BERING STRAIT NORSEMAN II 2015 MOORING CRUISE REPORT

Research Vessel Norseman II, Norseman Maritime Charters

Nome-Nome, 1st July – 9th July 2015

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and the Bering Strait 2015 Science Team

Funding from NSF Arctic Observing Network Program PLR-1304052 & ARC-1107106

(Photo from www.norsemanmartime.com)

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As part of the Bering Strait project funded by NSF-AON (Arctic Observing Network), in July 2015 a team of US scientists undertook a ~ 8 day cruise in the Bering Strait and southern Chukchi Sea region on the US vessel Norseman II, operated by Norseman Maritime Charters.

The primary goals of the expedition were:

1) recovery of 3 moorings carrying physical oceanographic (Woodgate-NSF), bio-optical (Whitledge) and whale acoustic (Stafford) instrumentation. These moorings were deployed in the Bering Strait region in 2014 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), ocean acidification (Juranek and Hales) and whale acoustic (Stafford) instrumentation. The funding for the physical oceanographic components of these moorings comes from NSF-AON.

3) accompanying CTD sections (without water sampling).

4) collection of accompanying ship's underway data (surface water properties, ADCP, meteorological data).

The cruise loaded and offloaded in Nome, Alaska.

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 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. Understanding the processes setting these fluxes is vital to prediction of future change in this region and likely in the Arctic and beyond.

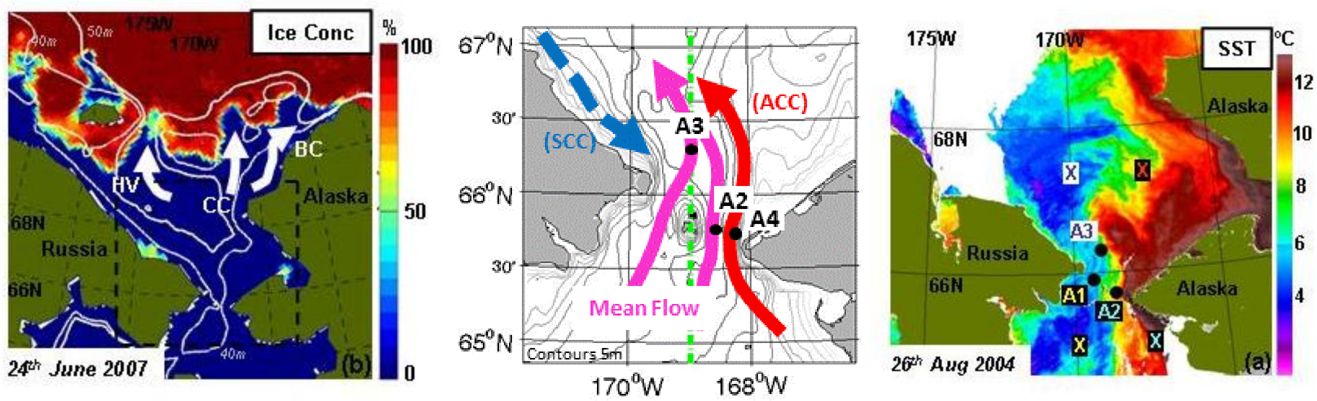


Figure 1: (Left) *Chukchi Sea ice concentration (AMSR-E) with schematic topography. White arrows mark three main water pathways melting back the ice edge [Woodgate et al., 2010].*
(Middle) *Detail of the Bering Strait, with schematic flows and mooring locations (black dots – A2, A3, A4). The main northward 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 168º 58.7'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, seen 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.*, submitted]. Data from these moorings 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], and assess the strong contribution of the Alaskan Coastal Current (ACC) to the fluxes through the strait [*Woodgate and Aagaard*, 2005]. 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]. While ~ 1/3rd of this change is attributable to weaker local winds, 2/3rds appears to be driven by basin-scale changes between the Pacific and the Arctic. Remote data (winds, SST) prove insufficient for quantifying variability, indicating interannual change can still only be assessed by in situ year-round measurements [*Woodgate et al.*, 2012]. Indeed, data from 2013 indicate a surprisingly low flow year.

The work to be accomplished/started on this cruise will extend this mooring time-series to summer 2016.

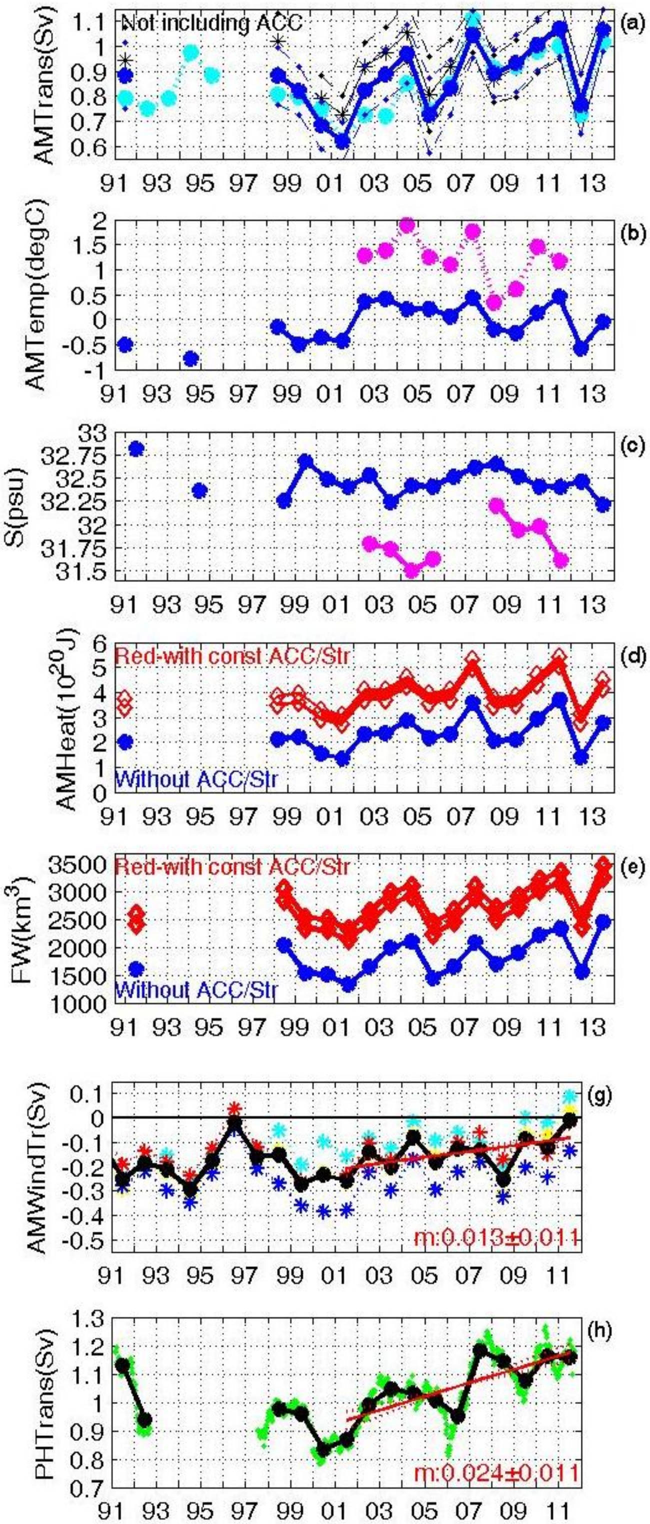


Figure 2, adapted from [Woodgate et al., 2012; Woodgate et al., submitted]

a) *transport calculated from A3 (blue) or A2 (cyan), with error bars (dashed) calculated from variability; including adjustments estimated from 2007-2009 Acoustic Doppler Current Profiler (ADCP) data for 6-12m changes in instrument depth (black);*

b) *near-bottom temperatures from A3 (blue) and A4 (magenta-dashed);*

c) *salinities from A3 (blue) and A4 (magenta);*

d) *heat fluxes: blue - from A3 only; red – including ACC correction (1×10^{20}J) and contributions from surface layer of 10m (lower bound) or 20m (upper bound) at SST, with black x indicate heat added from 20m surface layer;*

e) *freshwater fluxes: blue – from A3 only; red – including 800-1000km^3 (lower and upper bounds) correction for stratification and ACC;*

g) *to 2011, transport attributable to NCEP wind (heading 330º, i.e., northwestward) at each of 4 points (coloured X in Figure 1) and the average thereof (black); and*

h) *to 2011, transport attributable to the pressure-head term from the annual (black) or weekly (green) fits.*

*Uncertainties are order 10-20%. Red lines on **(g)** and **(h)** indicate best fit for 2001-2011 (trends=m±error, in Sv/yr, error being the 95% confidence limit from a 1-sided Student's t-test).*

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; NSF's Freshwater Initiative (FWI) and Arctic Model Intercomparison Project (AOMIP), and the international Arctic SubArctic Ocean Fluxes (ASOF) program. 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 measure of integrated change in the Bering Sea, and an indicator of the role of Pacific Waters in the Arctic Ocean.

2015 CRUISE SUMMARY:

The 2015 cruise was, in the end, remarkably successful, with all mooring operations being smoothly accomplished, and, due to the extremely efficient CTD operations of the Norseman II, a total of 258 CTD casts taken on 15 CTD lines (3 repeated). However, fog at the start of the cruise delayed operations, and we were fortunate that a temporary clearing of the fog allowed the mooring work to be accomplished so early in the cruise - much of the remainder of the cruise was foggy. Sea-states were workable for the entirely of the cruise, with wind speeds being almost always less than 20 knots, and typically less than 10 knots.

The on-load for the cruise started late afternoon on Wednesday 1st July 2015, and we sailed ~ 10pm that evening, after arrival of the final crew on the (delayed) evening flight into Nome.

Arriving on the first mooring site (A4) ~ noon (local time) on Thursday 2nd July 2015, we found insufficient visibility to attempt mooring recovery and so took a pre-recovery CTD cast (in the ~ 4 knot current) and proceeded to A2. There the fog situation was equally bleak, and so we took the A2 pre-recovery CTD cast, and proceeded to A3, arriving ~ 5pm. There, visibility was improved. Mooring A3-14 was recovered without hitch, and mooring A3-15 was redeployed that evening, and a post-deployment CTD cast taken. Through the night, we steamed ADCP/underway data sections across the strait (including NBS westbound), in order to be in place at A2 by morning.

On the morning of Friday 3rd July, the fog was still dense at site A2, so we proceeded to A4, where (~ 11:30am) visibility was sufficient to attempt recovery. However, although one release confirmed release, the mooring did not surface. (The initial release malfunctioned, but that alone should not have trapped the mooring at the sea floor.) At ~ 12:30pm, we started dragging operations (in the ~ 4 knot current) and at ~ 1:30pm the mooring was sighted on the surface. Recovery of the dragging gear resulted in also recovering an old mooring anchor, but after that situation was resolved, the mooring A4-14 was also safely recovered. We then steamed back to site A2, but as that was still fog bound, instead we returned to site A4 and redeployed the mooring A4-15, taking a post-deployment CTD cast including a water sample for the ocean acidification sensors, and returned to site A2, by early evening (~8pm). While the strait was clear of fog from A4 to within ~ 1nm of A2, the A2 mooring site itself remained persistently fog covered, with clear skies also from ~ 1nm west of the mooring to the Diomedes. Conditions did not improve with waiting, and thus we ran ADCP/underway data lines through the night (north along DL, east along NBS, east along MBS), returning to A2 by the morning.

Thursday 4th July morning was also still foglocked at site A2, although with clear skies east of the mooring towards the Diomede. Rather than merely wait, we started the BS CTD line running from the Diomedes to Prince of Wales, where, by ~ 3pm the fog was lifting, and, as we returned to site A2, the whole strait finally (briefly) became clear. Mooring A2-14 was recovered without hitch, and mooring A2-15 redeployed and a post-deployment CTD cast taken.

For the rest of the cruise, we took CTD lines to characterize the hydrography of the region, repeating historic CTD lines taken in the strait since ~ 2004. Full details are given below. Some sections were run twice within a few days to assess temporal variability. A new line (NNBS) was established between the AL line through mooring A3 and the cross strait lines (starting at 66N, NBS), to map the flow between the strait proper and the mooring site.

We left the Bering Strait region ~ 1:15am (local) on Thursday 9th July, and arrived in Nome ~ 12:30pm the same day. The offload was completed by 3:30pm, when the science team left the ship.

