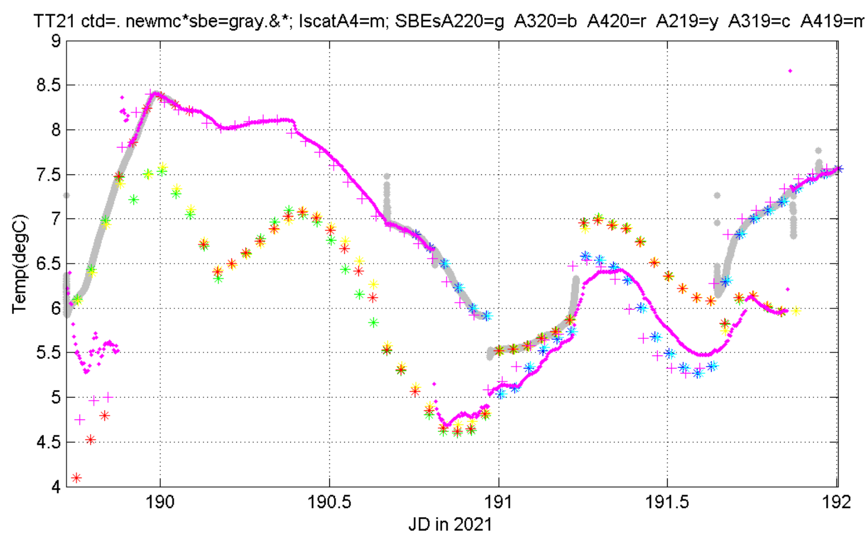
a) cleaning does not improve agreement, but indeed in some cases, makes agreement worse.

b) an initially good agreement (A420) can become 0.3psu off during a subsequent soak. The latter point shows the importance of including the other spare instruments in this analysis and considering all the points of evidence (e.g., agreement with in the water CTD casts and subsequent mooring deployments) before concluding a record is erroneously fresh.

Summary of comparisons to SBE924 *(grey in plots below, accuracy 0.01°C, 0.001S/m, 0.05psu)*

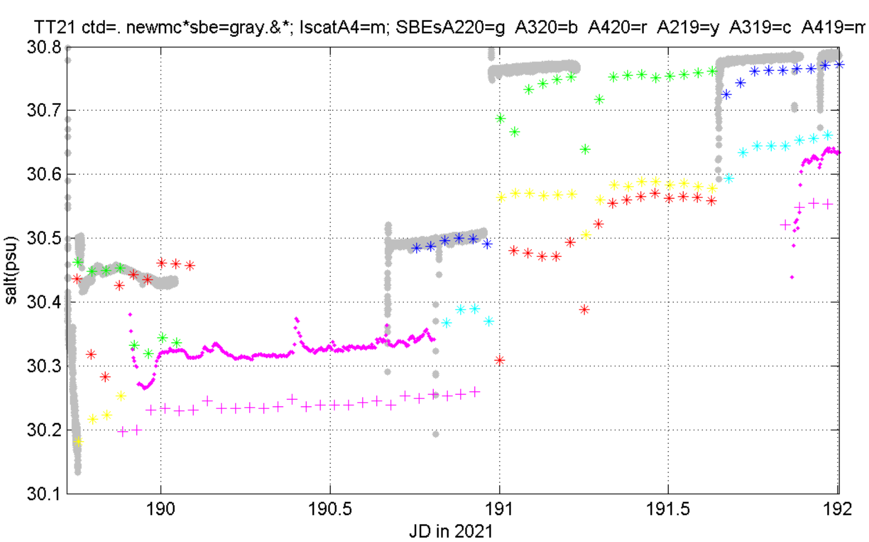
What	A2-19SBE *yellow*	A3-19SBE *cyan*	A4-19SBE *magenta*	A4-19ISC *magenta*	A2-20SBE *green*	A3-20SBE *blue*	A420SBE *red*
SN	***2341***	***1698***	***1700***	***20935***	***1226***	***1225***	***0004***
TAcc	*0.01°C*	*0.01°C*	*0.01°C*	*0.002°C*	*0.01°C*	*0.01°C*	*0.01°C*
CAcc	*0.001S/m*	*0.001S/m*	*0.001S/m*	*0.0003S/m*	*0.001S/m*	*0.001S/m*	*0.001S/m*
SAcc	*0.05psu*	*0.05psu*	*0.05psu*	*0.008psu*	*0.05psu*	*0.05psu*	*0.05psu*
PRECAL	Mar2019	Mar2019	Mar2019	Jun2019	Jan2004	Sep2009	Sep2008
First Soak	-0.2psu,	-0.1psu	-0.23psu	-0.15psu	~0.0psu	~0.0psu	~0.0psu
Second Soak	-0.2psu	-0.13psu	-0.22psu	-0.15psu	-0.02psu	-0.02psu	-0.3psu
POSTCAL							
First soak							
Second soak							

(Acc = manufacturer's accuracy for temperature (T), conductivity (C) and thus computed salinity (S))



This plot shows all the recovered instruments and the calibration CTD, colors as per the table above.

The plots below are 1 per instrument, as per colors in the table above, with grey being the CTD reference. For each plot, use the temperature record to find when the instrument was in the tank with the reference, and then compare the salinity records to find the approximate offset.



. **Action item: - return to this once SBEs have been post-cruise calibrated and spare records are available. Revisit test methodology in Seattle to improve reliability. Note that washing can change calibration by 0.1psu. and either the tank may be in error by 0.3pu, or there is some issue with SBE#0004.**

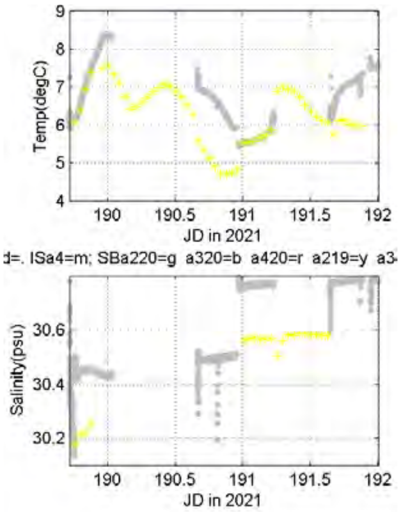
Action item: Once all SBEs have been post-cruise calibrated, also do:

- comparison to CTD casts

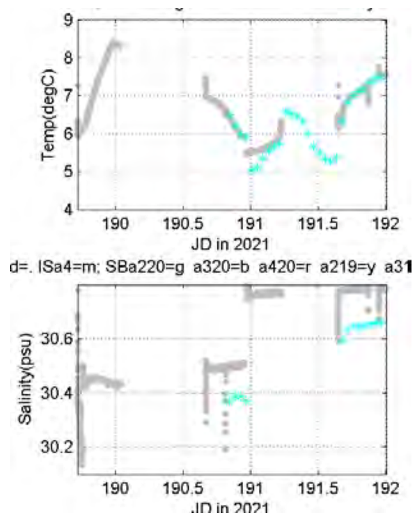
- comparison to instruments on same moorings

TEST TANK RESULTS BY INSTRUMENT

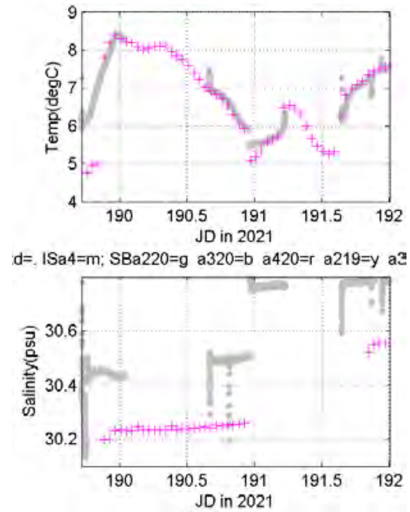
A2-19SBE



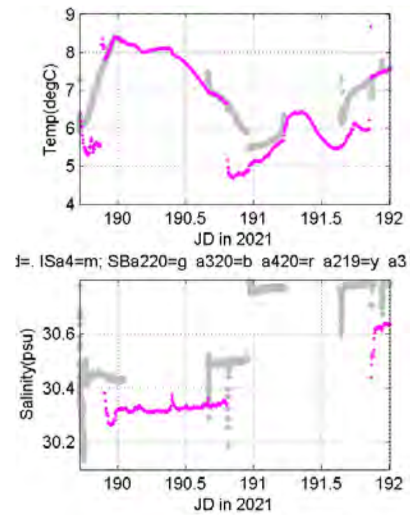
A3-19SBE



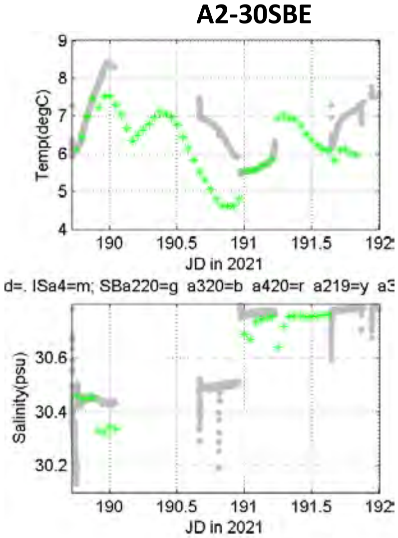
A4-19SBE



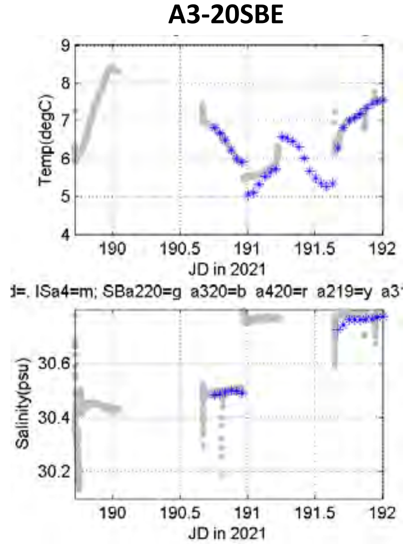
A4-19ISC



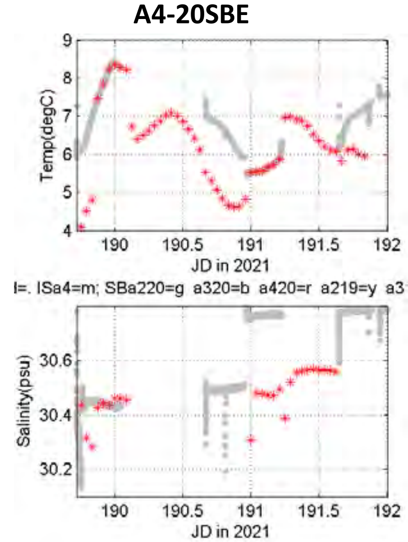
A2-30SBE



A3-20SBE



A4-20SBE



Update May 2022 - checking for salinity calibrations in all moored instrumentation.

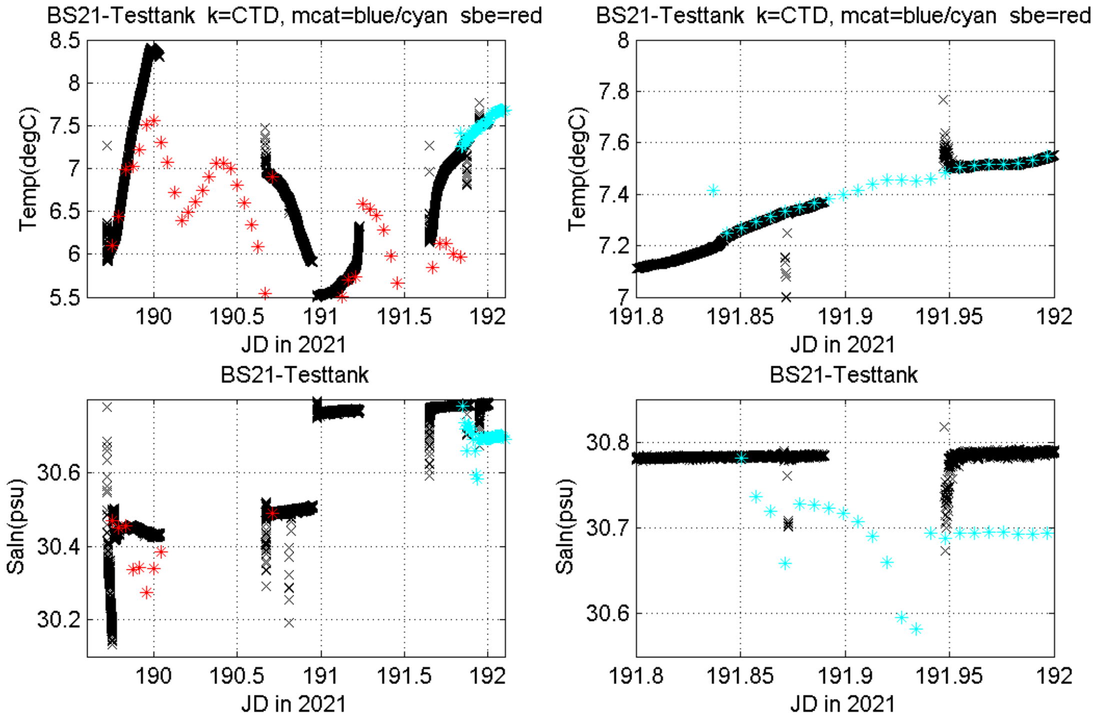
Discard 2nd Soak in test tank for being unreliable. All unmarked units are PSU

2019	A219sbe	A219isc	A319sbe	A319isc	A419sbe	A419iscat
	2341		1698		1700	20935
Notes	replatinized		replatinized		replatinized	replatinized
SAcc	*0.05psu*	*0.008psu*	*0.05psu*	*0.008psu*	*0.05psu*	*0.008psu*
1) PRE						
Tank - S1	-0.22 psu		-0.1psu		-0.2 psu	-0.1psu
- S2 to CTD	-0.2 psu		-0.13psu		-0.25psu	-0.15psu
- S2 to MC	NA		-0.035 psu or		-0.14 psu	-0.06psu
Rec CTD	-0.23,-0.25		-0.18,-0.18		Unclear	-0.14
Next Year	-0.08psu		-0.05		-0.15	NA
ISCAT/SBE	Too short		Too short		Too fresh	Too salty
Other moor	Unclear		Unclear		Unclear	Unclear
TFreeze	Yr1ok,Yr2TooF		Yr1ok,Yr2TooF		Yr1ok,Yr2TooF	tooF 2nd yr
2)PPP	0.0941psu		0.3346psu		0.1663psu	0.1072psu
Tank- S1	-0.12psu		+0.2psu		-0.04psu	0.0psu
- S2 to CTD	-0.1psu		+0.28 psu		-0.08psu	-0.05psu
- S2 to MC			+0.2psu		+0.02psu	+0.05psu
Rec CTD	-0.14, -0.16		+0.15,+0.15		unclear	-0.04
Next yr	-0.02psu		+>0.15		-0.08psu	NA
Iscat/SBE	Too short		Too short		ok	ok
Other moor	Unclear		Unclear		Unclear	Unclear
Tfreeze	Ok		tooS 2nd yr		tooF 2nd yr	tooF 2nd yr
CONCLUDE	**Use POST cal -0.02psu by yr1 -0.1 psu by yr2**		**PostCal is off Use Precal -0,05psu by yr1 -0.1psu by yr2**		**Use POST cal -0.04 to -0.08 psu off**	**Use POST cal Tfreeze suggests Yr2 ~0.1fresh, but this not found in test tank**

2020	A220sbe	A220iscat	A320sbe	A320iscat	A420sbe	A420iscat
	1226	None	1225	None	0004	None
Notes	Not replat.		Not replat		Too old to cal.	
SAcc	*0.05psu*	*0.008psu*	*0.05psu*	*0.008psu*	*0.05psu*	*0.008psu*
1) PRE						
Tank - S1	0 psu		0 psu		0 psu	
- S2 to CTD	-0.02psu		-0.01		-0.28	
- S2 to MC			+0.08			
Rec CTD	-0.006		0.001,0.005		Not clear	
Next Year	NA		NA		NA	
ISCAT/SBE	NA		NA		Is ok	
Other moor	Not clear		Not clear		Not clear	
TFreeze	TooF perhaps		ok		ok	
2)PPP	-0.0166psu		0.0075psu		NOT CALED	
Tank- S1	0 psu		0 psu		NOT CALED	
Rec CTD	-0.019		0.007, 0.013			
Next yr	NA		NA		NA	
Iscat/SBE	NA		NA		NA	
Other moor	Not clear		Not clear			
Tfreeze	Better		ok			
CONCLUDE	**Use postcal, as Tfreeze better, likely all better than 0.02psu**		**Use postcal, to match previous methods. All better than errors 0.02psu**		**Use precal, as that is all we have, but agrees well on all tests, so likely ok, better 0.01psu**	

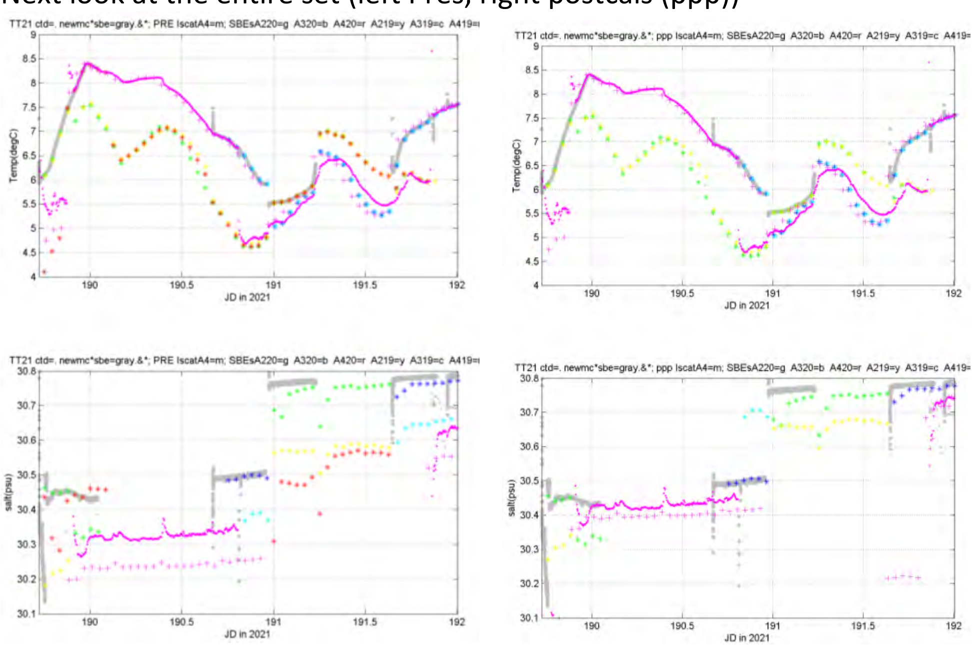
FINDINGS:

First check is of all the references in the test tank - the CTD 924, and then two newly calibrated instruments, SBE16-0005 and SBE37(Microcat) 22408)



** This suggests some issues with the test tank towards the end. So put all references on next the plots.

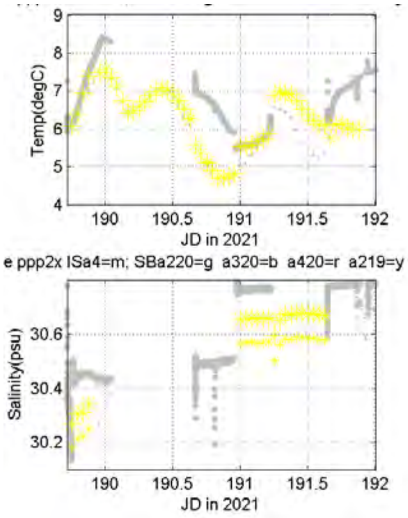
Next look at the entire set (left Pres, right postcals (ppp))



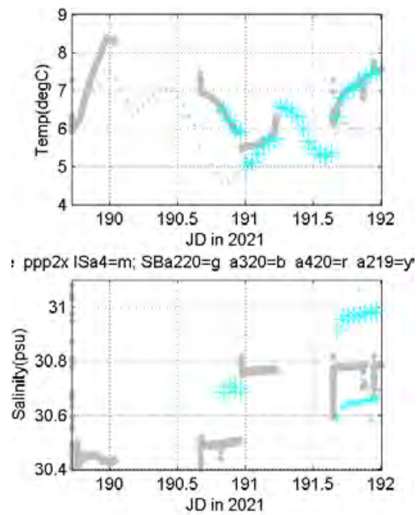
- Postcals generally improve the agreement, other than 1319#1698 where postcal is 0.2 saltier than initial soak.
- 0004 (A4-20) is missing from plots as Seabird did not calibrate it
- second soak appears problematic, with generally worse agreement to first soak.

Now by instrument, looking at pre and ppp. (larger symbols are ppp, A420 no ppp).

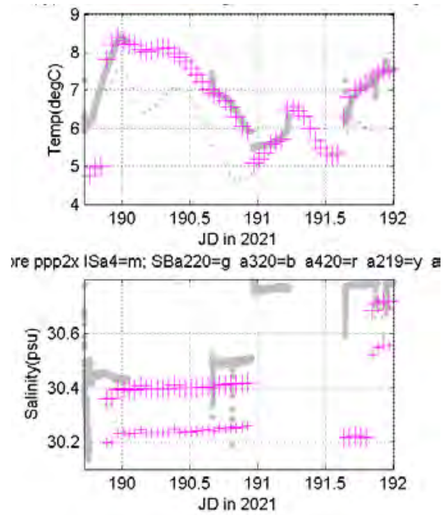
A2-19SBE



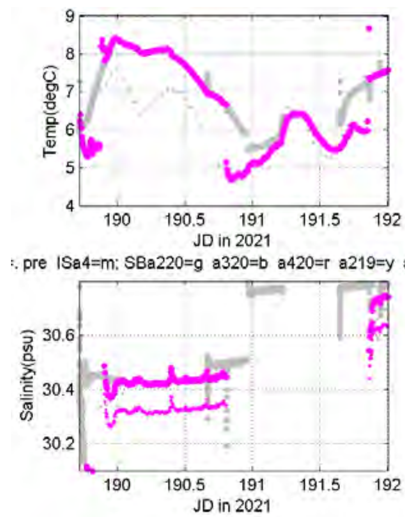
A3-19SBE



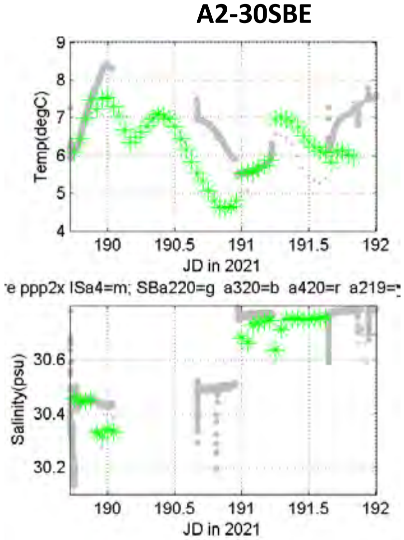
A4-19SBE



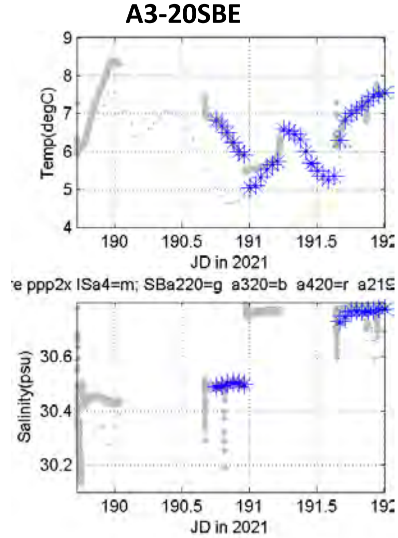
A4-19ISCAT



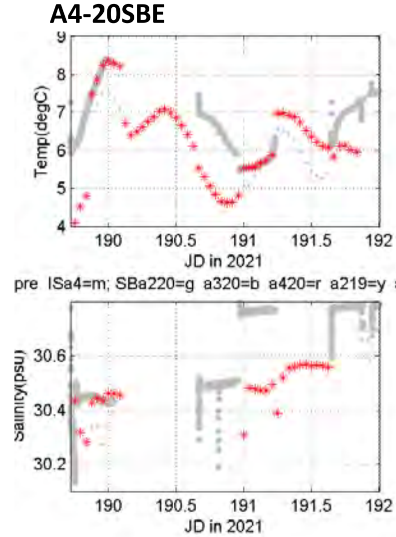
A2-30SBE



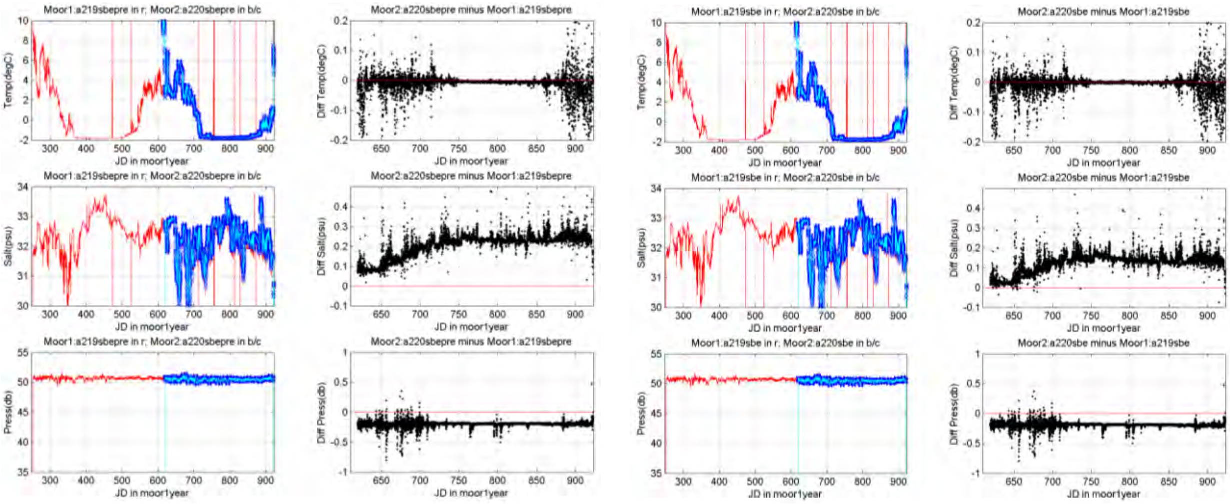
A3-20SBE

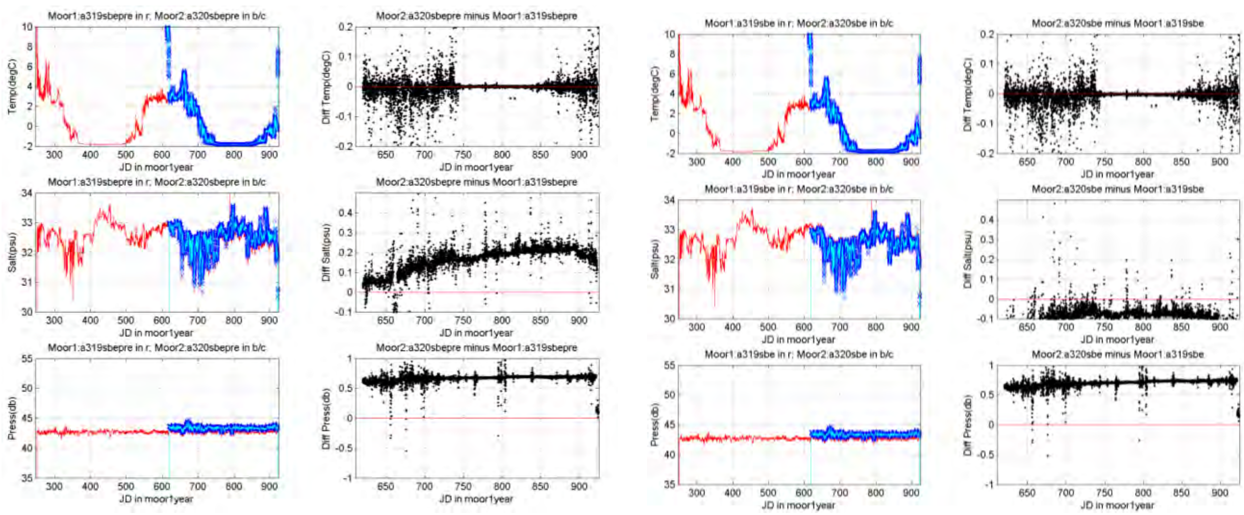


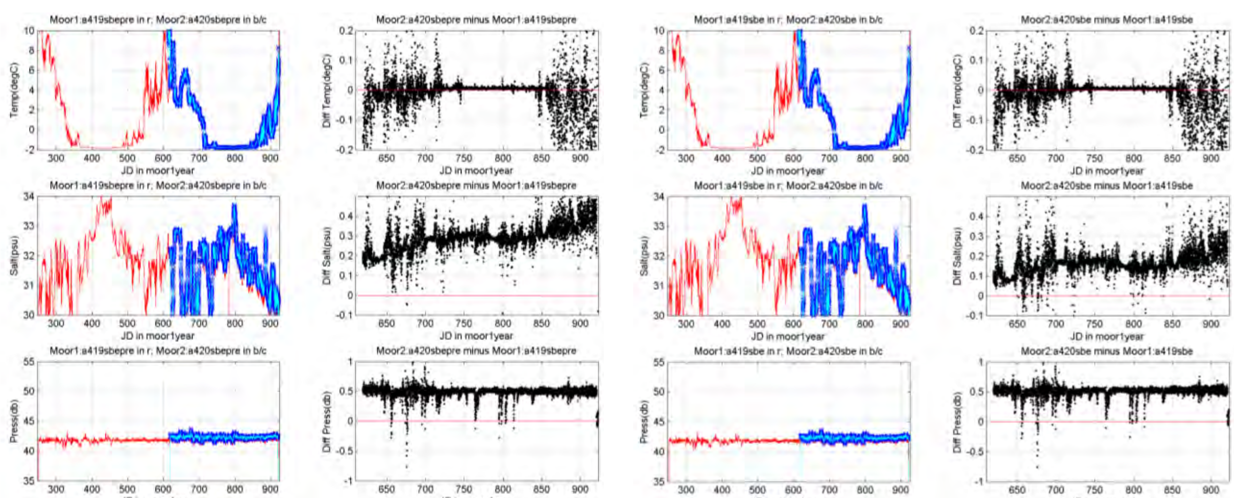
A4-20SBE



Compare to the next year (left = compare of pre cals, right = compare of postcals)



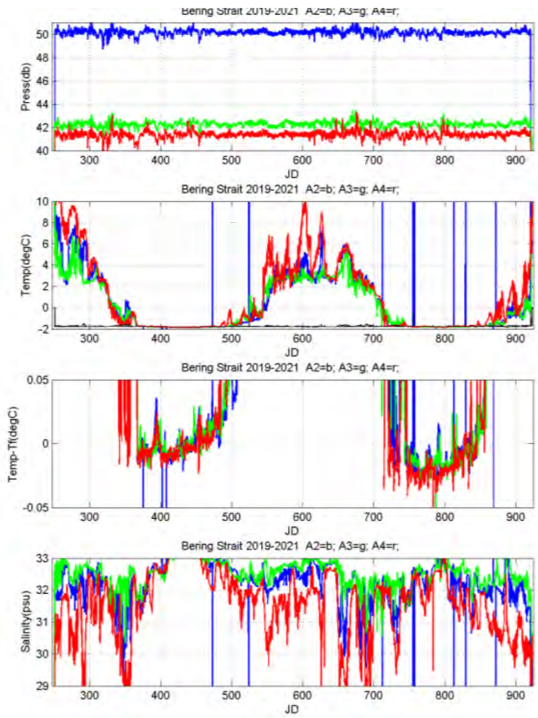


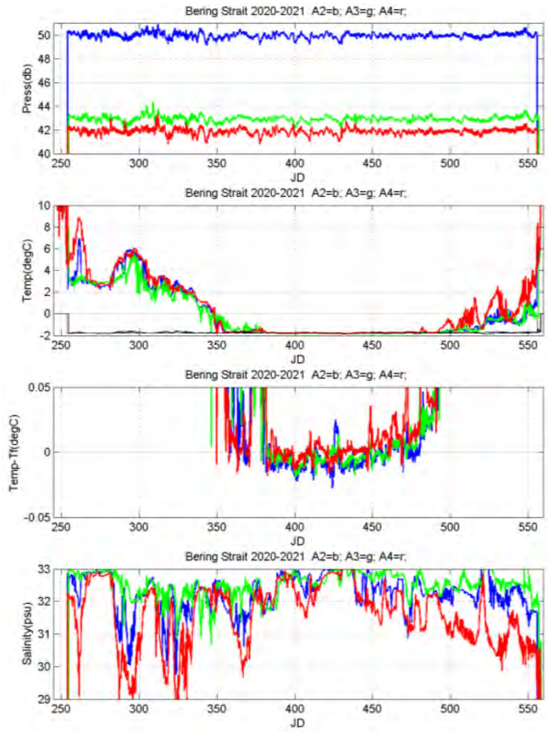


See table for conclusions

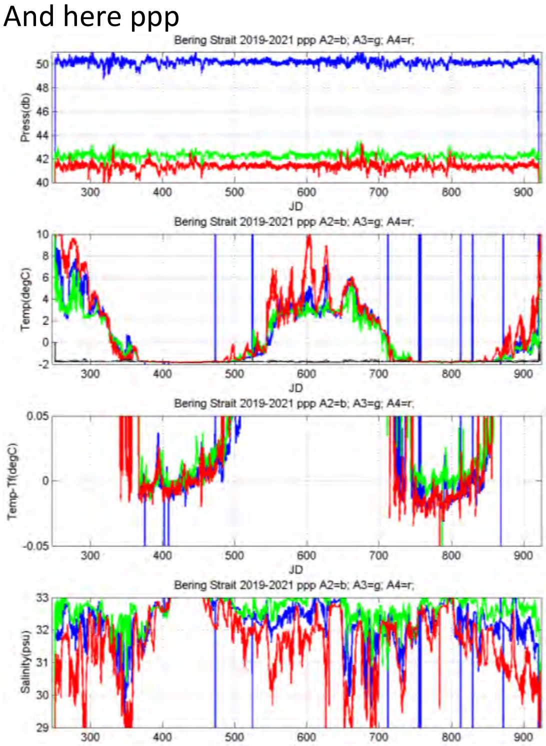
Compare freezing points in winter:

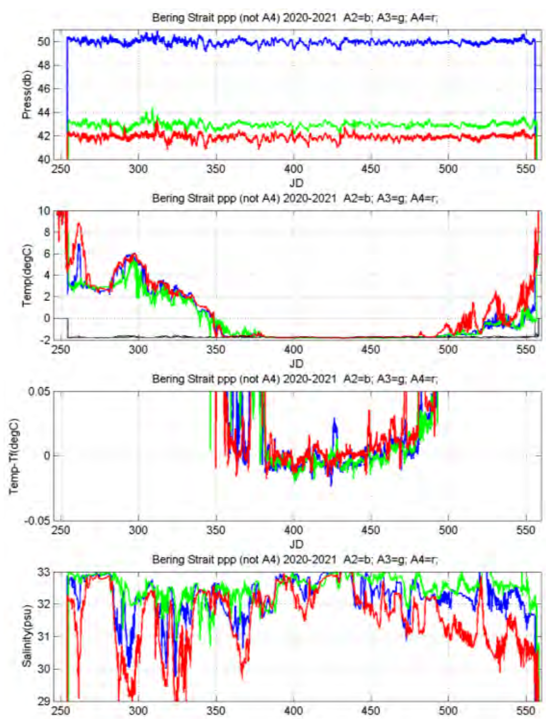
This is precals:





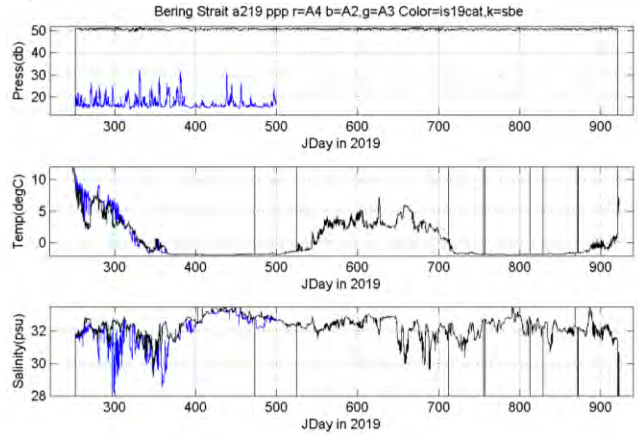
And here ppp

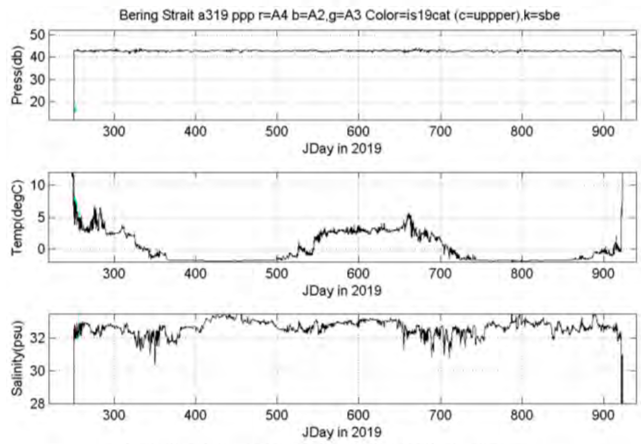


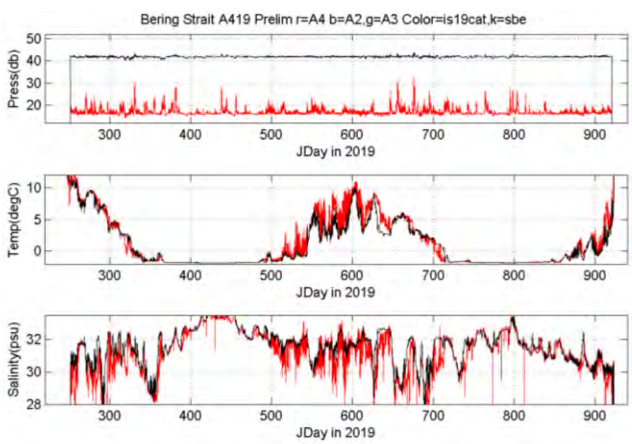


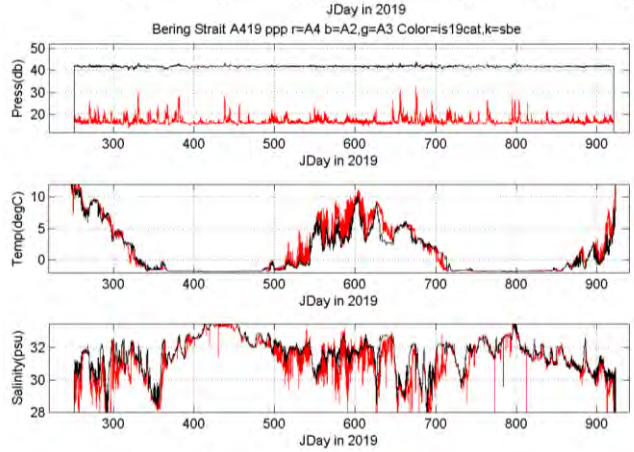
For first winter Ax19s seem ok, but by second winter freezing point is depressed too much.