Overall, the cruise accomplished the most extensive quasi-synoptic spatial survey of the southern Chukchi Sea in recent times. Similar (though less extensive surveys were taken in 2011 and 2012 from the Khromov [*Woodgate and RUSALCA11ScienceTeam*, 2011; *Woodgate and RUSALCA12ScienceTeam*, 2012] and in 2013 and 2014 from the Norseman II [*Woodgate and BeringStrait2013ScienceTeam*, 2013; *Woodgate et al.*, 2014]. Prior to that the last extensive surveys were in 2003 and 2004 from the Alpha Helix [*Woodgate*, 2003; *Woodgate*, 2004]). Our 2015 cruise accomplished more stations due to a combination of extremely efficient CTD operations (including taking profiles only, no bottles, and the high winch speed ~ 1m/s). In addition to a large scale water mass survey of the region, the repeat of several lines (and several stations) during this or subsequent cruises this year will allow for quantification of temporal variability.

For full station coverage, see map and listings below. Preliminary results are given in the various sections.

Summary of CTD lines.

BS (US portion) – the main Bering Strait line, run at the start and at the end of the cruise. This line has been occupied by past Bering Strait mooring cruises. US portion only run here. This line was usually ~ 2nm resolution. On both running of this section, we decreased the station spacing to ~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. BS23 was not taken during this cruise. BS24 was only taken on the second running of the line.

DL – a high resolution (1nm in the southern part) line running north from the Diomede Islands to study the hypothesized eddy and mixing region north of the islands. This was run at the start and end of the cruise.

AL (US portion) – another previously-run line (~ 1.7nm 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. This line was run both at the start and at the end of the cruise.

CS (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).

LIS – from Cape Lisburne towards the WNW, a previous RUSALCA line, run by us also in 2011, 2012, 2013, and 2014 and close to the CP line occupied in previous Bering Strait cruises in 2003 and 2004 (station spacing ~ 3.6nm).

CCL – 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), incorporating a rerun of the high resolution DL line at the southern end. In the past, this line has been run at ~ 10nm resolution – on this cruise we decreased the station spacing to ~ 5nm for most of the line.

NNBS – a new line run 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.

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

BS – the original BS line, rerun at ~ 1nm resolution at the end of the cruise.

SBS – a line new in 2014, run just south of the strait, crossing the Alaskan Coastal Current before it enters the strait proper (~ 2.2nm resolution)

Summary of ADCP/Underway data lines

The ship's ADCP recorded for the duration of the cruise. Between mooring operations, two surveys of the strait were run were run exclusively for ADCP and underway data collection, viz:

- from A3 back towards A2 (incorporating a westward run of **NBS** line);
- a set of sections from A2, back to A2, incorporating a north running of the **Dl** line, and west to east runnings of the **NBS** and **MBS** lines.

See maps for details of these lines.

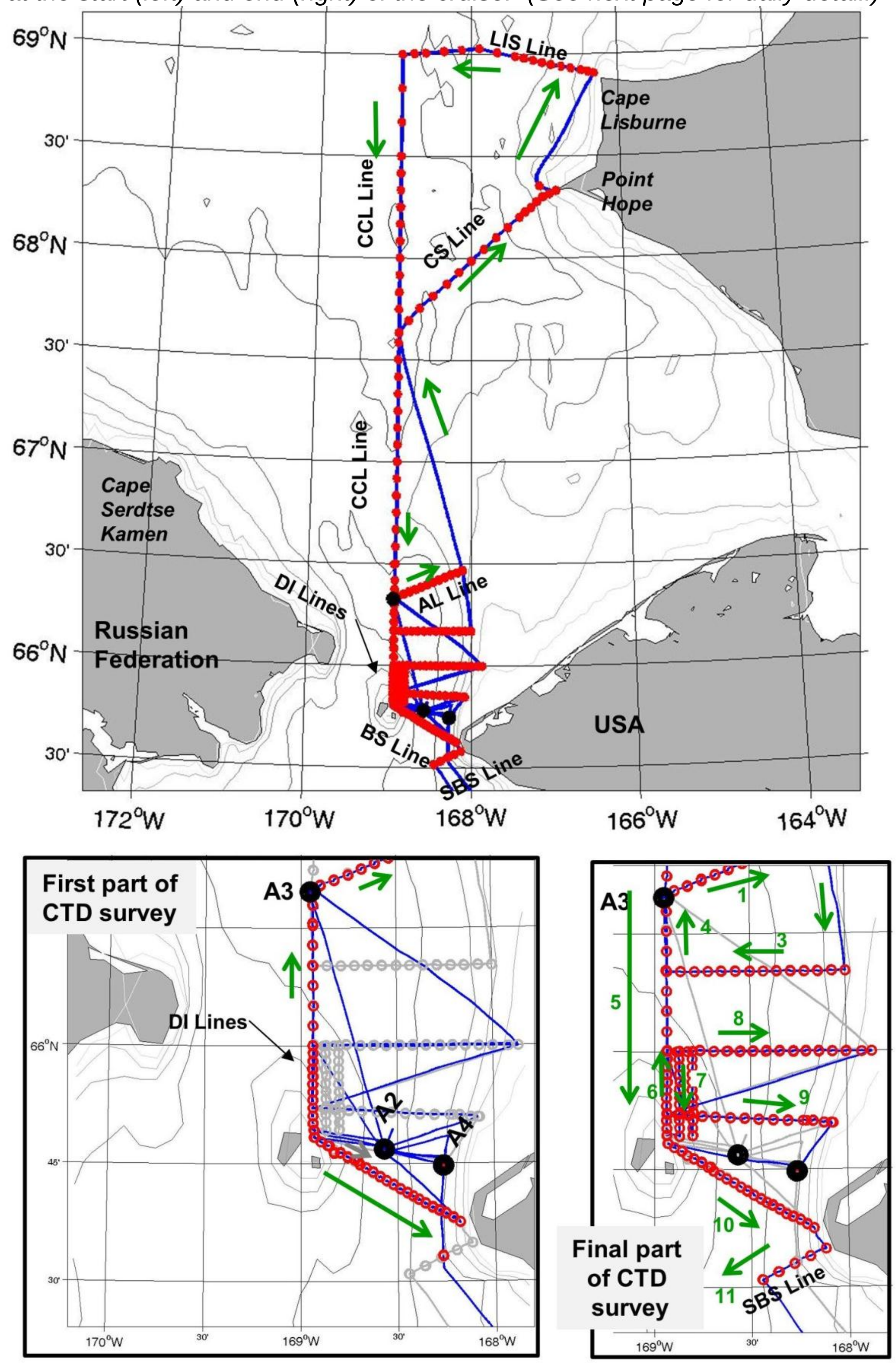
Outreach

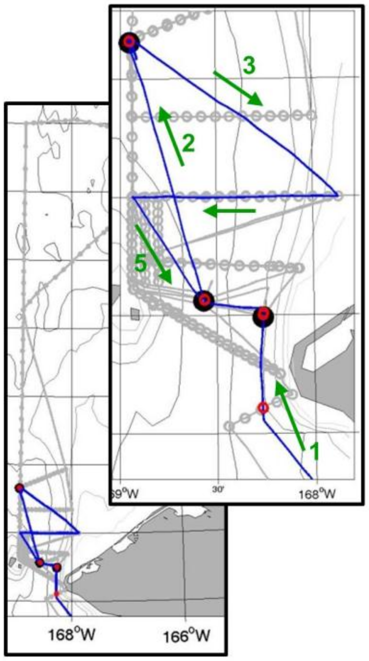
During the cruise, a daily cruise blog was written by the cruise participants and updated live on the web (psc.apl.washington.edu/BeringStraitBlog2015.html). By the end of the cruise, over 600 people had visited the blog, including people from at least 30 of the US states, and 22 countries around the world (see map, right).

A copy of the final blog is included at the end of this report.

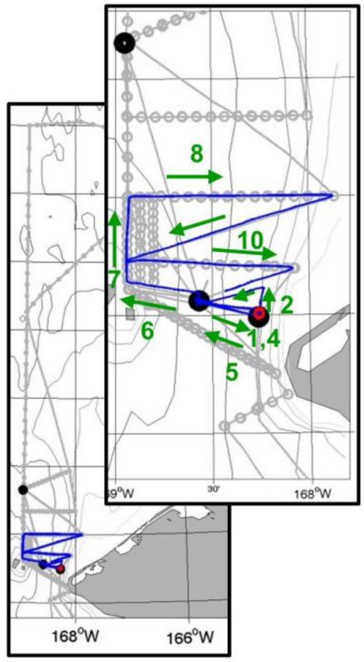
Contents

BERING STRAIT 2015 MOORING CRUISE MAP: *Ship-track, blue. Mooring sites, black. CTD stations, red. Green arrows indicate direction of travel. Depth contours every 10m from the International Bathymetric Chart of the Arctic Ocean (IBCAO) [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.)*

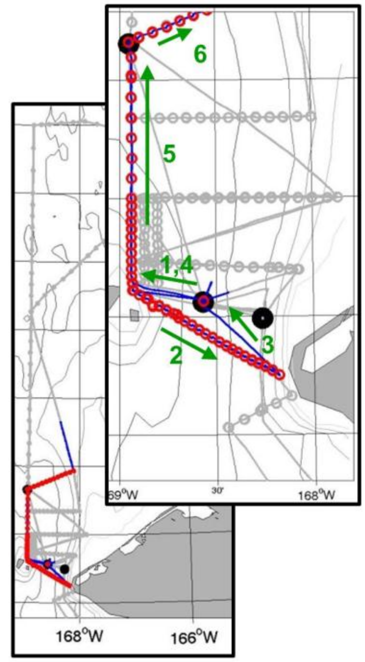




Day 1 *(local time)*
0800 2nd July 2015
- 0800 3rd July 2015

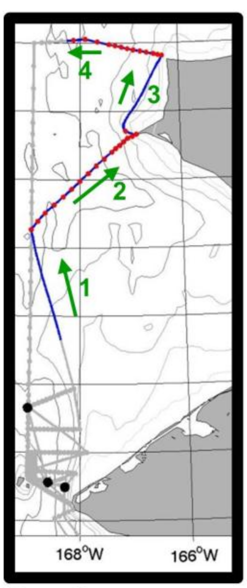


Day 2 *(local time)*
0800 3rd July 2015
- 0800 4th July 2015

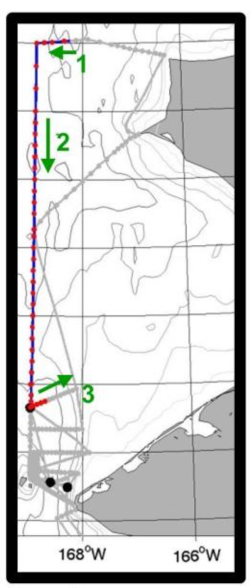


Day 3 *(local time)*
0800 4th July 2015
- 0800 5th July 2015

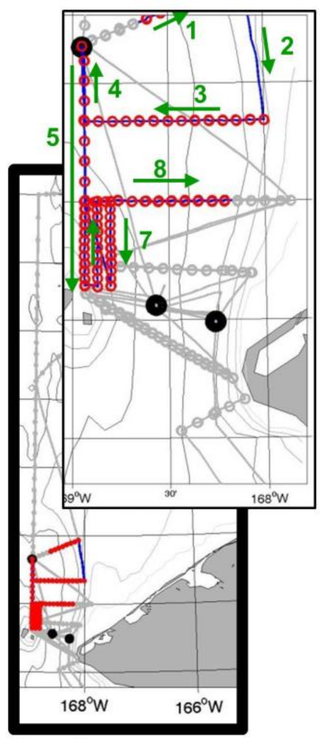
Bering Strait 2015
Mooring Cruise
Norseman II



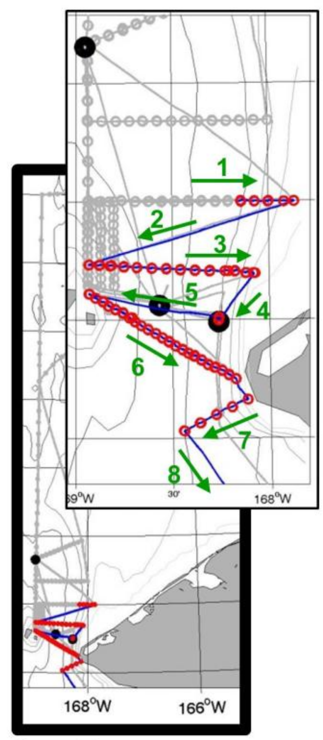
Day 4 *(local time)*
0800 5th July 2015
- 0800 6th July 2015



Day 5 *(local time)*
0800 6th July 2015
- 0800 7th July 2015



Day 6 *(local time)*
0800 7th July 2015
- 0800 8th July 2015



Day 7 *(local time)*
0800 8th July 2015
- 0800 9th July 2015

BERING STRAIT 2015 SCIENCE PARTICIPANTS

1.	Rebecca Woodgate (F)	UW	*Chief Scientist and UW PI*
2.	Jim Johnson (M)	UW	*UW Technical Mooring lead*
3.	Max Showalter (M)	UW	*UW Grad-student (Mooring/CTD team)*
4.	Robert Daniels (M)	UW	*UW Undergrad-student (Mooring/CTD team)*
5.	An Nguyen (F)	MIT	*MIT Co-PI*
6.	Kate Stafford (F)	UW	*UW Co-PI Marine Mammal moorings/observations*
7.	Melania Guerra (F)	UW	*UW Postdoc Marine Mammal moorings/observations*
8.	Maggie Buktenica (F)	OSU	*OSU Grad-student, Ocean Acidification moorings*