Now look at ISCATS and SBE data together by mooring:

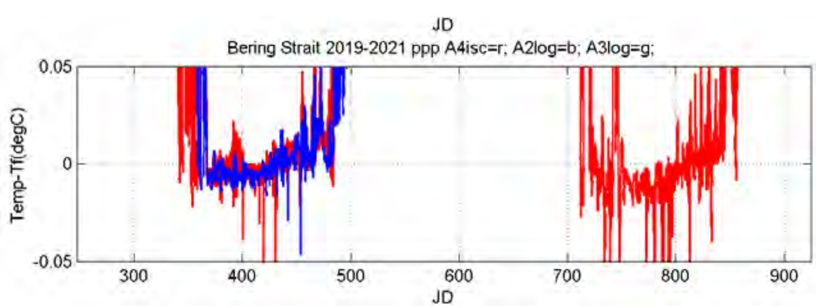




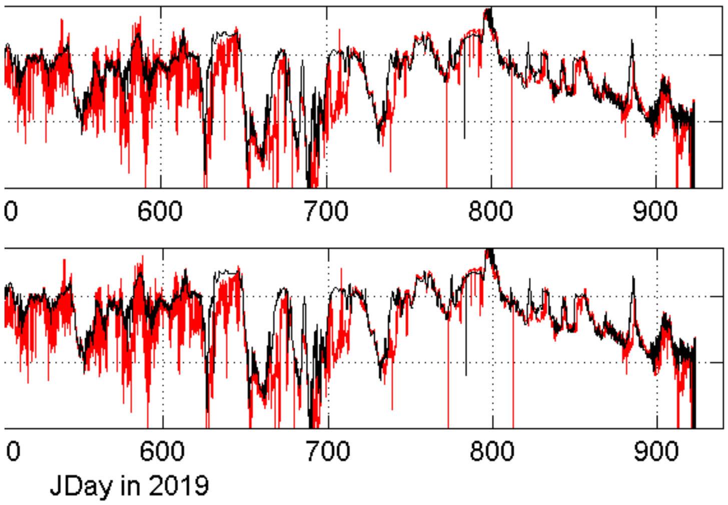




Only A4 has iscat long enough to be useful.



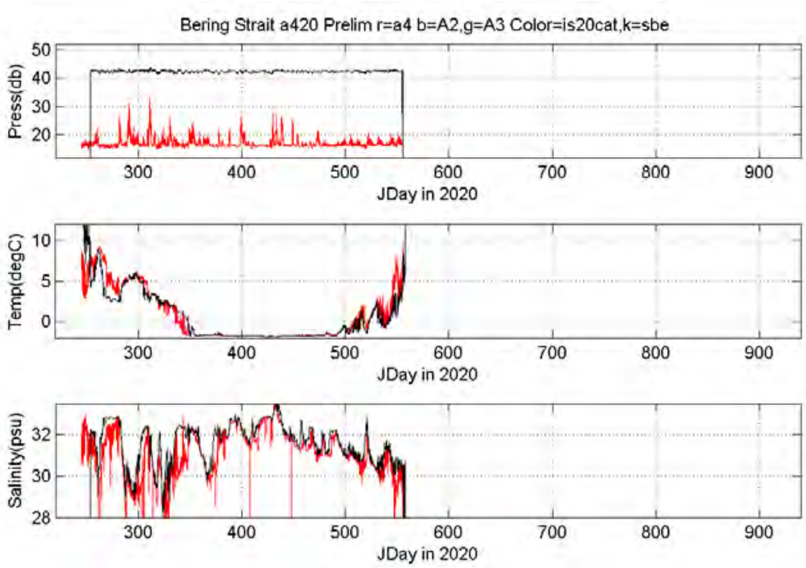
Note that ISCAT winter temperatures suggest year1 salinities ae reasonable, but that A4-19isc salinities may be somewhat too fresh.
(0.005degC equivalent to 0.1 psu),
Although this is not found in the test tank results



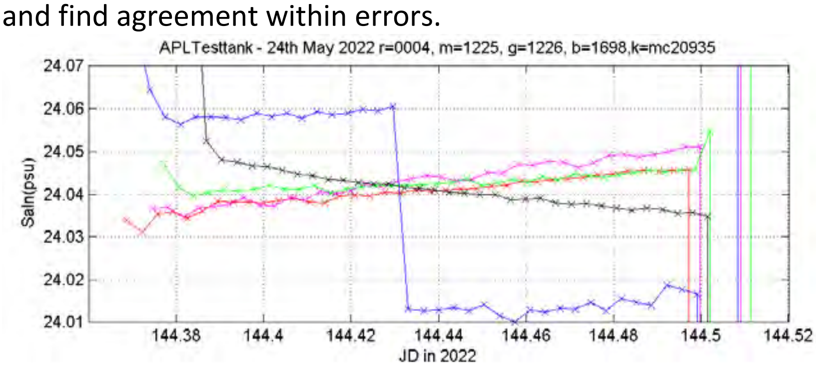
Precal is incorrectly stratified

.. postcal is better.

And then A419isc to compare to A420SBE (only precal)



As missing postcal on A4-20 (#0004) check in Seattle against newly calibrated instruments (May 2022) and find agreement within errors.



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

Recoveries: ***Aural Marine Mammal Acoustic*** sensors on both A3 were deployed by Kate Stafford, (UW). This instruments were cleaned and data storage returned to Seattle for analysis. Preliminary analysis suggests the instrument recorded throughout the mooring deployments.

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 2021 MOORING POSITIONS AND INSTRUMENTATION

ID	LATITUDE (N) (WGS-84)	LONGITUDE (W) (WGS-84)	WATER DEPTH /m (corrected)	INST.
2019 Mooring Recoveries				
A2-19	65 46.855	168 34.070	56	ISCAT, ADCP, SBE16
A4-19	65 44.748	168 15.765	48	ISCAT, ADCP, SBE16
A3-19	66 19.604	168 57.046	57	MISCAT, ADCP with SBE16, MMR

ID	LATITUDE (N) (WGS-84)	LONGITUDE (W) (WGS-84)	WATER DEPTH /m (corrected)	INST.
2020 Mooring Recoveries				
A2-20	65 46.86	168 34.60	56	ADCP, SBE16
A4-20	65 44.75	168 16.31	49	ADCP, SBE16
A3-20	66 19.60	168 57.60	59	ADCP with SBE16, MMR

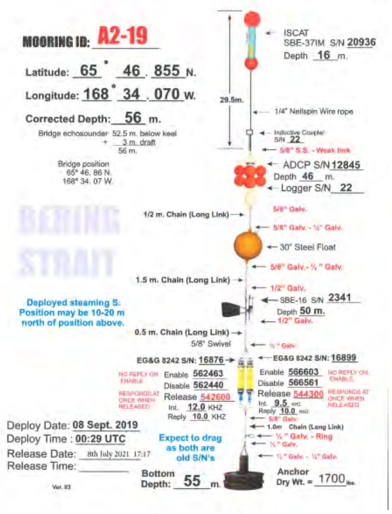
ID	LATITUDE (N) (WGS-84)	LONGITUDE (W) (WGS-84)	WATER DEPTH /m (corrected)	INST.
2021 Mooring Deployments				
A2-21	65 46.849	168 34.089	57	ISCAT, ADCP, SBE16
A4-21	65 44.737	168 15.767	50	ISCAT, ADCP, SBE16
A3-21	66 19.636	168 56.993	59	MISCAT, ADCP with SBE16, new MMR

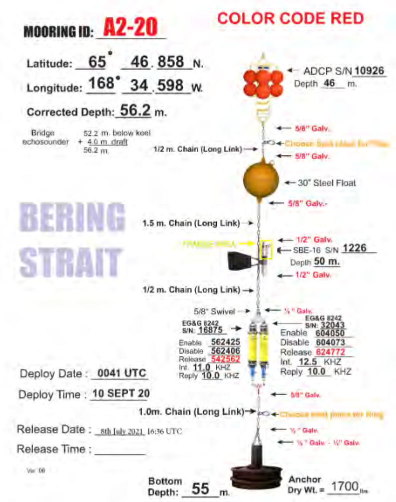
ADCP = RDI Acoustic Doppler Current Profiler
ISCAT = near-surface Seabird TS sensor in trawl resistant housing, with near-bottom data logger
MISCAT = ISCAT with two near-surface sensors (one at ~ 8m, one at ~ 16m)
SBE16 = Seabird CTD recorder, SBE37 = Seabird CTD recorder
MMR=Marine Mammal Recorder (new=new APL version)
For 2019 deployments, water depths are assuming a ship's draft of 3m.
For 2020 and 2021 deployments, water depths are assuming a ship's draft of 4m.

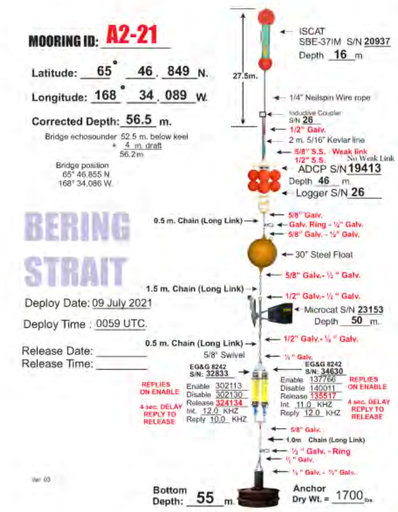
BERING STRAIT 2021 SCHEMATICS OF MOORING RECOVERIES AND DEPLOYMENTS

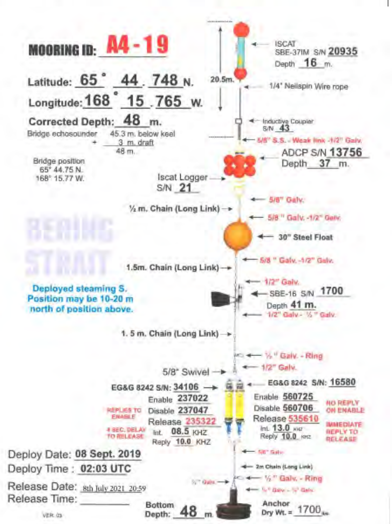
RECOVERED **DEPLOYED**

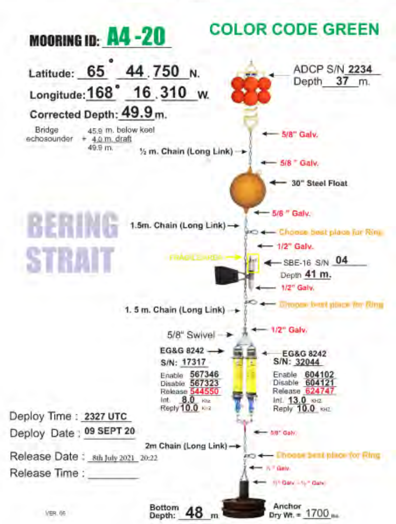
= in the eastern channel of the Bering Strait

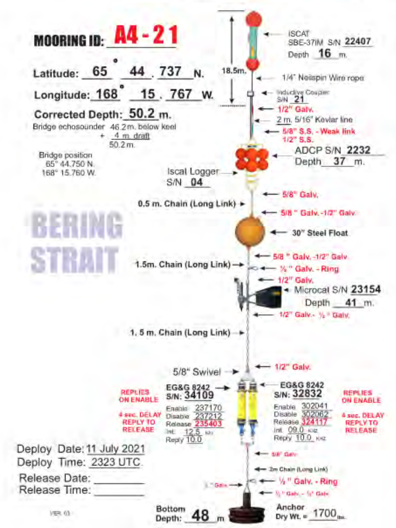




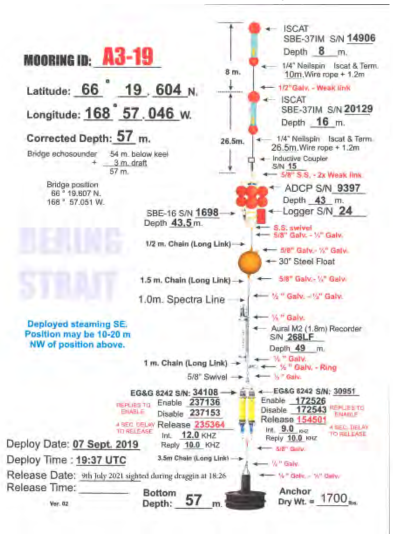


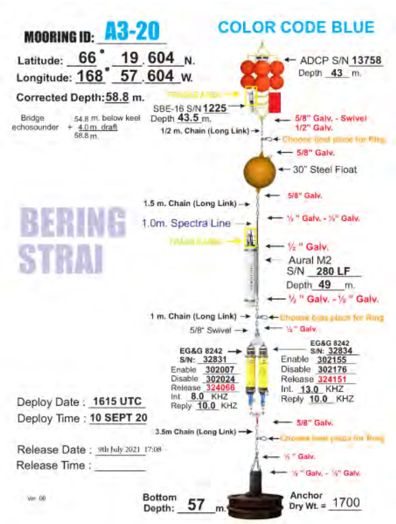


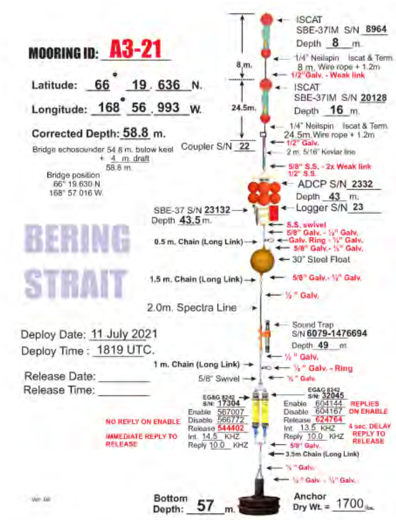




= at the climate site, ~ 60km north of the Strait







BERING STRAIT 2021 RECOVERY PHOTOS

A2-20 Recovery

A2-19 Recovery

BERING STRAIT 2021 RECOVERY PHOTOS (continued)




**A2-19
Recovery
(Bio)**








BERING STRAIT 2021 RECOVERY PHOTOS (continued)

BERING STRAIT 2021 RECOVERY PHOTOS (continued)

A3-20 Recovery

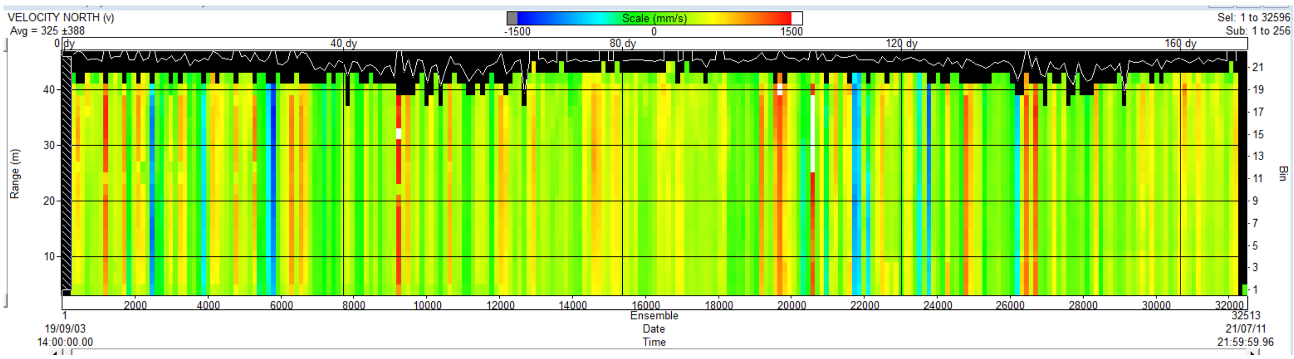
A3-19 Recovery

BERING STRAIT 2021 PRELIMINARY ADCP RESULTS

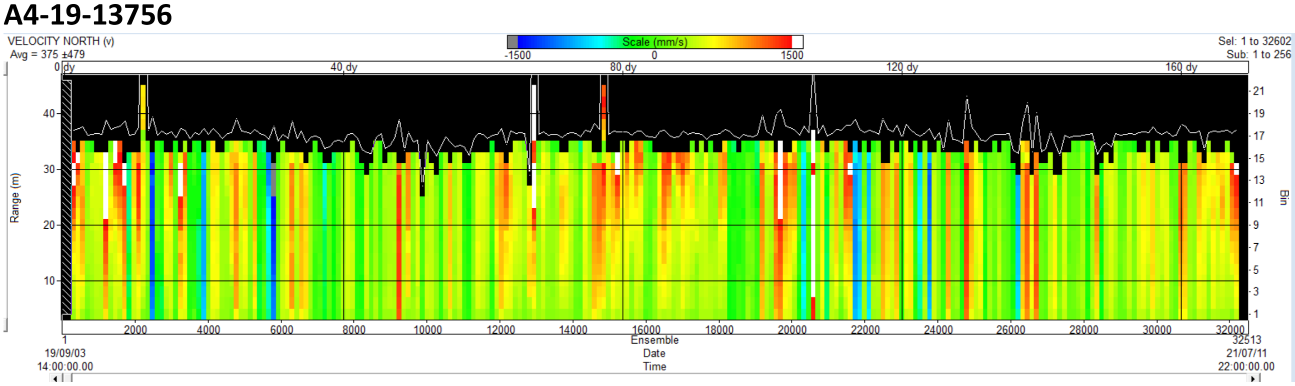
Preliminary plots of northward velocity, and velocity magnitude from the six recovered ADCPS are given below.

NORTHWARD VELOCITY from Bering Strait 2019-2021 ADCPs

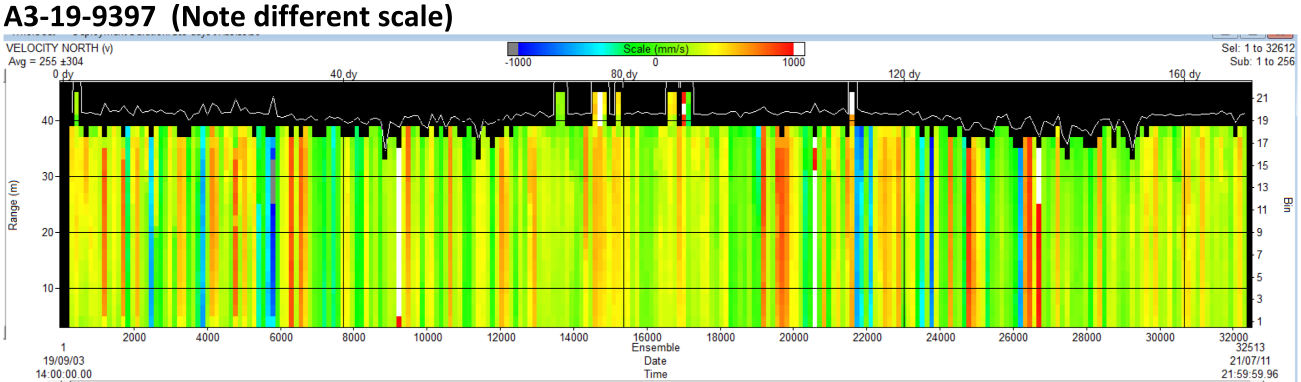
A2-19-12845



A4-19-13756

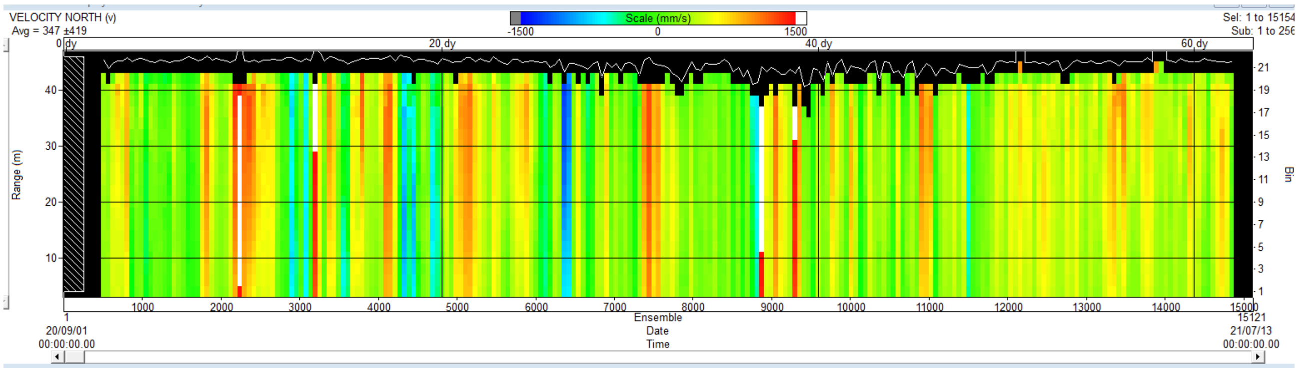


A3-19-9397 (Note different scale)

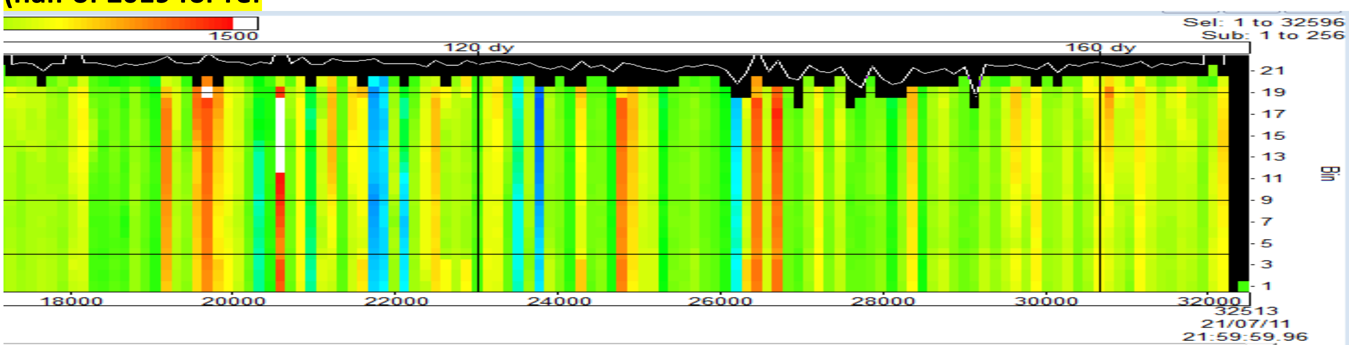


NORTHWARD VELOCITY from Bering Strait 2020-2021 ADCPs

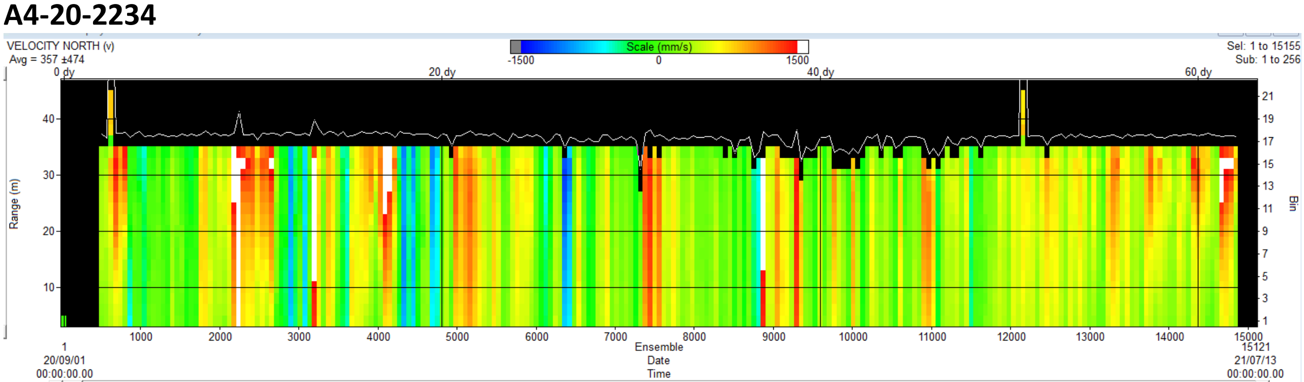
A2-20-10926



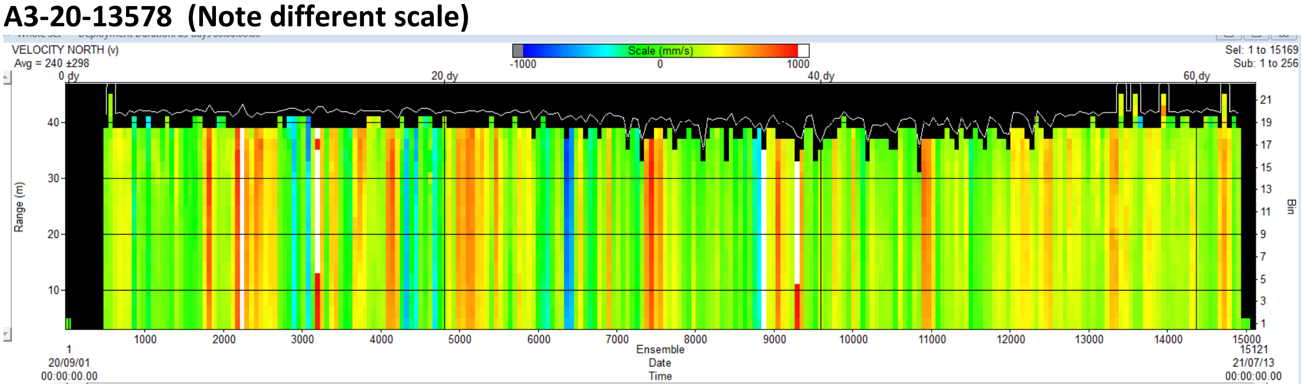
(half of 2019 for ref



A4-20-2234

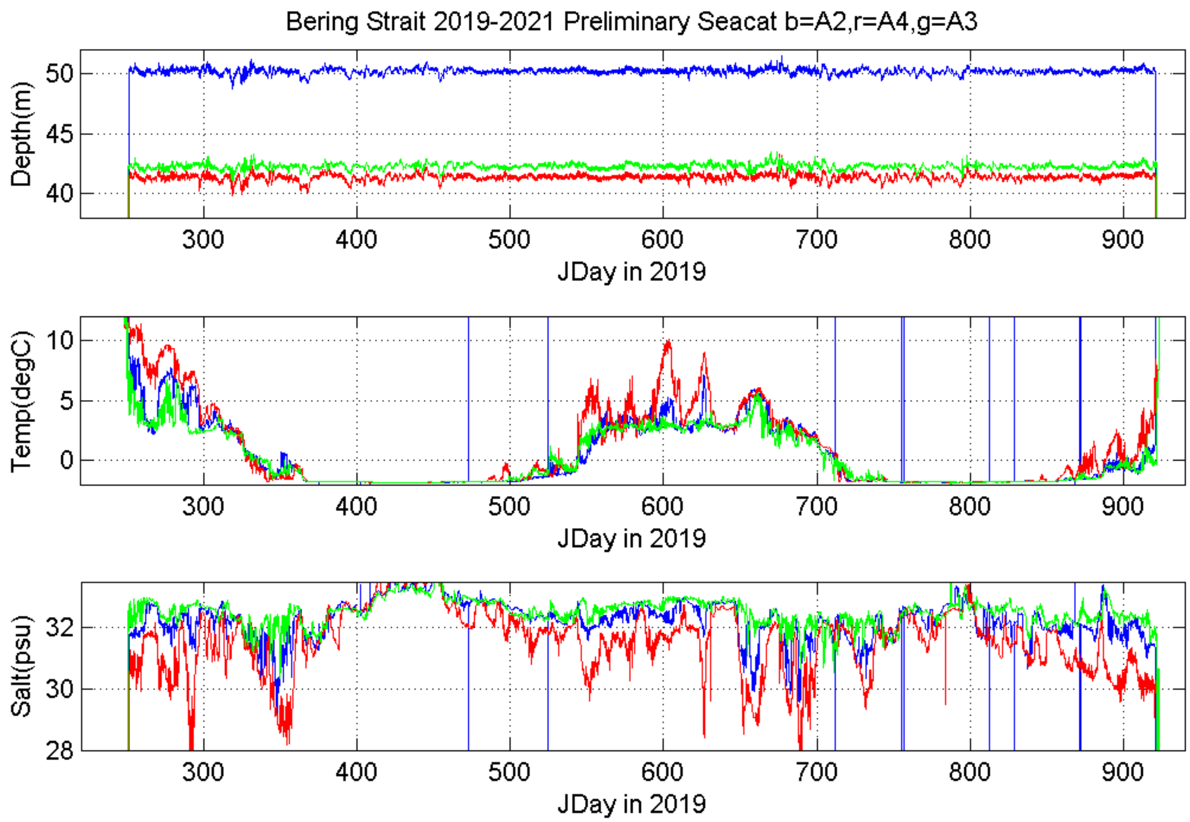


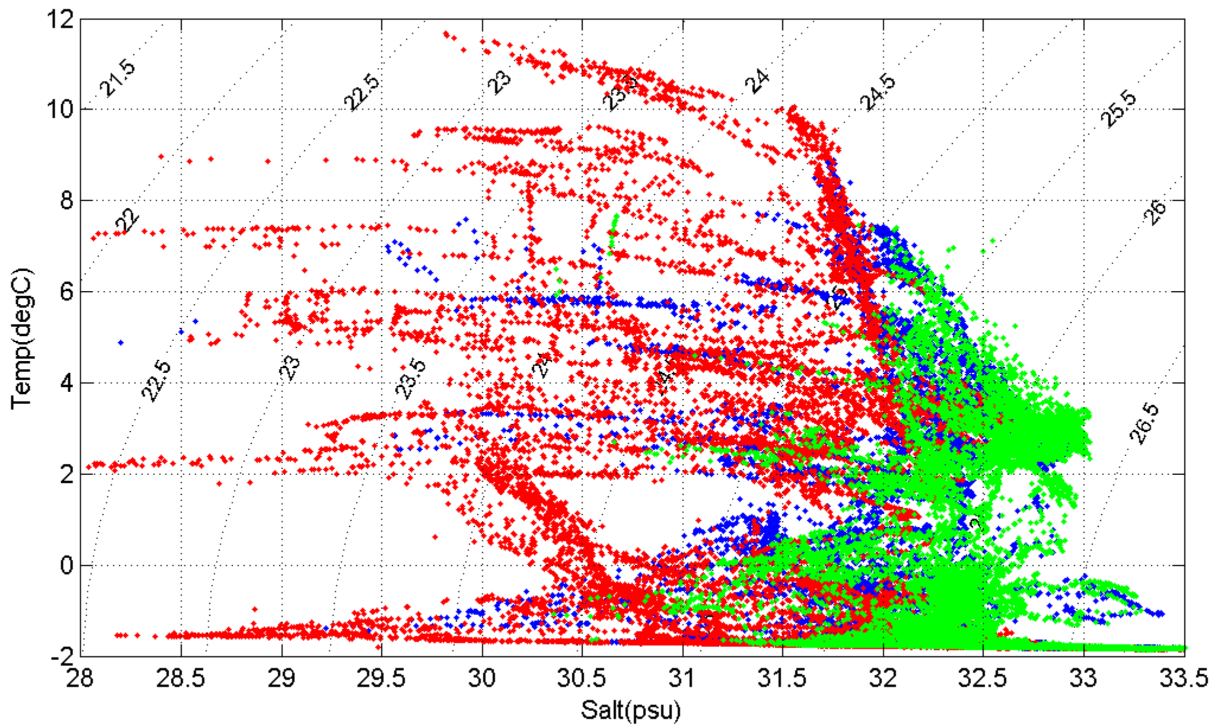
A3-20-13578 (Note different scale)



BERING STRAIT 2019-2021 SBE PRELIMINARY RESULTS (2 years, Ax19data)

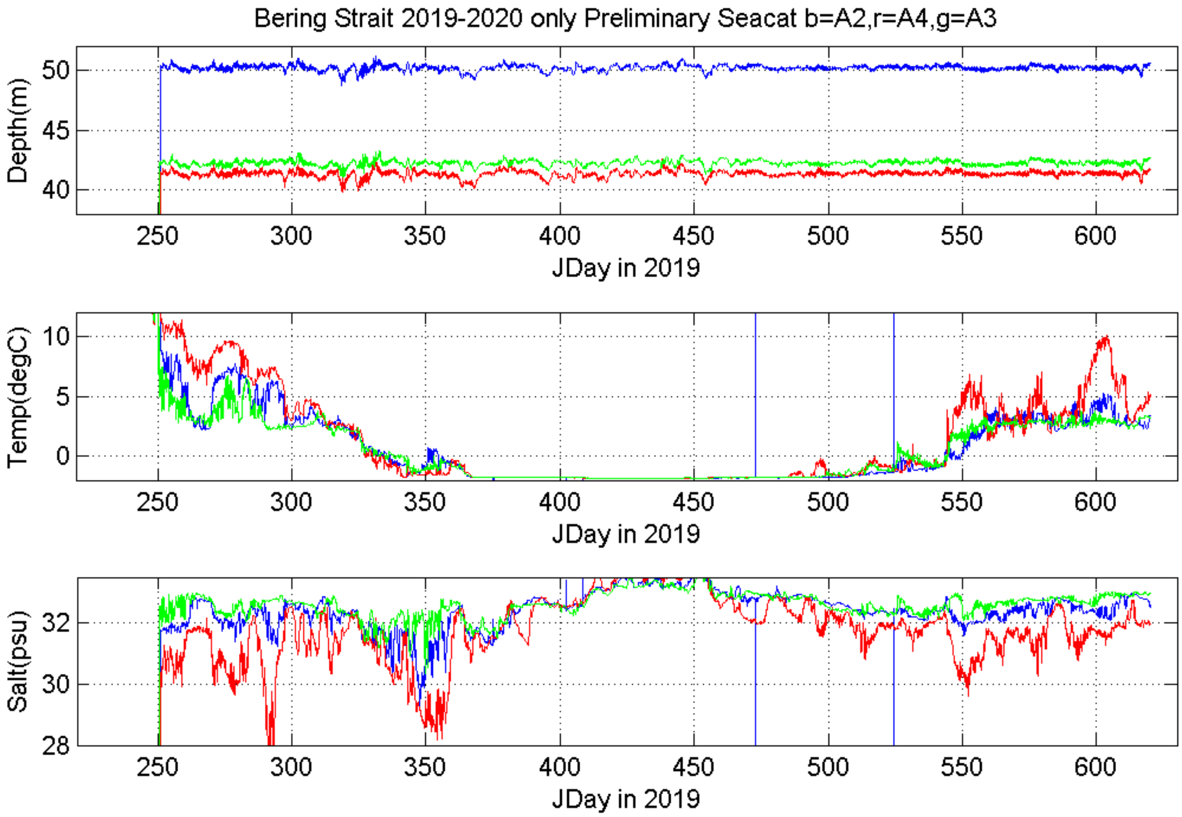
– all lower level TS Sensors

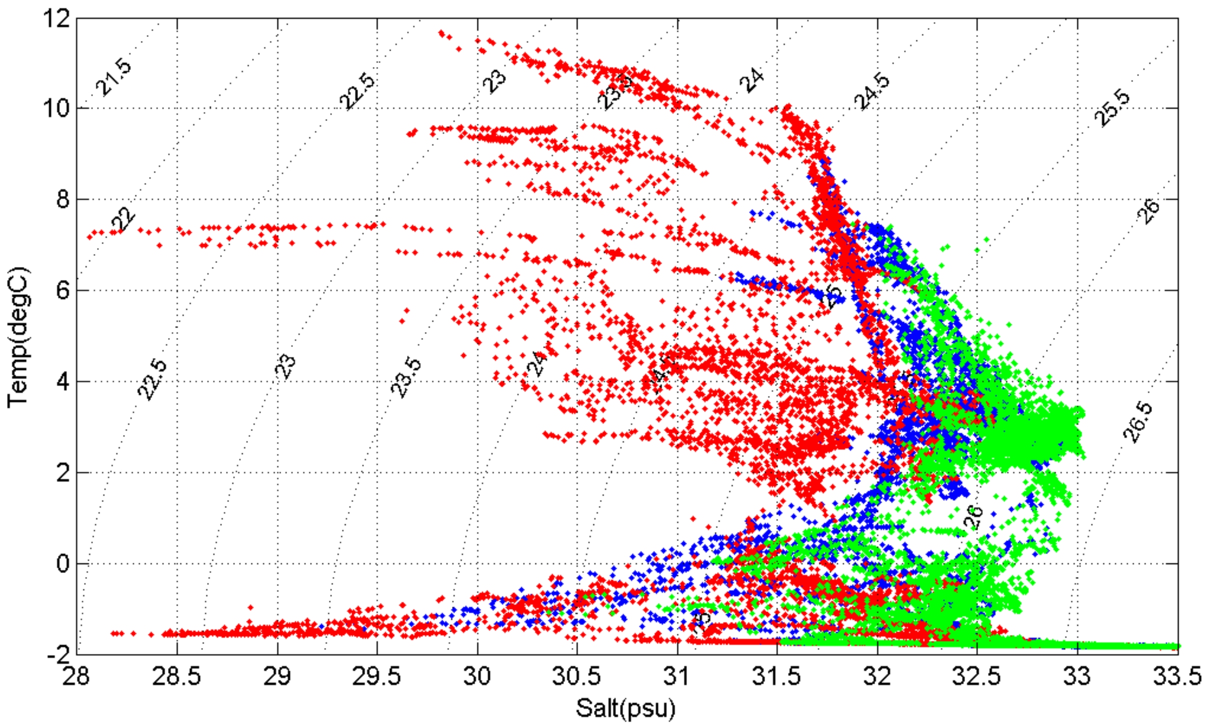




BERING STRAIT 2019-2020 SBE PRELIMINARY RESULTS (Ax19 data)