UW – University of Washington, US
MIT – Massachusetts Institute of Technology, US
OSU – Oregon State University, US

BERING STRAIT 2015 NORSEMAN II CREW

1.	Mike Hasting (M)	NMC	*Captain*
2.	Jim Howard (M)	NMC	*Mate*
3.	Perry Taitano (M)	NMC	*Chief Engineer*
4.	Jim Wells (M)	NMC	*Deck Boss*
5.	Austin Church (M)	NMC	*Deck Hand*
6.	Jorin Watson (M)	NMC	*Deck Hand*
7.	Marlin Casey (M)	NMC	*Chief Cook*
8.	Teresa Matmartin (F)	NMC	*Night Cook*

NMC – Norseman Maritime Charters, http://www.norsemanmaritime.com/index

Ship contract arranged by
Olgoonik Fairweather LLC, http://www.fairweather.com/fairweatherscience.html

BERING STRAIT 2015 CRUISE SCHEDULE (Times: Alaskan Daylight Time (GMT-8), 24hr format)

October 2014 to cruise	*Arrangement of charter of Norseman II by NSF and others for the Bering Strait mooring work*
End of April 2015	*Shipment of container of UW equipment to Nome, ETA mid-June*
Saturday 27th June 2015	*Science team (Rebecca, Jim, An, Max, Robert) arrive Nome*
Sunday 28th June 2015 *(Mild, sunny)*	*UW Instrument preparation (start instruments, build ADCPs, ISCATS)* *Restuff container*
Monday 29th June 2015 *(Overcast, choppy)*	*Testing and teaching of CTD operations* *Maggie arrives midday, preps OSU sensors for deployment* *Kate and Melania arrive evening*
Tuesday 30th June 2015 *(Overcast, choppy)*	*Teaching and preparation for CTD, Blog, & mooring operations* *Kate gives talk at UAF-Nome for local community*
Wednesday 1st July 2015 *(Overcast, choppy)*	*Ship arrives am. Science team due at boat 1400* *Spot container for onload, but leave ship to clear decks, return 1500* *Start on-load ~ 1530. Finished by 1730* *1730 ship safety drill and ship orientation* *Throw lines ~ 2215 (after late evening flight brings second cook)* Discussion of mooring and CTD operations with captain and crew
Thursday 2nd July 2015 *(Foggy, choppy seas)* *(Fog clears briefly,* *seas come down)*	Steaming towards site A4-14 1040 CTD test cast south of strait 1230 On site at A4-14, but too foggy for recovery. Do A4-14 pre-recovery CTD cast, Steam to A2-14 1245 On site at A2-14, but too foggy for recovery Do A2-14 pre-recovery CTD cast, Steam to A3-14 1715 On site at A3-14. Do pre-recovery CTD cast 1830 Clear enough for recovery. Start A3-14 recovery operation. Mooring releases on first attempt, all on board 1850 Prep for A3-15 deployment 2121 Start A3-15 deployment. Complete 2144. 2155 CTD at A3-15. Steam overnight for ADCP and underway data from A3 to east end of NBS, along NBSwestward, then to A2 for 0800
Friday 3rd July 2015 *(Foggy, choppy seas)* *(Less foggy, choppy seas)* *(Foggy)* *(Clear)* *(Foggy at A2, clear either side*	~ 0800 On site at A2-14, but too foggy for recovery. Steam to A4-14 ~ 1125 On site at A4-14, visibility just ok for recovery 1127 Start A4-14 recovery operation, release confirms but mooring does not surface. 1203 Commence dragging operations for A4-14 (in ~4 knot current) 1334 Mooring sighted, but old anchor caught on trawl must be dealt with prior to grappling for floating mooring 1418 A4-14 recovery complete. Steam to A2-14 ~1530 On site at A2-14. Still too foggy, return to A4 for deployment 1810 Start deployment of A4-14, Complete 1840. 1900 and 1915 two CTD casts at A4-15 with water sampling ~2030 Back at A2-14 again, but still too foggy. Wait for fog to clear.

of A2, and clear also N of Diomede Islands)

~2100 Still foggy. Abort mooring operations for the night. Steam ADCP/underway lines through night, North along DI, east along NBS, east along MBS, returning to A2 by ~ 0800

Saturday 4th July 2015
(Foggy, fairly calm)
(Clear along US coast)
(Fog clearing to evening)

~0830 On site at A2-14. Still too foggy, Steam to west of BS line.
Start BS line 0935, running east (BS11-BS22, with 0.5 stations)
End BS line at BS22 1507, Steam to A2-14, Finally clear of fog.
1628 Start A2-14 recovery operation.
Mooring releases on first attempt, all on board 1640
Prep for A2-15 deployment
1945 Start A2-15 deployment. Complete 1953. CTD cast at A2-15.
Steam to southern end of DI Line
Start DI line 2122, running north (DI1-19)

Sunday 5th July 2015
(Foggy, fairly calm)

End DI line 0152, Steam to A3-15
Start A3 line 0207, running towards US (A3-15 – AL24)
End A3 line 0543, Steam to CS10US
Start CS line 1313, running towards US (CS10US – CS19)
Primary CTD system pump issue casts (CS14-CS19), 2ndary ok.
End CS line 2128, Steam to LIZ1 (up coast, avoiding shallows)
2200 Fix pump issue and run test cast to check

Monday 6th July 2015
(Foggy in patches)

Start LIZ line 0218, running away from US (LIZ1-14)
End LIZ line 0925, Steam to CCL22
Start CCL line 0947 running south (CCL22 – A3)
(Decrease station spacing to 5nm from CCL19 to CCL8)

Tuesday 7th July 2015
(Generally foggy, seas building afternoon)

End CCL line 0640 at A3-15
Rerun A3 line 0640, running towards US (A3-15 – AL24)
End A3 line 1009, Steam to NNBS7.5 (near US)
Start NNBS line 1227, running west (NNBS7.5 – NNBS1)
End NNBS line 1606, Steam north to A3-15,
Cast at A3-15 1704, Steam to line DI 19
,
Rerun DI line 1723, running south (DI19-DI1)
End line 2228, Steam to DLa1
Start DLa line 2241, running north (DLa1-DLa12)

Wednesday 8th July 2015
(Clear by islands)

End DLa line 0049, Steam to DLb12
Start DLb line 0102, running south (DLb12-DLb1)
End line 0328, Steam to NBS1
Start NBS line 0455, running towards US (NBS1-9 with 0.5)
End NBS line 0910 Steam to MBSn1
Start MBSn line 1216, running towards US (MBSn1-MBSn8 with 0.5)
End MBSn line 1739, Steam to A4-15
1645 Second water sampling cast at A4-15, Steam to BS11,

(Clear by evening)

Rerun BS line 1849 running towards US (BS11-BS22 with 0.5s)
End BS line 2333, Steam to BS24 (also SBS1)
Start SBS line 2358, running away from US (SBS21-SBS5)

Thursday 9th July 2015 End SBS line 0116, Turn for Nome
(Sunny, light winds, warm) Off Nome by 1235, and docked by 1250
~ 1300 Northland bring down flat and Container to ship , start offload
~1430 Offload complete (including taking shipment to air cargo)
~ 1530 Complete final transfer of underway data, leave ship
Science team flies from Nome on evening flight, some overnighting in Anchorage, some continuing on late evening flights

Friday 10th July 2015 *Science team arrives back at home institutions*

Bering Strait 2015 Mooring cruise TOTALS

7.6 days at sea (away from Nome) ***2215 1st July – 1250 9th July 2015***
8.0 days on ship (including on/offload) ***1530-1730 1st July – 1300-1530 9th July 2015***

Moorings recovered/ deployed: ***3/3***
CTD casts: ***258 (including 2 test casts)***

SCIENCE COMPONENTS OF CRUISE

The cruise comprised of the following science components:

- **Mooring operations** – 3 mooring recoveries, 3 mooring deployments

- **CTD operations**

Line	Cast #s	# Stat	Dist (nm)	Time (hrs)	Start Time (GMT)	End Time (GMT)	Nm per Stat.	Hr per Stat.
Test casts	**1,81**	**2**						
Pre Recovery	**2,3,4**	**3**						
Post Deployment	**5,6,7, 31, 230**	**5**						
CTD BS11-BS22	**8-30**	**23**	**22**	**4.50**	4th July 2015 1735	4th July 2015 2307	**1.00**	**0.20**
CTD DL1-DL19	**32-50**	**19**	**30**	**4.50**	5th July 2015 0522	5th July 2015 0952	**1.67**	**0.24**
transit to A3			*3*	*0.25*				
CTD A3- AL24	**51-63**	**13**	**22**	**3.60**	5th July 2015 1007	5th July 2015 1343	**1.83**	**0.28**
transit to CS			*73*	*6.50*				
CTD CS10-CS19	**64-80**	**17**	**63**	**8.25**	5th July 2015 2113	6th July 2015 0528	**3.94**	**0.49**
transit to LIS			*37*	*4.83*				
CTD LIS1-14,CCL22	**82-98**	**17**	**58**	**7.57**	6th July 2015 1018	6th July 2015 1747	**3.63**	**0.45**
transit to CCL21			*10*	*1.13*				
CTD CCL21-A3	**99-128**	**30**	**152**	**19.33**	6th July 2015 1900	7th July 2015 1445	**5.24**	**0.64**
CTD A3 – AL24	**128-140**	**13**	**22**	**3.50**	7th July 2015 1440	7th July 2015 1809	**1.83**	**0.27**
Transit to NNBS			*18*	*2.3*				
CTD NNBS7.5 to NNBS1	**141-154**	**14**	**22**	**3.65**	7th July 2015 2027	8th July 2015 0006	**1.69**	**0.26**
transit to A3			*9*	*1.00*				
CTD A3 & DL19-DL1	**155-174**	**20**	**30**	**5.40**	8th July 2015 0104	8th July 2015 0628	**1.67**	**0.27**
transit to DLa1			*1.7*	*0.22*				
CTD DLa1-DLa12	**175-186**	**12**	**11**	**2.13**	8th July 2015 0641	8th July 2015 0849	**1.00**	**0.18**
transit to DLb12			*1.7*	*0.25*				
CTD DLb12B-DLb1	**187-198**	**12**	**11**	**2.43**	8th July 2015 0902	8th July 2015 1128	**1.00**	**0.20**
transit to NBS1			*11*	*1.45*				
CTD NBS1-NBS9	**199-215**	**17**	**27**	**4.25**	8th July 2015 1255	8th July 2015 1710	**1.69**	**0.25**
transit to MBSn1			*26.5*	*3.10*				
CTD MBSn1-MBSn8	**216-229**	**14**	**21**	**3.38**	8th July 2015 2016	8th July 2015 2339	**1.62**	**0.24**
transit to BS11	**230**	**1**	*25*	*3.17*				
CTD BS11-BS22	**231-253**	**22**	**22**	**4.73**	9th July 2015 0249	9th July 2015 0733	**1.05**	**0.22**
Transit to SBS1			*3*	*0.25*				
CTD SBS1to SBS5	**254-258**	**5**	**13.4**	**1.30**	9th July 2015 0758	9th July 2015 0916	**2.25**	**0.26**

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

- Whale Observations (including acoustic instruments on the moorings)

UW whale observer, Kate Stafford, took observations of marine mammal and was responsible for the moored acoustic whale recorders.

- Moored Nutrient Observations

Recovered mooring A3-14 carried an ISUS nutrient sensor from Terry Whitledge, UAF.

- Moored Ocean Acidification Observations

Deployed mooring A4-15 included pCO2 and pH sensors from Laurie Juranek and Burke Hales (OSU) to measure ocean acidification. Water samples at the instrument depth were also taken for calibration of moored instrumentation.

- Biofouling Observations

Ad hoc observations of mooring biofouling were made by UW grad student Max Showalter.

MOORING OPERATIONS (Woodgate, Johnson, Nguyen, Showalter, Daniels)

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 2011 suggest that heat and freshwater fluxes are increasing through the strait [*Woodgate et al.*, 2006; *Woodgate et al.*, 2010; *Woodgate et al.*, 2012], with 2012 being a year of low flow, but 2013 returning to higher flow conditions. The data recovered this cruise will indicate if 2014 shows further increase or a return to older conditions. An overview of the Bering Strait mooring work (including access to mooring and CTD data) is available at http://psc.apl.washington.edu/BeringStrait.html. A map of mooring stations is given above.

Three UW moorings were recovered on this cruise. These moorings (all in US waters – A2-14, A4-14, A3-14) were deployed from the Norseman II in July 2014, with mooring funding from NSF-AON.

Three UW moorings (A3-15, A2-15, A4-15) were deployed on this 2015 Norseman II cruise under funding from NSF-AON (PI: Woodgate and Heimbach, *PLR1304052*). 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.

All moorings (recovered and deployed) carried upward-looking ADCPs (measuring water velocity in 2m bins up to the surface, ice motion, and medium quality ice-thickness); lower-level temperature-salinity sensors; and iscats (upper level temperature-salinity-pressure sensors in a trawl resistant housing designed to survive impact by ice keels). One of the recovery sites (A3, the climate site) also carried an ISUS nitrate sensor. This was not redeployed. The three recovered moorings carried marine mammal acoustic recorders, and acoustic recorders were deployed on the three new moorings also. The newly deployed A4-15 mooring also carried new pCO2 and pH sensors to study ocean acidification. 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 suggested to be a major part of the heat and freshwater fluxes [*Woodgate and Aagaard*, 2005; *Woodgate et al.*, 2006]. 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 nutrient sampler, ocean acidification and 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, 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.**

2015 Recoveries and Deployments: Mooring operations mostly went smoothly in 2015.

For recoveries, the ship positioned ~ 200m away from the mooring such as to drift towards the mooring site. Ranging was done from the port forward 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.** Without exception, acoustic ranges agreed to within 30m of the expected mooring position. 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.**

Two of the moorings (A3-14 and A2-14) released immediately and were sighted at the surface within seconds of the confirmation of the release code. The recovered moorings were all equipped with springs in the release mechanism, to assist with freeing the mooring hook on release. It appears this function well, and thus the springs should be used in all future deployments. These springs were included in the 2015 deployments. **Action item: Use springs on all future mooring deployments.** In these two moorings no problems were found with mooring releases on this cruise, even though only a short amount of chain (1m) is between the release and the anchor. This supports previous ideas that some mooring release issues related to the bottom pressure gauges on the mooring, rather than the shortness of the release to anchor distance. **Action item: Review Bottom Pressure Gauge design for future use**. Although biofouling was light, with very some biofouling present on the release links, which were painted with the blue antifouling paint. ***Action items: Continue with biofouling paint on releases and with double releases, but check that paint does not foul the release or the spring.***

On mooring A2-14, the second to be attempted, the first release responded that it had failed to release the mooring. To cover this eventuality, we always deploy using two releases in parallel. The second release confirmed release, but the mooring did not surface. Several passes over the mooring confirmed it was still in its original position, and thus dragging operations were started. Dragging hooks and weights were attached to the ship's trawl wire and ~ 150m (500ft) of trawl wire was paid out while the ship attempted to steam in circles around the mooring position at a range of ~ 50m. The very strong currents (~4 knots) made maintaining a ship heading very tricky. After 30min, the trawl was recovered, and the mooring position checked acoustically again. The trawl was then weighted with extra weights and redeployed, and the ship continued to attempt to steam in circles around the mooring position. Finally, after a further 70min of trawling the mooring was sighted in front of the ship.

However, as the trawl wire was being recovered, it came tight on some obstacle on the sea-floor, and the ship had to back down on that position to recover the obstruction. This obstruction was finally hoisted up with the trawl, and was an old double anchor from UAF (deployed likely between 2007 and 2012, although possibly earlier). Dealing with such a heavy weight, which was only jammed on the trawl hooks and included severely rusted chain, was challenging, especially under the time constraint of the surfaced mooring drifting away from the ship. However, the old anchor was finally secured and redeployed, the ship returned to the drifting mooring. . **Action items: Check into why release 17301 failed to release. Continue with double releases. Reconsider dragging techniques. Bring spares of dragging gear. Talk through dragging operations at start of cruise (as when needed, must be brought into play swiftly). Use heavy weight on trawl.**

Note that, on final recovery of the mooring, there was no obvious indication of why the mooring had not surfaced with the release of the 2nd release. Our current hypothesis is that extremely strong currents (data suggest 2 knots at depth, ~ 4 knots at the surface) caused excessive tilt in the releases, somehow jamming them. **Action items: Use mooring data to estimate release tilt under actual flow conditions. Revisit double release design to check cannot lock up under high current.**

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. The line from the hook was then passed back to through the stern A-frame, and tied with a "cats 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, only the iscat on A2-14 was present at the time of recovery.) Then the entire mooring was then elevated and recovered onto deck. At times. additional loops of line, which would be passed through shackels or chain, were used to provide a lifting point. 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, and samples were taken for biofouling identification. **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.**

Fog was a major hindrance to mooring recoveries this year. 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 per A4-14. 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 the US EEZ. **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.** It is worth remembering that although in exceptionally calm seas, the ship's radar may be able to pick up the steel float on a surfaced mooring, even the mild sea states of this year's recoveries were enough to mask the top float on the radar. While in previous years, fog has been more common near the islands, this year the central strait was the most foggy. Fog frequently (but not always) thinned or cleared towards late afternoon or evening. **Action item: Assess causes of foggy conditions, in order to predict best strategy for finding workable visibility.**

Biofouling was moderate to heavy in the recoveries this year. In 2013 and 2014, the A4 mooring had the most biofouling. This year, A4 had the most biofouling on the ADCP, but A2 had equal biofouling at depth. A3 was only moderately biofouled. A more complete biofouling report is included below. Fouling was by barnacles and bryozoan-like growth on several parts of the moorings, with the one recovered iscat (from A2-14) also having some small mussels. Overall though, release hooks were generally clear of biofouling, and, salinity cells were clear of biological growth. Note that the (unpumped) SBE included in the ISUS instrument cage on A3-14 was at 45deg angle to the horizontal, and as we will see below, this degraded salinity measurements. **Action item: Quantify A3-13 SBE in ISUS cage for silt in cell degrading salinity data. Continue to mount SBEs as close to vertical as possible.**

Mooring deployments were done through the aft A-frame, using the A-frame hook 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 knots) into the wind/current, starting between 250m and 600m from the mooring site (the latter at A4 due to the stronger currents.) At the start of the deployment, the iscat was deployed by hand and allowed to stream behind the boat. The first pick was positioned below the ADCP, allowing most of the mooring to come off the deck during the first 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 rather than relying on body weight.** 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 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 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. 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. These positions match to within 30-60m of the ship's measurements of the GPS of the aft A-frame. **Action item: Continue to bring own GPS unit.** 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 assisting with tending the quick release lines during lifting. The lines were passed off to the crew on the dog runs prior to deployment.

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.

Instrumentation issues: Most instrumentation was started in Nome or aboard ship in the days prior to sailing. All instrumentation was started successfully, using the older laptops. **Action item: Check new laptops with all instrumentation.** Iscat housings and ADCP frames were assembled using a group of 5 people in Nome (2 teams). Due to remarkably good weather, the teams worked hard to accomplish all building and container restowing in one day, dedicated the other days in Nome to learning CTD driving, starting the Blog, and preparatory data coding. The extra days before the cruise should be kept, as they allow for unforeseen issues, for example, requests for early loading as in previous years.

Instrument set up went smoothly. The iscat loggers were equipped this year with alkaline batteries. The newer software for the ADCPs was found to erase the bottom track measurements unless preventative steps were taken. **Action item: Continue to inventory numbers of the couplers, continue to test each coupler with an iscat prior to deployment. Make sure all spare instruments contain batteries, and have suitable pressure sensors and deployment history.**

Overall, data recovery on the moorings was good, with a few issues. All instruments were downloaded using the older laptops with serial ports. **Action item: Bring same number of laptops for these downloads.**

ISCAT SBE37IMS: Of the 3 iscats deployed on the recovered moorings, only 1 top sensor containing the inductive SBE37s (A2-14) was recovered. The recovered SBE37IM downloaded without incident, and returned a full data record. Data indicate mooring pull downs to over 30m at times.

On mooring A4-14, the iscat was lost just above the bottom stopper block on the top float and logger data suggest the iscat was lost on 9th Feb 2015 between 14:45 and 15:15, while at a depth of ~ 15m. **Action item: Check ice keel depths at this time, and look for iscat on ADCP data.**

On A3-14, the iscat was lost at the weak link. Logger data suggest this loss occurred between 14:03 and 14:34 on 16th August 2014, while the iscat was at ~ 16m depth, possibly due to either mechanical failure or some non-ice intervention. However, the marine mammal acoustic recorders give no record of a ship at that time, and preliminary analysis of the error in ADCP velocity (which can indicates presence of the iscat) suggests instead the iscat was still present until ~ 16 March 2015. If this is the case, then we can only hypothesize about causes of early loss of communication (e.g., unplugging of coupler, failure of coupler, loss of sea water connection, loosening of clamps due to mooring strumming). Logger batteries were still high (9-10V) on recovery. **Action item: Check ADCP tilt for iscat presence, and keep depths. Revisit prior iscat successes and failures. Be sure deployments have sufficient slack in communications cable.**

ISCAT LOGGERS: All 3 loggers were operational on recovery. For the 2 systems where the iscat was lost (A3-14 and A4-14) the loggers (logger 22 on A3, and logger 23 on A4) yielded good data up to the presumed point of iscat loss. In each case, however, there are periods of time where the logger recorded either junk data (in both loggers) or skipped records (in logger 22 on A3). For analysis, these missing data times have been assigned dummy data values (-9.99). Typically logger clocks were ~ 20min slow by the time of recovery. However, as the data is recorded with the SBE37 timestamp, this clock drift has not been corrected for. This should be revisited if time accuracy of less than 1hr is required. The record from logger 26 on A2-14, although full length, also contained some data glitches, but since the iscat was recovered, time was not taken to correct this logger record. **Action item: Investigate why loggers write erroneous data. Purchase new iscats for 2016 deployments. On recovery, check on the tightness of the IM couplers on the wire incase that is the cause of erroneous data. On deployment, be sure to record DC command to file, and to write serial number on iscat shield.**

. **ADCPs:** All the 3 ADCPs recovered were still running on recovery, and all yielded mostly good data on download, although with some issues. From A4-14, ADCP 12845 functioned as per plan. From A3-14, ADCP 10926 functioned well during the deployment, but stopped for 7min at about the time of mooring release and recovery, and restarted again. Thus, the year-record is complete, but the cause for restarting is unclear. **Action item: Investigate why ADCP 10926 restarted on recovery.** A more substantial issue was with ADCP 1495 on A2-14. This started correctly pre deployment, but during deployment stopped temporarily (2hrs) on 14th July (a few days after deployment) and on 17th July (1hr), in each case restarting with the same plan. However, on 7th August 2015, it stopped again, and restarted ~ 9hrs later without bottom track and using only factory calibrations. **Action item: do on shore checks of all compasses, especially 1495, return 1495 to manufacturer for service to investigate in-water loss of plan and frequent stopping.**

SBEs: At least one seabird SBE16 was recovered from each mooring. None of these instruments were pumped. The SBEs on A4-14 and A2-14 were vaned (on A4-14 in our traditional vaned system; on A2-14 via a vane on the Marine Mammal recorder). On mooring A3-14, the SBE was deployed on the ADCP vane without vaning. Mooring A3-14 also carried a second SBE16 (SN0005), mounted at ~ 45deg within the cage of the ISUS sensor. Although all salinity cells were clear of biofouling on recovery, the salinity records from A3 show the 45deg mounted sensor drifting fresh, likely due to partial clogging of the cell (not shown). These data are not included in the plots given below. Sizeable (up to 0.1 psu) changes over the year are not uncommon in past data, as the salinities cells are scoured by sediment. These drifts will be identified (and corrected for) on post-cruise calibration. **Action item: Once post calibrations are available, check start and end times with CTD casts to assess reliability of data.** Two of the recovered SBEs (2264 on A4-14 and 2341 on A3-14) returned data with numerous spikes. **Action item: Despike.**

Action items: Do more thorough comparison of salinities with CTD casts and consecutive moorings. Revisit all prior salinity records. Mount SBEs vertically. Clean cells on instruments.

A preliminary review of the SBE data show annual cycles of temperature and salinity. Direct comparison with older data is necessary to ascertain interannual changes.

Other Instrumentation: Other instruments on the moorings were recovered for other groups. These instruments are:

ISUS nitrate sensors on A3-14 (#88). This instrument was deployed by Dan Naber on behalf of Terry Whitledge, UAF, and has been returned to UAF for downloading.

Aural Marine Mammal Acoustic sensors on all moorings (#113 on A2-14; #234 on A4-14; #96 on A3-14) A2-13 (#235) were deployed by Kate Stafford, (UW). All three instruments recorded throughout the year. More details are given in the Marine Mammal report below.

Deployed moorings also carried other instrumentation.
These instruments are:

Ocean acidification sensors on mooring A4-15 (see report below).

Marine Mammal Acoustic sensors on all moorings (see report below).

Note that ISUS sensors were not redeployed this year.