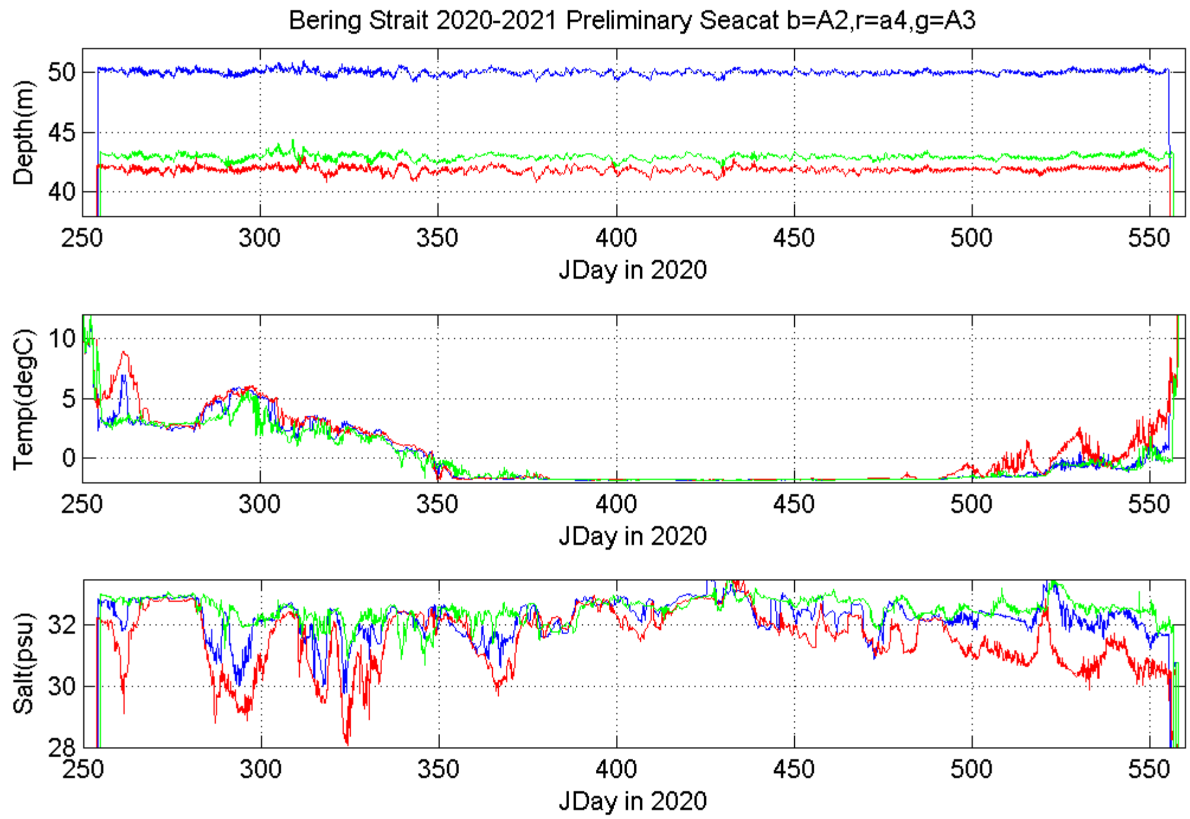
– all lower level TS Sensors (first year of data only)

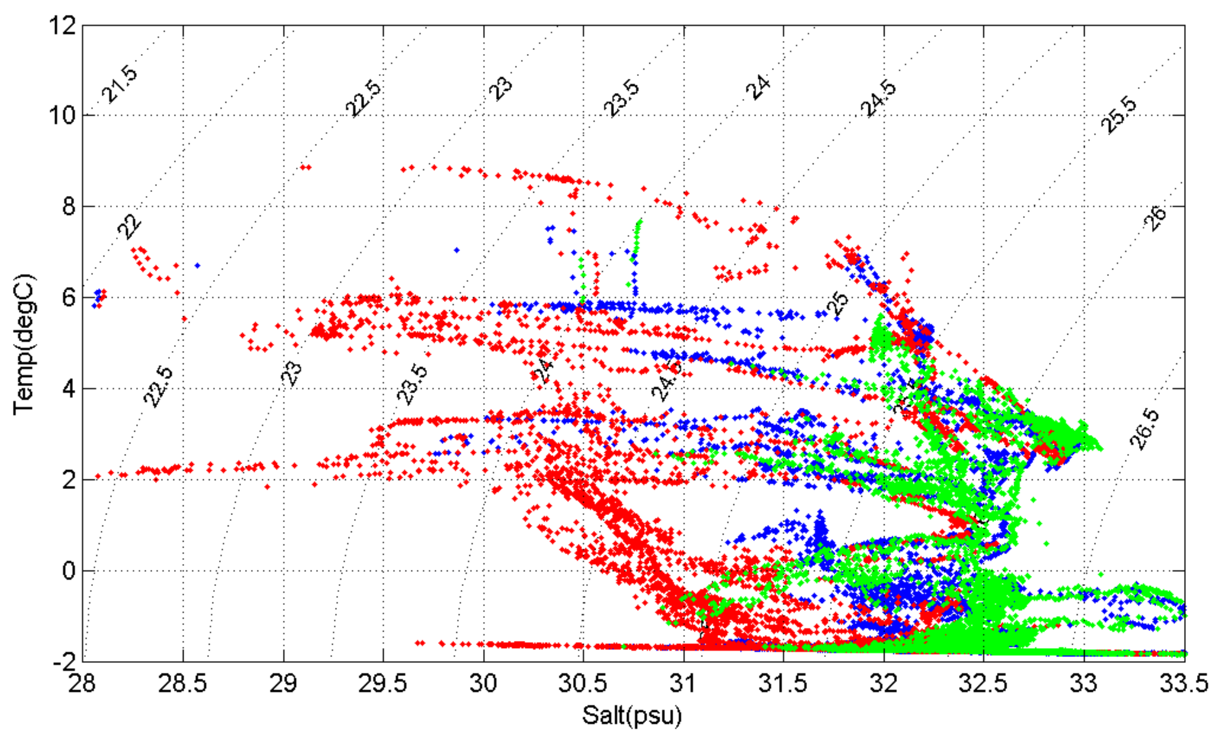




BERING STRAIT 2020-2021 SBE PRELIMINARY RESULTS (Ax20 data)

– all lower level TS Sensors



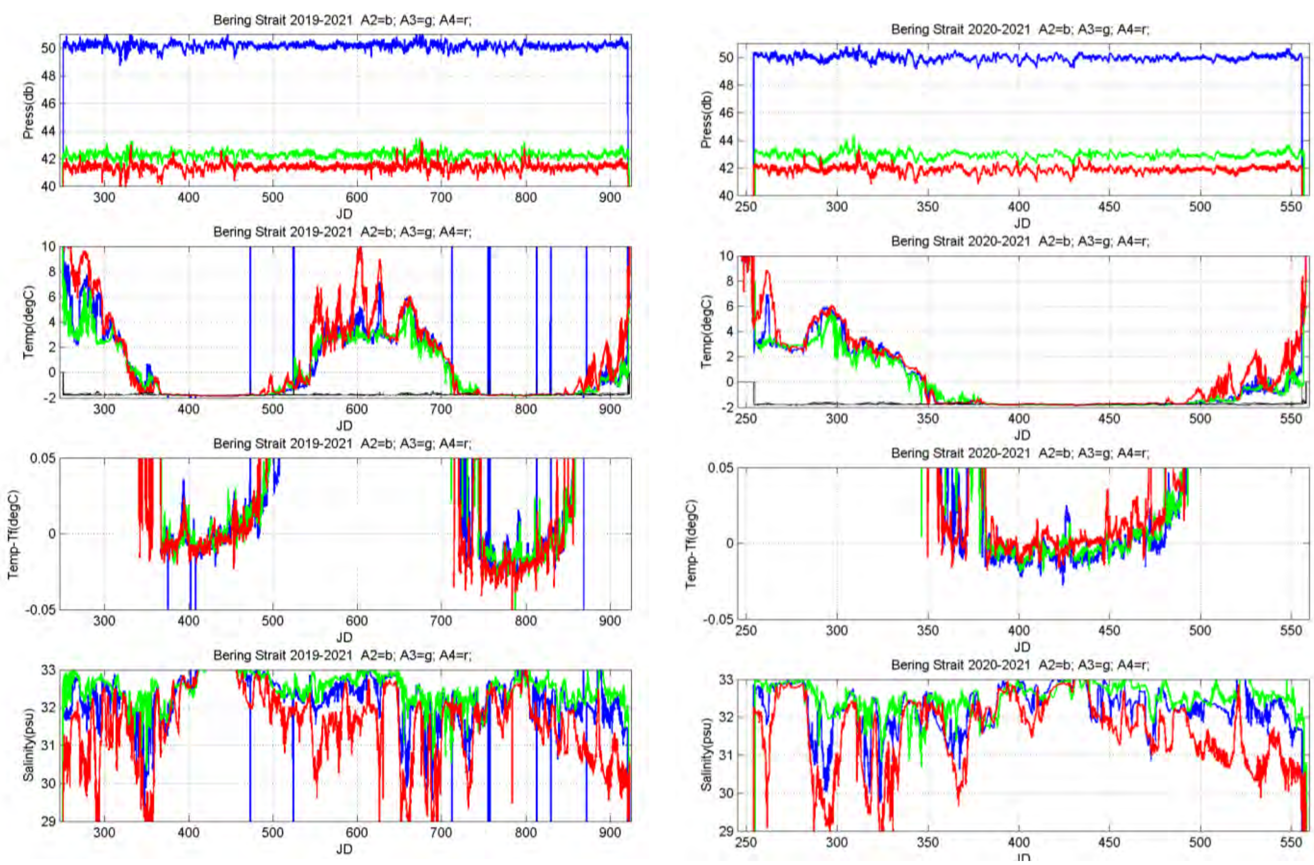


BERING STRAIT 2019-2021 SBE PRELIMINARY RESULTS (2 years, Ax19data)

– all lower level TS Sensors

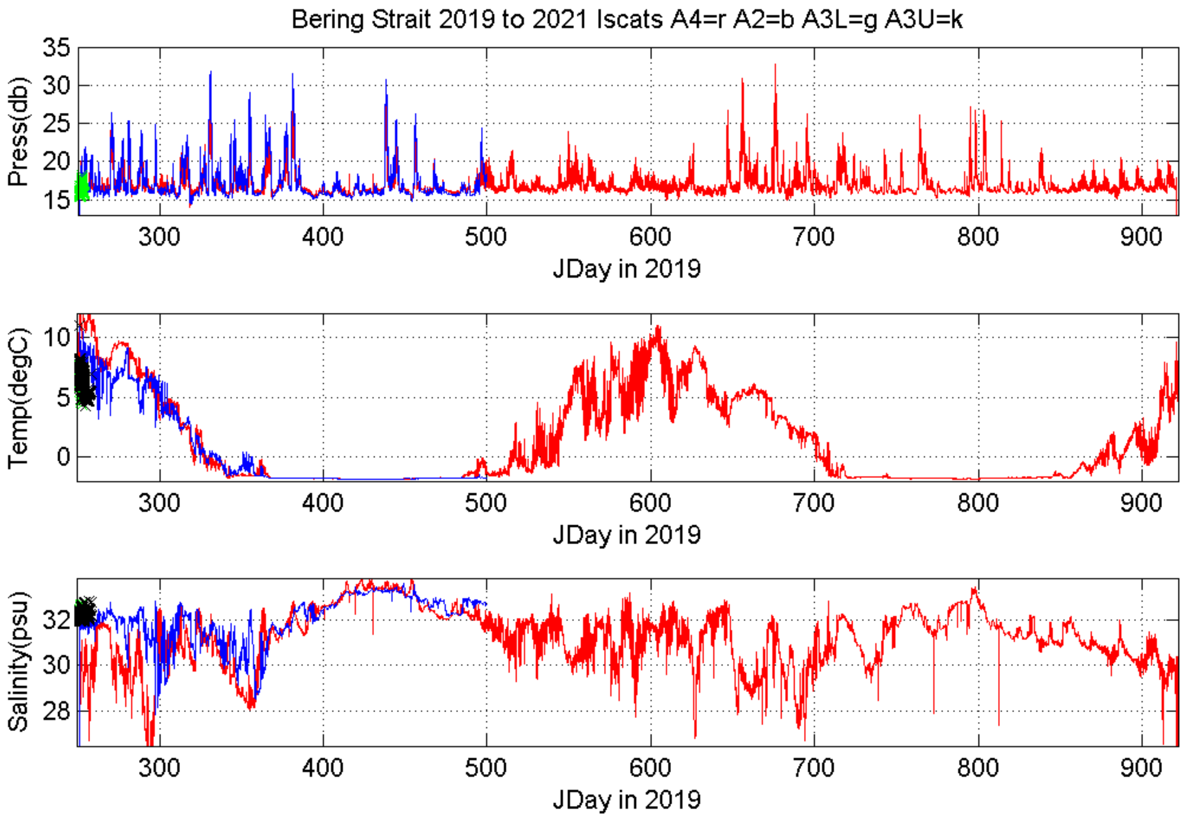
Comparison to freezing temperature

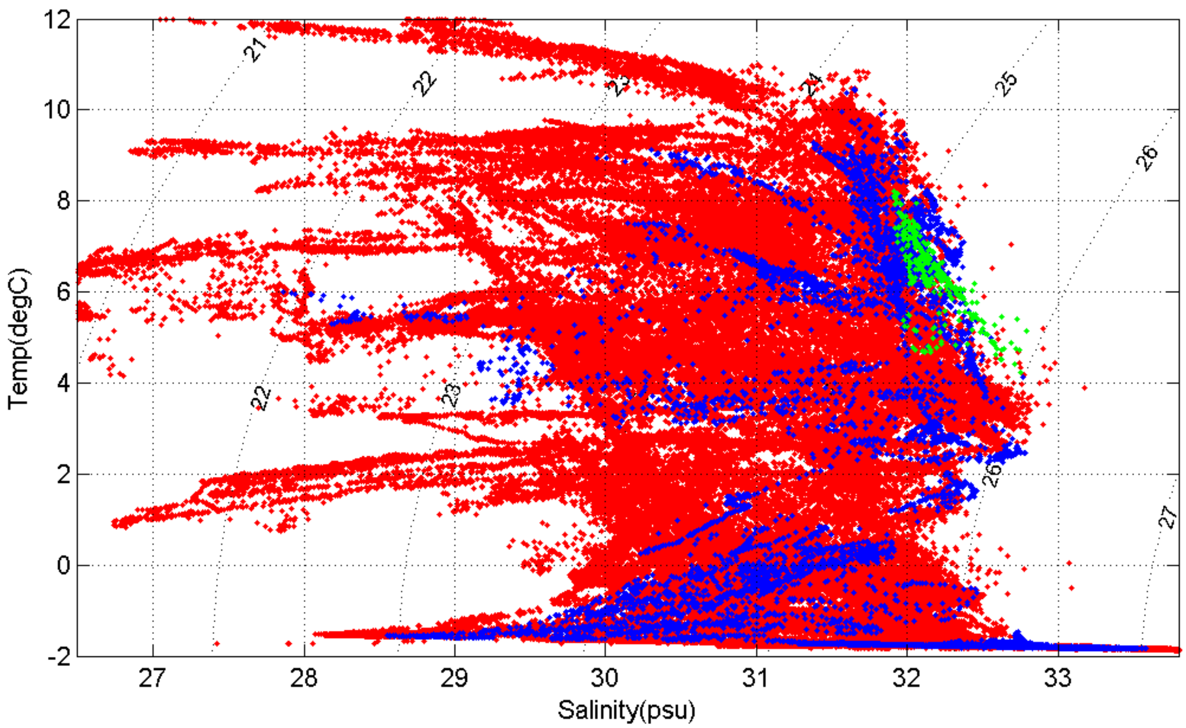
Note the Ax19s have a greater freezing temperature departure in winter, indicating the cumulative effect of biofouling



BERING STRAIT 2019-2021 ISCAT PRELIMINARY RESULTS (2 years)

– all upper level TS Sensors

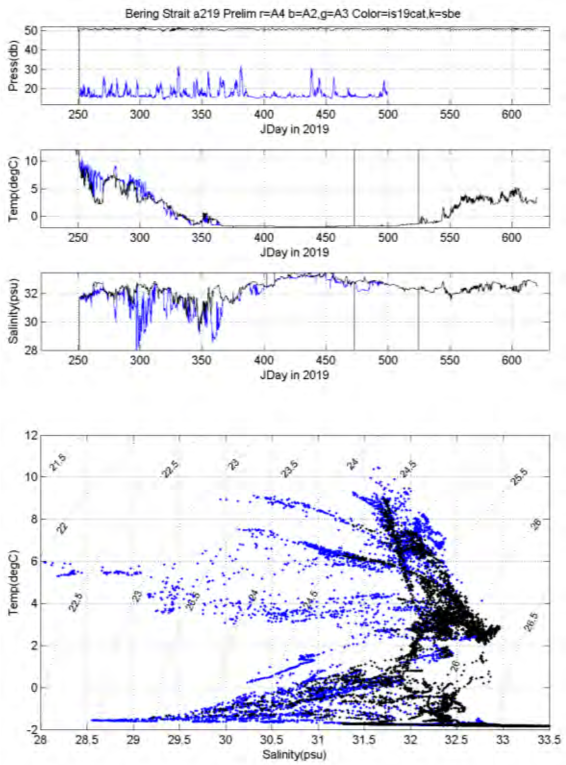




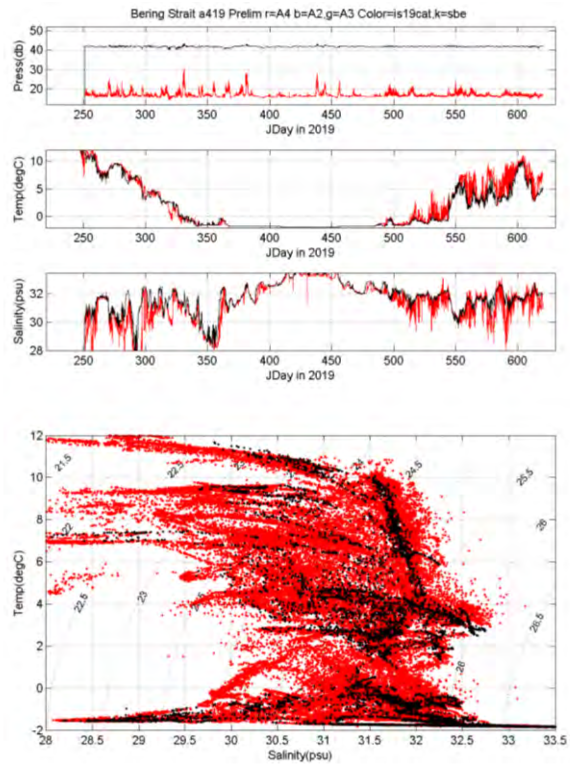
BERING STRAIT 2019-2020 ISCAT and SBE PRELIMINARY RESULTS (Ax19data)

–upper and lower TS sensors by mooring

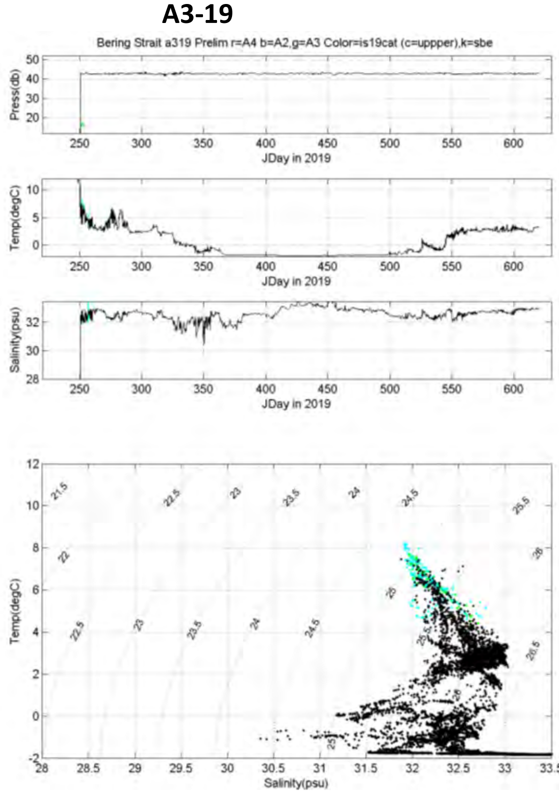
A2-19



A4-19



A3-19

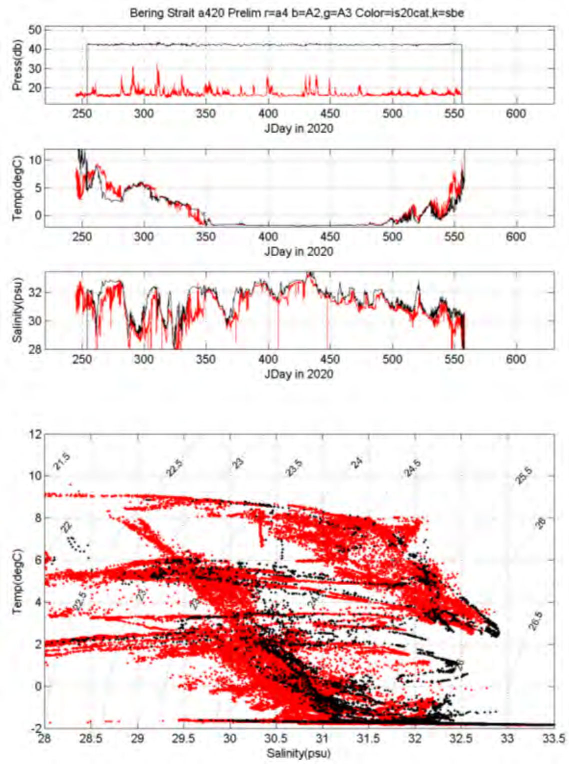


BERING STRAIT 2020-2021 ISCAT and SBE PRELIMINARY RESULTS (Ax19&Ax20data)

–upper and lower TS sensors by mooring
(only A419 iscat still present)

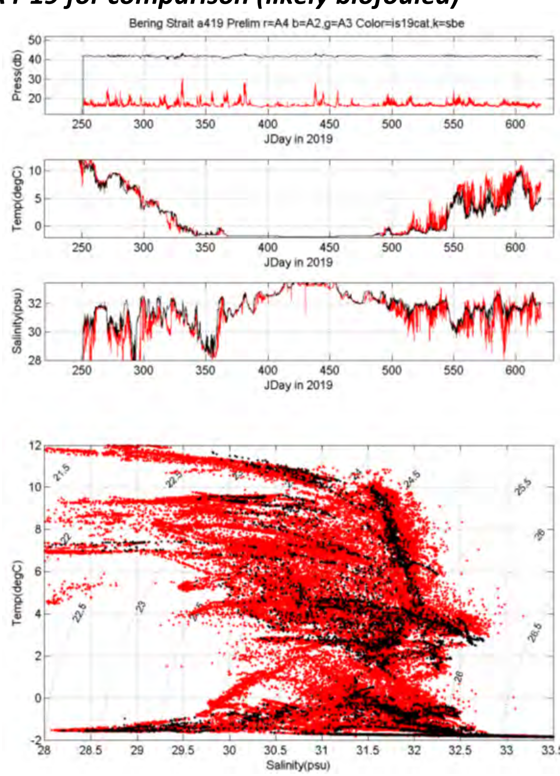
A2-20 (no iscat deployed)

A4-20 (iscat from A3-19)



A3-20 (no iscat deployed)

A4-19 for comparison (likely biofouled)



CTD OPERATIONS (On-board lead: Christensen)

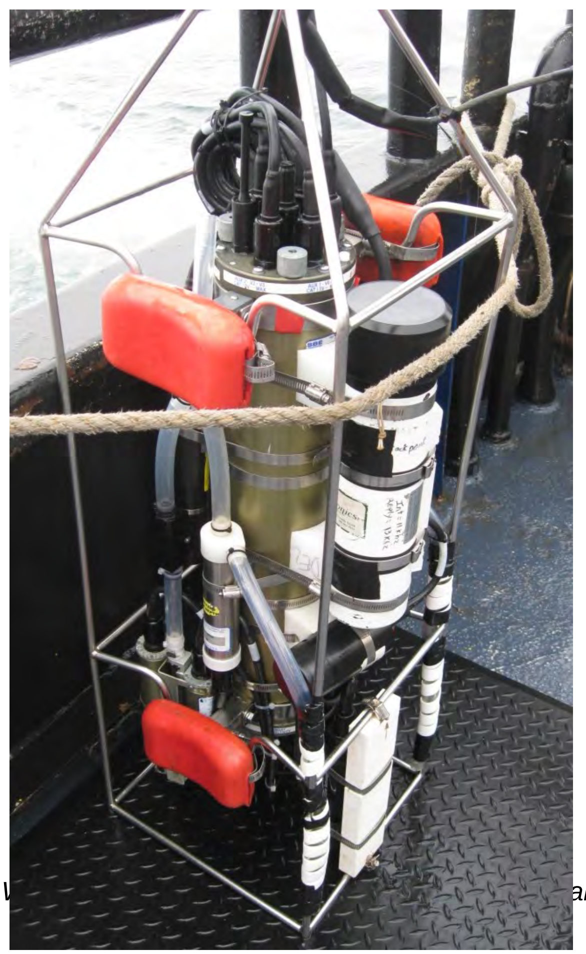
As in previous years, in 2021 the moorings were supported by annual CTD sections. This year (as per 2014, 2015, 2016, 2017, 2018 and 2019) these sections were run without taking any bottle samples, although this year a separate pumped system was used to take trace metal and nutrient samples (and two samples for later O18 analysis).

The CTD rosette system used on this cruise was loaned from APL-UW and, was the same set up as in 2016, 2017, 2018 and 2019 (the same set up as in 2014/2015,with the exception of the transponder). The full package consisted of:

one SBE9+ with pressure sensor
(SN26451 – calibration 17th June 2019)
two SBE3 temperature sensors
(T1 = SN0843 – calibration 28th Jan 2021)
(T2 = SN0844 – calibration 28th Jan 2021)
two SBE4 conductivity sensors
(S1 = SN0484 – calibration 11th Feb 2021)
(S2 = SN0485 – calibration 2nd Feb 2021)
two SBE43 oxygen sensors
(Ox1 = SN1753 – calibration 4th Feb 2021)
(Ox2 = SN1754 – calibration 4th Feb 2021)
one Wetlabs FLNTURT fluorescence/turbidity sensor (SN1622 – calibration 11th March 2010)
one Benthos Altimeter (SN50485, repaired spring 2015)
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 a y-like connection system, whereby the exit vent of the loop was at the same depth as the intake as per recommendation from the manufacturer. The top of the Y contained a slow leak valve (the vent plug) to keep the system sea-water primed on removal from the water. Tests in Seattle in 2014 showed air in the system was expunged after ~ 45s of emersion in water.

All instruments were housed in one frame (see left, photo from prior cruise), weighted with diving weights to ensure a close-to-vertical cast, as per 2014**.**

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 2021, we found the termination had been changed to a plug which did not fit our system. Thus a temporary fix was installed for a test cast by Robert Daniels and Jim Johnson, and after the test cast, a more permanent potted connection was installed. **Action item: Check with ship pre cruise re termination.**

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 forward GPS (since the aft-Aframe GPS was giving the wrong date). **Action item: Check the ship is carrying a spare GPS antenna.**

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, and regularly (every few casts) transferred ashore via google drive for analysis. Additionally, as each cast was completed, a WhatsApp photo of the screen shot was sent ashore for cruise/data quality tracking.

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 2021 the crew operated the winch from a remote console on the deck by the A-frame, and still, as in previous years, winch speed was an issue. 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.**

The A-frame was set slightly outboard and not repositioned during the cast - the package was lifted to the height of the aft rail of the ship by the winch, and swung inboard by hand. 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 at the rail.

Once mooring work was complete, CTD operations were run 24hrs, using a team (per watch) of 1 science team member driving the CTD, and 2-3 personnel on deck - one (ship's crew) driving the winch, and one or two ship's crew/scientists recovering the instrument. This cruise, the science team provided 1 person for deck for 12 hrs a day in good weather and for an extra 12hrs in bad weather, since in bad weather, it was deemed necessary to always have two persons catching the CTD as it came aboard.

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 lines. Since the CTD system required ~ 1min in the water to allow for the pumps to turn on (initiated by a manual command sent by the CTD driver), the CTD was generally put over the side and down to ~ 7m before the ship had come to a complete stop. Experience allowed the crew to time this such that, by the end of the 1min soak, the ship had come to a sufficient stop. Once the ship was stopped, the CTD pump was on and data were reliable, the CTD package was returned to ~ 1m depth (just below surface) and then was lowered to the sea floor, target depth ~ 3m above bottom, see discussion below. Only a brief (1-2 s) pause was taken at the bottom before the CTD was returned to the surface, and then recovered. If the cast was successful, the ship would start to move away just as the package was being recovered. Note on these stations, taken without any bottles, it was not necessary for the cast to be entirely vertical.

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**.

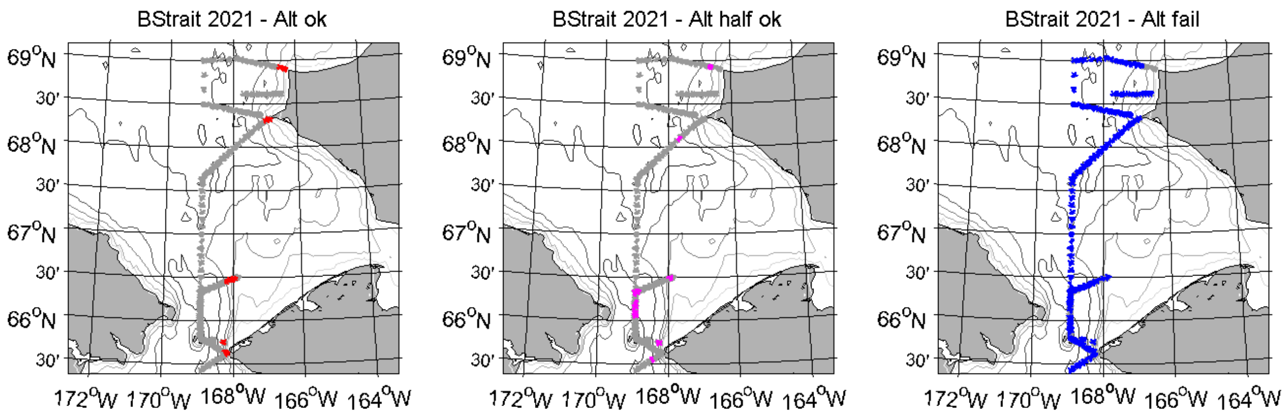
Prior to each cast the turbidity sensor was cleaned by rinsing with soapy water and freshwater and wiping. **Action item: Bring syringe with better fit for flushing the CTD cell.**

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 rarely functioned, some casts stop 5m-6m above the bottom.

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

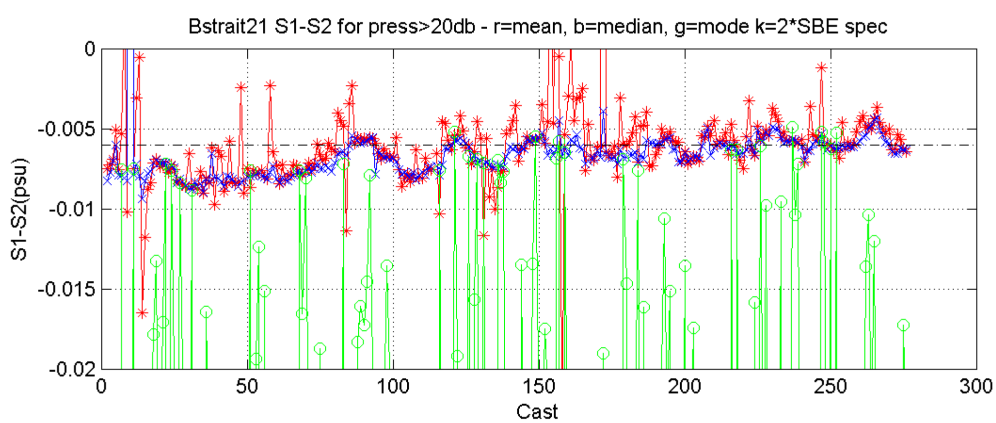
1) For casts up to and including 10. Significant mismatch was found between the up and down casts in salinity and oxygen, indicative of a timing mismatch between the sensors. (Cast 10 was run with pumps off to check the pumps were working - they were.) Investigation of the system found the TS duct was missing. When this was replaced (for cast 11 onwards), the mismatch became much smaller - almost unnoticeable in salinity, though still present in oxygen. The later was found to be greatly improved by data processing (see below).

2) Altimeter. In previous years, it was found that the altimeter only performed well intermittently, and the pattern of success and failure appeared to be strongly correlated with water temperature. This year, being early the season, the waters were generally colder and the altimeter was primarily useless. **On viewing sections, recall bottom 3+m may be unsampled. Actin Item: Next year, reconsider bottom depth decisions in light of warmer waters.**

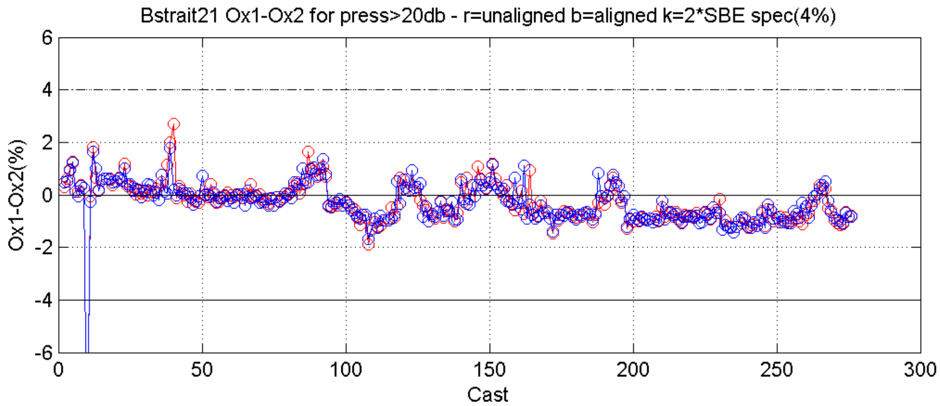


3) Vent plug blocking. As in previous years, the blocking of the vent plug due to impurities in the water was a continual concern. We instigated a cast-by-cast check that the tubes were draining once the CTD was recovered and if either was slow, the plugs would be cleaned with wire. **Action item: Continue this check in other years.** High vigilance to this issue this year resulted in fewer problems with the data, but data should still be checked for this problem. (Suspect casts: 16, 42, 62, 63, 117, 172(recast as 173)

4) Offset between Salinity sensors. Prior years found an offset in salinity between the two sensors on the CTD. This year, a similar offset was observed (with S1 reading fresher as in prior years). The CTD should be accurate to 0.003psu, and thus discrepancies of < 0.006psu (marked as dashed line on plot) are within specifications. Early in the cruise (and after cast 222, which is suspected to have hit bottom), the sensors were flushed, and at the start of the cruise an airtest test taken which may be used later for information. In general, agreement was just within manufacturer's specifications. **Action item: Flush cells with freshwater on deck at start of cruise and at regular intervals.**



5) Offset between Oxygen sensors. Once aligned in post processing, differences between oxygen sensors were also within manufacturer's specifications.



6) Other cast issues:
- cast 25 was yoyoed after the main cast to examine the Oxygen maximum. For the archives, a trimmed version of this file has been made (with the original cast number) including the original full down and up cast. The full yoyed cast is retained as "orig".

- cast 114 was aborted as the CTD came out of the water, and recast as cast 115

- cast 172 (end of the LIS line) has an usual midlayer intrusion, worth further investigation

- cast 172 had vent plug issues, and was immediately recast (without recover) as cast 173

- cast 222 contains interesting layering at the surface (and is suspected to have hit bottom, making oxygen data suspect on the upcast.

NOTES ON BERING STRAIT 2021 CTD PROCESSING

For 2021, we have new cals for T, C and Ox, so we are running with:

Pressure 17thJune 2019 - this is the new one, and has a new SN of 26451
T1 (#843) 28th Jan 2021
T2 (#844) 28th Jan 2021
C1 (#484) 11th Feb 2021
C2(#485) 2nd Feb 2021 -
Ox1 (1753) 4th Feb 2021
Ox2 (1754) 4th Feb 2021
FLNTURT (#1622) - 11th March 2010-

These are accurately in the BStrait21nnn.xmlcon files.

SUMMARY OF PROCESSING ISSUES 2021

=== casts 0-10 were done missing TS duct and thus there is significant alignment issue with Conductivity. As these were all calibration casts looking at the deep water, while the issue appeared in the layers above/below a temperature gradient, these casts have not yet been specially processed

== cast 10 was done with pumps off (a repeat of cast 9)

== cast 16 - vent plug issues

== cast 25, as an oxygen test, was yoyoed after the main cast to below the depth of the oxygen maximum and recovered slowly. ... original file is included as 025orig. 025 is trimmed to only the full initial cast

.

== cast 42 - suspect vent plug issue
== cast 62 - vent plug issues
== cast 63 - vent plug issues

== cast 114 was aborted as CTD came out of water. Recast as 115
== cast 117 - salinity issues

== cast 158 spike in C1

== cast 172 - vent plug issues, Recast as 173

= cast 222 is suspected to have hit bottom. Oxygen data suspicious on up cast.

== many casts struggle with sharpness of thermocline giving spikes in Salinity. - aligning seems to fix this
== Almost all casts show align issues with Oxygen - using Ox34 seems to mostly fix this

Results recorded by cast in master CTD log file **RWnoteson2021BstraitCTDcasts.xls**

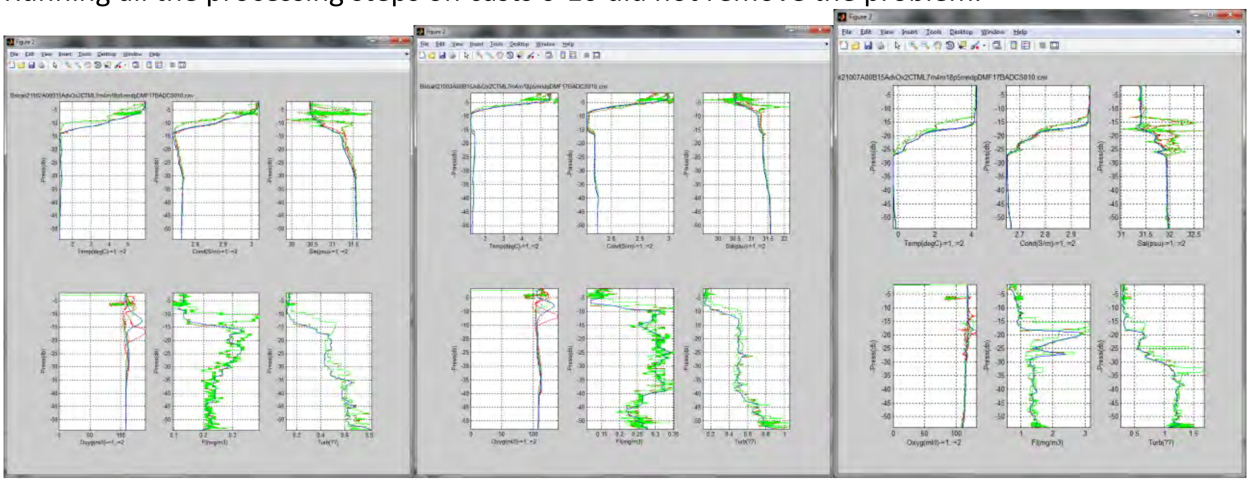
FULL NOTES ON BERING STRAIT 2021 CTD PROCESSING   Rebecca Woodgate (based on 2019)
Start with files from SeaSave for each cast, i.e.,
Bstrait21nnn.hex and Bstrait21nnn.hdr

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

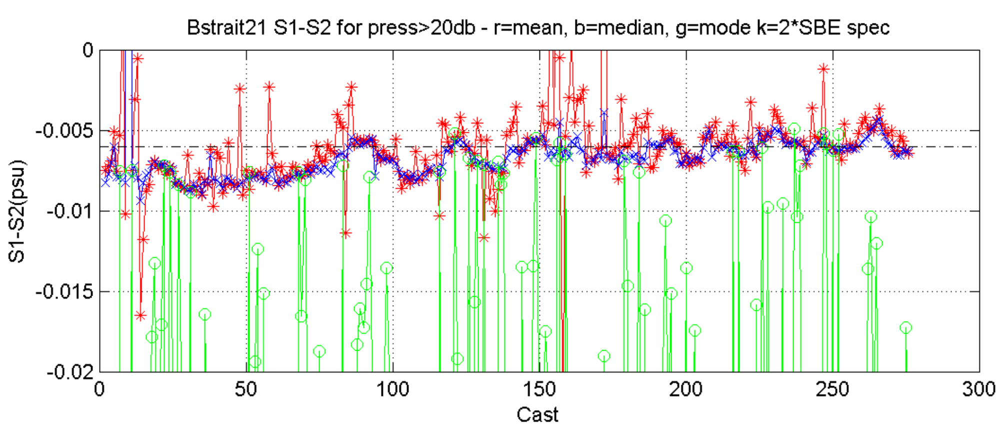
=== 1)   First make up a file to be used for quick plotting. This contains all variables, but is not corrected in any way.
IN SBEDATA PROCESSING, RUN: DATA CONVERSION
(PSA file for this = 001_DatCnvBStrait2021_allvars.psa)
Inputs are: BStrait21nnn.hex and BStrait21nnn.hdr
*In FILE SETUP
-- CHECK box 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
...—Merge Header file
-- Select output variables... as in previous years 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)
-- 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.
THIS GIVES files called: BStrait21nnn.rw1.cnv

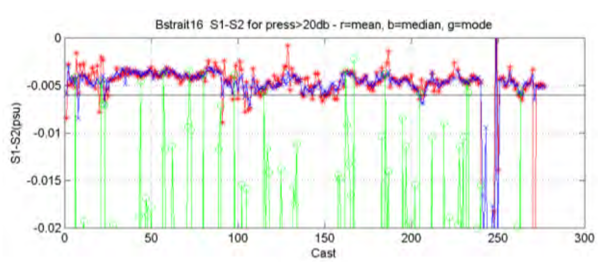
=== 2) Do first basic quality control by plotting everything in Matlab
Matlab master code = **testplotsBStrait2018RW.m** which calls subroutine **CTDQCpump.m**
Inputs are: BStrait18nnn.rw1.cnv
Checks here include:
--- that the pump comes on
--- that the altimeter is working
--- that T1=T2, S1=S2 and Ox1=Ox2
--- preliminary identification of spikes and other issues.