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 2015 MOORING POSITIONS AND INSTRUMENTATION

ID	LATITUDE (N) (WGS-84)	LONGITUDE (W) (WGS-84)	WATER DEPTH /m (corrected)	INST.
2014 Mooring Deployments				
A2-14	65 46.85	168 34.09	56 (55m from data)	ISCAT, ADCP, SBE16 with MMR
A4-14	65 44.72	168 15.82	49 (48m from data)	ISCAT, ADCP, SBE16, MMR
A3-14	66 19.60	168 57.06	58 (57m from data)	ISCAT, ADCP with SBE16, SBE16 with ISUS, MMR

ID	LATITUDE (N) (WGS-84)	LONGITUDE (W) (WGS-84)	WATER DEPTH /m (corrected)	INST.
2014 Mooring Deployments				
A2-15	65 46.86	168 34.08	56	ISCAT, ADCP, SBE16 with MMR
A4-15	65 44.76	168 15.77	49	ISCAT, ADCP, SBE16 with MMR, SAMI pH and pCO2 with SBE37
A3-15	66 19.60	168 57.04	58	ISCAT, ADCP with SBE16, MMR

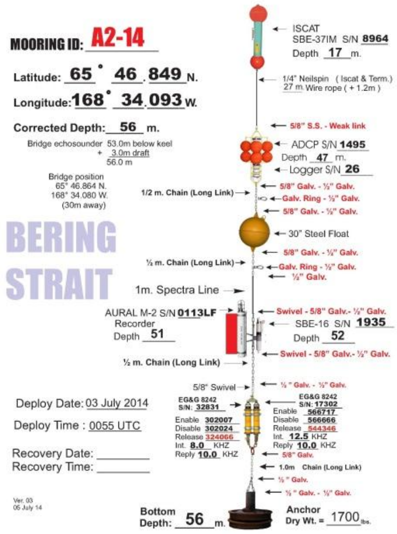
ADCP = RDI Acoustic Doppler Current Profiler
ISCAT = near-surface Seabird TS sensor in trawl resistant housing, with near-bottom data logger
ISUS= Nutrient Analyzer
SBE16 = Seabird CTD recorder , SBE37 = Seabird CTD recorder
MMR=Marine Mammal Recorder
SAMI pH and pCO2 = SAMI instruments for measuring ocean acidification parameters of pH and pCO2.

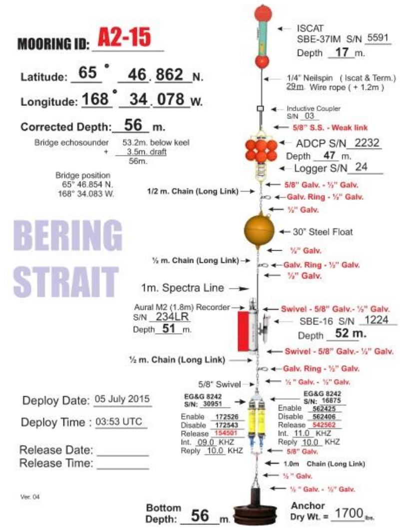
Note that recovered instrumentation suggest water depths as shown in the upper table. Prior estimates of water depth are from the ship's echosounder, assuming a draft of 3m. These data suggest that 2m is a better estimate of the ship's draft. **Action item: Consider this for CTD casts next year.**

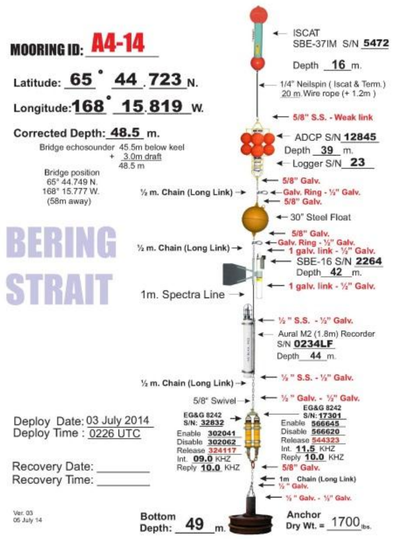
BERING STRAIT 2015 SCHEMATICS OF MOORING RECOVERIES AND DEPLOYMENTS

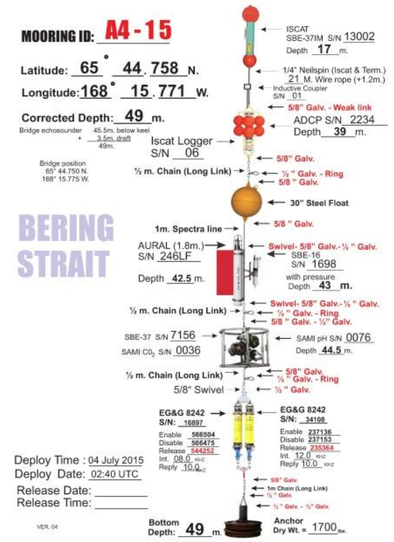
RECOVERED / DEPLOYED

= in the eastern channel of the Bering Strait

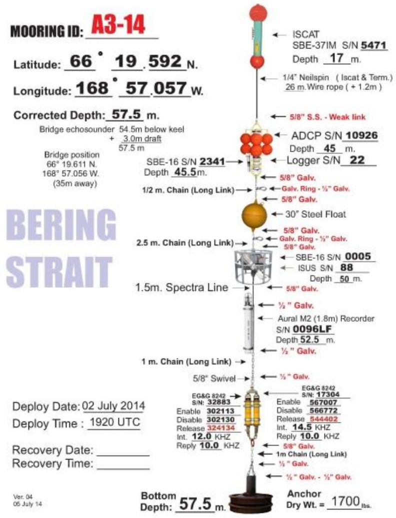


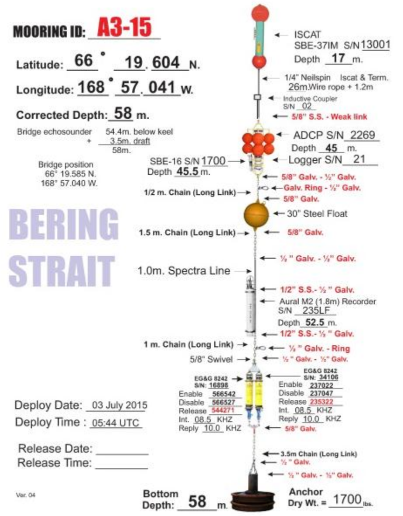






= at the climate site, ~ 60km north of the Strait



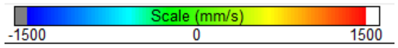


BERING STRAIT 2015 RECOVERY PHOTOS

A3-14
Recovery

A4-14
Recovery

BERING STRAIT 2015 RECOVERY PHOTOS (continued)

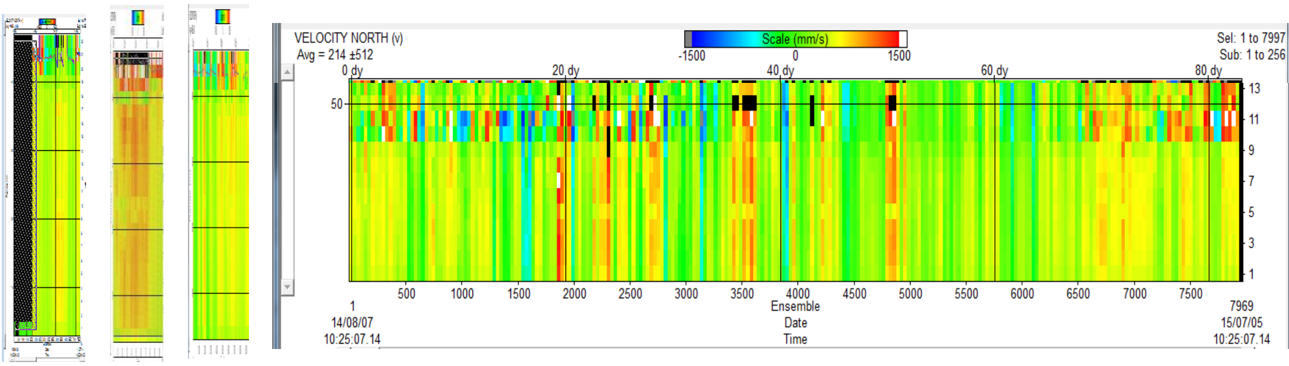


NORTHWARD VELOCITY from ADCPs.

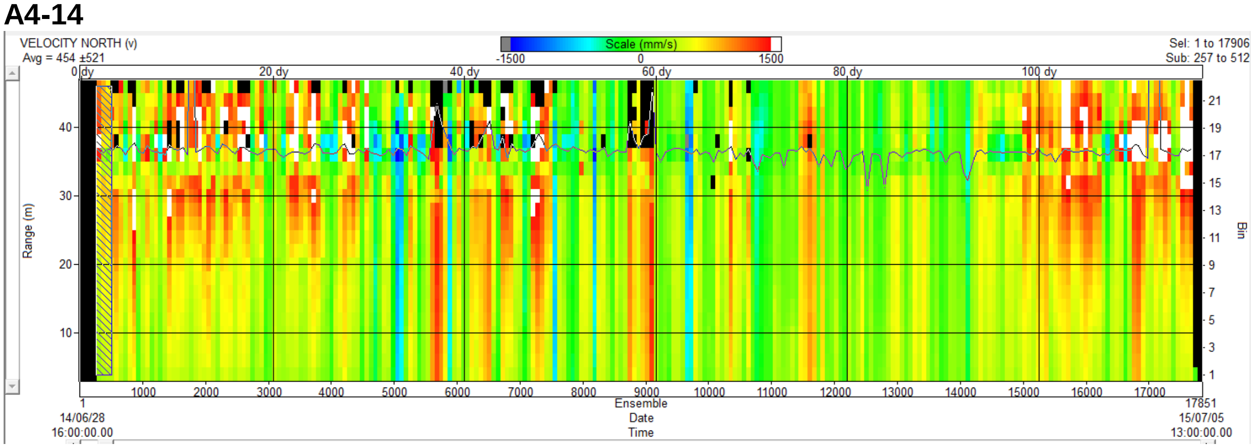
A2-14

Wrote 4 files:

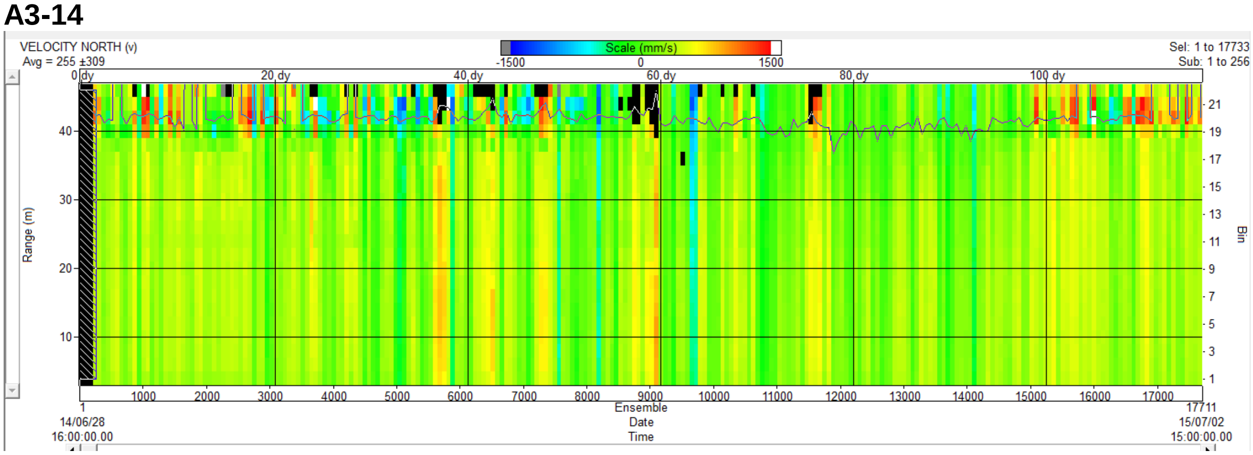
1495D000.000 =2014/Jun/28:1600 – 2014/Jul/14:1800 – original settings
1495D001.000 =2014/Jul/14:2040 – 2014/Jul/17:0140 – original settings (but 2hr40min gap at start)
1495D002.000 =2014/Jul/17:0249 – 2014/Aug/7:0049 – original settings (but1hr9min gap at start)
_RDI_000.000 = 2014/Aug/7:1025 – 2015/Jul/6:1425 – factory settings, no BT (after ~ 10hr gap)



A4-14

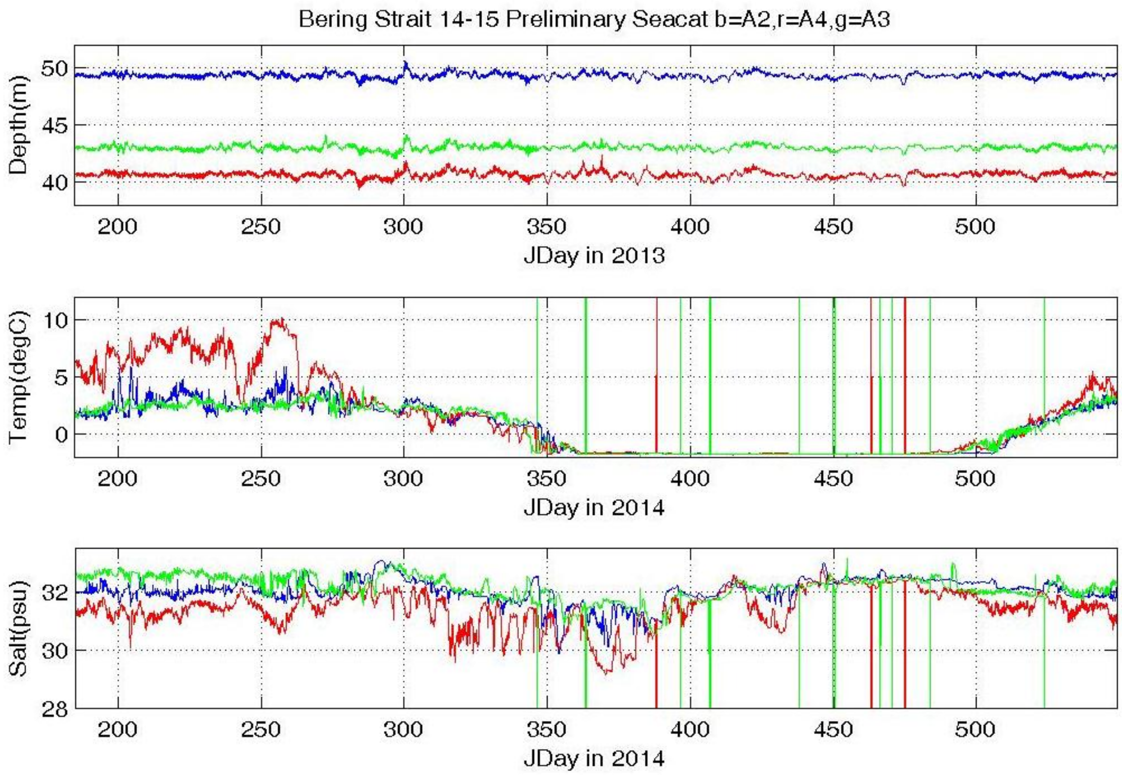


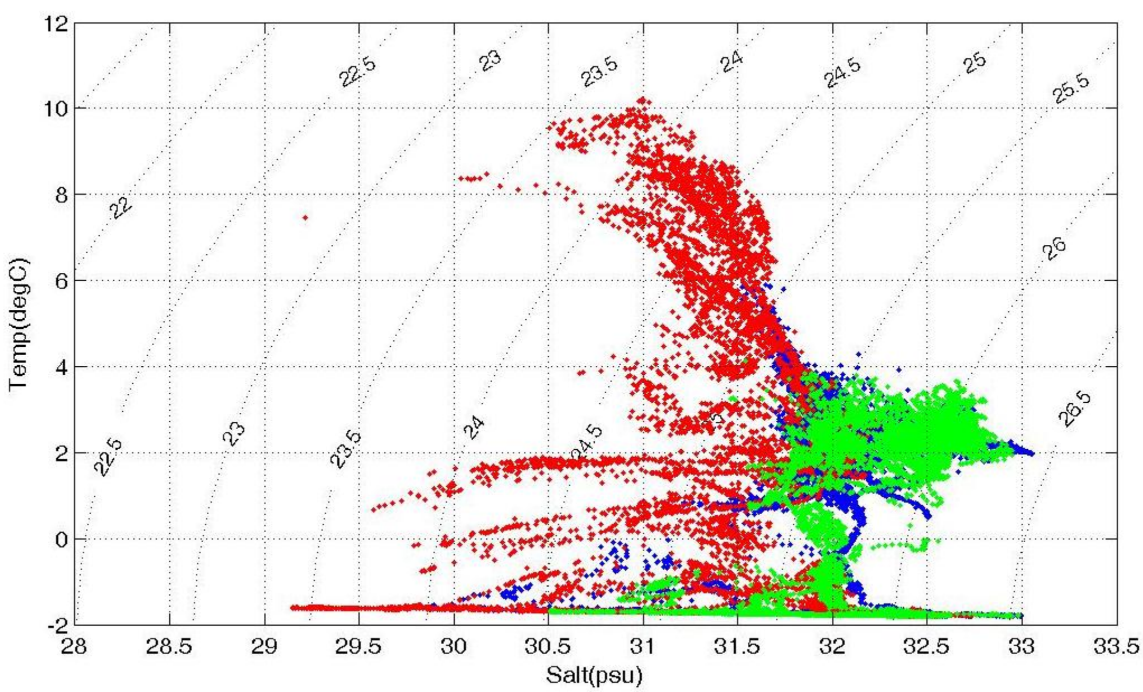
A3-14



BERING STRAIT 2015 SBE PRELIMINARY RESULTS

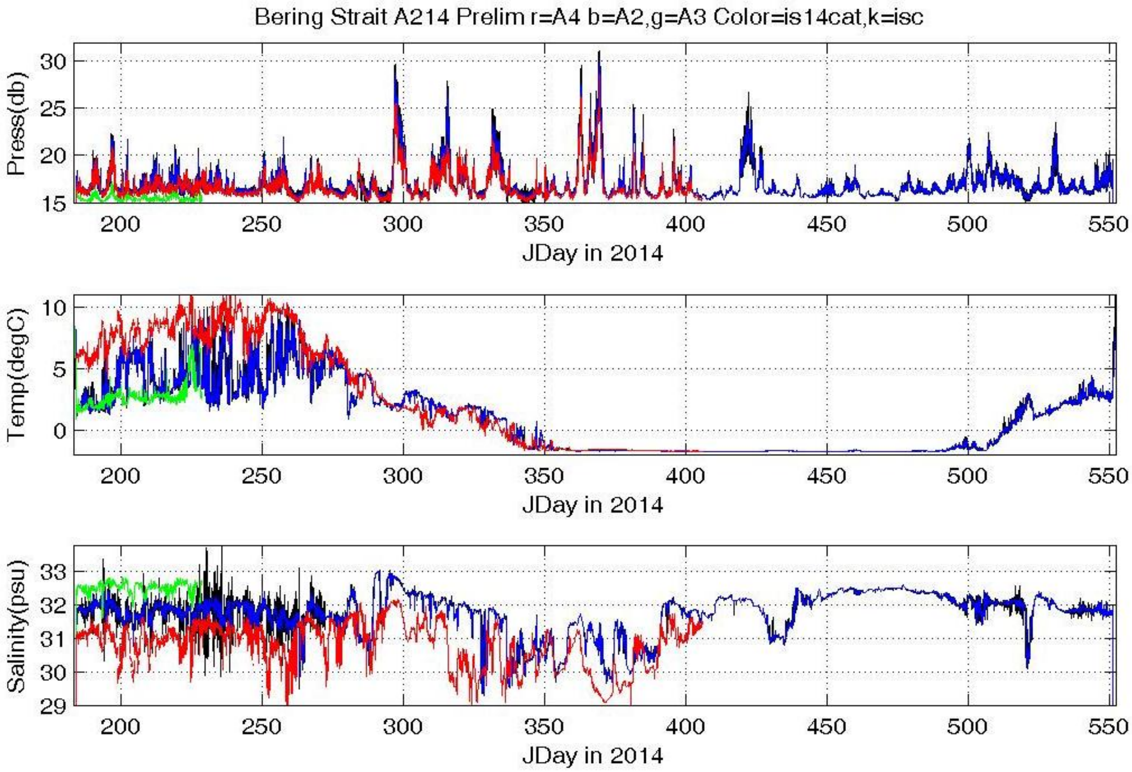
– all lower level TS Sensors (excluding suspected clogged cell)

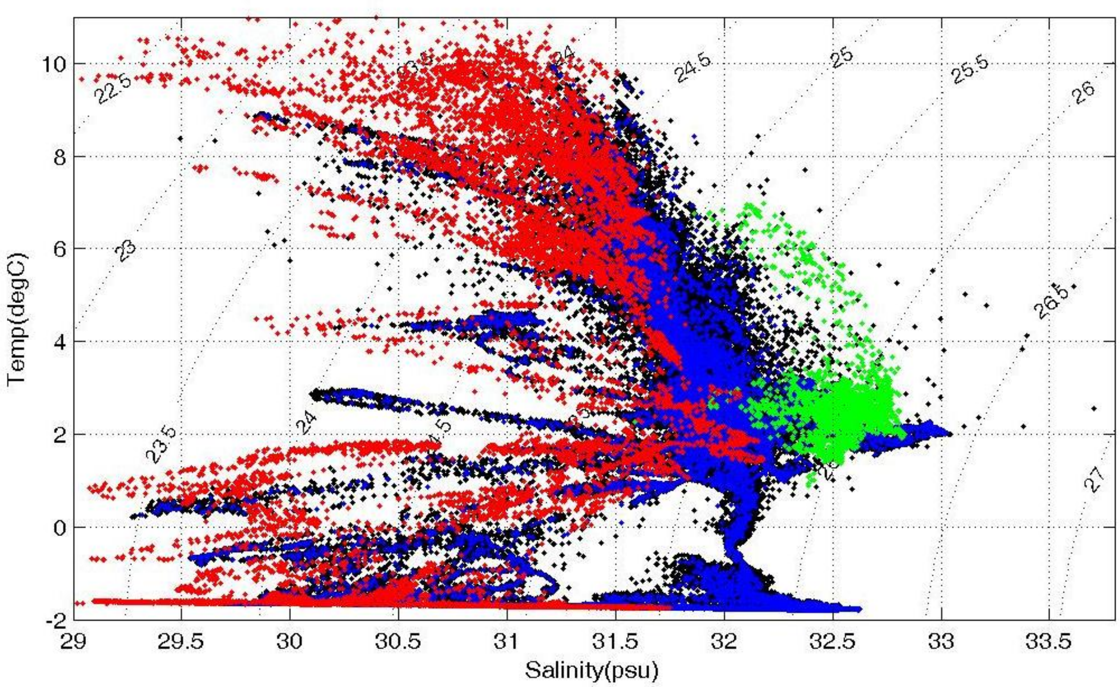




BERING STRAIT 2015 PRELIMINARY ISCAT RESULTS

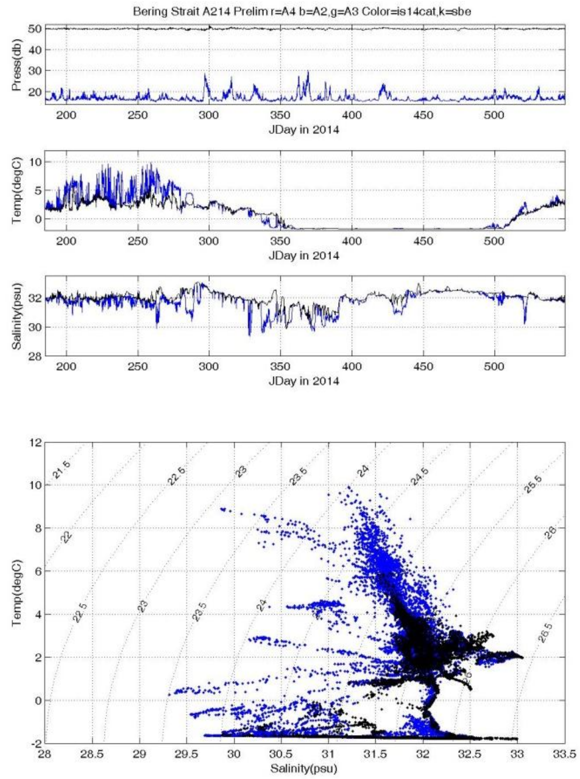
– all upper level TS Sensors



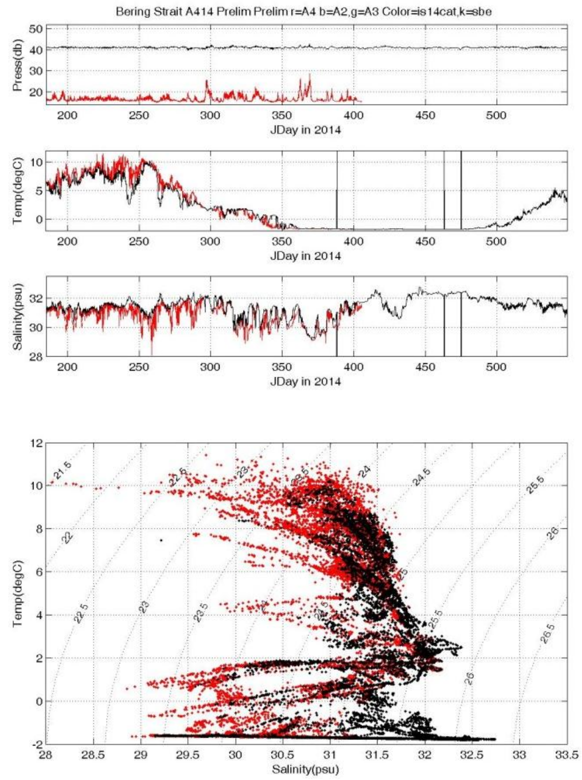


BERING STRAIT 2015 PRELIMINARY ISCAT AND SBE RESULTS (per mooring)