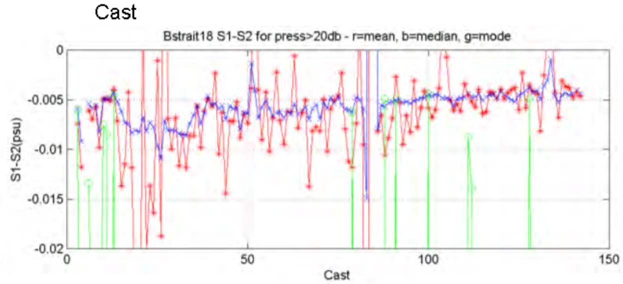
Running all the processing steps on casts 0-10 did not remove the problem.



Examination of the system found that the TS Duct was missing.
Once the TDuct was installed, salinity differences became closer to and finally within manufacturer's specs







Worse than 2016 but on a par with 2018

=== 3) Now work through the 7 steps 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 = DatCnvBStrait2021_CTDforprocess.psa)
Inputs are: BStrait21nnn.hex and BStrait21nnn.hdr
*In FILE SETUP
-- CHECK box on match instrument to configuration 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.)*
-- 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)
-- 15) 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.
THIS GIVES files called: BStrait21nnn.cnv

=== 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 = FilterBStrait2021_CTDforprocess.psa)
Inputs are: BStrait21nnn.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
*In FILE SETUP
-- Name append = A00B15 *... this indicates data was filtered (Note: makes only small changes to the data)*
THIS GIVES files called: BStrait21nnnA00B15.cnv

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

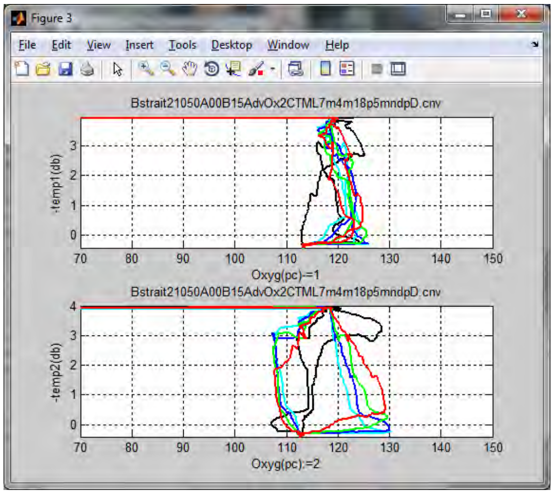
This step is to compensate for the delay between the water passing the various sensors in the pumped pathway. For the SBE9plus, the manuals suggest that
- the temperature advance relative to pressure =0
- that the salinity advance relative to pressure is 0.073s, but this advance is set in the SBE11plus 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.

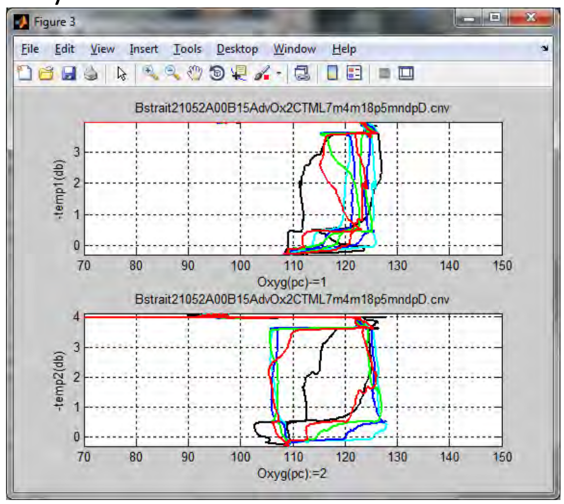
IN SBEDATA PROCESSING, RUN: ALIGN
(PSA file for this = AlignCTDBStrait2021_CTDforprocessOx34.psa)
Inputs are: BStrait21nnnA00B15.cnv
*In DATA SETUP
--> Enter Advance values
-- Oxygen: 2 *(as recommended in SBE9+ manual (2 to 5), and tests suggest in 2014 and 2015)*
-- All others: 0
*In FILE SETUP
-- Append added = AdvOx5
THIS GIVES files called: BStrait21nnnA00B15AdvOx2.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.
R=2,g=3,b=4,c=5
Previous years have segregated casts into which colors are good. Here we look at casts up to 30 and spot check beyond that:

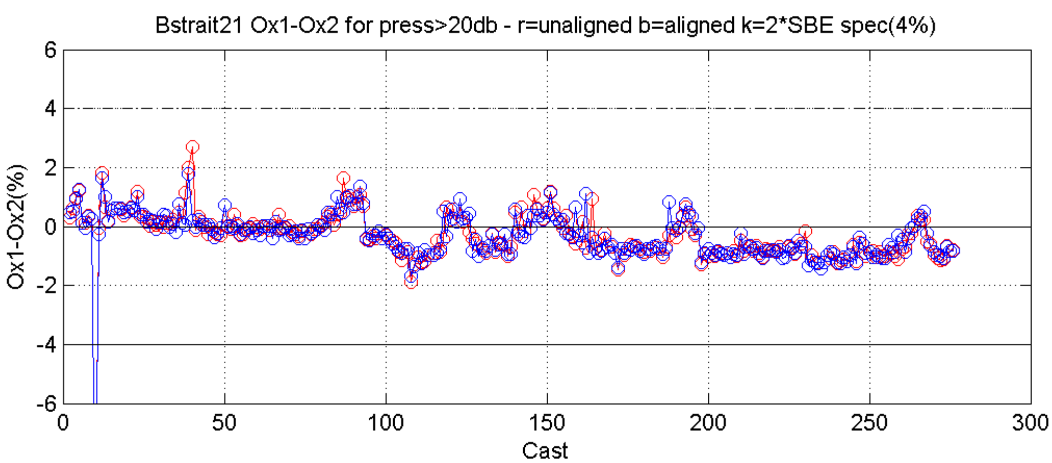
Black (0)	Red (2)	Green(3)	Blue (4)	Cyan (5)	Unclear
Primary Sensors	10,14,15,20	13,16,18,19,21,22,23 24,25,26,27,28,30	12		
Secondary Senors		19	18,20,21,22,23,24,25 ,26,29,30	15.16,27	

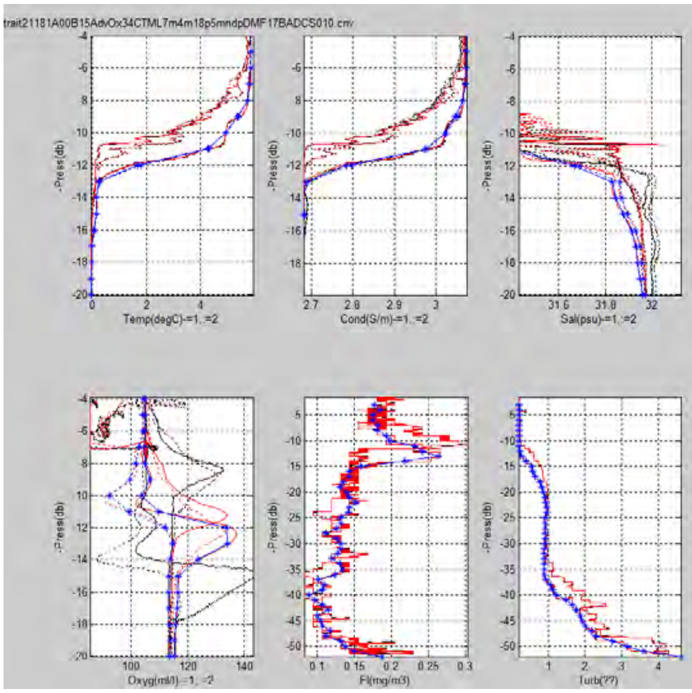
By this tally, Green(3) has the best fit most often is Green (3) for system1 and blue (4) for system 2.
Use this here even though previous years have used (2).
Again show that up and down casts by differ by 5%-10%.





Finally conclude:
- at this stage will use Ox1, as it shows less spread than Ox2.
- alignment is generally best for both as +3 for system 1 and +4 for system 2.
- recognize that up and down casts may differ by 5%-10% .
- agreement between sensors within manufacturer's specs





Check to see how much aligning fixes the problems in S and Ox with sharp T gradient:
K = unaligned
- Note S inversion
- Note Ox + and -ve peaks at different depths

Red = aligned (Ox34)
Blue = Bin av down cast.

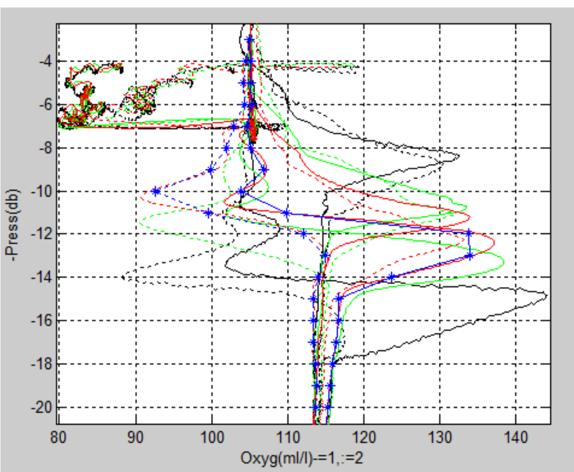
SO
- has fixed S overrun very effectively

- has moved ox peaks to be about same mag, and all +ve and a reasonable depth given difference in depth on up and down cast.

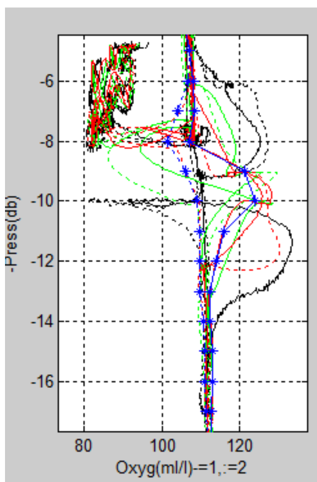
And this is all well reflected in bin average

And ox at 34 (red) is slightly better than ox at2 (green)

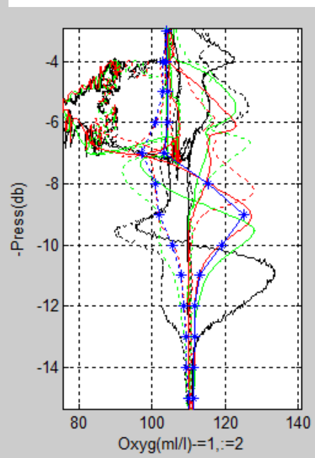
181



183



184



184 -- ok with Ox1, less so with ox2

=== 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 = CellTMBStrait2021_CTDforprocess.psa)
Inputs are: BStrait21nnnA00B15AdvOx234.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: BStrait21nnnA00B15AdvOx34CTM.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 we again adopted these settings. The only problematic casts are:

Cast 25,.. which was yoyoed because of initial discrepancies in the data.

In preliminary processing, copy the original hex file to 025orig, and take a trimmed version through the processing instead

IN SBEDATA PROCESSING, RUN: LOOP EDIT
(PSA file for this = LoopEditBStrait2021_CTDforprocess.psa)
Inputs are: BStrait21nnnA00B15AdvOx34CTM.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: BStrait21nnnA00B15AdvOx34CTM 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 = DeriveCTDBStrait2021_CTDforprocess.psa)
Inputs are: BStrait21nnnA00B15AdvOx34CTML7m4m18p5mndp.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.
*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: BStrait21nnnA00B15AdvOx34CTM 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_FilterCTDBStrait2021_CTDforprocess_MF17.psa)

Inputs are: BStrait21nnnA00B15AdvOx34CTM 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%

-- Append added = MF17

THIS GIVES files called: BStrait21nnnA00B15AdvOx34CTM L7m4m18p5mndpDMF18.cnv

=== 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 = BinAvgBStrait2021_CTDforprocess.psa)

Inputs are: BStrait21nnnA00B15AdvOx34CTM L7m4m18p5mndp.cnv &
BStrait21nnnA00B15AdvOx34CTM L7m4m18p5mndpDMF17.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: BStrait21nnnA00B15AdvOx34CTM L7m4m18p5mndpDBADCS010.cnv &
BStrait21nnnA00B15AdvOx34CTM L7m4m18p5mndp DMF17BADCS010.cnv

In 2021 this marks the end of the CTD pre processing.

BERING STRAIT 2021 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:** "**Is transponder in?**"
    - **Deck to Driver:** "**Transponder in**"

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 report wave height, air visibility, water visibility"**
    - 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
    - **Driver to Deck**: "**Come to surface**" AND CHECK CTD COMES UP

4. CTD comes up ** COMPARE SENSOR PAIRS - decide if data good enough to leave station
    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**"
    - 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, Pipes are/not draining**", and default is ship leaves for next station.

5. 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)
If leaves CTD for long time, check "transponder is out"

Deck responsibilities every cast:

- checking sensor cleaned and transponder in
- 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 if pipes are draining once CTD is on deck.
    - if not draining, clean vent plugs and report to CTD operator to add to notes.
- report if jelly fish remains on salinity cells

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

BERING STRAIT 2021 CTD LINES

A total of 14 CTD lines were run on the cruise.

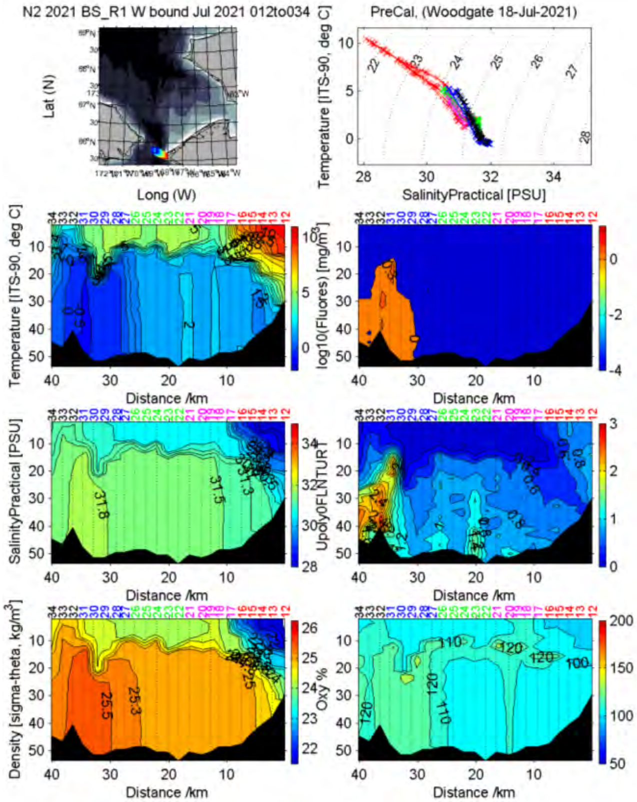
Preliminary sections were plotted using code from An Nguyen from the preliminary processed data, which uses pre-cruise calibrations, and the quality control procedures outlined above to give 1m bin averages for plotting.

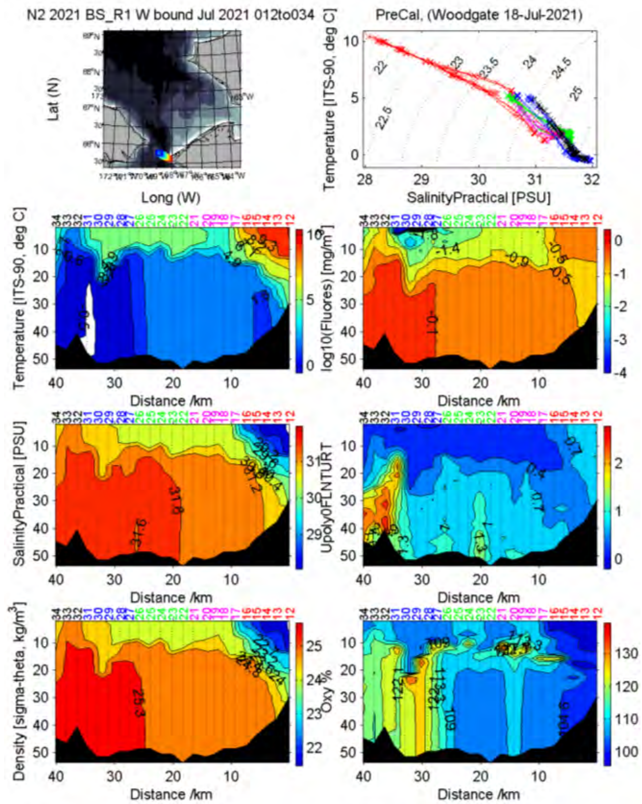
The plots below give all 14 sections on the same scales (left) and on a scale for that section (right), presented in order of data acquisition. Note that:
- this uses the S1 and Ox1 data,
- typically stops 2 to 3+ m above the bottom.

Several repeat sections were run on the cruise (see naming below)

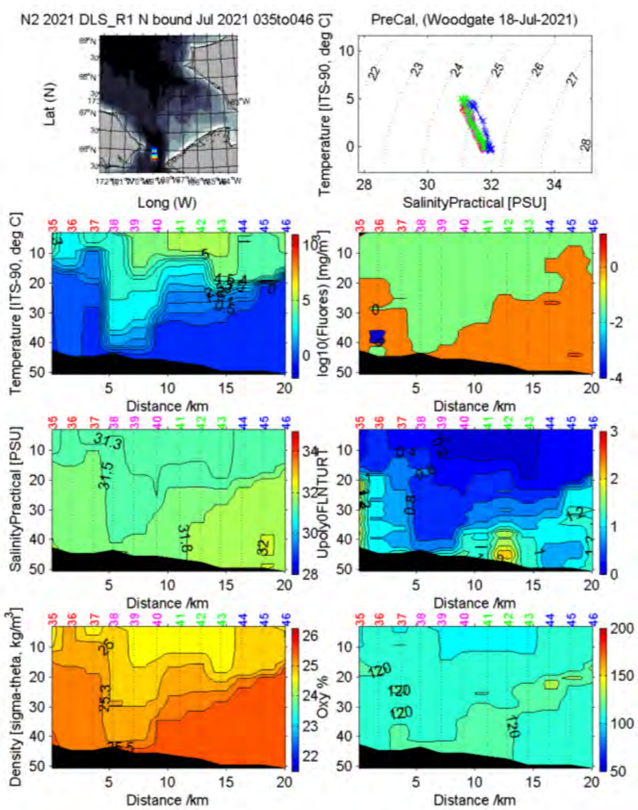
For full positions and times see event log and data file headers.

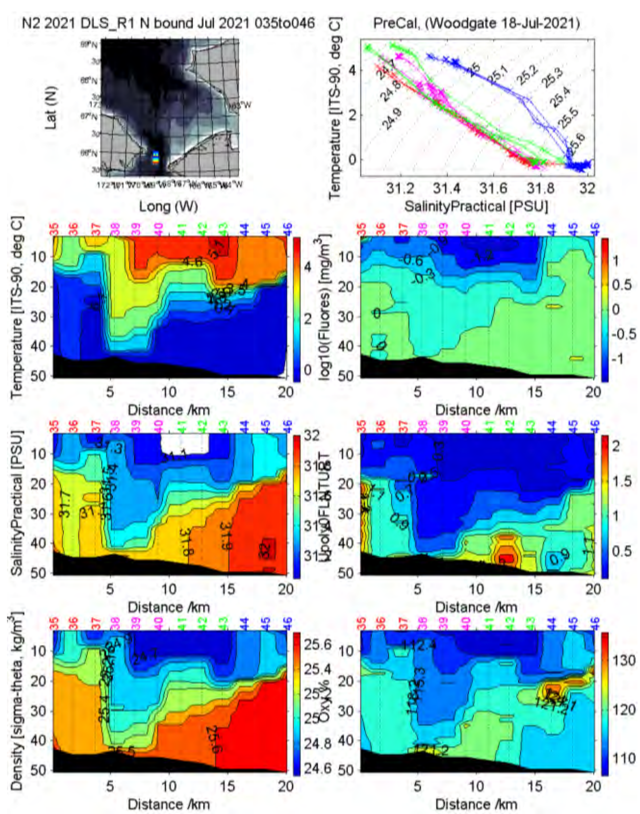
1) Bering Strait line (BS) – first running, Westward



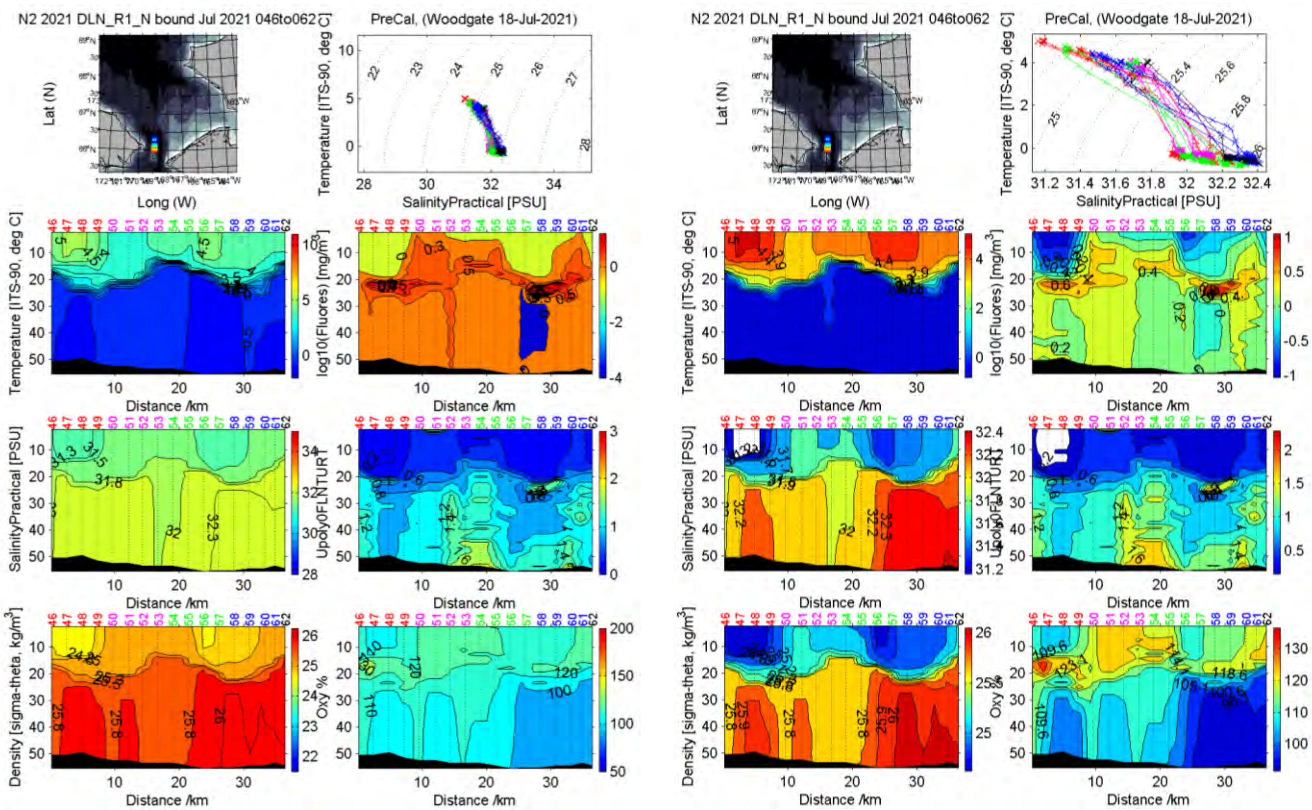


2) Diomede Islands line south part (DLS) - first running, Northward

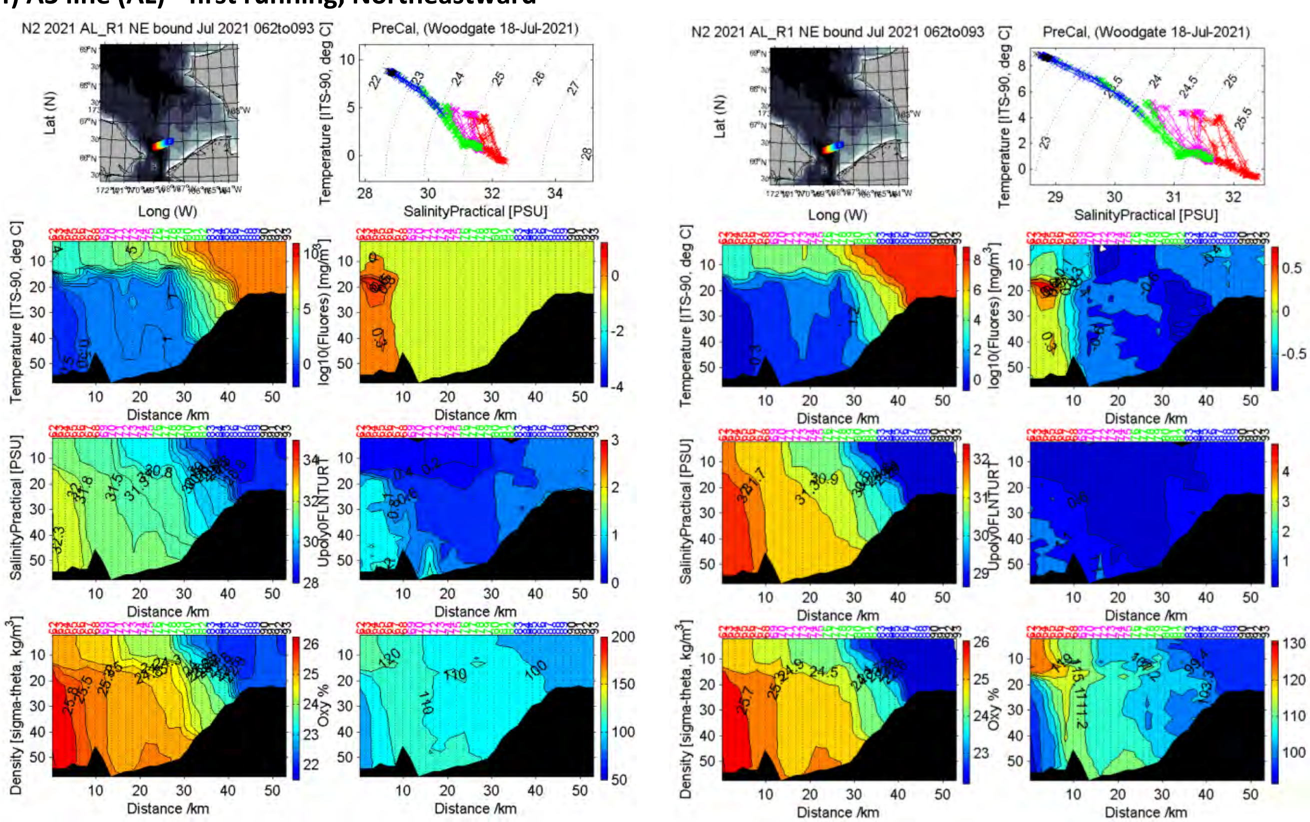




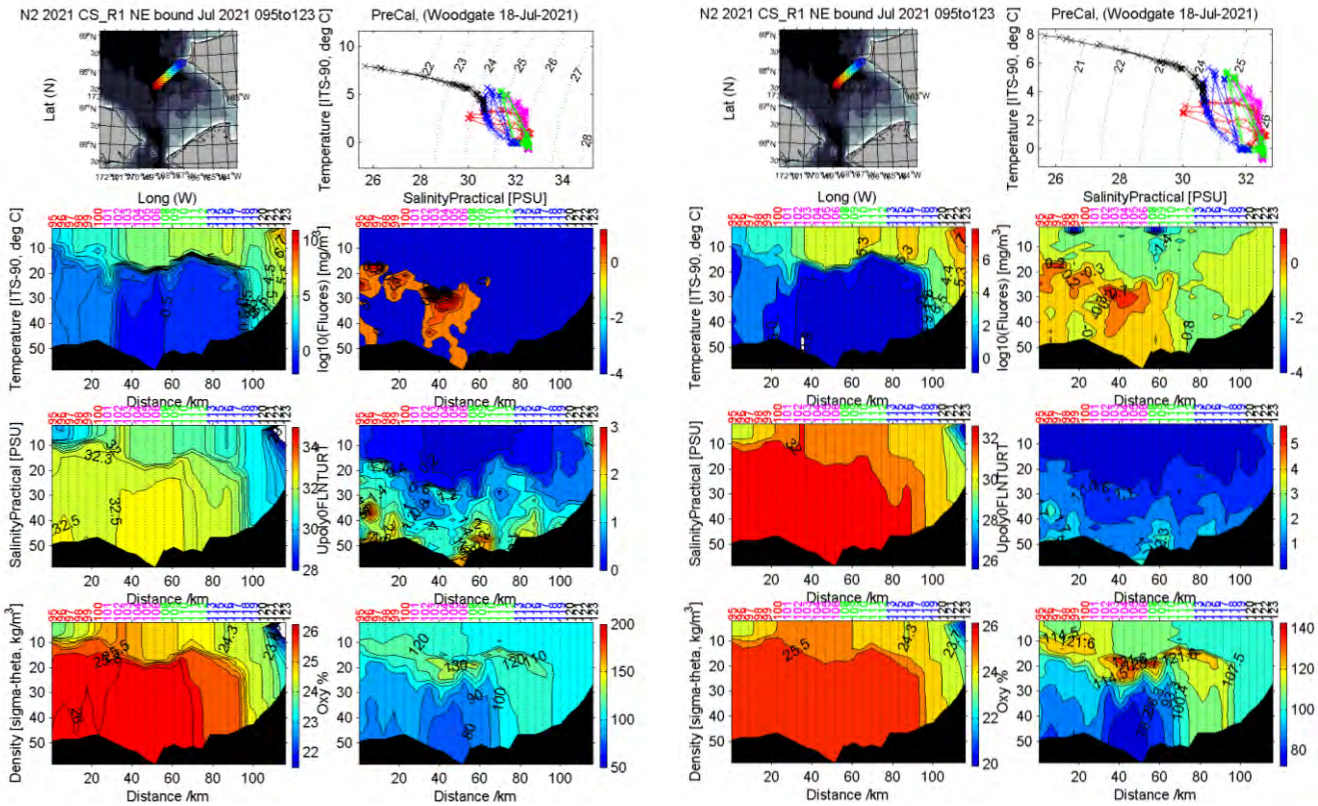
3) Diomede Islands line north part (DLN) - first running, Northward



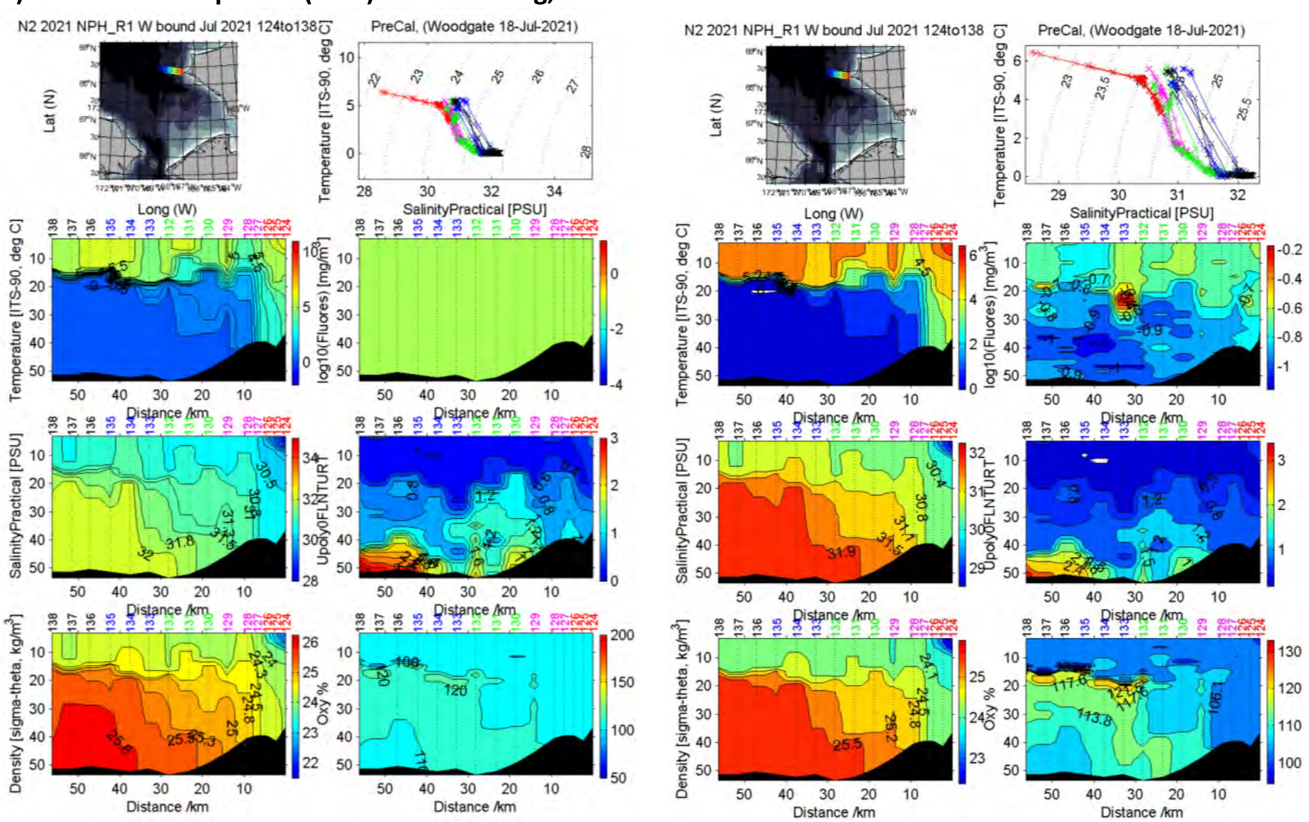
4) A3 line (AL) - first running, Northeastward



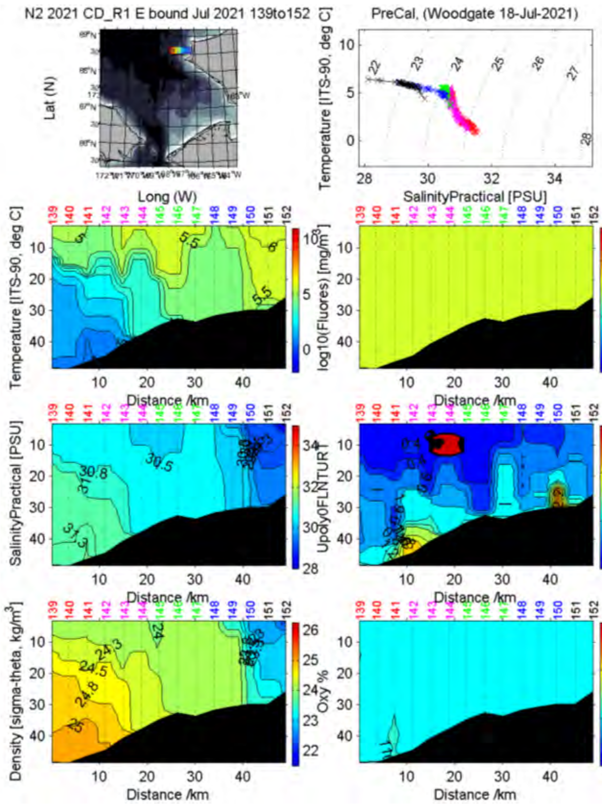
5) Cape Serdtse-Kamen line (CS) - first running, Northeastward