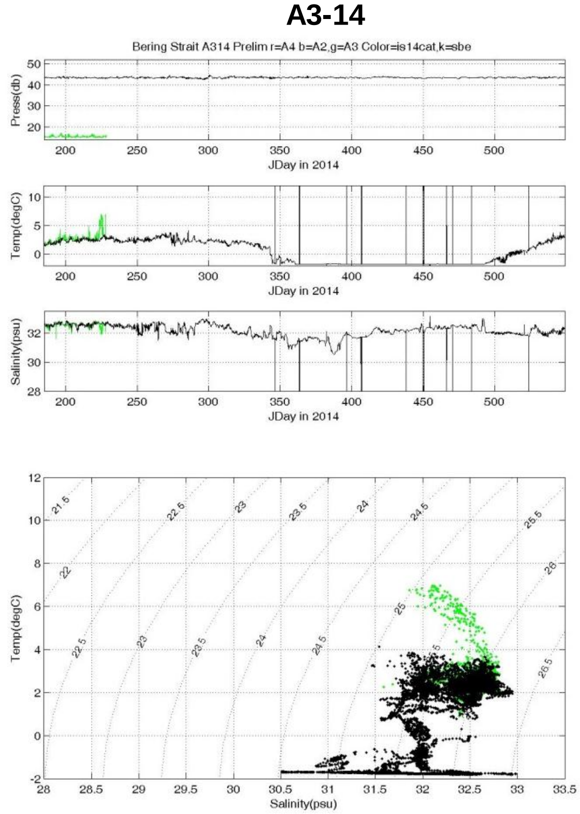
A2-14



A4-14



A3-14



BERING STRAIT 2015 IDENTIFICATION OF MAIN BIOFOULING ORGANISMS, Gordon Showalter

Biofouling - Introduction

As the Bering Strait witnesses increased heat flux from the Pacific Ocean into the Chukchi *[Woodgate et al., 2006]*, marine organisms must adapt with one of three outcomes: decreased competitive advantage, increased competitive advantage, or no change in competitive advantage. Each of these responses may cause system-wide reverberations, both locally and globally. Indeed, ecosystems within the Chukchi and Bering Sea are complex and demonstrate high levels primary productivity that feed multiple heterotrophic levels [*Sakshaug*, 2004; *Hill and Cota*, 2005]. Because of the dynamic and extreme nature of the Arctic, these ecosystems may only display themselves for observation or sampling on short time scales throughout the year.

The Bering Strait moorings provide us an opportunity to directly observe the ecosystem change at annual intervals within this region. Identification and cataloging of major fouling organisms accumulated on the mooring surfaces provide year-round sampling of multiple levels of the native ecosystem to accompany direct physical observations of the in situ environment. These biofouling communities provide an easily sampled biological context to physical observations of the changing Arctic, thereby providing insight to the broader organismal response to climate change in high latitudes.

Detailed within this report are descriptions of critical species of the fouling communities found on the three moorings recovered in the Bering Strait mooring cruise, 1st July to 9th July, 2015. Photographic documentation and tentative identification accompany the descriptions.

Biofouling – Science Background

Biofouling, biological colonization of an artificial surface, represents an ever-present nuisance to aquatic infrastructure, especially marine. The presence of micro- and macrofauna on man-made surfaces can increase drag and subsequent fuel costs, cause material corrosion and discoloration, and decrease general performance and lifespan of ships, pipes and cables, structures, or instruments in the ocean [*Callow and Callow*, 2002; *Railkin*, 2003].

Canonical theory of fouling communities predicts a primary succession of micro- and macro-fouling. Immediately after placement of a surface into seawater, organic materials being adhering to the surface via Van der Waals forces. Copiotrophic bacteria swim toward this now nutrient-rich surface and begin colonizing within the first two hours [*Railkin*, 2003]. As the coptiotrophs consume nutrients, oligotrophic bacteria begin to outcompete and outgrow the first colonizers. Planktonic diatoms land on the surface, contributing to microbial fouling. This process takes place over a period of two to three weeks.

Following micro-fouling, macro-fouling occurs in two stages. The first stage sees quickly growing bryozoans, hydroids, anemones, and polychaetes colonize the surface within 1 to 2 years of its submersion. Slow-growing invertebrates then begin settling on the surface in the second stage of macro-fouling [*Railkin*, 2003].

Species richness on biofouled surfaces varies highly, in accordance with the *Theory of Island Biogeography*, which highlights the dominance of immigration and extinction within an insular ecosystem [*Wilson and MacArthur*, 1967; *Railkin*, 2003]. So, while knowledge of succession can predict state of biofouling, other predictions, like extent or specific composition of the fouling community, remain elusive or inaccurate. For example, relative biomass of fouling communities decreases in higher latitudes as compared to warmer waters, but as highlighted below, relative biofouling can shift from heavy to light in as little as twenty nautical miles.

Vertical distribution and surface properties also affect fouling communities upon the same principle of immigration and extinction. Photosynthesizing diatoms active within high PAR regions of the water column have a higher likelihood of colonizing shallow surfaces as compared to deeper surfaces, whereas larval invertebrates often exhibit sensitivities to light, gravity, or current [*Crisp*, 1984]. Seasonality also exerts selective pressures on fouling organisms: the Bering Strait moorings, deployed in mid summer and recovered one year later, will likely exclude organisms which cannot maintain competitive advantage with overwintering species.

Biofouling – Summary and Analysis of Biofouling Patterns

For each of the three moorings recovered, biofouling analysis consisted of a broad visual inspection, photographic documentation, and selective sampling of dominant species for later identification. Sampling did not take into account vertical distribution or surface-type differentiation on the mooring. Manual recovery of common species was performed using traditional instrument cleaning tools. Descriptions of species and location were noted down, and organisms were photographed for later identification. **Action item: recover species into sterile discrete sampling containers with seawater to separate by distribution along mooring. Preserve samples to return to Seattle for further identification.**

The moorings exhibited similar patterns of speciation, but varied in extent and diversity. Mooring A4-14 showed extensive fouling in comparison to moorings A2 and A3. Mooring A4-14 corresponded to the region of highest current, which supports the accepted theory that biofilming and fouling increase under high flow [*Railkin*, 2003].

Relative to each mooring, the ADCP floats showed extensive barnacle communities on their dorsal surfaces, with moderate algal and bryozoan colonies. Moderate barnacle communities fouled the ADCP proper and battery, with moderate algal and bryozoan colonies. On moorings A2 and A4, cyprid larvae grew atop existing barnacles.

Extensive barnacles, algae, and bryozoans encrusted the dorsal surface of the 30" steel float, with moderate to minimal on the ventral surface. On moorings A2 and A4, cyprid larvae grew atop existing barnacles. Barnacles observed on dorsal surfaces of floats had crowded to grow approximately 0.5 – 2 cm long and 0.5 – 2 cm in diameter. Bryozoan communities lightly covered the field of barnacles.

Moderate barnacle biomass covered the AURAL/Seabird package with moderate to high barnacle or bryozoan and algal biomass covering the vein. Minimal barnacle fouling and moderate bryozoan and algal communities covered the acoustic release.

One ISCAT (A2) was recovered, demonstrating minimal relative fouling by barnacles, but moderate fouling by algal and bacterial filming. Low levels of macrofouling may be related to the presence of antifouling paint on the ISCAT housing, as well as tributyltin oxide poison within the instrument.

Also present on the instrumentation package across (excluding the acoustic release and in dense barnacle fields) were ascidians (sea squirts) and nudibranchs (sea slugs) attached in small number (3-5 total). One polychaete annelid was removed from mooring A3-14. One sipuncular worm was removed from mooring A2-14, but was damaged during mooring recovery and likely not a permanent resident of the mooring. Putative sacs of nudibranch eggs were visible on A2-14 and A3-14.

No microbial analyses were performed. **Action item**: **recover microbial samples into cryogenic vials for freezing and later genomic sequencing.**

Primary resources for identification include the *Organisation for Economonic Cooperation and Development's Catalogue of Main Marine Fouling Organisms* and the World Register of Marine Species.

Biofouling – Major Fouling and Species Identification

Barnacle communities were largely homogenous across the entirety of the moorings. These acorn barnacles ranged in size from roughly 0.5 cm to 2 cm in diameter, and roughly 0.5 cm to 2 cm in length. Samples showed 6 plates, with rostral overlap of the two adjacent plates. Scuta and terga formed a closed, rhomboidal center with oblique angling of radii. Putative identification implicates *Balanus crenatus* as the major species associated with the mooring. *B. crenatus* is known to reside in the North Pacific, preferring strong currents and exhibiting fast growth. Morphology, range, and description suggest the collected samples were *B. crenatus [OECD, 1963; WoRMS, 2015]*.

Bryozoa collected from each of the three moorings match closely with descriptions of the genus *Bugula,* an arboreal-type bryozoan of branches emanating from a single stock. *Bugula* is thought to be globally distributed, in part due to its nature as an invasive species *[OECD, 1963; WoRMS, 2015]*.

Hydroids removed from the surfaces likely belong with the genus *Halecium*, a cosmopolitan, dendritic polyp of similar morphology to the collected samples. Accurate identification of hydroids requires magnification of hydranths, and would benefit from observation near in situ (in seawater) *[OECD, 1963; WoRMS, 2015]*.

A total of four nudibranchs (sea slugs) were isolated from the moorings, all of nearly identical morphology. A fleshy body of muted, dark salmon color with white spots and small, light cerata symmetrically lining the back characterized the specimens. Samples likely belong to the family *Dendronotidae* based on morphology. Genus or species level classification was not achieved. Presence of egg sacs on floats provides confirmation of nudibranch classification, but samples of egg sacks were not recovered for analysis due to their fragility *[OECD, 1963; WoRMS, 2015]*.

Several tunicates (sea squirts) of nearly identical morphology were recovered from the moorings. These organisms had a clear membrane with some visible internal structures, but no discernable siphons. Based on morphology and distribution, the specimens have been identified as likely belonging to the genus *Corella*, and putatively the species *inflata. Corella inflata* has been previously recovered from the Bering Strait *[OECD, 1963; WoRMS, 2015]*.

Two varieties of sea anemone were pulled from the old anchor recovered unintentionally during mooring dragging operations, representing unique additions to the collection of fouling specimens from the moorings. These anemones possibly group with the *Urticina* genus, species of which are common in the North Pacific, however identification by an experienced macro-biologist may provide a more accurate answer. Identification is inhibited when the specimen is not submerged and tentacles are not visible *[OECD, 1963; WoRMS, 2015]*.

Action item: examine morphology of live specimens in controlled seawater environment for more complete identification. Provide tools and containers, such as tweezers and sterile tubes, for recovery and preservation of more delicate samples. Bring a dissecting microscope for accurate identification of meio and microfauna, as well as diatoms and algal cells.

Fouling organisms recovered from mooring A2-14, showing (1) sipuncular worm, (2) bryozoan, (3) nudibranchs, (4 – 6) barnacles, (8-9) hydroids, and (10) anemones. Not pictured are sea squirts Corella inflate removed from moorings A3 and A4. Not identified in the figure is element (7).

CTD OPERATIONS (Woodgate, Nguyen, Showalter, Buktenica, Daniels, Guerra, Johnson)

As in previous years, in 2015 the moorings were supported by annual CTD sections. In general (as per 2014) these sections were run without taking any bottle samples, although this year, as will be discussed below, two casts for water samples were taken at site A4 for calibration of moored instrumentation.

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

- one SBE9+ with pressure sensor (SN5915 – calibration 20th March 2015)
- two SBE3 temperature sensors (SN0843, SN0844 – calibration 16th and 7th March 2015)
- two SBE4 conductivity sensors (SN0484, SN0485 – calibration 6th March 2015)
- two SBE43 oxygen sensors (SN1753, SN1754 – calibration 6th March 2015)
- one Wetlabs FLNTURT fluoresence/turbidity sensor (SN1622 – calibration 11th March 2010)
- one Benthos Altimeter (SN50485, repaired spring 2015)
- two Seabird pumps (SN not confirmed, but expected to beSN0340, SN5236)
- one EG&G Model D-CAT transponder (SN31892)

The temperature, conductivity and oxygen probes were paired as

	Temperature	Conductivity	Oxygen	Pump
Primary	#843	#484	#1753	50-02-05-0340
Secondary	#844	#485	#1754	5T-90543-05-5236

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 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), 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 last year on the Norseman II. Chris Siani, APL, assisted with wiring and CTD tests of this system while the ship was in Seattle in May 2014, and retermination in Seattle in April 2015. 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 aft A-frame. An event log was maintained on the CTD computer. The log, and data files (and a screen dump of the cast) were copied to a thumb drive as a backup after each cast.