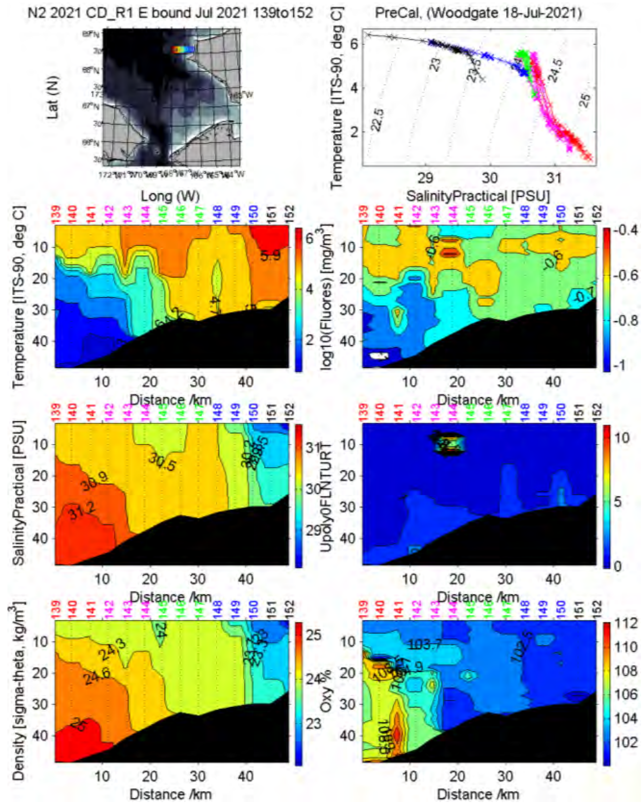


6) North Point Hope line (NPH) - first running, Northwestward

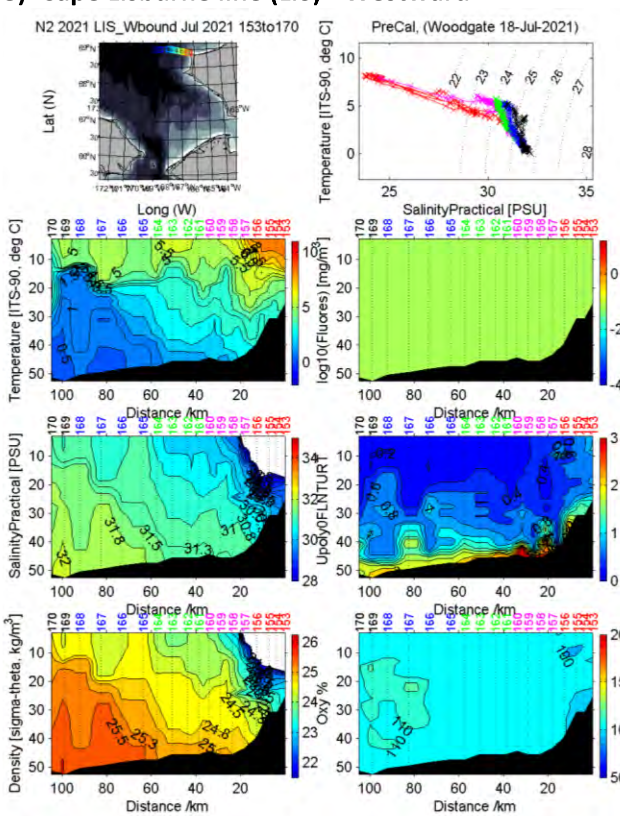


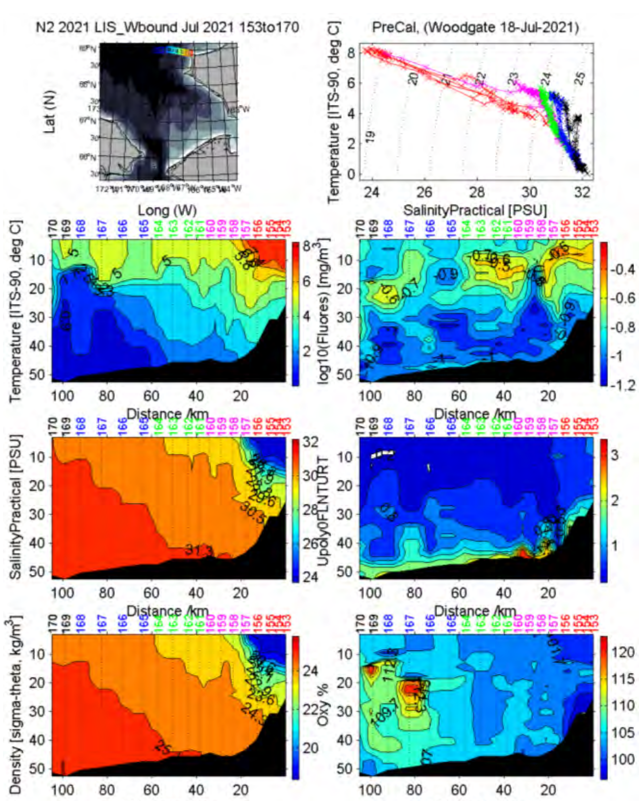
7) Cape Dyer line (CD) Eastward



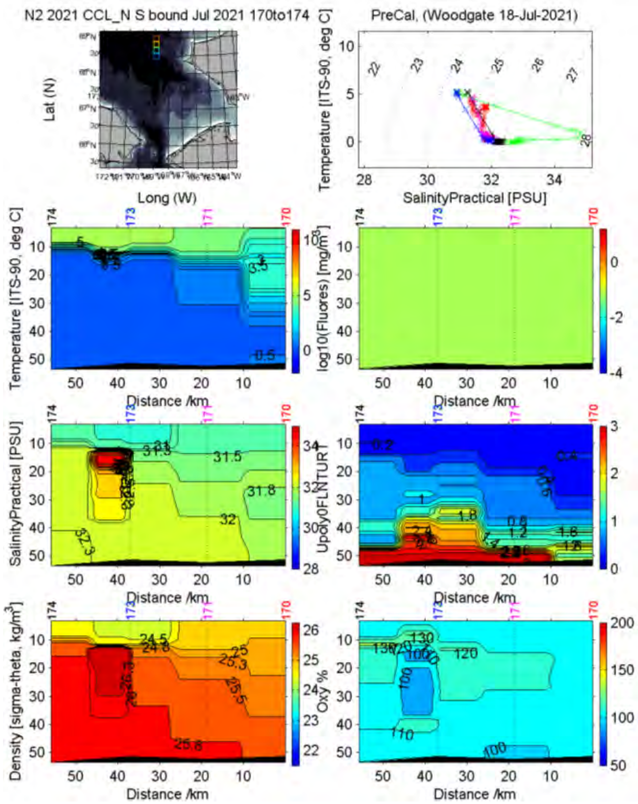


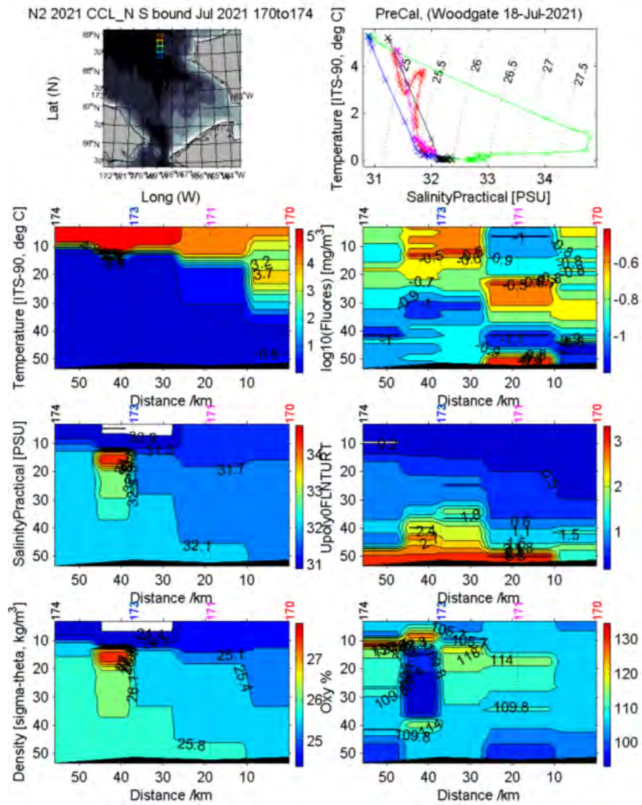
8) Cape Lisburne line (LIS) - Westward



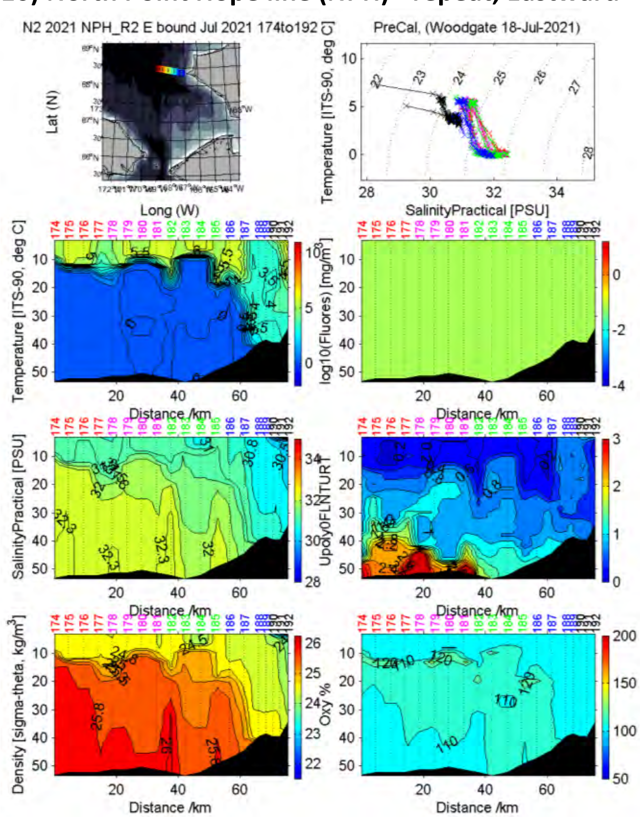


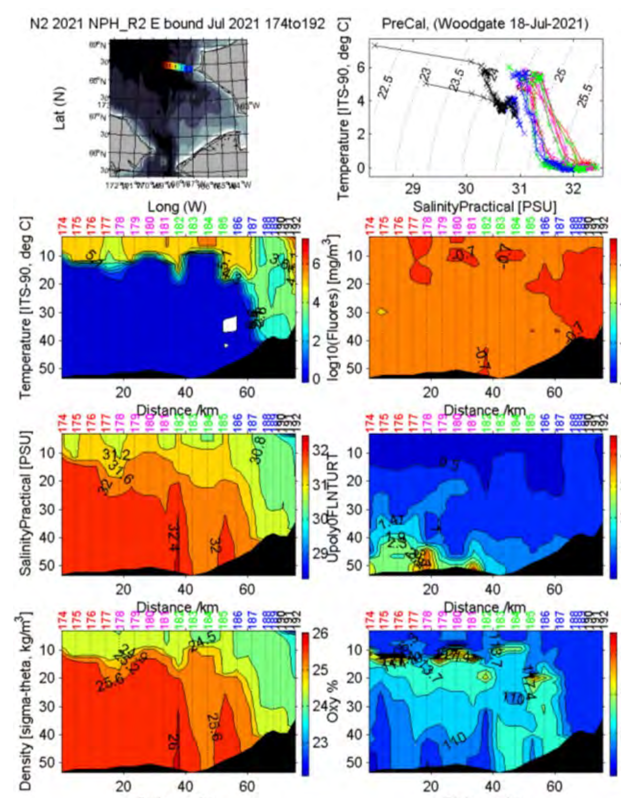
9) Chukchi Central line North part (CCL-N) - southward



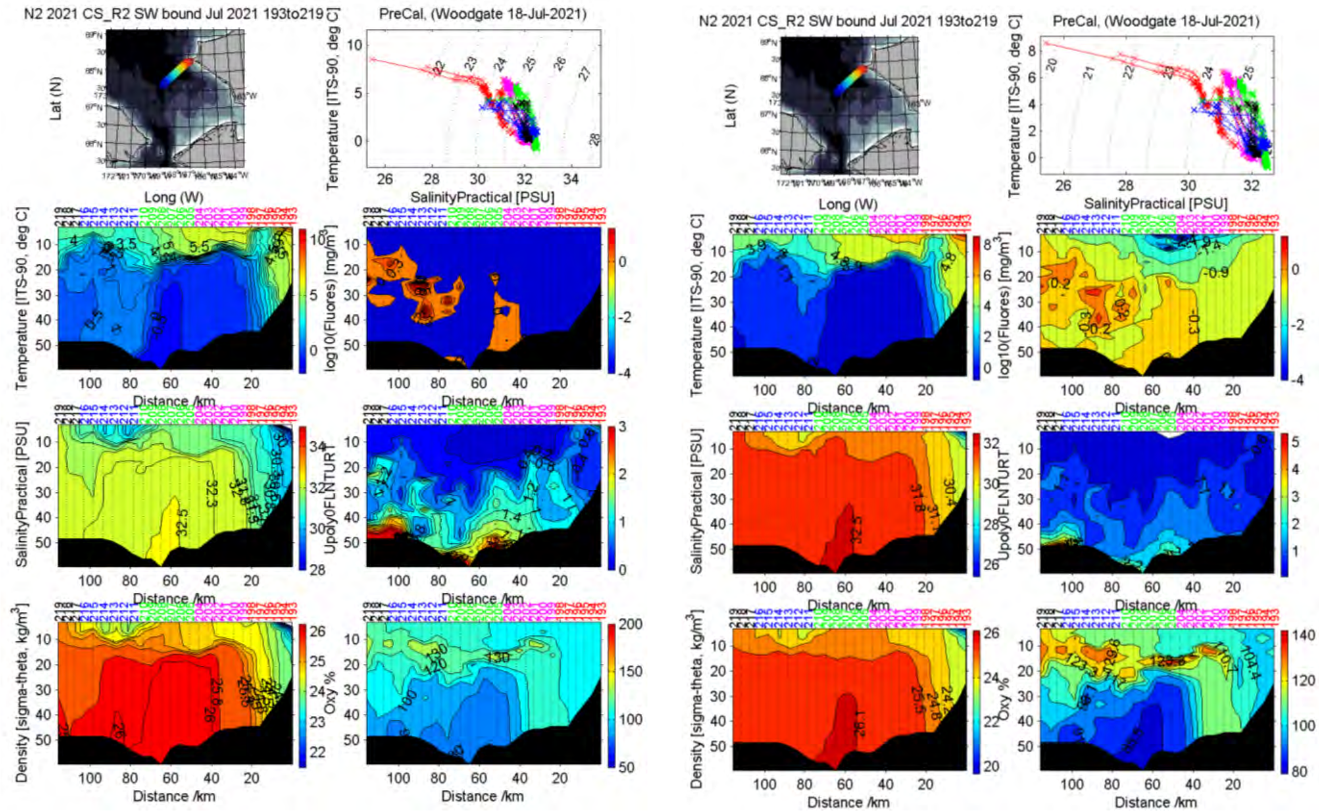


10) North Point Hope line (NPH) - repeat, Eastward

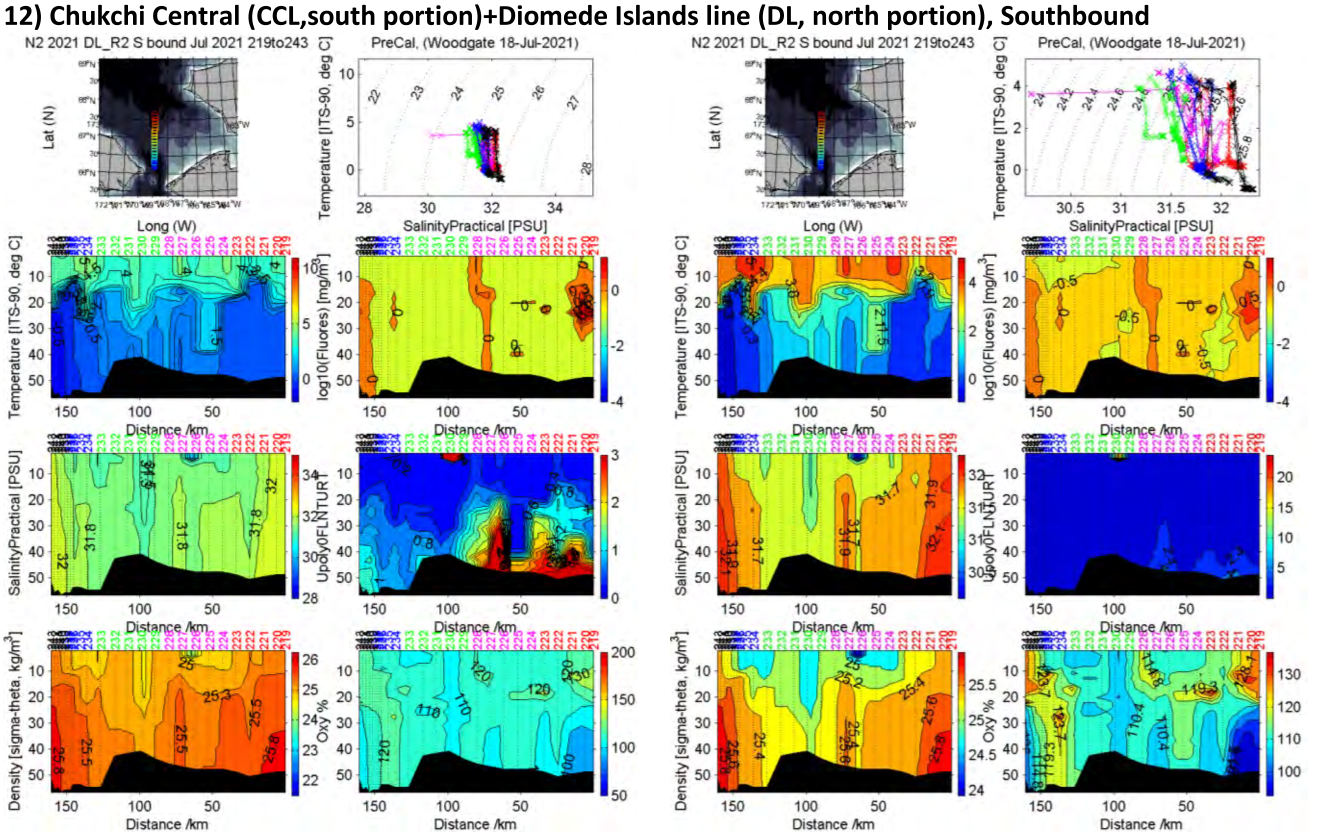




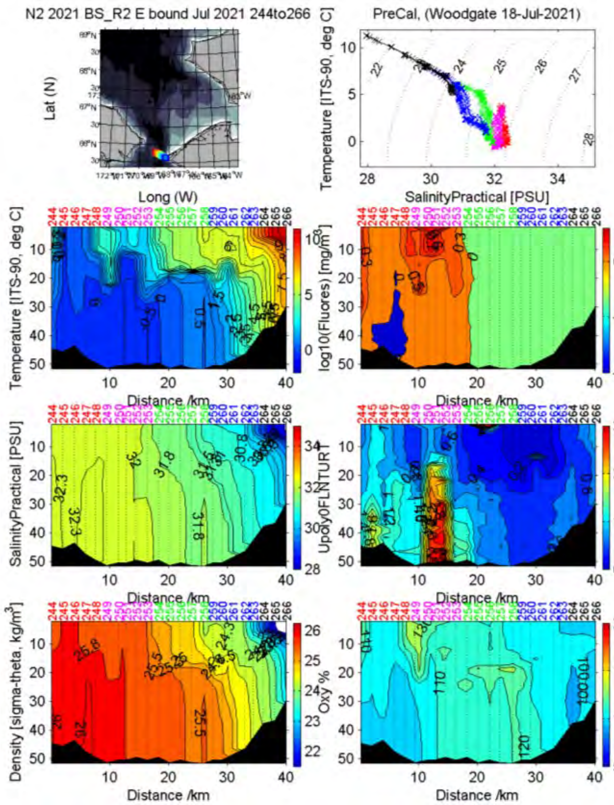
11) Cape Serdtse-Kamen line (CS) - repeat, Southwestward

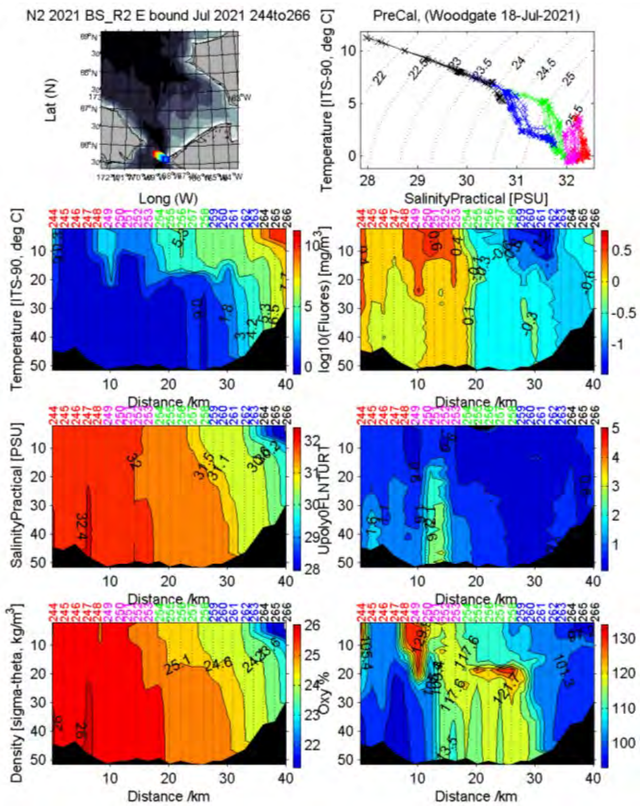


12) Chukchi Central (CCL,south portion)+Diomede Islands line (DL, north portion), Southbound

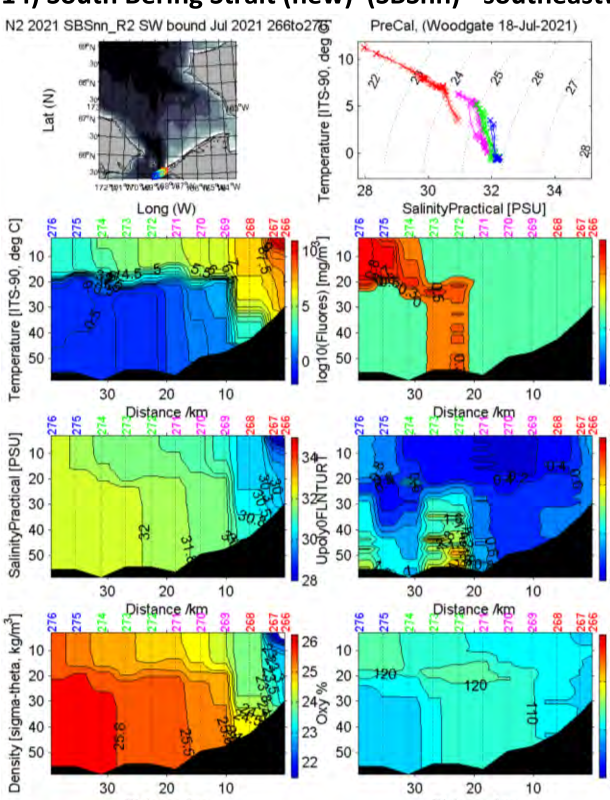


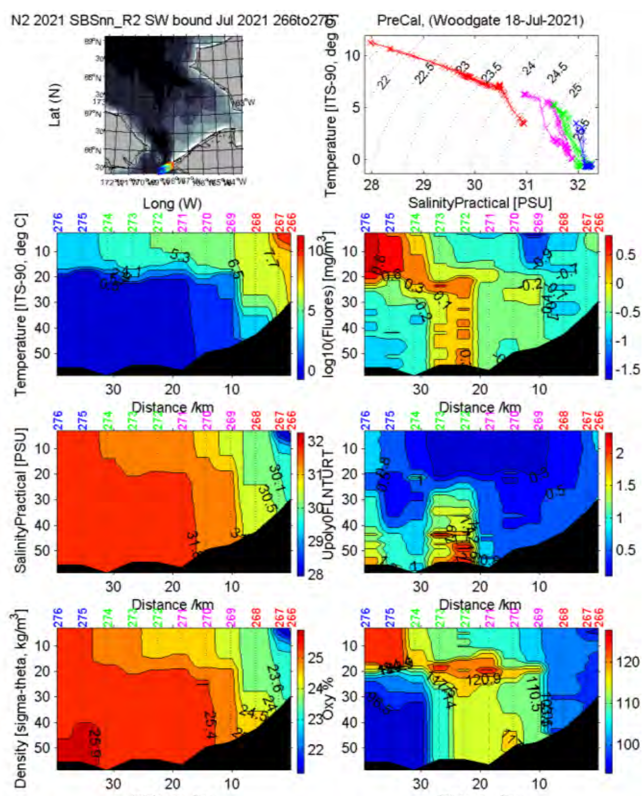
13) Bering Strait (BS) - repeat, Southeastward





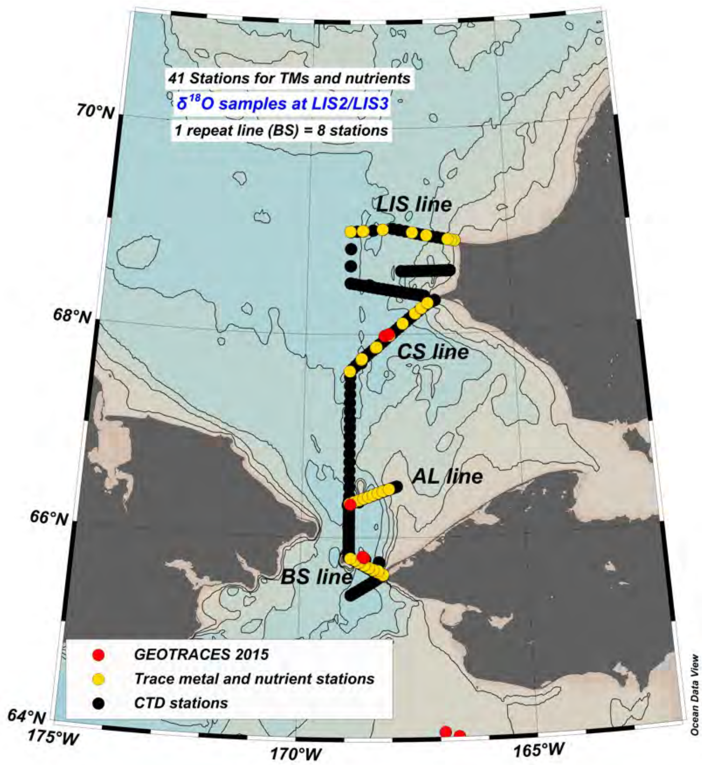
14) South Bering Strait (new) (SBSnn) - southeastward





BERING STRAIT 2021 TRACE METAL AND NUTRIENT PUMPING AND DELTA O18 REPORT (Laramie Jensen)

Summary: 41 stations (33 separate locations) were sampled for trace metals and nutrients (yellow dots in map below), 78 trace metal samples and 76 nutrient samples collected at the surface (5m) and lower layer (variable depending on bottom depth), 2 samples for δ^{18}O (LIS2 and LIS3 surface only).



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 releases trace metals through diagenesis or non-reductive dissolution) or riverine input. Freshwater intrusions (salinity <30psu) were observed frequently through the CTD transects, especially along the Alaskan coast at Stations LIS1-3. Rivers may act as a source or diluent for metals and nutrients. Variations in temperature and salinity indicate the presence of multiple water masses along the CTD lines sampled. The major objective of the 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, both spatially and in time. 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 (manufacturer: Wilden, see picture below) with a maximum flow capacity of 56 liters/minute using the ship's 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 along its length to 3/8in Nylon line. An 8lb kettleball weight was attached directly to the Nylon rope and a RBR Concerto[3] CTD (measuring temperature, conductivity, pressure and oxygen every 0.125 s) was lashed to the rope below the end of the pipe with Dynacon line (see figure). Thus the end of the tubing sat approximately 1.5m above the kettleball weight. The depth of the end of the tubing in the water was estimated from the length of tube placed in the water, and post-cast, ascertained from the pressure record of the RBR CTD. Typically, the desired "bottom" depth was 5m shallower than the bottom depth as determined by the ship altimeter.

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 maximum capacity, the pump cleared the pipe in 60-70 seconds, this being 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 65 seconds at maximum capacity/speed.

At every station the tube/rope/CTD/weight apparatus was lowered to the desired depth and the pump was turned, pushing water through the tubing via the diaphragm pump. After the flush had occurred, the clamps on the C-flex tubing were adjusted such that the flow of seawater from the pump was directed primarily through the Acropak capsule filter (described below). Immediately following collection of the trace metal and nutrient samples (both filtered) the pump was turned off on deck and the tubing apparatus was either recovered or moved to a new depth location (ie after the surface sample at 5m, tubing apparatus was moved directly to the "bottom" depth). After both casts (surface and bottom) the tubing apparatus was recovered back on deck, the pump was turned off, and the filter was placed back into the bag. The entire system was left on deck during a sampling line. Location and times of stations samples are marked Laramie stations in the cruise event log attached to this report.

Water was filtered before collection in sample bottles to remove particulates and organic material. Both the filtered and unfiltered flow were attached to the main Grainger tubing via a plastic Y-split connected to acid-cleaned C-flex tubing. Connections along the C-flex were reinforced with zipties and plastic hose clamps. Flow between the two was controlled by opening and shutting plastic snap clamps around the C-flex. Early in the cruise, it was determined that the maximum capacity of the pump would exceed the pressure capacity of the Acropak-200 0.2 μm filter (shown below). Thus, after flushing the system, pressure was reduced to ~80 psi via the regulator and the filtered flow was only slightly restricted so that the Acropak filter could be filled and flowing enough to sample but not creating significant back pressure. When the filter was significantly clogged (particularly along LIS line) the gas lock of the filter capsule was opened to help alleviate pressure. The filter was stored in two small polybags and another larger poly bag with the rest of the outflow tubing (see figure below) to reduce contamination.

Filtered samples (trace metals (TM) and nutrients (nuts)) 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 double bagged in 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 7/18/2021. Note that volume was estimated for incomplete samples (clearly less than 250 mL volume) and acidification volume was adjusted accordingly (i.e., if only 50 mL of seawater was collected, 100 μL of Optima HCl was used). This occurred for the following samples: AL18.5 surf, CS12 surf, and BS13 (repeat) surf due to sample loss during sampling/storage.

Trace metal samples will be analyzed at the University of Washington in the Bundy Lab in the Fall of 2021.

O18 samples: Given the remarkable freshness of water around the east end of the LIS line, 2 opportunistic samples were taken for delta O18 analysis. Two samples, both surface, were collected in 250 mL low density polyethylene bottles (Nalgene). The bottles were acid cleaned with hydrochloric and nitric acid (and thoroughly rinsed with MQ water) before the cruise. Samples taken from the surface pumping at LIS2 and LIS3. Bottles were rinsed three times, filled to overflow, and sealed with parafilm, and stored at room temperature. These samples were analyzed by Andy Schauer at the ISOLAB in the Earth and Space Science (ESS) department of the University of Washington and reported below. Data suggests more freshwater in LIS3 surface sample compared to LIS2 but high values overall.

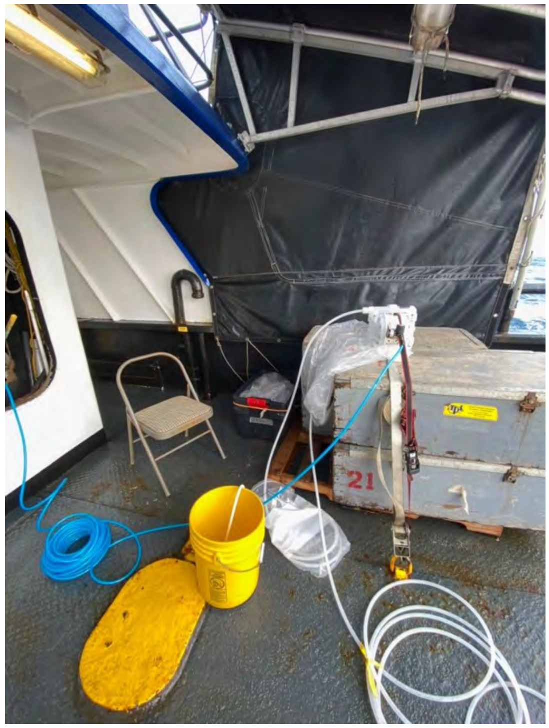
Date of analysis	Sample	Mean H2O (ppmv)	StdDev	Mean dD VSMOW	StdDev	Mean d18O VSMOW	StdDev
8/3/21 22:12	LIS3	19566	166.5983	-33.3819	0.098396	-4.2915	0.019424
8/4/21 1:19	LIS2	19574.6	61.476	-23.657	0.16012	-3.0929	0.025762
8/4/21 22:03	LIS2	19615	106.066	-23.6629	0.094302	-3.1141	0.020107
8/5/21 1:09	LIS3	19544	57.8835	-32.6919	0.21168	-4.2751	0.015659
Average	LIS2	19594.8	122.594	-23.65995	0.18582594	-3.1035	0.03267984
	LIS3	19555	176.3675	-33.0369	0.23343135	-4.2833	0.02494987

The full Delta018 analysis is included as an appendix to this report.

Issues encountered during trace metal/nutrient sampling:

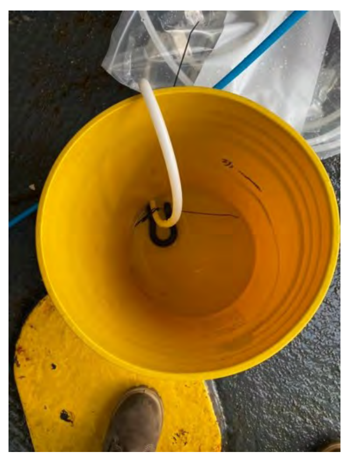
- **Back pressure on filters**: As described above, the max pressure output of 125 psi from the Wilden pump was too high for the Acropak capsule filters.
    - **Solution(s) at sea:** Reduced pressure to ~80 psi when actively sampling. Also, only slightly closed the unfiltered tubing so that some pressure was relieved via that route. Tubing was reinforced with zipties rather than plastic hose clamps.
    - **In the future:** Larger capacity capsule filters (1500 vs 200 cm^2 effective filtration area) will help with this issue as well as stronger tubing that is pre-attached to the Y-split mechanism so time does not have to be spent changing the tubing and reinforcing the joints.
- **Filters clogging:** The Acropak capsule filters "took on color" and became noticeably clogged sometimes after only ~1L of water was passed through. This meant that the back pressure on the filter was increased causing the tubing to disconnect or form a pocket of seawater resembling a water balloon. Only four 200 size capsule filters were brought and every one of them was used. This problem was especially noticeable on the BS (repeat) and LIS lines.
    - **Solution(s) at sea:** Sometimes the airlock on the Acropak capsule filter was opened to help relieve the back pressure. Likewise, the unfiltered side was also opened to prevent the C-flex tubing from swelling. Filter use was budgeted for the most important lines.
    - **In the future:** Larger capacity Acropak filters, while expensive, make more sense for this environment. Decreasing the pressure on the pump further may also help.
- **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: As suggested by** a crewmember, consider building some sort of plastic cage/enclosure to have on the very end so that the tubing could remain protected during recovery.
- **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 the desired depth.
    - **In the future:** Reconsider using a block and A-frame for tubing sampling. This may not be possible for quick deployment/recovery purposes, and may in any case squash the tubing.
- **Trace metal cleanliness:** Ideally, sampling would be done in a clean, positive pressure environment, but this was not available on this ship. 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 a 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 trace metal pump sampling on deck

View of trace metal pump sampling on deck



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.

Clogged/used Acropak 200 (0.2um) filter. Top is the barbed connection that would be attached to the white C-flex tubing. To the right is the air valve that was opened during flushing to prevent bubbles from clogging the filter. Note that the folded Supor filter inside the capsule is dark green/brown after sampling.

BERING STRAIT 2021 UNDERWAY DATA REPORT – Woodgate (UW)

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 this year, 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. Although the system was not logging data on the transit from Homer to Nome, by Nome logging of the 1s NMEA string was enabled. On the morning of the 7th July 2021 (before the science party arrived), the Norseman2 performed a compass calibration of the system off Nome. This calibration calls for calm seas, which were not available, but is believed to have delivered a direction calibration good to about 10deg. The system is designed to provide apparent and theoretical (i.e. true?) wind speed and direction, air and wind chill temperature, pressure and (optional but included) humidity, using acoustic sensors and its own 3D compass. This information is sent in the NMEA $IMDA string. Since the navigation NMEA strings are also stored, it should be possible to extract this information in conjunction with ship's motion information.
From the hourly observations of wind, the consensus on the ship was that the speed readings may be too high. Also, temperature and wind chill temperature were always the same, suggesting some problem in these data streams. Further investigation was not possible at sea.
Action items: Extract desired information from stored NMEA strings. Quality control especially wind speed and temperature data where possible (e.g., where ship changes direction). Compare against weather prediction models.
For most of the cruise with brief exceptions during the AL and LIZ lines, the winds appeared to be mostly from the south, with extreme weather experienced during the CS line, before the final BS line and during the final BS and SBSnn lines and on the transit back to Nome at the end of the cruise.
Action item: Add meteorological data plots to this report.

AFT A-FRAME GPS: Two issues were encountered with the Aft Aframe GPS;
a) wiring to the Aframe was faulty, Thus early in the cruise the GPS was remounted on the aft rail of the O1 deck.
b) the GPS unit was reporting dates in November 2001 instead of 2021. This appears to be the GPS week number roll over issue, viz. an ambiguity in date because of the GPS week counter is only stored to a certain number of digits. Thus, for most systems (CTD, and underway), the forward GPS position was used.

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.**

During the transit to Nome, when the system was originally turned on, the SBE38 data stream appeared to be all dummy values. However, without making any apparently significant change, the data stream appeared to correct itself and was being correctly recorded for the main cruise period. Action item: Investigate.

As for some of the transit to Nome this system used the aft-GPS, correction must be made on those data for the GPS week number roll over issue. Additionally, at times the system time was not set to UTC. However this string is only recorded in the header file of the data - the timestamp of the data is taken from the NMEA string, which always had the correct UTC time, but sometimes the wrong date. **Action item: Correct calibrated data for clock issues.**

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.

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.

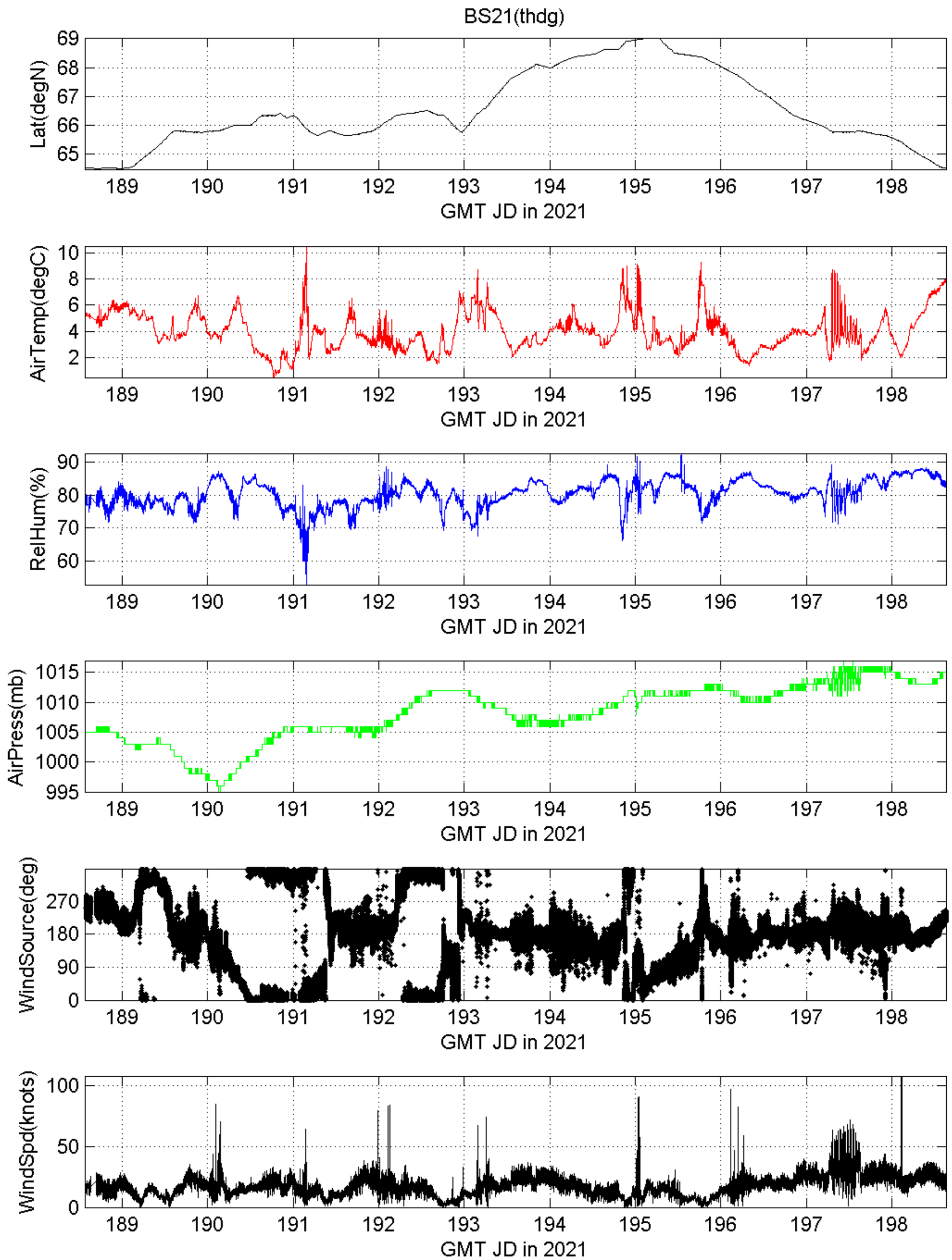
BERING STRAIT 2021 METEOROLOGICAL DATA PLOTS

Preliminary analysis (and comparison to ERA, JRA and NCEPdata suggests in this year are 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).

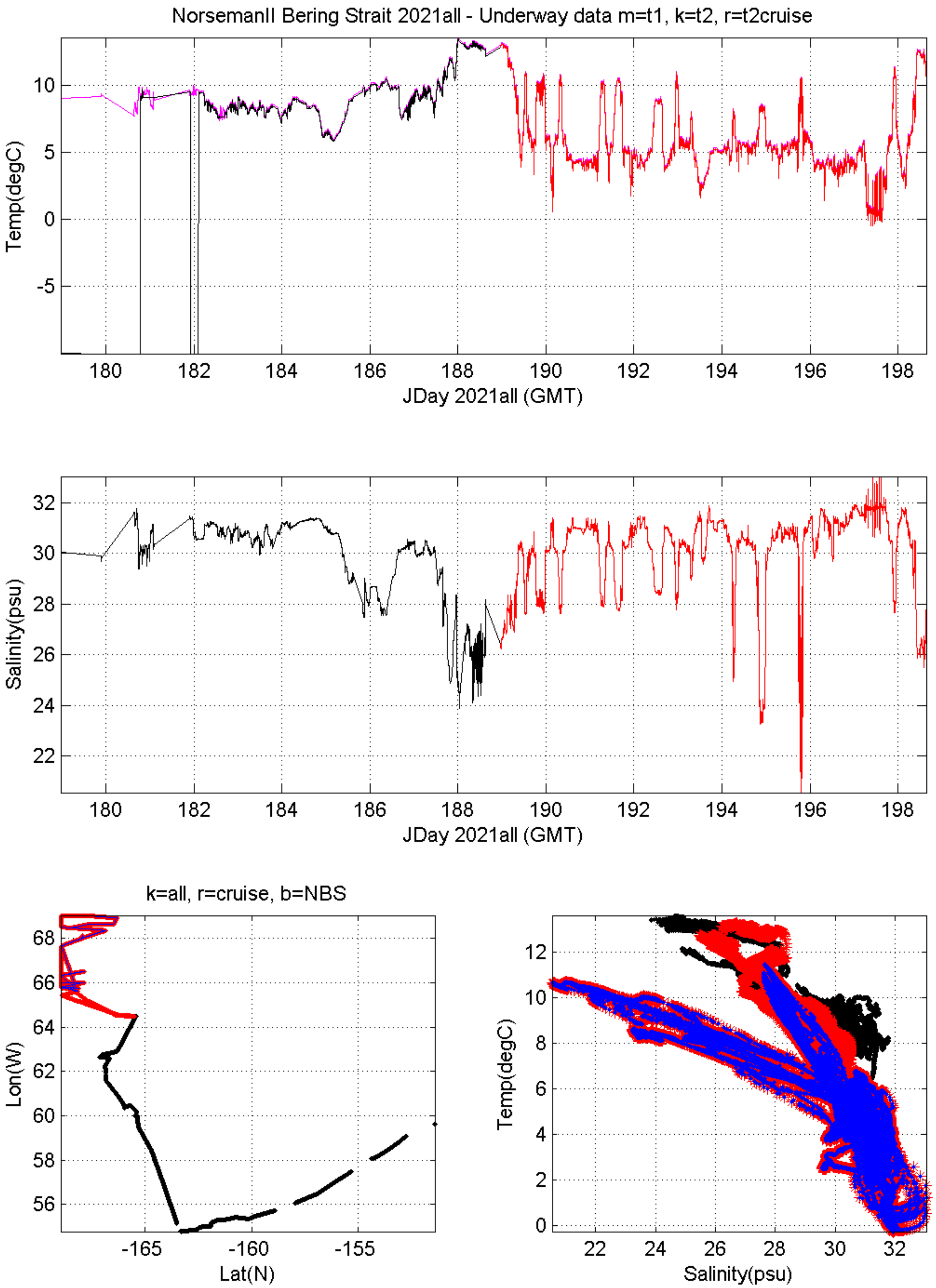
These differences are all greater than the stated accuracy of the sensor https://www.airmar.com/weather-description.html?id=153   (0.5m/s for speed; 1.1degC for temperature, 0.5hPa for pressure).

Note the nstrument calculates true wind direction and speed (and this is not reproducible exactly from relative wind and ship heading



BERING STRAIT 2021 UNDERWAY TEMPERATURE SALINITY DATA

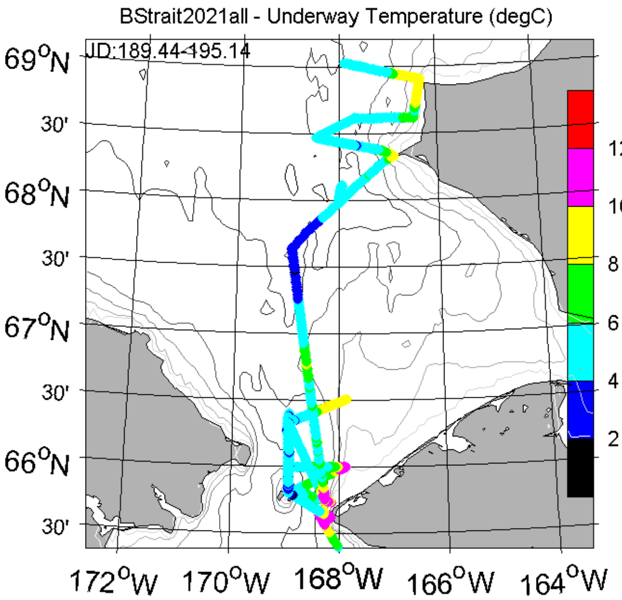
Including data from transit from Homer

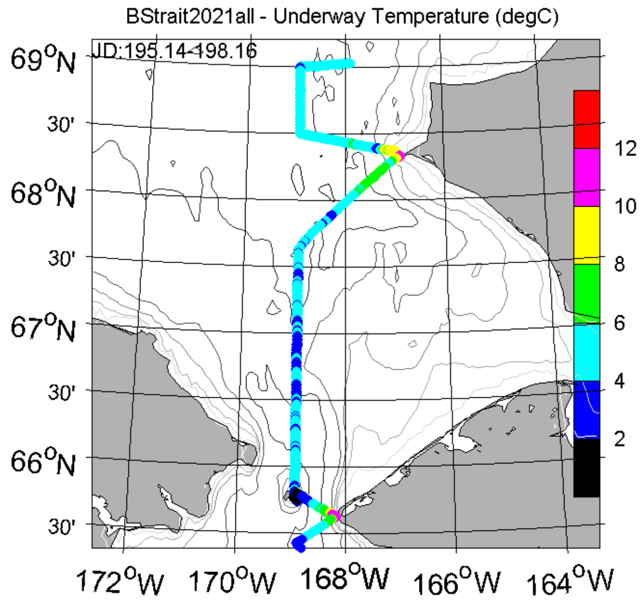


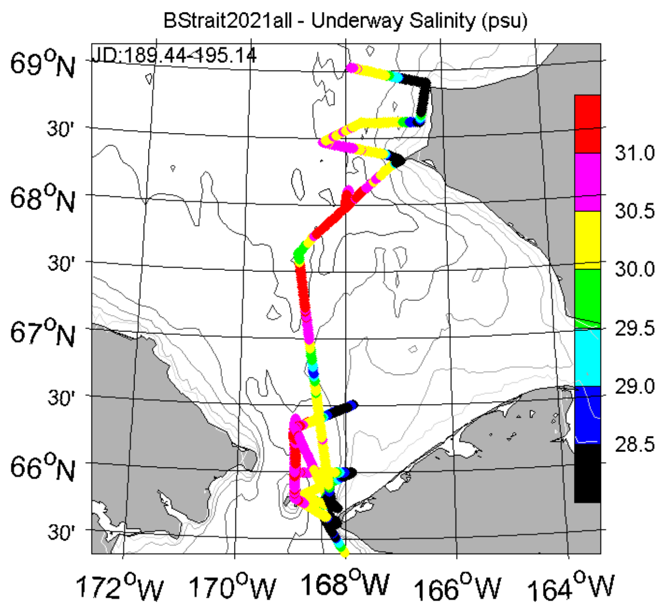
BERING STRAIT 2021 UNDERWAY TEMPERATURE SALINITY DATA (continued)

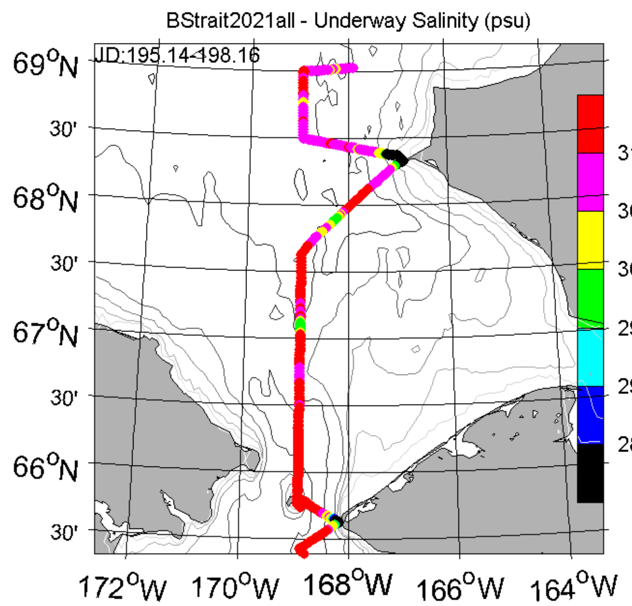
(Note multiple runnings of the Bering Strait (and other) lines are masked in these plots.)

First Half **Second half**



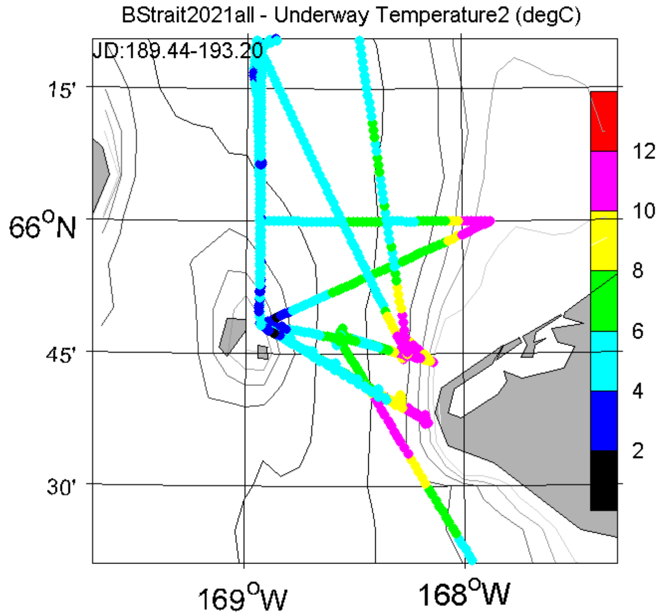


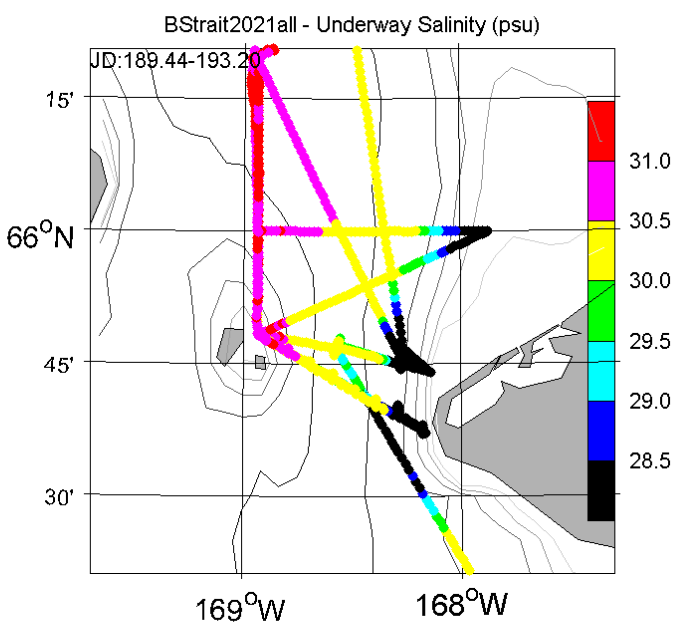




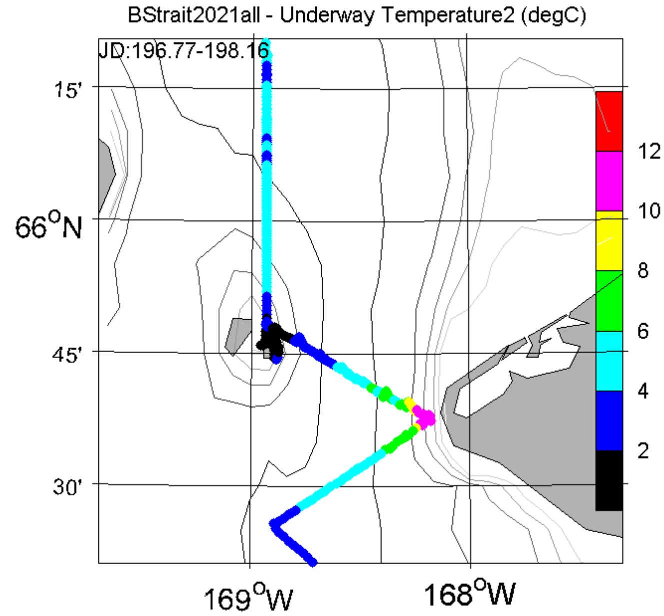
Focus on the strait only

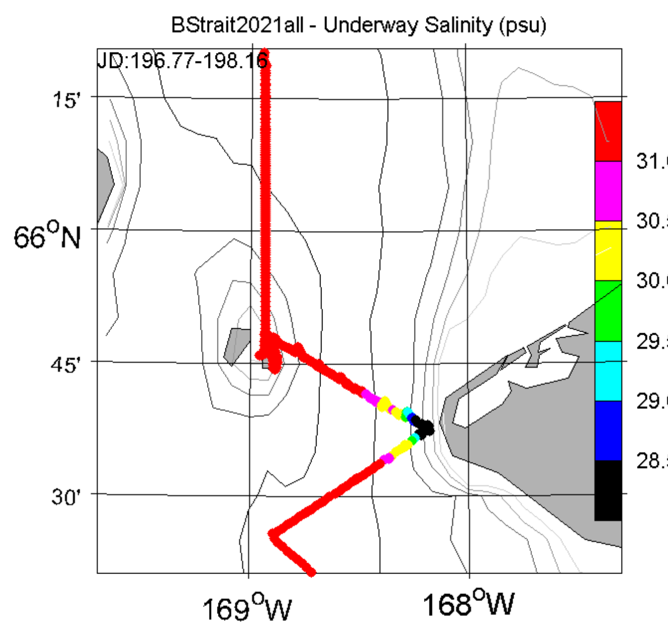
First Half





Second half





BERING STRAIT 2021 TARGET CTD POSITIONS

```
%=========================================================
% Stations for BStrait Mooring Cruise 2021 NorsemanII
%=========================================================
% Vers: 25th July 2021
%
% 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.
% == 3 moorings to recover
% == 3 moorings to deploy
%-----------------------------------------
% RECOVERIES of moorings deployed in 2019
%-----------------------------------------
%NAME      Lat(N)       Long (W)     Water   Top
%          deg min      deg min      depth   Float
% A3-19    66  19.604    168  57.046    57m     8m
% A2-19    65  46.855    168  34.070    56m    16m
% A4-19    65  44.748    168  15.765    48m    16m
%-----------------------------------------
% RECOVERIES of moorings deployed in 2020
%-----------------------------------------
%NAME      Lat(N)       Long (W)     Water   Top
%          deg min      deg min      depth   Float
% A3-20    66  19.604    168  57.604    57m    43m
% A2-20    65  46.858    168  34.598    56m    46m
% A4-20    65  44.750    168  16.310    50m    37m
%---------------------------------
% DEPLOYMENTS for this 2021 cruise
%---------------------------------
% Target same as 2012 positions.
%NAME     Lat(N)       Long (W)     Water
%         deg min      deg min      depth
% A3-21   66  19.61     168  57.05    58m
% A2-21   65  46.86     168  34.07    56m
```

% A4-21   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.
%
% 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. (No bottles
% will be taken on any CTD casts of this cruise.)
% 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
  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
%
%This might also be run at the extra high resolution
% of 2014, viz:
65.805  168.933     65      48.31   168     55.96   %       BS11
65.797  168.897     65      47.79   168     53.79   %       BS11.5
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
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
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
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
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
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
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
```

```
65.599  168.161      65    35.96   168    9.66    %     BS23
65.582  168.117      65    34.91   168    7       %     BS24
%
%
%=========================
% 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
  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
%
%
%==========================================================
% 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).
%---------------------------------------------------------
% - 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
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.
%
%
%================================================
% 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
0 0  65   49.28    168   56.2  % DL1
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 + 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 - 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
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
%
%
%===
% 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
%
%
%===========================================
% 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
%
%
%=============================
% LIS = Cape Lisburne Line
%=============================
% - 17 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
%-------------------------------
%    Lat (N)       Long (W)     Name
%    deg min      deg   min
0 0   68   54.40    166   19.80  % LIS 1 + net
0 0   68   54.80    166   25.15  % LIS 2
0 0   68   55.20    166   30.51  % LIS 3
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
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
0 0   69    0.60    167   38.70  % LIS 9
0 0   69    1.80    167   53.40  % LIS 10 + net
0 0   69    1.35    168    7.95  % LIS 11
0 0   69    0.90    168   22.50  % LIS 12
0 0   69    0.45    168   37.05  % LIS 13
0 0   69    0.23    168   46.62  % LIS 14n + net
0 0   69    0.00    168   56.00  % CCL22n % was 56.2
%
%
%==============================
% 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
%---------------------------------------
%     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
%
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
%
%=========================================
%  Higher RES CCL Line S from CS10US
% (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

%
%=======================================
% 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
%
%
%====================================
% 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
%
%
%==
% 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

 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
%============================================================

%=============================================
%
% Two new lines to map the ACC as and after it rounds Point Hope
%
%==============================================
% 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
%
%
%==============================================
% 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.
% - 14 stations, 2nm spacing
% - Distance 26nm
% - new in 2016
%   - ** CHECK DEPTH OF SHALLOWEST  CD1
%----------------------------------------------
%     Lat (N)      Long (W)     Name
%     deg min      deg min
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
%===================================================
%==================================================
% DL = Diomede Line EXTRAS(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
%
% (The info about is withOUT the 0.5)********
%-------------------------------------------------
%     Lat (N)      Long (W)     Name
%     deg min      deg   min
```

```
0 0  66   0.00   168  56.2  % DL12
0 0  66   1.28   168  56.2  % DL12.5
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
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
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
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
0 0  66  17.84   168  56.2  % DL19
0 0  66  18.73   168  56.2  % DL19.5
%
%
%===========================
% AL = A3 Line (US portion) - with extras
%==========================
% 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 A3-15 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

% (The info about is withOUT the 0.5)********
%
%----------------------------------------------------
% Lat (N) Long (W)   Lat (N)     Long (W)     Name
%                deg min     deg   min

%
  66.3270  168.9510  66   19.6100  168   57.0500   % A3-17
% *** Adjust this first position to be safe distance (300) from A3-17
  66.3335  168.9230  66   20.0000  168   55.3800   % new AL12.5
  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
  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
  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
  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
  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
  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
  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
  66.4635  168.1410   66   27.8050  168    8.4450   % new AL23.5
  66.4690  168.1050   66   28.1600  168    6.2900   % AL24
%
%Then these are new
  66.4745  168.0690   66   28.5150  168    4.1350   % new AL24.5
  66.4800  168.0330   66   28.8700  168    1.9800   % AL25
  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
%
%=============================
% 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
  0   0        68   54.80    166   25.15  % LIS 2
  0   0        68   55.20    166   30.51  % LIS 3
  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
  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
69.0033 167.5633   69   00.20    167   33.8   % NEW ** LIS 8.5
%
%DO NOT DO LIS 9
%   0   0        69    0.60    167   38.70  % LIS 9  ** on Q cable - do not do
%DO NOT DO LIS 9
%
69.0167 167.7267   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
  0   0        69    0.90    168   22.50  % LIS 12
  0   0        69    0.45    168   37.05  % LIS 13
  0   0        69    0.23    168   46.62  % LIS 14n + net
  0   0        69    0.00    168   56.00  % CCL22n % was 56.2
%
%=====================================================
% - South Bering Strait section
%==================================================================
% 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
%=========================================================
```

```
% CS = Cape Serdtse Kamen to Point Hope Line (US portion)
% - with extras.
%==========================================================
% 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
%----------------------------------------------------------
% - 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
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
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
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
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
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
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 **

%==========================================================
% North North Bering Strait Line (NNBS)
```

```
%==========================================
%
% Add a shallower station to 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

 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 (Extended)
%-------------------------------------------
%  Crossing from Point Hope to the ENE roughly.
% ======= 2019
% - updated to add an extra 20nm and 8 stations,
% with extras at 2.5nm space to CCL
% - now have 19 stations, and 40nm
%
% Run from east (NPH1) to west (NPH11)
% - estimate 3hrs 15min to NPH11 and then another
% - 4 hrs for the rest
%--------------------------------------------
%    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
% NEW
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
%End of new

%============================================
% CD- Cape Dyer (extended)
%--------------------------------------------
%  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.
% - 27 stations, 2nm spacing
% - first 14 due west to match 2016 line, now
% then angles to meet CCL20 at the Convention line
% - Distance 54nm
% - 27 stations
%   - ** CHECK DEPTH OF SHALLOWEST  CD1
%--------------------------------------------
%     Lat (N)     Long (W)     Name
%     deg min      deg min
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 2016 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

%===
% 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

%===
% - 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
%

%==
% 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

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% Bering Strait 2021 NORSEMAN2 log CTD

%Date	Time	1	Cast NO	Dov	Depth (r	Lat (deg)	Lat (min)	Lon (deg)	Lon(min)	Altimeter	%	StationID			Windspe	Wind	Oper	Fog	WaterCl	Comments
%Please fill in all data for every event (CTD/net tow)										0=bad 1=go	%				knots			0 = cle	0=clear, 1=noclear	
%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=Pumping cast for Trace Metals										Altimeter	%							Fog	Waterclarity	
%#,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 down																				
%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 2021 **AND GET A WIRE TO CLEAN PUMPS WHEN NEEDED** **Wire Out**

SET LAPTOP TIME TO GMT

%Date	Time	1	Cast NO	Dov	Depth (r	Lat (deg)	Lat (min)	Lon (deg)	Lon(min)	Altimeter	%	StationID	Surf	Bot	Wind Speed(kn	Dir	Oper	Fog	Water Clarity	Comments
20210707	**2348**	**1**	**0**	**0**	**0**	**64**	**28.795**	**165**	**40.148**		%	**dry test**			**21.2**	**68**	**KC**			**dry test on deck to check the CTD termination (re-terminated by Robert) and setup; Aft GPS is non-functional so we will use the forward GPS in future casts.**
20210707	15	1	**1**	1	17.2	64	29.124	165	44.362	0	%	shallow wet test			18.9	87	KC			just a soak (5-10m, not going to depth) to test the termination; took a long moment for the pump to turn on, but otherwise all clear
20210707	17	1	**1**	2	17.2	64	29.157	165	44.338	0	%	shallow wet test			23	50	KC			
20210708	1603	1	**2**	1	53	65	46.963	168	34.528	0	%	A2-20 recovery precast	218	268	12.7	156	KC	0	5m	pre-mooring recovery cast, A2-20; also the first full cast
20210708	1606	1	**2**	2	53.5	65	47.099	168	34.512	0	%	A2-20 recovery precast			16.3	163	KC			
20210708	1607	1	**3**	1	53	65	46.947	168	34.104	0	%	A2-19 recovery precast	217	267	13	161	KC	0	5m	pre-mooring recovery cast, A2-19; moved in small increments down at bottom to get below 51m
20210708	1612	1	**3**	2	53.3	65	47.106	168	34.096	0	%	A2-19 recovery precast			12.7	177	KC			
20210708	1910	1	**4**	1	46.5	65	45.023	168	16.238	0	%	A4-20 recovery precast	217	278	23.4	266	RJD	0	1m	pre-mooring recovery cast, A4-20; adjusted computer time to better match UTC prior to this cast (previously a ~43s offset)
20210708	1917	1	**4**	2	46.5	65	45.45	168	16.086	0	%	A4-20 recovery precast			27	244	RJD			
20210708	1925	1	**5**	1	45.8	65	44.956	168	15.803	1	%	A4-19 recovery precast	217	299	23	230	RJD	0	1m	pre-mooring recovery cast, A4-19; lots of line paid out, strong current. Speed was slightly slow.
20210708	1933	1	**5**	2	45.9	65	45.397	168	15.712	1	%	A4-19 recovery precast			24	144	RJD			
20210709	117	9	**00a**	0	0	65	46.935	168	34.107	0	%	dry test post A2-21					KC			dry test on deck. Cleaned vent plugs and ran FW through C cell
20210709	126	1	**6**	1	53	65	46.959	168	34.083	0	%	A2-21 calibration cast	217	267	21	154	JG	0	5 m	some discrepancy in oxygen sensors and "strangeness" in Salinity; cleaned vent plugs and ran FW through C cell again
20210709	130	1	**6**	2	53	65	47.053	168	34.027	0	%	A2-21 calibration cast					JG			
20210709	256	5	**0**	1	40	65	48.044	168	49.935		%	Laramie pump test	0	40			LJ			rainy and windy, test cast was done during transit from A2 to A3. pumped roughly 2.5 Gal to the surface. Just a downcast included here, will do upcasts as well in th
20210709	1611	1	**7**	1	55.1	66	19.581	168	57.618	0	%	A3-20 recovery precast A	217	265	20	342	KC	0	3m	Figuring out CTD issues with pump (vent plug cleaned): go down slowly, stay at bottom for 10 counts, come up to surface and then recast without taking out of wat
20210709	1618	1	**7**	2	55	66	19.497	168	57.721	0	%	A3-20 recovery precast A					KC			
20210709	1619	1	**8**	1	55.1	66	19.485	168	57.74	0	%	A3-20 recovery precast B	217	267	17	340	KC	0	3m	Second cast to diagnose CTD pump problems on upcast; same protocol as previous cast
20210709	1627	1	**8**	2	55	66	19.399	168	57.863	0	%	A3-20 recovery precast B			20	345	KC			
20210709	1637	1	**9**	1	55	66	19.575	168	56.988	0	%	A3-19 recovery precast A	217	272	19.4	11	KC	0	3m	pre-mooring recovery cast A3-19; moved p2 temperature sensor up slightly to match output level
20210709	1645	1	**9**	2	55.1	66	19.514	168	57.123	0	%	A3-19 recovery precast A					KC			
20210709	1646	1	**10**	1	55.3	66	19.499	168	57.112	0.5	%	A3-19 recovery precast B	217	266	20	15	KC	0	3m	pre-mooring recovery cast A3-19 B; ran cast without pump for sensor diagnostics
20210709	1651	1	**10**	2	55.1	66	19.391	168	57.203	0.5	%	A3-19 recovery precast B			21.1	342	KC			
20210710	20	1	**11**	1	54.8	66	19.633	168	57.22	0.5	%	A3-21 calibration	218	269	18.2	351	JG		2m	A3-21 post deployment calibration cast, replumbed CTD as well for connecting T and C.
20210710	26	1	**11**	2	54.8	66	19.609	168	57.32		%	A3-21 calibration			17.8	350	JG			
20210710	1552	1	**12**	1	29.5	65	37.4	168	10.542	0.5	%	BS22	214	255	14	185	JG		3m	BS22 - time is just an estimate, forgot to write it down
20210710	1558	1	**12**	2	29.5	65	37.495	168	10.593		%	BS22			14.2	175	JG			
20210710	1601	5	**1**	1	28.9	65	37.638	168	10.631		%	BS22-Laramie					JG		3m	1st Laramie cast
20210710	1612	5	**1**	2	28.9	65	38.035	168	10.625		%	BS22 Laramie					JG			
20210710	1620	1	**13**	1	36.7	65	38.014	168	12.786	0.5	%	BS21.5	214	254	11	175	JG		4m with algae	
20210710	1623	1	**13**	2	37	65	38.178	168	12.823		%	BS21.5			9	174	JG			
20210710	1631	1	**14**	1	40.2	65	38.553	168	14.862		%	BS21	217	244	20	143	JG		4m	
20210710	1634	1	**14**	2	40.4	65	38.683	168	14.846		%	BS21			17.5	199	JG			
20210710	1644	1	**15**	1	44	65	38.89	168	17.038		%	BS20.5	216	262	20.8	149	JG			Cleaned vent plugs before cast
20210710	1647	1	**15**	2	44.3	65	39.054	168	17.023		%	BS20.5			20.6	183	JG			
20210710	1653	5	**2**	1	44.7	65	39.344	168	17.088		%	BS20.5 Laramie					JG			2nd Laramie Cast
20210710	1714	5	**2**	2	44.7	65	40.366	168	17.311		%	BS20.5 Laramie					JG			Depth not recorded
20210710	1729	1	**16**	1	46.8	65	39.258	168	18.982		%	BS20	218	265	18.8	193	JG	0	3m	
20210710	1733	1	**16**	2	46.9	65	39.495	168	19.006		%	BS20			19.5	230	JG			
20210710	1742	1	**17**	1	48.7	65	39.791	168	21.293		%	BS19.5	218	263	21.3	201	JG		4m less chunky vis	
20210710	1745	1	**17**	2	48.8	65	39.948	168	21.178		%	BS19.5			20.9	208	JG			
20210710	1754	1	**18**	1	50.3	65	40.223	168	23.487	0	%	BS19	217	265	10	181	JG		5m	
20210710	1757	1	**18**	2	50.1	65	40.394	168	23.464		%	BS19			19.4	171	JG			
20210710	1802	5	**3**	1	50.7	65	40.559	168	23.513		%	BS 19 Laramie					JG		4m	
20210710	1813	5	**3**	2	50.4	65	40.984	168	23.359		%	BS19 Laramie			21.3	268	RJD			
20210710	1821	1	**19**	1	51	65	40.635	168	25.284		%	BS18.5	217	267	25	162	RJD		5m	
20210710	1826	1	**19**	2	51.2	65	40.811	168	25.386		%	BS18.5			20	188	RJD			
20210710	1832	1	**20**	1	51.17	65	41.126	168	25.93		%	BS18	217	280	22	181	RJD		5m	
20210710	1834	1	**20**	2	52.1	65	41.215	168	26.865		%	BS18			22	186	RJD			
20210710	1844	1	**21**	1	52.1	65	41.662	168	29.217		%	BS17.5	217	275	12	179	RJD			
20210710	1848	1	**21**	2	52.2	65	41.81	168	29.263		%	BS17.5			20	158	RJD			
20210710	1850	5	**4**	1	51.9	65	42.023	168	29.265		%	BS17.5 Laramie					JG			
20210710	1857	5	**4**	2	51.7	65	42.167	168	29.143		%	BS17.5					JG			

20210710	1907	1	**22**	1	52.9	65	42.154	168	31.224	0.5	%	BS17	217	278	28	200	JG	0	5m	
20210710	1911	1	**22**	2	53.3	65	42.28	168	31.273		%	BS17			21	161	JG			
20210710	1920	1	**23**	1	50.2	65	42.719	168	33.379		%	BS16.5	217	276	13	183	JG			
20210710	1922	1	**23**	2	50.1	65	42.868	168	33.253	0	%	BS16.5			21	192	JG	0		
20210710	1933	1	**24**	1	49.9	65	43.233	168	35.534		%	BS16	218	270	25	150	RJD	0	5m	
20210710	1936	1	**24**	2	50	65	43.325	168	35.547		%	BS16			25	153	RJD	0		
20210710	1938	5	**5**	1	49.9	65	43.478	168	35.475		%	BS16 Laramie			20	161	RJD	0	5m	
20210710	1946	5	**5**	2	50	65	43.734	168	35.244		%	BS16 Laramie					RJD	0		
20210710	2012	1	**25**	1	50.3	65	43.767	168	37.516		%	BS15.5	218	270	31	181	RJD	0	5m	
20210710	2015	1	**25**	2	50.2	65	43.858	168	37.468		%	BS15.5			22	188	RJD	0		
20210710	2029	1	**26**	1	49.9	65	44.242	168	39.791		%	BS15	218		27	170	RJD	0	5m	
20210710	2033	1	**26**	2	50.3	65	44.353	168	39.795		%	BS15			24	170	RJD	0		
20210710	2040	1	**27**	1	50.6	65	44.774	168	41.58		%	BS14.5	218	281	25	171	RJD	0	5m	
20210710	2045	1	**27**	2	50.4	65	44.911	168	41.595		%	BS14.5			23	170	RJD	0		
20210710	2047	5	**6**	1	51.3	65	45.106	168	41.666		%	BS14.5 Laramie			24	160	RJD	0	5m	
20210710	2047	5	**6**	2	51.2	65	45.21	168	43.171		%	BS14.5					RJD	0		Recovery time missing
20210710	2103	1	**28**	1	51.4	65	45.387	168	43.365		%	BS14	217	271	21	181	RJD	0	5m	Vent plugs cleaned
20210710	2108	1	**28**	2	51.4	65	45.387	168	43.365		%	BS14			24	180	RJD	0		
20210710	2116	1	**29**	1	51.3	65	45.781	168	45.505		%	BS13.5	217	275	18	181	RJD	0	5m	
20210710	2120	1	**29**	2	51.1	65	45.9	168	45.999		%	BS13.5			24	190	RJD	0		
20210710	2128	1	**30**	1	50.3	65	46.198	168	47.563		%	BS13	218	282	20	208	RJD	0	5m	Vent plugs cleaned
20210710	2133	1	**30**	2	50.1	65	46.366	168	47.695		%	BS13			22	171	RJD	0		
20210710	2135	5	**7**	1	50.5	65	46.545	168	47.546		%	BS13 Laramie			21	185	RJD	0	5m	
20210710	2143	5	**7**	2	50.7	65	46.601	168	47.78		%	BS13 Laramie					RJD	0		
20210710	2149	1	**31**	1	48.6	65	46.802	168	49.702		%	BS12.5	217	277	22	200	RJD	0	5m	Vent plugs cleaned
20210710	2155	1	**31**	2	48	65	46.949	168	49.864		%	BS12.5			20	200	RJD	0		
20210710	2200	1	**32**	1	43.2	65	47.178	168	51.611		%	BS12	217	261	23	180	RJD	0	4m	
20210710	2205	1	**32**	2	43	65	47.251	168	51.785		%	BS12			24	175	RJD	0		
20210710	2213	1	**33**	1	46	65	47.673	168	53.816		%	BS11.5	217	265	24	165	RJD	0	4m	Vent plugs cleaned
20210710	2217	1	**33**	2	46.1	65	47.682	168	53.855		%	BS11.5			22	170	RJD	0		
20210710	2218	5	**8**	1	46.3	65	47.702	168	53.89		%	BS11.5 Laramie			20	172	RJD	0		
20210710	2225	5	**8**	2	46.3	65	47.702	168	53.89		%	BS11.5 Laramie			18	210	RJD	0		Recovery postion missing - set to be same as deploy
20210710	2233	1	**34**	1	44.9	65	48.196	168	55.863		%	BS11	217	270	22	181	RJD	0	2m	
20210710	2238	1	**34**	2	45	65	48.25	168	55.905		%	BS11			24	180	RJD	0		
20210710	2245	1	**35**	1	46.3	65	49.211	168	56.095		%	DL1	217	268	30	181	RJD	0	4m	Vent plugs cleaned
20210710	2250	1	**35**	2	45.7	65	49.436	168	56.189		%	DL1			27	184	RJD	0		
20210710	2256	1	**36**	1	45.8	65	50.154	168	56.381		%	DL2	217	262	27	172	RJD	0	3m	
20210710	2300	1	**36**	2	45.9	65	50.289	168	56.5		%	DL2			13	180	RJD	0		
20210710	2308	1	**37**	1	47.1	65	51.188	168	56.12		%	DL3			27	171	RJD	0	3m	
20210710	2312	1	**37**	2	47	65	51.328	168	56.213		%	DL3			16	188	RJD	0		
20210710	2318	1	**38**	1	44.7	65	52.097	168	56.291	0	%	DL4	217	256	26.6	169	KC	0	3m	Vent plugs cleaned
20210710	2322	1	**38**	2	44.3	65	52.14	168	56.299	0	%	DL4			20.9	190	KC			
20210710	2329	1	**39**	1	46.3	65	53.064	168	56.185	0	%	DL5	217	258	20.6	168	KC	0	3m	
20210710	2334	1	**39**	2	46.5	65	53.093	168	56.159	0	%	DL5			20	190	KC			
20210710	2342	1	**40**	1	47.8	65	54.092	168	56.205	0	%	DL6	217	258	16.5	181	KC	0	4m	Vent plugs cleaned
20210710	2346	1	**40**	2	47.8	65	54.136	168	56.158	0	%	DL6			19.5	210	KC			
20210710	2355	1	**41**	1	47.9	65	55.169	168	56.238	0	%	DL7	217	260	22.3	189	KC	0	5m	
20210710	2358	1	**41**	2	47.9	65	55.23	168	56.227	0	%	DL7			24.3	199	KC			
20210711	6	1	**42**	1	48.7	65	56.112	168	56.219	0	%	DL8	217	261	17.7	174	KC	0	6m	Vent plugs cleaneed; arge hysteresis on downcast in oxygen; keeping an eye on it for the next cast
20210711	10	1	**42**	2	48.5	65	56.169	168	56.209	0	%	DL8			20.1	198	KC			
20210711	17	1	**43**	1	49.6	65	57.046	168	56.233	0	%	DL9	218	263	24.2	177	KC	0	7m	Vent plugs cleaned; still mismatch between oxygens on the downcast
20210711	21	1	**43**	2	49.5	65	57.112	168	56.187	0	%	DL9			18.2	180	KC			
20210711	30	1	**44**	1	50.5	65	58.042	168	56.273	0	%	DL10	217	263	19.3	176	KC	0	4m	
20210711	34	1	**44**	2	50.6	65	58.089	168	56.307	0	%	DL10			15.5	215	KC			
20210711	41	1	**45**	1	50.9	65	58.983	168	56.133	0	%	DL11	217	264	24.1	195	KC	0	4m	
20210711	45	1	**45**	2	51.1	65	59.071	168	56.151	0	%	DL11			20.2	214	KC			
20210711	53	1	**46**	1	51.3	65	59.983	168	56.203	0	%	DL12	216	264	22.9	188	KC	0	4m	
20210711	57	1	**46**	2	51.4	66	0.061	168	56.227	0	%	DL12			27.8	214	KC			
20210711	105	1	**47**	1	51	66	1.236	168	56.205	0	%	DL12.5	217	264	23.9	181	KC	0	4m	Huge spike in fluorescence; mislabeled in station name for seasave (DL13 rather than DL12.5)
20210711	111	1	**47**	2	50.8	66	1.471	168	56.212	0	%	DL12.5			20.9	212	KC			
20210711	120	1	**48**	1	51.8	66	2.524	168	56.212	0	%	DL13	218	261	21.7	182	KC	0	4m	New winch driver: extremely fast for the first part of down cast (15m in 2 sec), asked to slow down and speed seemed okay; data seemed okay too - move on to nex
20210711	125	1	**48**	2	51.8	66	2.603	168	56.178	0	%	DL13			16.6	204	KC			
20210711	134	1	**49**	1	51.9	66	3.805	168	56.202	0.5	%	DL13.5	218	266	18.5	177	KC	0	4m	
20210711	139	1	**49**	2	52	66	3.885	168	56.174	0.5	%	DL13.5			19.1	179	KC			
20210711	148	1	**50**	1	53.7	66	5.065	168	56.22	0.5	%	DL14	217	266	21.4	167	KC	0	3m	
20210711	152	1	**50**	2	53.9	66	5.176	168	56.254	0.5	%	DL14			9.3	185	KC			
20210711	209	1	**51**	1	53.4	66	6.432	168	56.103	0.5	%	DL14.5	217	260	16	190	RJD	0	2m	Went equal speeds on upcast and downcast, resolved difference in measurements
20210711	216	1	**51**	2	53.4	66	6.526	168	56.928	0.5	%	DL14.5			10	208	RJD			
20210711	227	1	**52**	1	53.2	66	7.636	168	56.269	0	%	DL15	217	267	20.8	189	KC	0	2.5m	Again, equal speeds on up and down
20210711	234	1	**52**	2	53.4	66	7.711	168	56.225	0	%	DL15			17.3	188	KC			
20210711	243	1	**53**	1	53.5	66	8.911	168	56.22	0.5	%	DL15.5	217	267	19.9	178	KC	0	3m	Attempting 1.5x speed on up compared to down - works well, implementing from this point. Cleaned vent plugs after this cast.
20210711	248	1	**53**	2	53.7	66	9.986	168	56.178	0.5	%	DL15.5			26.3	204	KC			
20210711	258	1	**54**	1	54.2	66	10.157	168	56.263	0.5	%	DL16	217	267	29.4	189	KC	0	2m	
20210711	303	1	**54**	2	53.9	66	10.245	168	56.215	0.5	%	DL16			22.7	203	KC			
20210711	313	1	**55**	1	55	66	11.437	168	56.213	0	%	DL16.5	217	268	23.8	191	KC	0	2m	Vent plugs cleaned before this cast
20210711	318	1	**55**	2	55.2	66	11.518	168	56.208	0	%	DL16.5			21	205	KC			
20210711	327	1	**56**	1	56.2	66	12.704	168	56.189	0.5	%	DL17	217	269	21.5	180	KC	0	2m	
20210711	332	1	**56**	2	56.3	66	12.777	168	56.13	0.5	%	DL17			18.6	202	KC			
20210711	343	1	**57**	1	55.6	66	13.99	168	56.206	0	%	DL17.5	217	269	20.4	177	KC	0	2m	
20210711	347	1	**57**	2	55.8	66	14.061	168	56.206	0	%	DL17.5			22.6	184	KC			

20210711	357	1	**58**	1	56.3	66	15.257	168	56.217	0	%	DL18	216	269	23.3	196	KC		0	2m	
20210711	402	1	**58**	2	56.3	66	15.325	168	56.207	0	%	DL18			19.7	201	KC				
20210711	412	1	**59**	1	55.9	66	16.535	168	56.189	0	%	DL18.5	217	268	21.2	209	KC		0	3m	
20210711	416	1	**59**	2	55.7	66	16.598	168	56.141	0	%	DL18.5			19.8	236	KC				
20210711	426	1	**60**	1	55.6	66	17.816	168	56.173	0	%	DL19	217	268	23.1	210	KC		0	3m	
20210711	431	1	**60**	2	55.5	66	17.893	168	56.098	0	%	DL19			15.2	241	KC				
20210711	439	1	**61**	1	55.7	66	18.706	168	56.189	0.5	%	DL19.5	216	267	19.4	210	KC		0	3m	End of the DL line
20210711	443	1	**61**	2	55.6	66	18.778	168	56.101	0.5	%	DL19.5			14.3	226	KC				
20210711	451	1	**62**	1	55.3	66	19.531	168	57.045	0.5	%	A3 mooring site	216	268	11.3	223	KC		0	3m	
20210711	456	1	**62**	2	55.4	66	19.595	168	57.001	0.5	%	A3 mooring site			13.7	243	KC				
20210711	504	1	**63**	1	55.5	66	19.957	168	55.296	0	%	AL12.5	216	268	16.3	240	KC		0	3m	
20210711	508	1	**63**	2	55.4	66	20.003	168	55.257	0	%	AL12.5			15.1	260	KC				
20210711	510	5	**9**	1	55.4	66	20.022	168	55.255		%	AL12.5 Laramie	5	45	13.6	264	KC				Starting to record amount of piping that is put into the water in tht ewire in/out columns here. Surface is where the surface sample is taken, Bot is where the bottor
20210711	518	5	**9**	2	55.3	66	20.13	168	55.288		%	AL12.5 Laramie			5.1	312	KC				
20210711	527	1	**64**	1	55.4	66	20.398	168	53.777	0	%	AL13	216	269	16	292	KC		0	3m	
20210711	532	1	**64**	2	55.5	66	20.472	168	53.835	0	%	AL13			12.6	311	KC				
20210711	541	1	**65**	1	53.9	66	20.708	168	51.488	0.5	%	AL13.5	216	265	5.5	302	KC		0	3m	
20210711	546	1	**65**	2	53.8	66	20.707	168	51.481	0.5	%	Al13.5			13.4	302	KC				
20210711	554	1	**66**	1	54.3	66	21.115	168	49.488	0	%	AL14	216	267	16.3	301	KC		0	3m	
20210711	559	1	**66**	2	54.2	66	21.185	168	49.551	0	%	AL14			10.7	300	KC				
20210711	600	5	**10**	1	54.3	66	21.201	168	49.58		%	AL14 Laramie	5	45	13.3	293	KC				
20210711	608	5	**10**	2	54.3	66	21.264	168	49.55		%	AL14 Laramie			14	302	KC				
20210711	618	1	**67**	1	54.3	66	21.445	168	47.292	0	%	AL14.5	218	266	16.2	295	KC		0	3m	
20210711	623	1	**67**	2	54.2	66	21.529	168	47.266	0	%	AL14.5			17.5	307	KC				
20210711	631	1	**68**	1	46.4	66	21.766	168	45.137	0	%	AL15	217	259	24.3	311	KC		0	3m	
20210711	635	1	**68**	2	46.2	66	21.826	168	45.106	0	%	AL15			17.2	316	KC				
20210711	644	1	**69**	1	50.9	66	22.126	168	42.995	0	%	AL15.5	217	263	12.9	320	KC		0	3m	
20210711	649	1	**69**	2	50.9	66	22.199	168	42.99	0	%	AL15.5			8.3	327	KC				
20210711	650	5	**11**	1	50.8	66	22.211	168	42.999		%	AL15.5 Laramie	5	45	10.2	317	KC				
20210711	658	5	**11**	2	50.8	66	22.267	168	42.967		%	AL15.5 Laramie			7.8	8.3	KC				
20210711	709	1	**70**	1	56.7	66	22.512	168	40.789		%	AL16	216	270	14	314	JG		0.5	3m	
20210711	712	1	**70**	2	56.5	66	22.563	168	40.835		%	AL16			8.7	323	JG				
20210711	723	1	**71**	1	56.4	66	22.861	168	38.644	0	%	AL16.5	216	270	13	343	JG		0.5	3m	
20210711	728	1	**71**	2	56.5	66	22.882	168	38.645	0	%	AL16.5			16	336	JG				
20210711	737	1	**72**	1	54.8	66	23.202	168	36.534	0	%	AL17	217	268	13.3	336	JG		0	3m	
20210711	742	1	**72**	2	55	66	23.243	168	36.54	0	%	AL17			18	346	JG				
20210711	743	5	**12**	1	55.1	66	23.248	168	36.529		%	AL17 Laramie	5	45			JG				
20210711	750	5	**12**	2	55	66	23.257	168	36.523		%	AL17 Laramie					JG				
20210711	759	1	**73**	1	54.3	66	23.554	168	34.767	0	%	AL17.5	216	268	19.3	322	JG		0	3m	
20210711	804	1	**73**	2	54.5	66	23.567	168	34.861	0	%	AL17.5			16.4	350	JG				
20210711	815	1	**74**	1	52.6	66	23.91	168	32.222	0	%	AL18	217	267	14.3	359	JG		0	3m	
20210711	820	1	**74**	2	52.7	66	23.9	168	32.306	0	%	AL18			14.1	1.9	JG				
20210711	830	1	**75**	1	53	66	24.256	168	29.86	0	%	AL18.5	216	267	13.4	19	JG		0	3m	
20210711	834	1	**75**	2	52.9	66	24.207	168	29.89	0	%	AL18.5			7	12.7	JG				
20210711	836	5	**13**	1	53	66	24.202	168	29.925		%	AL18.5 Laramie	5	45			JG				
20210711	843	5	**13**	2	53.1	66	24.209	168	29.94		%	AL18.5 Laramie					JG				
20210711	854	1	**76**	1	53.3	66	24.623	168	27.852	0	%	AL19	217	267	15.6	337	JG		0	4m	
20210711	858	1	**76**	2	53.3	66	24.628	168	27.974	0	%	AL19			15.4	350	JG				
20210711	908	1	**77**	1	52.4	66	24.996	168	25.587	0	%	AL19.5	216	265	13.8	7.4	JG		0	4m	
20210711	912	1	**77**	2	52.1	66	25.041	168	25.658	0	%	AL19.5			18	2	JG				
20210711	922	1	**78**	1	52.3	66	25.316	168	23.516	0	%	AL20			20.4	354	JG		0	4m	
20210711	927	1	**78**	2	52.1	66	25.302	168	23.556	0	%	AL20			18.5	352	JG				
20210711	928	5	**14**	1	52.2	66	25.301	168	23.554		%	AL20 Laramie	5	45			JG				
20210711	935	5	**14**	2	52.1	66	25.293	168	23.533		%	AL20 Laramie					JG				
20210711	1020	1	**79**	1	50.8	66	25.665	168	21.283	0	%	AL20.5	216	263	12.9	13.6	JG		0	3m	
20210711	1025	1	**79**	2	50.7	66	25.7	168	21.184	0	%	AL20.5			16	359	JG				
20210711	1031	1	**80**	1	47.4	66	26.036	168	19.211	0	%	AL21	216	261	7.9	5.8	JG		0	3m	
20210711	1036	1	**80**	2	47.3	66	26.045	168	19.294	0	%	AL21			15	354	JG				
20210711	1046	1	**81**	1	43	66	26.426	168	17.022	0	%	AL21.5	217	256	10.6	4.5	JG		0	3m	
20210711	1050	1	**81**	2	42.9	66	26.451	168	17.068	0	%	AL21.5			14	354	JG				
20210711	1051	5	**15**	1	43.1	66	26.462	168	17.058		%	AL21.5 Laramie	5	40			JG				
20210711	1058	5	**15**	2	42.8	66	26.557	168	16.99		%	AL21.5 Laramie					JG				
20210711	1109	1	**82**	1	40.1	66	26.765	168	14.903	0	%	AL22	217	253	9.8	8.4	JG		0	3m	
20210711	1113	1	**82**	2	40.1	66	26.792	168	14.958	0	%	AL22			16	5	JG				
20210711	1123	1	**83**	1	36.5	66	27.116	168	12.668	0	%	AL22.5	216	250	17	6.4	JG		0	3.5m	
20210711	1127	1	**83**	2	36.5	66	27.113	168	12.725	0	%	AL22.5			20.3	349	JG				
20210711	1137	1	**84**	1	32.3	66	27.493	168	10.459	1	%	AL23	216	245	14.2	6.1	JG		0	3m	forgot to turn pump on, cast delayed slightly
20210711	1142	1	**84**	2	32.1	66	27.579	168	10.327	1	%	AL23			13.4	7.2	JG				
20210711	1143	5	**16**	1	31.9	66	27.584	168	10.328		%	AL23 Laramie	5	30			JG				
20210711	1149	5	**16**	2	31.8	66	27.63	168	10.323		%	AL23 Laramie					JG				
20210711	1157	1	**85**	1	28.6	66	27.803	168	8.495	0	%	AL23.5	217	240	10.4	4	JG		0	3m	
20210711	1201	1	**85**	2	28.7	66	27.798	168	8.561	0	%	AL23.5					JG				
20210711	1211	1	**86**	1	26.4	66	28.134	168	6.298	1	%	AL24	217	241	16.6	17	JG		0	3m	
20210711	1214	1	**86**	2	26.2	66	28.154	168	6.233	1	%	AL24			17.1	350	JG				
20210711	1222	1	**87**	1	24.2	66	28.443	168	4.162	1	%	AL24.5	217	239	13.6	6.2	JG		0	2m	
20210711	1226	1	**87**	2	24.2	66	28.443	168	4.078	1	%	AL24.5			18	334	JG				
20210711	1234	1	**88**	1	22.7	66	28.787	168	1.967	1	%	AL25	217	237	13.2	22.1	JG		0	2m	
20210711	1237	1	**88**	2	22.6	66	28.782	168	1.886	1	%	AL25			12.9	356	JG				
20210711	1237	5	**17**	1	22.6	66	28.782	168	1.886		%	AL25 Laramie					JG				
20210711	1241	5	**17**	2	22.6	66	28.777	168	1.886		%	AL25 Laramie					JG				

20210711	1250	1	89	1	21.8	66	29.114	167	59.853	0	%	AL25.5	217	237	11.3	6.2	JG	0	2m	
20210711	1254	1	89	2	21.9	66	29.066	167	59.794	0	%	AL25.5			17.2	357	JG			
20210711	1302	1	90	1	21.5	66	29.454	167	57.663	1	%	AL26	216	236	15.4	10.6	JG	0	2m	
20210711	1306	1	90	2	21.5	66	29.443	167	57.571	1	%	AL26			17.2	354	JG			
20210711	1314	1	91	1	21.6	66	29.776	167	55.508	0.5	%	AL26.5	216	236	14.8	19.8	JG	0	2m	
20210711	1317	1	91	2	21.4	66	29.75	167	55.419	0.5	%	AL26.5			14.4	11.7	JG			
20210711	1325	1	92	1	22	66	30.115	167	53.33	0	%	AL27	216	236	14.1	15.9	JG	0	2m	
20210711	1328	1	92	2	22	66	30.068	167	53.262	0	%	AL27			14.6	22.8	JG			
20210711	1337	1	93	1	22.1	66	30.439	167	51.187	0	%	AL27.5	216	236	8.3	16	JG	0.5	3m	
20210711	1341	1	93	2	22.1	66	30.409	167	51.255	0	%	AL27.5			14	18.5	JG			
20210711	2329	1	94	1	45.8	65	44.921	168	15.558	0.5	%	A4-21 post-deployment cali	216	262	12	201	KC	0	2.5m	before cast, raised system two's pump ~1 cm
20210711	2334	1	94	2	45.5	65	45.066	168	15.38	0.5	%	A4-21 post-deployment calibration			11.3	227	KC			
20210712	1326	1	95	1	49	67	38.057	168	56.002	0	%	CS10US	217	264	26.1	214	JG	0	4m	
20210712	1330	1	95	2	48.9	67	38.153	168	55.982	0	%	CS10US			23.4	184	JG			
20210712	1332	5	18	1	48.9	67	38.184	168	55.991		%	CS10US Laramie	5	45			JG			
20210712	1338	5	18	2	48.9	67	38.32	168	56.018		%	CS10US Laramie					JG			
20210712	1357	1	96	1	48.5	67	39.859	168	52.058	0	%	CS10.25	217	264	24.2	197	JG	0	4m	
20210712	1401	1	96	2	48.6	67	39.929	168	51.997	0	%	CS10.25					JG			
20210712	1430	1	97	1	48.4	67	41.552	168	48.235	0	%	CS10.5	218	265	24.9	206	JG	0	3m	
20210712	1434	1	97	2	48.7	67	41.64	168	48.211	0	%	CS10.5			22.1	193	JG			
20210712	1452	1	98	1	48.4	67	43.381	168	43.952	0	%	CS10.75	218	265	24.7	174	JG	0	3m	
20210712	1458	1	98	2	48.6	67	43.526	168	43.795	0	%	CS10.75			25.4	161	JG			
20210712	1513	1	99	1	48.5	67	43.301	168	39.945	0	%	CS11	217	268	27	200	RJD	0	4m	Vent plug cleaned
20210712	1520	1	99	2	48.9	67	45.258	168	39.73	0	%	CS11			24	190	RJD			
20210712	1520	5	19	1	48.5	67	45.245	168	39.725		%	CS11 Laramie	5		26	198	RJD	0	4m	
20210712	1532	5	19	2	48.7	67	45.701	168	39.325		%	CS11 Laramie			24	185	RJD			
20210712	1549	1	100	1	48.5	67	47.065	168	34.596	0	%	CS11.25	218	262	32	200	RJD	0	4m	
20210712	1552	1	100	2	48.8	67	47.147	168	34.533	0	%	CS11.25			21	175	RJD			
20210712	1611	1	101	1	48.9	67	48.746	168	29.589	0	%	CS11.5	218	267	32	209	RJD	0	5m+	
20210712	1616	1	101	2	49.1	67	48.953	168	29.122	0	%	CS11.5			23	171	RJD			
20210712	1634	1	102	1	51.5	67	50.632	168	24.162	0	%	CS11.75	218	264	25	198	RJD	0	5m+	
20210712	1638	1	102	2	51.6	67	50.744	168	23.949	0	%	CS11.75			23	178	RJD			
20210712	1655	1	103	1	54.9	67	52.27	168	18.186	0	%	CS12	217	262	24	202	RJD	0	5m	
20210712	1701	1	103	2	55.1	67	52.393	168	19.13	0	%	CS12			28	204	RJD			
20210712	1702	5	20	1	55.2	67	52.416	168	19.138		%	CS12 Laramie	5		26	198	RJD	0	5m	
20210712	1719	5	20	2	55.4	67	52.556	168	18.045		%	CS12 Laramie			25	177	RJD			
20210712	1732	1	104	1	56.8	67	54.151	168	13.825	0	%	CS12.25	218	267	24	197	RJD	0	5m	
20210712	1736	1	104	2	56.7	67	54.254	168	13.767	0	%	CS12.25			25	181	RJD			
20210712	1754	1	105	1	57.5	67	55.779	168	9.093	0	%	CS12.5	217	273	28	212	RJD	0	5m+	
20210712	1757	1	105	2	57	67	55.929	168	8.937	0	%	CS12.5			22	170	RJD			
20210712	1816	1	106	1	60.2	67	57.496	168	4.317	0	%	CS12.75			30	190	RJD	0	5m	
20210712	1821	1	106	2	60.1	67	57.601	168	4.287	0	%	CS12.75			25	172	RJD			
20210712	1840	1	107	1	53.6	67	59.224	167	59.388	0	%	CS13	217	264	21	211	RJD	0	5m	
20210712	1845	1	107	2	53.3	67	59.35	167	59.287	0	%	CS13			28	177	RJD			
20210712	1846	5	21	5	53.1	67	59.353	167	59.273	0	%	CS13 Laramie	5	45	25	190	RJD	0	5m	Stopped operations due to sea state
20210712	1855	5	21	5	53.1	67	59.353	167	59.273		%	CS13 Laramie			29	187	RJD			Recovery postion missing - set to be same as deploy .. did have lon at 167 59.23
20210713	25	1	108	1	53.9	67	59.242	167	59.43	0	%	CS13	217	265	26.1	201	KC	0	5m	Operations are back on! Repeat station for CS13. Placed zip ties on exhaust end of SBE 43 system 2 to secure them better (as per suggested by Seabird)
20210713	28	1	108	2	53.5	67	59.318	167	59.424	0	%	CS13			25	211	KC			
20210713	47	1	109	1	51.1	68	0.904	167	54.613	0	%	CS13.25	217	263	29.1	195	KC	0	5m	
20210713	51	1	109	2	51.3	68	0.976	167	54.626	0	%	CS13.25			25.4	170	KC			
20210713	109	1	110	1	52.7	68	2.63	167	49.819	0	%	CS13.5	218	267	22.1	219	KC	0	4m	Had one of the larger rolls we've seen in the cruise so far (knocked a viny float out of the wire basket on the 01 deck, could hear it rolling around from the lab). No e
20210713	113	1	110	2	53.1	68	2.72	167	49.82	0	%	CS13.5			21.3	184	KC			
20210713	132	1	111	1	52.6	68	4.339	167	44.873	0	%	CS13.75	217	266	24.8	189	KC	0	3m	
20210713	136	1	111	2	53	68	4.417	167	44.854	0	%	CS13.75			26.2	174	KC			
20210713	155	1	112	1	51.7	68	6.061	167	40.058	0.5	%	CS14	217	265	24.1	216	KC	0	4m	
20210713	159	1	112	2	51.6	68	6.158	167	40.072	0.5	%	CS14			27.1	196	KC			
20210713	200	5	22	1	51.2	68	6.171	167	40.079		%	CS14 Laramie	5	45	22.9	203	KC	0		
20210713	209	5	22	2	50.5	68	6.37	167	40.165		%	CS14 Laramie			18.5	193	KC			
20210713	225	1	113	1	49.2	68	7.54	167	35.371	0	%	CS14.25	218	261	19.5	209	KC	0	4m	Swell seems to be shrinking a bit; hopeful the trend will continue
20210713	230	1	113	2	48.9	68	7.624	167	35.4	0	%	CS14.25			20.7	179	KC			
20210713	246	1	114	1	47.8	68	9.049	167	30.863	0	%	CS14.5	217	222	21.4	166	KC	0	4m	CTD came out of the water before going down. Returned to soak depth and started a new cast to be safe.
20210713	249	1	114	2	47.8	68	9.095	167	30.945	0	%	CS14.5			20.3	145	KC			
20210713	249	1	115	1	47.8	68	9.095	167	30.945	0	%	CS14.5	217	261	20.3	145	KC	0	4m	Data seems all good even after surface breach in cast before
20210713	255	1	115	2	47.3	68	9.214	167	30.924	0	%	CS14.5			19.6	145	KC			
20210713	314	1	116	1	47.1	68	10.564	167	26.18	0	%	CS14.75	218	261	14.4	198	KC	0	4m	
20210713	318	1	116	2	47	68	10.669	167	26.187	0	%	CS14.75			21.7	151	KC			
20210713	335	1	117	1	46.9	68	12.039	167	21.467	0	%	CS15	218	261	17.1	156	KC	0	4m	CTD moved a bit under the stern, but we couldn't "bump forward" since the pumping sample had already started.
20210713	340	1	117	2	46.3	68	12.149	167	21.546	0	%	CS15			19.1	183	KC			
20210713	338	5	23	1	46.9	68	12.145	167	21.543		%	CS15 Laramie	5	45	17.4	185	KC			
20210713	347	5	23	2	46.8	68	12.301	167	21.665		%	CS15 Laramie			18.5	179	KC			
20210713	403	1	118	1	44.4	68	13.548	167	16.686	0	%	CS15.5	217	256	17.5	187	KC	0	4m	
20210713	408	1	118	2	45.1	68	13.653	167	16.706	0	%	CS15.5			16.4	154	KC			
20210713	424	1	119	1	43.3	68	14.955	167	12.324	0	%	CS16	217	261	10	174	KC	0	4m	
20210713	429	1	119	2	43.5	68	15.09	167	12.505	0	%	CS16			17.1	147	KC			
20210713	429	5	24	1	43.5	68	15.106	167	12.514		%	CS16 Laramie	5	40	20.7	124	KC	0	4m	
20210713	438	5	24	2	44	68	15.302	167	12.513		%	CS16 Laramie			21.2	121	KC			
20210713	457	1	120	1	40.4	68	16.572	167	7.584	0	%	CS16.5	217	252	15.6	134	KC	0	4m	
20210713	501	1	120	2	40.4	68	16.649	167	7.622	0	%	CS16.5			13.1	166	KC			
20210713	518	1	121	1	37	68	17.94	167	2.966	0	%	CS17	217	249	20.2	146	KC	0	3m	Pt. Hope visible
20210713	522	1	121	2	36.9	68	18.002	167	3.065	0	%	CS17			16.5	141	KC			

20210713	523	5	25	1	36.7	68	18.021	167	3.066		%	CS17 Laramie	5	35	17.5	139	KC	0	3m	
20210713	531	5	25	2	37.2	68	18.161	167	3.105		%	CS17 Laramie			17.4	137	KC			
20210713	552	1	122	1	32.4	68	18.854	166	57.823	0	%	CS18	216	247	22.9	151	KC	0	2m	
20210713	555	1	122	2	33	68	18.902	166	58.159	0	%	CS18			20.8	144	KC			
20210713	620	1	123	1	25.7	68	19.873	166	52.483	0	%	CS19	217	241	15.7	134	KC	0	1.5m	
20210713	623	1	123	2	26.2	68	19.928	166	52.843	0	%	CS19			18.8	148	KC			
20210713	712	1	124	1	35.4	68	22.411	167	8.09	0	%	NPH1	217	250	20	137	JG	0	2m	
20210713	715	1	124	2	35.7	68	22.555	167	8.235	0	%	NPH1			22	179	JG			
20210713	725	1	125	1	40	68	22.662	167	11.275	0	%	NPH2	217	256	16.8	175	JG	0	2m	
20210713	729	1	125	2	39.7	68	22.791	167	11.28	0	%	NPH2			14	141	JG			
20210713	741	1	126	1	39.8	68	22.871	167	14.595	0	%	NPH3	217	256	16.5	148	JG	0	3m	
20210713	745	1	126	2	39.6	68	22.952	167	14.646	0	%	NPH3			18.2	141	JG			
20210713	755	1	127	1	40.1	68	23.11	167	18.024	0	%	NPH4	217	256	17.9	136	JG	0	3m	
20210713	759	1	127	2	39.6	68	23.218	167	18.001	0	%	NPH4			19.5	178	JG			
20210713	811	1	128	1	41.8	68	23.357	167	21.527	0	%	NPH5	216	258	10.1	129	JG	0	3m	
20210713	815	1	128	2	41.2	68	23.49	167	21.5	0	%	NPH5			19.3	172	JG			
20210713	835	1	129	1	46	68	23.804	167	28.167	0	%	NPH6	217	263	17.8	138	JG	0	3m	
20210713	839	1	129	2	46.1	68	23.882	167	28.26	0	%	NPH6			15.1	166	JG			
20210713	858	1	130	1	49.1	68	24.284	167	34.963	0	%	NPH7	216	264	18.7	145	JG	0	4m	
20210713	902	1	130	2	49.3	68	24.36	167	35.104	0	%	NPH7			14.5	137	JG			
20210713	921	1	131	1	51.3	68	24.768	167	41.723	0	%	NPH8	217	267	13	135	JG	0	3m	Wildfire smoke most of the morning
20210713	926	1	131	2	51.2	68	24.885	167	41.719	0	%	NPH8			14	186	JG			
20210713	1012	1	132	1	52.5	68	25.195	167	48.462	0	%	NPH9	217	268	17	140	JG	0	4m	
20210713	1017	1	132	2	52.7	68	25.274	167	48.549	0	%	NPH9			13.1	128	JG			
20210713	1036	1	133	1	52.7	68	25.728	167	55.204	0	%	NPH10	217	268	6.7	143	JG	0	4m	
20210713	1041	1	133	2	53	68	25.851	167	55.151	0	%	NPH10			14.5	120	JG			
20210713	1102	1	134	1	52.1	68	26.229	168	1.927	0	%	NPH11	217	267	17.1	169	JG	0	4m	
20210713	1107	1	134	2	51.8	68	26.306	168	1.867	0	%	NPH11			15.3	153	JG			
20210713	1127	1	135	1	51	68	26.704	168	8.796	0	%	NPH11.5	217	265	15.9	154	JG	0	4m	Vent plug for T1/C1 didn't drain. Cleaned both after Cast 135
20210713	1132	1	135	2	50.7	68	26.809	168	8.682	0	%	NPH11.5			9.4	161	JG			
20210713	1151	1	136	1	50.7	68	27.132	168	15.598	0	%	NPH12	217	264	4.9	121	JG	0	4m	Vent plug drained after cleaning
20210713	1156	1	136	2	50.4	68	27.181	168	15.76	0	%	NPH12			8.4	138	JG			
20210713	1215	1	137	1	51.3	68	27.596	168	22.217	0	%	NPH12.5	217	264	7.1	111	JG	0	4m	
20210713	1220	1	137	2	51.2	68	27.672	168	22.235	0	%	NPH12.5			11.9	121	JG			
20210713	1239	1	138	1	50.7	68	28.948	168	28.092	0	%	NPH13	216	264	12.5	141	JG	0	4m	
20210713	1244	1	138	2	50.6	68	28.997	168	28.173	0	%	NPH13			15.5	123	JG			
20210713	1509	1	139	1	50.8	68	37.036	167	40.988	0	%	CD14	217	262	10	135	RJD	1	2M	
20210713	1518	1	139	2	50.8	68	37.121	167	40.991	0	%	CD14			11	162	RJD			
20210713	1533	1	140	1	49.4	68	36.884	167	35.696	0	%	CD13	218	261	9	157	RJD	1	3m	
20210713	1537	1	140	2	49.3	68	36.894	167	35.641	0	%	CD13			8	153	RJD			
20210713	1553	1	141	1	47.5	68	36.96	167	29.911	0	%	CD12	218	261	11	148	RJD	1	3m	
20210713	1557	1	141	2	47.8	68	37.027	167	29.902	0	%	CD12			12	131	RJD			
20210713	1613	1	142	1	45.1	68	36.961	167	24.435	0	%	CD11	218	257	10	137	RJD	1	2m	
20210713	1618	1	142	2	45.1	68	37.012	167	24.501	0	%	CD11			11	140	RJD			
20210713	1634	1	143	1	42.3	68	37.011	167	18.65	0	%	CD10	218	254	12	155	RJD	1	3m	
20210713	1640	1	143	2	42.1	68	37.001	167	18.54	0	%	CD10			13	120	RJD			
20210713	1654	1	144	1	38.8	68	36.946	167	13.286	0	%	CD9	218	252	13	174	RJD	1	2m	
20210713	1658	1	144	2	39	68	37.024	167	13.129	0	%	CD9			13	18	RJD			
20210713	1713	1	145	1	36.1	68	36.98	167	7.749	0	%	CD8	218	249	12	151	RJD	1	2m	
20210713	1718	1	145	2	36.1	68	37.05	167	7.182	0	%	CD8			10	120	RJD			
20210713	1731	1	146	1	34.7	68	36.962	167	2.269	0	%	CD7	218	246	10	167	RJD	1	2m	
20210713	1735	1	146	2	34.7	68	37.027	167	2.058	0	%	CD7			12	142	RJD			
20210713	1750	1	147	1	33.4	68	36.958	166	56.7	0	%	CD6	218	248	9	145	RJD	1	2m	
20210713	1754	1	147	2	33.4	68	37.006	166	56.491	0	%	CD6			12	170	RJD			
20210713	1810	1	148	1	32.4	68	36.982	166	51.13	0	%	CD5	218	245	12	178	RJD	1	3m	
20210713	1814	1	148	2	32.3	68	37.032	166	50.913	0	%	CD5			7	121	RJD			
20210713	1829	1	149	1	31.8	68	36.982	166	45.49	0	%	CD4	218	246	15	180	RJD	1	3m	
20210713	1833	1	149	2	31.6	68	37.024	166	45.175	0	%	CD4			8	178	RJD			
20210713	1845	1	150	1	31	68	37.001	166	40.022	0	%	CD3	218	246	13	180	RJD	1	3m	
20210713	1850	1	150	2	31.1	68	37.082	166	39.619	0	%	CD3			12	160	RJD			
20210713	1902	1	151	1	30.1	68	36.975	166	34.521	0	%	CD2	218	245	9	190	RJD	1	3m	
20210713	1906	1	151	2	30	68	37.046	166	34.174	0	%	CD2			10	167	RJD			
20210713	1919	1	152	1	26.7	68	37.02	166	29.025	0	%	CD1	218	242	12	180	RJD	1	2m	
20210713	1923	1	152	2	26.8	68	37.146	166	28.727	0	%	CD1			13	170	RJD			
20210713	2127	1	153	1	26.5	68	54.374	166	19.948	1	%	LIS1	218	240	3	17	RJD	0	1m	
20210713	2130	1	153	2	26.7	68	54.394	166	20.037	1	%	LIS1			3	47	RJD			
20210713	2131	5	26	1	26.5	68	54.4	166	20.051		%	LIS1 Laramie	5	25	3	44	RJD	0	1m	Put out 30m of tubing by mistake, hit the bottom. Pulled up to 25m before turning on pump
20210713	2140	5	26	2	26.4	68	54.394	166	20.011		%	LIS1 Laramie			4	16	RJD			
20210713	2153	1	154	1	31.2	68	54.756	166	24.958	1	%	LIS2	218	244	4	14	RJD	0	1m	
20210713	2156	1	154	2	31.3	68	54.753	166	25.138	1	%	LIS2			2	340	RJD			
20210713	2200	5	27	0	31.3	68	54.753	166	25.138		%	LIS2 Laramie + water sampl	5	5	2	27	RJD	0	1m	018 water sample as well as a nutrient/trace metal sample.Laramie/Rebecca
20210713	2200	5	27	0	31.3	68	54.753	166	25.138		%	LIS2 Laramie + water sampl	5	5	2	27	RJD	0	1m	Surface sample, so no finish position
20210713	2215	1	155	1	32.4	68	55.144	166	30.365	1	%	LIS3	218	241	4	277	RJD	0	1m	
20210713	2219	1	155	2	32.7	68	55.145	166	30.503	1	%	LIS3			5	300	RJD			
20210713	2219	5	28	1	32.7	68	55.146	166	30.525		%	LIS3 Laramie+watersample	5	25	7	300	RJD	0	1m	018 water sample as well as a nutrient/trace metal sample.Laramie/Rebecca
20210713	2227	5	28	2	32.6	68	55.161	166	30.515		%	LIS3 Laramie+water sample			6	310	RJD			
20210713	2249	1	156	1	39.7	68	55.789	166	38.374	0.5	%	LIS4	218	253	2	312	RJD	0	2m	
20210713	2254	1	156	2	39.8	68	55.808	166	38.494	0.5	%	LIS4			2	318	RJD			
20210713	2316	1	157	1	44.4	68	56.394	166	46.303	0	%	LIS5	217	257	13.6	342	KC	1	2m	
20210713	2322	1	157	2	44.3	68	56.479	166	46.375	0	%	LIS5			14.9	28.6	KC			

20210713	2344	1	**158**	1	44.7	68	56.992	166	54.588	0	%	LIS6	217	259	9.9	79.2	KC	1	2m	Spike in one of the oxygen sensor on the way down. The rest of the data seemed fine. Pumps were draining fine after.
20210713	2349	1	**158**	2	44.8	68	56.989	166	54.436	0	%	LIS6			11.9	105	KC			
20210714	10	1	**159**	1	45.2	68	57.603	167	1.888	0	%	LIS6.5	217	261	9.1	81.4	KC	1	2m	
20210714	15	1	**159**	2	45.3	68	57.66	167	2.041	0	%	LIS6.5			25.2	120	KC			
20210714	16	5	**29**	1	45.3	68	57.668	167	2.058		%	LIS6.5 Laramie	5	40	23	128	KC	1	2m	Started pouring rain at the end of the cast, pretty much cleared up during transit to next cast
20210714	23	5	**29**	2	45.2	68	57.712	167	2.29		%	LIS6.5 Laramie			19.3	118	KC			
20210714	42	1	**160**	1	45.1	68	58.186	167	9.285	0	%	LIS7	217	261	11.3	114	KC	1	2m	
20210714	46	1	**160**	2	45.3	68	58.17	167	9.5	0	%	LIS7			17.6	122	KC			
20210714	105	1	**161**	1	45.3	68	58.789	167	16.538	0	%	LIS7.5	217	261	16	113	KC	1	2m	
20210714	110	1	**161**	2	45.2	68	58.787	167	16.752	0	%	LIS7.5			14.8	115	KC			
20210714	130	1	**162**	1	46.1	68	59.42	167	23.9	0	%	LIS8	217	259	12.4	114	KC	1	2m	
20210714	134	1	**162**	2	46.2	68	59.41	167	23.975	0	%	LIS8			9.1	108	KC			
20210714	135	5	**30**	1	45.9	68	59.409	167	23.981		%	LIS8 Laramie	5	40	9.5	115	KC	1	2m	
20210714	143	5	**30**	2	45.9	68	59.486	167	24.023		%	LIS8 Laramie			3.7	87.2	KC			
20210714	211	1	**163**	1	46.7	69	0.197	167	33.762	0	%	LIS8.5	217	261	5.4	344	KC	1	3m	Skipping LIS9 for the Q cable… LIS8.5 and LIS9.5 instead
20210714	216	1	**163**	2	46.8	69	0.306	167	33.745	0	%	LIS8.5			9.8	30.1	KC			
20210714	243	1	**164**	1	47.6	69	0.979	167	43.598	0	%	LIS9.5	217	261	9.7	10.4	KC	1	3m	
20210714	248	1	**164**	2	47.6	69	1.069	167	43.665	0	%	LIS9.5			11.3	50.7	KC			
20210714	317	1	**165**	1	47.9	69	1.808	167	53.397	0	%	LIS10	217	260	16.2	50.3	KC	1	3.5m	
20210714	321	1	**165**	2	47.8	69	1.85	167	53.464	0	%	LIS10			18.5	44.3	KC			
20210714	401	1	**166**	1	48.7	69	1.334	168	7.942	0	%	LIS11	216	261	18.4	43.5	KC	0.5	2m	
20210714	405	1	**166**	2	48.8	69	1.379	168	8.057	0	%	LIS11			18.6	32.1	KC			
20210714	406	5	**31**	1	48.6	69	1.384	168	8.101		%	LIS11 Laramie	5	45	16.9	45.3	KC	0.5	2m	
20210714	414	5	**31**	2	48.6	69	1.396	168	8.291		%	LIS11 Laramie			19.5	56.1	KC			
20210714	450	1	**167**	1	49.2	69	0.882	168	22.5	0	%	LIS12	216	262	15.5	73.3	KC	0.5	4m	Noticed the upcast was about equal speed (or slower) to downcast. When asked to speed up a bit, the winch seemed resistant to the idea. There was a slight hiccup
20210714	455	1	**167**	2	49.3	69	0.91	168	22.633	0	%	LIS12			16.2	70.9	KC			
20210714	535	1	**168**	1	50.6	69	0.431	168	37.034	0	%	LIS13	217	263	15.4	63.6	KC	0	4m	Fog has cleared up into a fairly nice evening. Cast shows a nice cold/salty/turbid bottom layer in the last 5m or so.
20210714	540	1	**168**	2	50.5	69	0.485	168	37.18	0	%	LIS13			14.8	71	KC			
20210714	541	5	**32**	1	50.6	69	0.489	168	37.204		%	LIS13 Laramie	5	5	14.5	67.4	KC	0	4m	Filter tubing kept coming off when trying to sample at the surface, aborted bottom cast. No nutrient samples. Course of action: reattach same filter (to preserve a fi
20210714	550	5	**32**	2	50.9	69	0.49	168	38.26		%	LIS13 Laramie			10.4	71.1	KC			
20210714	613	1	**169**	1	51.2	69	0.208	168	46.64	0	%	LIS14n	217	265	12.4	45.8	KC	0	4m	Still a nice little bottom layer showing up.
20210714	618	1	**169**	2	51.1	69	0.255	168	46.835	0	%	LIS14n			16.5	66	KC			
20210714	642	1	**170**	1	51.3	68	59.994	168	56.09	0	%	CCL22n	216	265	15.5	77.4	KC	0	4m	Interesting warm, salty bump around 20m; looking at coordinates, it seems we sampled at the old CCL22 location (168deg 56.2')…
20210714	647	1	**170**	2	51.3	69	0.038	168	56.257	0	%	CCL22n			15.6	68.5	KC			
20210714	649	5	**33**	1	51.3	69	0.042	168	56.344		%	CCL22n Laramie	45	45	17.6	75.7	KC	0	4m	Bottom sample only
20210714	654	5	**33**	2	51.3	69	0.065	168	56.553		%	CCL22n Laramie			18.9	74.6	KC			
20210714	811	1	**171**	1	51.8	68	49.939	168	55.852	0	%	CCL21	217	265	15.9	99.9	JG	1	4m	
20210714	816	1	**171**	2	52	68	49.944	168	55.948	0	%	CCL21			15.5	77.9	JG			
20210714	930	1	**172**	1	51.7	68	39.99	168	55.975	0	%	CCL20	217	264	15	107	JG	1	4m	Fishy cast but cleared up on the upcast. Redid CTD cast at station. Next cast looks much cleaner. Missed a screenshot of 172
20210714	935	1	**172**	2	51.6	68	39.993	168	55.984	0	%	CCL20			11.9	98.9	JG			
20210714	937	1	**173**	1	51.8	68	39.995	168	56.046	0	%	CCL20 redo	217	264	9.6	90.7	JG	1	4m	T/C 1 not draining. Cleaned vent plug after this cast.
20210714	943	1	**173**	2	51.6	68	39.992	168	56.261	0	%	CCL20 redo			8.6	86.4	JG			
20210714	1101	1	**174**	1	53.6	68	29.989	168	56.019	0	%	CCL19	217	266	14.1	112	JG	1	4m	
20210714	1105	1	**174**	2	53.8	68	30.011	168	56.06	0	%	CCL19			8.5	120	JG			
20210714	1129	1	**175**	1	52.4	68	29.54	168	49.368	0	%	NPH14.5	217	265	9.6	244	JG	1	4.5m	
20210714	1134	1	**175**	2	52.3	68	29.564	168	49.579	0	%	NPH14.5			10.7	101	JG			
20210714	1156	1	**176**	1	52	68	29.069	168	42.57	0	%	NPH14	217	266	6.3	99.8	JG	1	4.5m	
20210714	1201	1	**176**	2	52	68	29.099	168	42.753	0	%	NPH14			7	94.7	JG			
20210714	1223	1	**177**	1	51.1	68	28.6	168	35.755	0	%	NPH13.5	217	265	7.2	150	JG	1	4m	
20210714	1229	1	**177**	2	51.2	68	28.681	168	35.779	0	%	NPH13.5			10.7	121	JG			
20210714	1250	1	**178**	1	50.6	68	28.045	168	29.082	0	%	NPH13	217	265	5	67.8	JG	0	4m	
20210714	1255	1	**178**	2	50.6	68	28.046	168	29.338	0	%	NPH13			8.8	145	JG			
20210714	1316	1	**179**	1	51.3	68	27.613	168	22.181	0	%	NPH12.5	217	265	7.9	148	JG	0	4m	
20210714	1321	1	**179**	2	51.3	68	27.677	168	22.266	0	%	NPH12.5			4.8	105	JG			
20210714	1343	1	**180**	1	50.3	68	27.096	168	15.418	0	%	NPH12	217	264	4.2	112	JG	0	4m	
20210714	1348	1	**180**	2	50.4	68	27.137	168	15.681	0	%	NPH12			7	106	JG			
20210714	1410	1	**181**	1	50.7	68	26.673	168	8.7	0	%	NPH11.5	217	265	7.3	142	JG	0	5m	
20210714	1415	1	**181**	2	50.7	68	26.752	168	8.611	0	%	NPH11.5			6.5	130	JG			
20210714	1435	1	**182**	1	51.8	68	26.177	168	1.947	0	%	NPH11	217	266	6.2	168	JG	0	5m	
20210714	1441	1	**182**	2	51.9	68	26.238	168	1.873	0	%	NPH11			5.6	134	JG			
20210714	1501	1	**183**	1	53.1	68	25.751	167	55.188	0	%	NPH10	218	267	6.3	134	JG	0	4.5m	I (JG) input 10.5 as the SBE header. It's NPH10.
20210714	1506	1	**183**	2	52.9	68	25.85	167	55.245	0	%	NPH10			7.4	117	JG			
20210714	1529	1	**184**	1	52.7	68	25.234	167	48.441	0	%	NPH9	218	265	6	142	RJD	0	5m	
20210714	1535	1	**184**	2	52.6	68	25.258	167	48.372	0	%	NPH9			7	111	RJD			
20210714	1555	1	**185**	1	51	68	24.787	167	41.604	0	%	NPH8	217	263	8	141	RJD	0	5m	
20210714	1602	1	**185**	2	50.9	68	24.872	167	41.457	0	%	NPH8			8	121	RJD			
20210714	1622	1	**186**	1	48.5	68	24.299	167	34.87	0	%	NPH7	218	262	6	137	RJD	0	5m	
20210714	1627	1	**186**	2	48.8	68	24.372	167	34.751	0	%	NPH7			6	127	RJD			
20210714	1647	1	**187**	1	45.7	68	23.871	167	28.083	0	%	NPH6	218	259	10	190	RJD	0	5m	
20210714	1650	1	**187**	2	45.1	68	23.847	167	27.961	0	%	NPH6			10	191	RJD			
20210714	1709	1	**188**	1	40.9	68	23.369	167	21.362	0	%	NPH5	218	253	6	163	RJD	0	3m	
20210714	1714	1	**188**	2	40.7	68	23.436	167	21.265	0	%	NPH5			5	144	RJD			
20210714	1724	1	**189**	1	40.1	68	23.088	167	18.037	0	%	NPH4	218	253	8	208	RJD	0	3m	
20210714	1729	1	**189**	2	39.6	68	23.114	167	17.892	0	%	NPH4			7	192	RJD			
20210714	1741	1	**190**	1	39.8	68	22.966	167	14.631	0	%	NPH3	218	252	2	197	RJD	0	2m	
20210714	1744	1	**190**	2	39.9	68	23.023	167	14.645	0	%	NPH3			4	205	RJD			
20210714	1754	1	**191**	1	39.9	68	22.605	167	11.354	0	%	NPH2	218	257	3	214	RJD	0	1M	
20210714	1801	1	**191**	2	40.5	68	22.775	167	11.402	0	%	NPH2			4	194	RJD			
20210714	1816	1	**192**	1	35.7	68	22.316	167	7.816	0	%	NPH1	218	255	4	233	RJD	0	2M	
20210714	1820	1	**192**	2	35.4	68	22.442	167	7.875	0	%	NPH1			5	214	RJD			

20210714	1918	1	**193**	1	25.7	68	19.978	166	52.175	1	%	CS19	218	241	5	270	RJD	0	1m	
20210714	1923	1	**193**	2	25.3	68	19.672	166	52.425	1	%	CS19			7	270	RJD			
20210714	1937	1	**194**	1	32.3	68	18.852	166	57.479	1	%	CS18	217	250	4	307	RJD	0	1m	
20210714	1941	1	**194**	2	32.4	68	18.837	166	57.862	1	%	CS18			5	275	RJD			
20210714	1956	1	**195**	1	36.4	68	17.976	167	2.872	0	%	CS17	218	251	2	226	RJD	0	1m	
20210714	2000	1	**195**	2	36.8	68	17.957	167	2.968	0	%	CS17			3	237	RJD			
20210714	2016	1	**196**	1	40.1	68	16.662	167	7.602	0	%	CS16.5	218	257	3	197	RJD	0	1m	
20210714	2020	1	**196**	2	40.2	68	16.638	167	7.837	0	%	CS16.5			2	198	RJD			
20210714	2038	1	**197**	1	43.8	68	15.009	167	11.995	0	%	CS16	218	259	4	181	RJD	0	3m	
20210714	2042	1	**197**	2	43.7	68	15.025	167	11.94	0	%	CS16			5	192	RJD			
20210714	2100	1	**198**	1	44.7	68	13.553	167	16.953	0	%	CS15.5	218	259	9	186	RJD	0	5m+	
20210714	2104	1	**198**	2	44.9	68	13.549	167	16.927	0	%	CS15.5			8	200	RJD			
20210714	2122	1	**199**	1	46.5	68	12.146	167	21.48	0	%	CS15	218	261	4	156	RJD	0	3m	
20210714	2128	1	**199**	2	46.8	68	12.178	167	21.498	0	%	CS15			8	182	RJD			
20210714	2146	1	**200**	1	47	68	10.623	167	26.041	0	%	CS14.75	218	261	8	170	RJD	0	5m+	Mislabeled in Seasave header: CS14.5 instead of CS14.75
20210714	2149	1	**200**	2	46.9	68	10.617	167	26.04	0	%	CS14.75			8	195	RJD			Dead whale (grey?) spotted around this/the next station
20210714	2222	1	**201**	1	47.6	68	9.126	167	30.722	0	%	CS14.5	218	261	7	147	RJD	0	5m	Mislabeled in Seasave header: CS14 instead of CS14.5
20210714	2227	1	**201**	2	47.6	68	9.082	167	30.852	0	%	CS14.5			7	159	RJD			
20210714	2245	1	**202**	1	48.6	68	7.722	167	35.272	0	%	CS14.25	218	262	9	168	RJD	0	5m+	Mislabeled in Seasave header: CS13.5 instead of CS14.25
20210714	2250	1	**202**	2	48.9	68	7.79	167	35.249	0	%	CS14.25			8	184	RJD			
20210714	2310	1	**203**	1	51.3	68	6.068	167	40.028	0	%	CS14	218	265	8	167	RJD	0	5m+	Mislabeled in Seasave header: CS13 instead of CS14
20210714	2315	1	**203**	2	51.2	68	6.102	167	39.986	0	%	CS14			8	168	RJD			
20210714	2334	1	**204**	1	52.5	68	4.371	167	44.941	0	%	CS13.75	218	267	9.4	164	KC	0	5m	
20210714	2338	1	**204**	2	52.4	68	4.339	167	44.963	0	%	CS13.75			14.7	178	KC			
20210714	2356	1	**205**	1	52.7	68	2.713	167	49.845	0	%	CS13.5	219	267	13.2	159	KC	0	5m+	Lovely fluorescence peak
20210715	0	1	**205**	2	52.6	68	2.731	167	50.035	0	%	CS13.5			12.4	163	KC			
20210715	19	1	**206**	1	51.3	68	0.977	167	54.724	0	%	CS13.25	219	266	13.4	155	KC	0	5m+	
20210715	24	1	**206**	2	51.4	68	0.985	167	54.894	0	%	CS13.25			10.1	151	KC			
20210715	44	1	**207**	1	53.3	67	59.268	167	59.464	0	%	CS13	219	269	13.5	146	KC	0	5m	
20210715	49	1	**207**	2	53.4	67	59.277	167	59.612	0	%	CS13			11.9	140	KC			
20210715	108	1	**208**	1	59.7	67	57.562	168	4.343	0	%	CS12.75	218	275	11.3	154	KC	0	5m+	
20210715	113	1	**208**	2	60	67	57.58	168	4.431	0	%	CS12.75			13.6	148	KC			
20210715	133	1	**209**	1	57.4	67	55.819	168	9.321	0	%	CS12.5	220	272	13.7	155	KC	0	5m+	
20210715	138	1	**209**	2	57.6	67	55.826	168	9.425	0	%	CS12.5			13.4	147	KC			
20210715	156	1	**210**	1	56.5	67	54.216	168	14.015	0	%	CS12.25	219	276	11.7	143	KC	0.5	4m	
20210715	202	1	**210**	2	56.4	67	54.32	168	14.18	0	%	CS12.25			12.4	145	KC			
20210715	227	1	**211**	1	54.9	67	52.515	168	18.814	0	%	CS12	219	269	15.8	137	KC	1	4m	Fog is rollin' in
20210715	232	1	**211**	2	54.8	67	52.501	168	18.908	0	%	CS12			13.6	142	KC			
20210715	256	1	**212**	1	51.3	67	50.684	168	24.154	0	%	CS11.75	218	267	13.5	119	KC	1	5m	
20210715	301	1	**212**	2	51.3	67	50.7	168	24.188	0	%	CS11.75			14.1	97.1	KC			
20210715	323	1	**213**	1	49.4	67	48.87	168	29.482	0	%	CS11.5	218	264	10.4	185	KC	1	5m	
20210715	328	1	**213**	2	49.5	67	48.859	168	29.515	0	%	CS11.5			7.1	198	KC			
20210715	349	1	**214**	1	48.8	67	47.13	168	34.612	0	%	CS11.25	218	263	10.6	160	KC	0	5m	Fog has blown out around this station
20210715	354	1	**214**	2	48.7	67	47.144	168	34.699	0	%	CS11.25			14.1	164	KC			
20210715	418	1	**215**	1	48.5	67	45.274	168	39.846	0	%	CS11	218	263	17	155	KC	1	5m	Fog is back in, interesting moving between banks of fog through here
20210715	423	1	**215**	2	48.6	67	45.335	168	39.85	0	%	CS11			17.2	158	KC			
20210715	444	1	**216**	1	48.5	67	43.5	168	44.083	0	%	CS10.75	218	263	10.1	137	KC	1	5m	
20210715	448	1	**216**	2	48.5	67	43.526	168	44.089	0	%	CS10.75			14.2	144	KC			
20210715	508	1	**217**	1	48.6	67	41.723	168	48.162	0	%	CS10.5	218	263	11.2	145	KC	1	5m	
20210715	513	1	**217**	2	48.7	67	41.757	168	48.241	0	%	CS10.5			10.4	150	KC			
20210715	532	1	**218**	1	48.6	67	39.857	168	51.877	0	%	CS10.25	218	264	14.4	150	KC	1	5m	
20210715	536	1	**218**	2	48.6	67	39.936	168	51.81	0	%	CS10.25			19.4	137	KC			
20210715	557	1	**219**	1	48.8	67	38.101	168	55.819	0	%	CS10	218	263	16.4	182	KC	1	5m	
20210715	602	1	**219**	2	48.9	67	38.159	168	55.74	0	%	CS10			15.6	148	KC			
20210715	628	1	**220**	1	48.5	67	35.015	168	55.899	0	%	CCL13.5	217	264	16.5	172	KC	1	4m	Fog is thickening even more now
20210715	633	1	**220**	2	48.5	67	35.087	168	55.823	0	%	CCL13.5			18.1	163	KC			
20210715	714	1	**221**	1	48.6	67	29.97	168	56.017	0	%	CCL13	219	264	16.8	185	JG	1	5m	Fog sucks
20210715	719	1	**221**	2	48.6	67	30.053	168	55.987	0	%	CCL13			21.1	182	JG			
20210715	803	1	**222**	1	48.5	67	24.944	168	55.984	0	%	CCL12.5	218	264	14.9	169	JG	1	4.5m	Got close to bottom, sensors and everything looked fine on recovery. Weird T/S inversion at base of mixed layer in all sensors down and upcasts. Flushed T1/C1 up p
20210715	808	1	**222**	2	48.5	67	25.014	168	55.984	0	%	CCL12.5			20.3	155	JG			
20210715	859	1	**223**	1	48.2	67	19.969	168	56.008	0	%	CCL12	217	264	19.3	163	JG	0	5m	Flushed T/C cells up past oxygen with FW multiple times after this cast. Didn't notice anything obvious. Cleaned vent plugs.
20210715	903	1	**223**	2	48.1	67	20.048	168	56	0	%	CCL12			18.1	154	JG			
20210715	955	1	**224**	1	47.8	67	14.976	168	56.031	0	%	CCL11.5	217	264	23.4	167	JG	0	4m	
20210715	959	1	**224**	2	47.4	67	15.041	168	56.051	0	%	CCL11.5			21.5	167	JG			
20210715	1051	1	**225**	1	47.1	67	9.969	168	55.963	0	%	CCL11	217	264	15.7	198	JG	0	5m	brief pause after cast to muck about in the engine room. Issue with air compressor for gear controls. Began motor to next station at 1123
20210715	1055	1	**225**	2	47.1	67	10.027	168	55.861	0	%	CCL11			17.2	211	JG			
20210715	1217	1	**226**	1	46.8	67	4.984	168	55.98	0	%	CCL10.5	218	263	19.5	190	JG	0	4m	Vent plug didn't drain on T2/C2. Cleaned vent plugs. Passed over a 1.2 PSU less fresh front at 1200 UTC via underway data
20210715	1222	1	**226**	2	47	67	5.072	168	55.903	0	%	CCL10.5			18.4	215	JG			
20210715	1315	1	**227**	1	46.3	66	59.982	168	55.987	0	%	CCL10	218	262	23.5	186	JG	0	4m	
20210715	1320	1	**227**	2	46.2	67	0.084	168	55.943	0	%	CCL10			224.2	203	JG			
20210715	1408	1	**228**	1	45.4	66	54.956	168	55.997	0	%	CCL9.5	219	261	18.1	194	JG	0	2m	
20210715	1413	1	**228**	2	44.9	66	55.047	168	55.916	0	%	CCL9.5			22.1	173	JG			
20210715	1457	1	**229**	1	43.4	66	49.959	168	56.017	0	%	CCL9	218	258	15.9	177	JG	0	2m	
20210715	1501	1	**229**	2	43.2	66	50.026	168	56.029	0	%	CCL9			22	183	JG			
20210715	1549	1	**230**	1	41.1	66	44.989	168	56.04	0	%	CCL8.5	218	255	21	171	RJD	0	3m	
20210715	1554	1	**230**	2	41.1	66	45.052	168	56.067	0	%	CCL8.5			18	169	RJD			
20210715	1645	1	**231**	1	42	66	39.945	168	56.067	0	%	CCL8	218	256	17	186	RJD	0	3m	
20210715	1649	1	**231**	2	41.9	66	40.013	168	56.107	0	%	CCL8			17	173	RJD			
20210715	1740	1	**232**	1	44.5	66	34.937	168	56.046	0	%	CCL7	218	256	20	171	RJD	0	3m	
20210715	1745	1	**232**	2	44.3	66	35.006	168	56.074	0	%	CCL7			21	179	RJD			

20210715	1834	1	**233**	1	55	66	29.922	168	56.052	0	%	CCL6	218	269	18	185	RJD	0	3m	
20210715	1841	1	**233**	2	55.4	66	29.92	168	56.097	0	%	CCL6			18	205	RJD			
20210715	1926	1	**234**	1	55.1	66	24.964	168	56.038	0	%	CCL5	217	269	18	184	RJD	0	3m	
20210715	1933	1	**234**	2	55	66	24.99	168	56.124	0	%	CCL5			18	162	RJD			
20210715	2000	1	**235**	1	54.3	66	22.25	168	56.121	0	%	CCL4	217	270	15	171	RJD	0	3m	Vent plug clean pre-cast
20210715	2006	1	**235**	2	54	66	22.315	168	56.163	0	%	CCL4			16	169	RJD			
20210715	2034	1	**236**	1	54.8	66	19.739	168	57.015	0	%	A3-21	219	270	25	160	RJD	0	3m	CTD file has "A3-17" as name in header
20210715	2039	1	**236**	2	54.8	66	19.813	168	57.063	0	%	A3-21					RJD			
20210715	2053	1	**237**	1	55.5	66	18.71	168	56.231	0	%	DL19.5	218	271	17	168	RJD	0	2m	
20210715	2059	1	**237**	2	55.2	66	18.799	168	56.275	0	%	DL19.5			18	164	RJD			
20210715	2113	1	**238**	1	55.2	66	17.809	168	56.286	0	%	DL19	218	271	25	140	RJD	0	3m	
20210715	2119	1	**238**	2	55.3	66	17.89	168	56.304	0	%	DL19			27	165	RJD			
20210715	2136	1	**239**	1	55.5	66	16.576	168	56.223	0	%	DL18.5	218	272	26	167	RJD	0	3m	
20210715	2142	1	**239**	2	55.7	66	16.671	168	56.23	0	%	DL18.5			28	171	RJD			
20210715	2203	1	**240**	1	56.5	66	15.247	168	56.246	0	%	DL18	218	271	24	164	RJD	0	3m	
20210715	2208	1	**240**	2	56.1	66	15.332	168	56.287	0	%	DL18			31	165	RJD			
20210715	2228	1	**241**	1	56	66	13	168	56.234	0	%	DL17.5	218	270	29	155	RJD	0	3m	
20210715	2232	1	**241**	2	55.3	66	14.052	168	56.231	0	%	DL17.5			16	170	RJD			
20210715	2250	1	**242**	1	55.8	66	12.715	168	56.241	0	%	DL17	218	271	28	172	RJD	0	2m	
20210715	2254	1	**242**	2	55.9	66	12.795	168	56.235	0	%	DL17			26	175	RJD			
20210715	2315	1	**243**	1	54.7	66	11.433	168	56.218	0	%	DL16.5	220	269	33.9	204	KC	0	2m	Winds are even higher now, calling it for a while after this station
20210715	2319	1	**243**	2	54.6	66	11.595	168	56.14	0	%	DL16.5			31.1	195	KC			
20210716	1435	1	**244**	1	44.6	65	48.233	168	56.121	0	%	BS11	221	264	37.5	188	JG	0	1m	
20210716	1439	1	**244**	2	45.7	65	48.404	168	55.896	0	%	BS11			31.1	217	JG			
20210716	1450	1	**245**	1	46	65	47.722	168	53.831	0	%	BS11.5	221	264	43	223	JG	0	1m	
20210716	1455	1	**245**	2	47	65	47.818	168	53.705	0	%	BS11.5			33.5	230	JG			
20210716	1456	5	**34**	1	47.5	65	47.858	168	53.667		%	BS11.5 Laramie	5		33	235	RJD	0	1m	
20210716	1503	5	**34**	2	47	65	48.032	168	53.521		%	BS11.5 Laramie			37	227	RJD			
20210716	1515	1	**246**	1	43.3	65	47.169	168	51.646	0	%	BS12	218	258	26	210	RJD	0	1m	
20210716	1520	1	**246**	2	43.2	65	47.197	168	51.599	0	%	BS12			27	198	RJD			
20210716	1531	1	**247**	1	48.3	65	46.706	168	49.489	0	%	BS12.5	218	261	27	215	RJD	0	1m	
20210716	1536	1	**247**	2	48.8	65	46.737	168	49.442	0	%	BS12.5			21	201	RJD			
20210716	1546	1	**248**	1	50.6	65	46.252	168	47.601	0	%	BS13	218	265	21	215	RJD	0	1m	
20210716	1551	1	**248**	2	50.6	65	46.352	168	47.434	0	%	BS13			21	211	RJD			
20210716	1550	5	**35**	1	51.6	65	46.467	168	47.134		%	BS13 Laramie			22	198	RJD	0	1m	
20210716	1611	5	**35**	2	51	65	46.937	168	46.999		%	BS13 Laramie			21	188	RJD			
20210716	1625	1	**249**	1	51.2	65	45.771	168	45.509	0	%	BS13.5	218	265	18	189	RJD	0	1m	
20210716	1629	1	**249**	2	51.2	65	45.799	168	45.424	0	%	BS13.5			22	189	RJD			
20210716	1639	1	**250**	1	51.2	65	45.213	168	43.181	0	%	BS14	218	265	22	181	RJD	0	1.5m	
20210716	1643	1	**250**	2	51.4	65	45.257	168	43.078	0	%	BS14			23	216	RJD			
20210716	1651	1	**251**	1	50.4	65	44.768	168	41.62	0	%	BS14.5	218	264	26	206	RJD	0	1m	
20210716	1655	1	**251**	2	50.4	65	44.798	168	41.516	0	%	BS14.5			23	217	RJD			
20210716	1656	5	**36**	1	50.4	65	44.861	168	41.428		%	BS14.5 Laramie			22	214	RJD	0	1.5m	
20210716	1705	5	**36**	2	50.1	65	44.661	168	40.48		%	BS14.5 Laramie			20	183	RJD			
20210716	1717	1	**252**	1	50.1	65	44.283	168	39.751	0	%	BS15	218	265	18	108	RJD	0	1m	
20210716	1721	1	**252**	2	50.1	65	44.357	168	39.581	0	%	BS15			24	190	RJD			
20210716	1732	1	**253**	1	50.1	65	43.817	168	37.746	0	%	BS15.5	218	264	25	187	RJD	0	1.5m	
20210716	1736	1	**253**	2	50.2	65	43.851	168	37.651	0	%	BS15.5			22	220	RJD			
20210716	1747	1	**254**	1	50.2	65	43.291	168	35.547	0	%	BS16	218	264	30	207	RJD	0	1m	
20210716	1752	1	**254**	2	49.9	65	43.345	168	35.45	0	%	BS16			26	182	RJD			
20210716	1752	5	**37**	1	50	65	43.414	168	35.408		%	BS16 Laramie	217	267	26	208	RJD	0	2m	
20210716	1800	5	**37**	2	50.2	65	43.293	168	35.29		%	BS16 Laramie					RJD			
20210716	1813	1	**255**	1	50.6	65	42.727	168	33.464	0	%	BS16.5	218	265	22	187	RJD	0	2m	
20210716	1818	1	**255**	2	50.1	65	42.774	168	33.382	0	%	BS16.5			25	212	RJD			
20210716	1828	1	**256**	1	53.1	65	42.191	168	31.292	0	%	BS17	218	264	21	184	RJD	0	3m	
20210716	1832	1	**256**	2	53.3	65	42.281	168	31.217	0	%	BS17			21	206	RJD			
20210716	1843	1	**257**	1	52.3	65	41.657	168	29.248	0	%	BS17.5	218	263	25	187	RJD	0	2.5m	
20210716	1847	1	**257**	2	51.9	65	41.74	168	29.251	0	%	BS17.5			24	197	RJD			
20210716	1828	5	**38**	1	51.7	65	41.748	168	29.253		%	BS17.5 Laramie			21	214	RJD	0	2m	
20210716	1857	5	**38**	2	52.1	65	41.953	168	29.151		%	BS17.5 Laramie			25	141	RJD			
20210716	1909	1	**258**	1	52	65	41.11	168	26.86	0	%	BS18	218	268	24	197	RJD	0	2m	
20210716	1914	1	**258**	2	51.9	65	41.189	168	26.797	0	%	BS18			27	217	RJD			
20210716	1923	1	**259**	1	50.9	65	40.673	168	25.183	0	%	BS18.5	217	264	28	211	RJD	0	4m	
20210716	1927	1	**259**	2	51.1	65	40.747	168	25.111	0	%	BS18.5			24	207	RJD			
20210716	1952	1	**260**	1	50.5	65	40.341	168	23.261	0	%	BS19	218	267	26	200	RJD	0	5m	
20210716	1956	1	**260**	2	50.3	65	40.439	168	23.2	0	%	BS19			22	197	RJD			
20210716	1957	5	**39**	1	50.4	65	40.533	168	23.169		%	BS19 Laramie			25	201	RJD	0	5m+	
20210716	2005	5	**39**	2	50.8	65	40.827	168	23.091		%	BS19 Laramie			30	198	RJD			
20210716	2020	1	**261**	1	49	65	39.811	168	21.277	0	%	BS19.5	218	265	29	201	RJD	0	5m+	
20210716	2024	1	**261**	2	48.9	65	39.894	168	21.218	0	%	BS19.5			25	211	RJD			
20210716	2037	1	**262**	1	46.9	65	39.245	168	18.987	0	%	BS20	218	263	32	217	RJD	0	5m	
20210716	2041	1	**262**	2	46.7	65	39.309	168	18.888	0	%	BS20			27	202	RJD			
20210716	2051	1	**263**	1	44.5	65	38.958	168	17.055	0	%	BS20.5	218	263	30	206	RJD	0	5m	Mistakenly named BS20 in cast header file
20210716	2055	1	**263**	2	44.1	65	39.082	168	17.02	0	%	BS20.5			24	204	RJD			
20210716	2056	5	**40**	1	44.2	65	39.271	168	17.002		%	BS20.5 Laramie			24	200	RJD	0	5m	
20210716	2106	5	**40**	2	44	65	39.302	168	17		%	BS20.5 Laramie			23	195	RJD			
20210716	2124	1	**264**	1	40.4	65	38.536	168	15.075	0	%	BS21	218	266	30	240	RJD	0	2m	
20210716	2128	1	**264**	2	40.9	65	38.725	168	15.717	0	%	BS21			27	299	RJD			
20210716	2149	1	**265**	1	37.1	65	38.027	168	12.858	1	%	BS21.5	218	262	24	191	RJD	0	3m	
20210716	2154	1	**265**	2	37.2	65	38.168	168	12.832	1	%	BS21.5			24	111	RJD			

20210716	2208	1	**266**	1	29.9	65	37.431	168	10.657	1	%	BS22	218	254	25	170	RJD	0	4m	
20210716	2212	1	**266**	2	30.5	65	37.644	168	10.81	1	%	BS22			30	215	RJD			
20210716	2214	5	**41**	1	30.2	65	37.77	168	10.922		%	BS22 Laramie			30	111	RJD	0	4m	
20210716	2224	5	**41**	2	31.5	65	37.978	168	11.354		%	BS22 Laramie			28	120	RJD			
20210716	2240	1	**267**	1	37.1	65	36.86	168	13.078	0	%	SBSnn1.5	218	258	28	240	RJD	0	2m	Cast named SBSnn2 in header, but is SBSnn1.5
20210716	2245	1	**267**	2	37.5	65	37.177	168	13.36	0	%	SBSnn1.5			26	210	RJD			
20210716	2306	1	**268**	1	44	65	35.628	168	17.385	0	%	SBSnn2.5	219	259	28.7	203	KC	0	2m	
20210716	2310	1	**268**	2	44.1	65	35.778	168	17.379	0	%	SBSnn2.5			24.4	150	KC			
20210716	2332	1	**269**	1	47.2	65	34.268	168	21.924	0	%	SBSnn3.5	219	263	21.9	216	KC	0	4m	
20210716	2337	1	**269**	2	47.6	65	34.383	168	21.932	0	%	SBSnn3.5			23.8	186	KC			
20210716	2356	1	**270**	1	50.2	65	33.089	168	26.283	0.5	%	SBSnn4.5	219	265	22.9	204	KC	0.5	4m	
20210717	1	1	**270**	2	50.1	65	33.204	168	26.222	0.5	%	SBSnn4.5			27.5	192	KC			
20210717	22	1	**271**	1	58.4	65	31.867	168	30.817	0	%	SBSnn5.5	219	274	21.8	210	KC	1	3m	
20210717	26	1	**271**	2	56.8	65	31.986	168	30.772	0	%	SBSnn5.5			21.6	194	KC			
20210717	46	1	**272**	1	54.9	65	30.634	168	35.292	0	%	SBSnn6.5	219	271	23.1	212	KC	1	2m	
20210717	51	1	**272**	2	54.6	65	30.732	168	35.229	0	%	SBSnn6.5			22.3	197	KC			
20210717	110	1	**273**	1	55	65	29.375	168	39.846	0	%	SBSnn7.5	220	272	22.3	208	KC	1	2m	
20210717	114	1	**273**	2	54.2	65	29.46	168	39.8	0	%	SBSnn7.5			22	201	KC			
20210717	133	1	**274**	1	58	65	28.152	168	44.286	0	%	SBSnn8.5	220	274	24.6	203	KC	1	2m	
20210717	138	1	**274**	2	58.2	65	28.253	168	44.236	0	%	SBSnn8.5			22.6	200	KC			
20210717	159	1	**275**	1	54.9	65	26.887	168	48.945	0	%	SBSnn9.5	219	272	19.7	184	KC	1	1m	
20210717	204	1	**275**	2	55.7	65	26.978	168	49.002	0	%	SBSnn9.5			21.6	203	KC			
20210717	222	1	**276**	1	56.7	65	25.661	168	53.421	0	%	SBSnn10.5	219	272	20.9	186	KC	1	1m	
20210717	227	1	**276**	2	56.9	65	25.725	168	53.466	0	%	SBSnn10.5			18.3	198	KC			

FILE FORMAT

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LABORATORY

IsoLab, Department of Earth and Space Sciences, University of Washington
206.543.6327 * isolab@uw.edu * https://isolab.ess.washington.edu/

METHOD

Your samples were analyzed on a Picarro - sn(HIDS2064) - named Abel. You can read more about our implementation of this method on our website here: https://isolab.ess.washington.edu/laboratory/water-dD-d18O.php or here https://isolab.ess.washington.edu/SOPs/abel.php

ANALYSIS

Start Time of Analysis: 2021/08/03 08:12:53
Original Filename: HIDS2064_IsoWater_20210803_150950_combined.csv
Reduced Filename: HIDS2064_IsoWater_20210803_150950_combined_reduced.txt
Run comments:

REFERENCE MATERIALS

All internationally recognized reference material accepted values can be found at the CIAAW (http://www.ciaaw.org/).
All IsoLab in-house reference material accepted values can be found at https://isolab.ess.washington.edu/resources/standards.php#water.
For this particular analysis, the accepted values are from the MATLAB script Water Standards: 190723.
Reference Waters in this run and their accepted values:

Reference Water	Accepted d	Accepted d18O (vs VSMOW)
KD	0.65	0
BW	-156.87	-20.01
SW	-75.63	-10.55

RUN INFORMATION

Number of Injections per vial: 10
Number of Injections discarded from beginning of each vial: 5
dD memory estimate: 0.84899
d18O memory estimate: 0.92273

Individual reference water vial raw measurement

TrayPos	Reference	RawMean	RawStdDev	RawMean	RawStdDev	RawMean	RawStdDev d18O
2	SW	20097.8	131.6613	-71.2606	0.065286	-6.6102	0.009365
4	RW	19693	214.5355	-14.6118	0.046949	8.9794	0.019604
6	KD	19829.4	144.1676	5.4224	0.11311	4.015	0.02487
8	BW	19702.4	155.9336	-152.178	0.07681	-16.1366	0.033254
14	RW	19885	286.256	-13.7372	0.10722	9.159	0.01239
16	BW	19936.2	190.0071	-152.29	0.1061	-16.1022	0.024489
18	KD	19824	91.2469	5.4064	0.15733	3.992	0.020396
20	SW	19864.8	35.8636	-70.4502	0.49765	-6.5546	0.054427
26	BW	19864.4	43.6268	-152.412	0.056116	-16.0962	0.018363
28	SW	19708.2	29.853	-70.9318	0.082433	-6.5984	0.01274
30	KD	19945.8	90.2258	5.5374	0.05513	3.9972	0.01429
32	RW	19795	72.6567	-13.7266	0.15068	9.1486	0.026651
34	USGS45	20004.4	181.4561	-5.6562	0.10175	1.746	0.030992
35	USGS45	19995.4	31.2698	-5.4624	0.11373	1.7776	0.02122

Reference Water	Mean_H2C	StdDev_H2	Mean_dD_	StdDev_dD	Mean_d18	StdDev_d1	n
raw KD	19866.4	68.8154	5.4554	0.071463	4.0014	0.012062	3
raw BW	19834.33	119.7648	-152.294	0.11693	-16.1117	0.0218	3
raw SW	19890.27	196.0445	-70.8809	0.40759	-6.5877	0.029295	3
corrected KD			0.65	0.087577	5.92E-16	0.014941	3
corrected BW			-156.87	0.10233	-20.01	0.019222	3
corrected SW			-75.5766	0.41998	-10.5347	0.02772	3

Accuracy and Precision Information from SW

	Accuracy	Precision
dD	0.053382	0.41998
d18O	0.015324	0.02772

Reference Waters

Date	TrayPos	Reference I	Mean_H2C	StdDev_H2	Mean_dD_	StdDev_dD	Mean_d18	StdDev_d18O
8/3/2021 9:47	T1-02	SW	20097.8	131.6613	-75.9793	0.065286	-10.5525	0.009365
8/3/2021 12:53	T1-04	RW	19693	214.5355	-19.4102	0.046949	4.9569	0.019604
8/3/2021 16:00	T1-06	KD	19829.4	144.1676	0.59782	0.11311	0.017232	0.02487
8/3/2021 19:06	T1-08	BW	19702.4	155.9336	-156.769	0.07681	-20.0321	0.033254
8/4/2021 9:38	T1-14	RW	19885	286.256	-18.5209	0.10722	5.1325	0.01239
8/4/2021 12:44	T1-16	BW	19936.2	190.0071	-156.868	0.1061	-20.0004	0.024489
8/4/2021 15:50	T1-18	KD	19824	91.2469	0.60107	0.15733	-0.00935	0.020396
8/4/2021 18:56	T1-20	SW	19864.8	35.8636	-75.1412	0.49765	-10.5027	0.054427
8/5/2021 4:15	T1-26	BW	19864.4	43.6268	-156.973	0.056116	-19.9975	0.018363
8/5/2021 7:21	T1-28	SW	19708.2	29.853	-75.6093	0.082433	-10.5488	0.01274
8/5/2021 10:27	T1-30	KD	19945.8	90.2258	0.75111	0.05513	-0.00788	0.01429
8/5/2021 13:33	T1-32	RW	19795	72.6567	-18.4815	0.15068	5.1166	0.026651
8/5/2021 16:39	T1-34	USGS45	20004.4	181.4561	-10.4197	0.10175	-2.2488	0.030992
8/5/2021 18:12	T1-35	USGS45	19995.4	31.2698	-10.2246	0.11373	-2.2177	0.02122

Sample Information:

Date	Tray-Pos	Sample Na	Mean_H2C	StdDev_H2	Mean_dD_	StdDev_dD	Mean_d18	StdDev_d18O
8/3/2021 22:12	T1-10	LIS3	19566	166.5983	-33.3819	0.098396	-4.2915	0.019424
8/4/2021 1:19	T1-12	LIS2	19574.6	61.476	-23.657	0.16012	-3.0929	0.025762
8/4/2021 22:03	T1-22	LIS2	19615	106.066	-23.6629	0.094302	-3.1141	0.020107
8/5/2021 1:09	T1-24	LIS3	19544	57.8835	-32.6919	0.21168	-4.2751	0.015659

Processed with: abel.m - 210601