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

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.

Last year, when the winch was new, there were some issues on winch control. However, this year these issues appear to have been resolved. The winch appeared to have only one speed (1m/s). This was used throughout the cruise (resulting in extremely speedy CTD operations).

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 personel on deck - one (ship's crew) driving the winch, one (ship's crew or science team member) recovering the instrument. The efficiency of the crew made for very speedy CTD operations, and combined with the fast winch speed, resulted in record low times for running lines (see table above), beating even last year's speedy CTD operations. Since the CTD system required ~ 1min in the water to allow for the pumps to turn on, the CTD was generally put over the side and down to ~ 5m 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 lowered to the sea floor. 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.

Last year's cruise report details issues with the automatic pump turn on for this CTD unit. Typically this CTD will automatically activate the pumps 1min after being immersed in salt water. However, investigations during the year indicated that this option had been removed from this CTD, and thus the pump turn on request had to be sent manually at the start of each cast. The CTD still introduced a 1min delay between receiving this command and turning on the pumps.

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

Ship's draft was estimated at 3m, and this should be taken into account in viewing the data. Note that mooring data suggest that 2m may be a more appropriate correction between echo sounder depth and true water depth.

This year's CTD operations encountered 3 significant problems:

1) Altimeter. Last year's operations found problems with the altimeter on this CTD package. Tests in Seattle post the 2014 cruise showed the altimeter to be faulty and it was returned to Benthos for repair. However, even the repaired instrument did not function well during the 2015 cruise. Although during some casts (see figure left) the altimeter functioned well, more frequently it gave reasonable data either only on part of the cast, or not at all. While there appears to be some spatial coherence to where the altimeter worked, repeat casts did not always show the same altimeter behaviour. The frequency of the altimeter is 200kHz, which is also one of the frequencies of the ship's echosounder. However, in 2014 turning off the ship's echosounder at the bridge during the cast did not fix the problem. This was not rechecked in 2015. Note the ship's ADCP is also functioning at 300kHz, and possibly could be another source of interference. **Action item: Investigate why altimeter does not work reliably.**

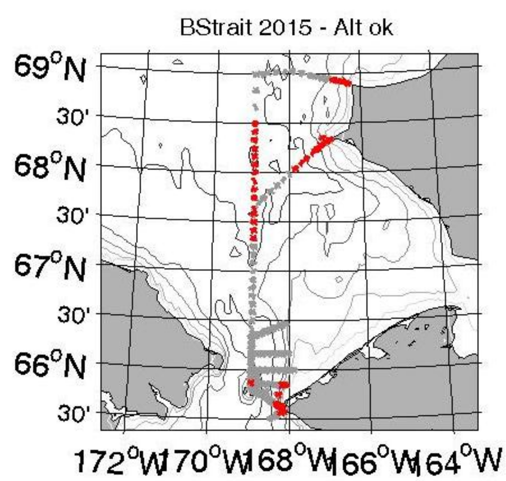


Figure (left): Sites where altimeter worked.

Finally, we abandoned attempts to solve this and just used the ship's echosounder depths and the SBE pressure sensor to decide on final depth for the CTD cast. We assumed a keel depth of 3m, and thus, as our target was 3m above bottom, we aimed to stop the CTD when CTD pressure matched the echosounder readout. However, other events (2) and mooring data suggest that 2m is a better estimate of keel depth. **Action item: Revise keel estimate to ~ 2m.**

2) Pump issue on primary system from cast 71 to 82 inclusive. On cast 71 (latter half of the CS line), data suggest that the CTD hit bottom. Deck tests shows that the pump on the primary system had stopped working. After the end of the CS line, the primary pump was dissembled, and it was found that a small stone was blocking the pump rotor. Once this was removed the pump functioned well again. **Action item: On processing CTD data, remember casts 71-82 have bad primary sensor data**.

3) Possible vent plug issues on Primary system for casts 131 to 155. Data from these casts suggest that the vent plug on the primary system may have been blocked, impairing pump operation only on the downcast. This issue resolved after cast 155, although the vent plug was cleaned before cast 157 just to be sure. The issue remained so long undetected because only the secondary sensors (which throughout give good data) were being routinely reviewed by the CTD driver. **Action item: Routinely compare primary and secondary sensors after each cast. Take thin wire necessary for cleaning the vent plug. Continue to run with dual system. For CTD processing, use secondary data for these casts**.

The CTD casts number 258 in total, including 2 test casts (one in-water test prior to arrival in the strait; one cast after the CS line to check the pump had been successfully repaired). CTD numbers relating to CTD lines are given in the table above. Note that the exceptional efficiency of the Norseman 2 crew allowed for these lines to be run in record time, meaning the data is more synoptic than in previous years.

Preliminary data processing was done on board by Rebecca Woodgate, using the Seabird data processing software as described below. Preliminary sections (using the secondary sensors and pre-cruise calibrations) were plotted by An Nguyen and are included below.

NOTES ON BERING STRAIT 2015 CTD PROCESSING
Rebecca Woodgate (based on 2014 processing)

Start with files from SeaSave for each cast, i.e.,
BStrait15nnn.hex and BStrait15nnn.hdr

Then run through 10 steps (9 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 = DatCnvBStrait2015_allvars.psa)
Inputs are: BStrait15nnn.hex and BStrait15nnn.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 (*new this year)*
-- Select output variables... for 2015 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) (*new this year)*
-- 9) Oxygen, SBE 43, 2 (saturation) (*new this year)*
-- 10) Fluorescence WET Labs WET star (mg/m^3)
-- 11) Upoly 0, FLNTURT
-- 12) Salinity, Practical (PSU) (*new this year)*
-- 13) Salinity, Practical, 2 (PSU) (*new this year)*
-- 14) Time, NMEA (seconds) (*new this year)*
-- 15) Latitude (deg) (*new this year)*
-- 16) Longitude (deg) (*new this year)*
-- 17) Altimeter (m) (*new this year)*
-- 18) Pump Status (*new this year)*
-- 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: BStrait15nnn.rw1.cnv

=== 2) Do first basic quality control by plotting everything in Matlab
Matlab master code = **testplotsBStrait2015RW.m** which calls subroutine **CTDQCpump.m**
Inputs are: BStrait15nnn.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.
Results recorded by cast in master CTD log file **BStrait2015_CTDissuesbycast.xls**
In 2015, issues found include:
-- casts 71 – 82 – Suspected hitting of bottom results in erroneous primary system data until pump fixed

-- casts 134- 153 – Suspected blocking of drain plug in primary system.
Overall, conclude:
-- use secondary sensors as main source of data, but be aware that Ox2 appears to have surface aberrations at the start of the down cast.

=== 3) Now work through the 8 steps of SBEDataConversion. Start by applying the calibrations to to get the converted files, but this time excluding all the derived variables.
IN SBEDATA PROCESSING, RUN: DATA CONVERSION
(PSA file for this = DatCnvBStrait2015_CTDforprocess.psa)
Inputs are: BStrait15nnn.hex and BStrait15nnn.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 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 (*new this year)*
-- Select output variables... for 2015 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) (*new this year)*
-- 12) Latitude (deg) (*new this year)*
-- 13) Longitude (deg) (*new this year)*
-- 14) Altimeter (m) (*new this year)*
-- 15) Pump Status (*new this year)*
-- 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: BStrait15nnn.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. Last year, we used A = 0.5 sec and B=0.15 sec, but this appears 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 different to last year).*
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 = FilterBStrait2015_CTDforprocess.psa)
Inputs are: BStrait15nnn.cnv
*In DATA SETUP
-- Lowpass filter A(sec): 0.0 *(was 0.5 last year, but this seems too smooth)*
-- 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*
THIS GIVES files called: BStrait15nnnA00B15.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.
So, of these, it is suggested we investigate the various oxygen options. This we run this step with various values for the oxygen advance and, by plotting oxygen against temperature, see which advance value gives the most consistent reading comparing the up and down casts. In 2015, the best agreement is found with an advance of +2, which is the same as last year.
IN SBEDATA PROCESSING, RUN: ALIGN
(PSA file for this = AlignCTDBStrait2015_CTDforprocessOx2.psa)
Inputs are: BStrait15nnnA00B15.cnv
*In DATA SETUP
--> Enter Advance values
-- Oxygen: 2 *(as recommended in SBE9+ manual (2 to 5), and tests suggest as per last year)*
-- All others: 0
*In FILE SETUP
-- Append added = AdvOx5
THIS GIVES files called: BStrait15nnnA00B15AdvOx2.cnv

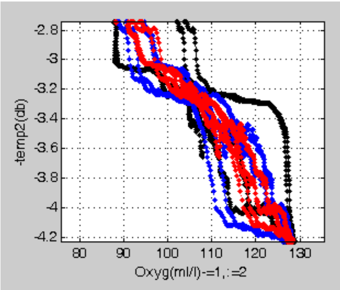


Illustration of Oxygen correction for cast 005. Black is original data, red is using Ox advance of 2, blue is using other examples of oxygen advance

=== 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 = CellTMBStrait2015_CTDforprocess.psa)
Inputs are: BStrait15nnnA00B15AdvOx2.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: BStrait15nnnA00B15AdvOx2CTM.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. This seems to work well with this routine. Prior years just used a 2m soak depth and that might be less successful with this routine.
IN SBEDATA PROCESSING, RUN: LOOP EDIT
(PSA file for this = LoopEditBStrait2015_CTDforprocess.psa)
Inputs are: BStrait15nnnA00B15AdvOx2CTM.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) = 5
    -- Minimum soak depth (m) = 2
    -- Maximum soak depth (m) = 6
      --> Check box Use deck pressure as pressure offset
      --> Check box Exclude scans marked bad
   *In FILE SETUP
   -- Append added = L5m2m6m
THIS GIVES files called: BStrait15nnnA00B15AdvOx2CTML5m2m6m.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 = DeriveCTDBStrait2015_CTDforprocess.psa)
Inputs are: BStrait15nnnA00B15AdvOx2CTML5m2m6m.cnv
   -- CHECK box on match instrument to configuration file
   *In DATA SETUP
      --> Select derived variables... add:
    -- Salinity (psu)
    -- Salinity,2 (psu)
   -- Salinity difference
    -- Sigma theta (kg/m3)
    -- Sigma theta,2 (kg/m3)
    -- Sigma theta difference
    -- Oxygen, SBE 43 (ml/l)
    -- Oxygen, SBE 43 (saturation)
    -- Oxygen, SBE 43, 2 (ml/l)
    -- Oxygen, SBE 43, 2 (saturation)
   *In FILE SETUP
   -- Append added = D
THIS GIVES files called: BStrait15nnnA00B15AdvOx2CTML5m2m6mD.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 a 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_FilterCTDBStrait2015_CTDforprocess_MF17.psa)
Inputs are: BStrait15nnnA00B15AdvOx2CTML5m2m6mD.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: BStrait15nnnA00B15AdvOx2CTML5m2m6mDMF17.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. We do this step both for the undespiked and the despiked data.

IN SBEDATA PROCESSING, RUN: BIN AVERAGE
(PSA file for this = BinAvgBStrait2015_CTDforprocess.psa)
Inputs are: BStrait15nnnA00B15AdvOx2CTML5m2m6m.cnv &
BStrait15nnnA00B15AdvOx2CTML5m2m6mDMF17.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: BStrait15nnnA00B15AdvOx2CTML5m2m6mDBADCS010.cnv &
BStrait15nnnA00B15AdvOx2CTML5m2m6mDMF17BADCS010.cnv

In 2015, this marks the end of the CD processing. (In 2014, we also ran ASCIIout to separate the data from the header file, but with improved data loading routines into matlab, this is no longer necessary.)

BERING STRAIT 2015 CTD LINES

A total of 15 CTD lines were run on the cruise, far more than planned in this short cruise. We were able to accomplish so many stations due to the efficiency and speed of ship and deck operations during the CTD work, and due to the great assistance from and preparedness of the ship's crew, which allowed us to start CTD operations immediately after mooring work.

Preliminary sections were plotted by An Nguyen from the corrected data. The plots below give all 15 sections on the same scales (and on their own scale), presented in order of data acquisition.

Various repeat stations and lines were run during the cruise, after intervals of hours and of days, i.e.: - the BS line

- the A3 line
- the DI line.

(Note that underway data was taken on more repeats also).

- casts at A4, A2 and A3

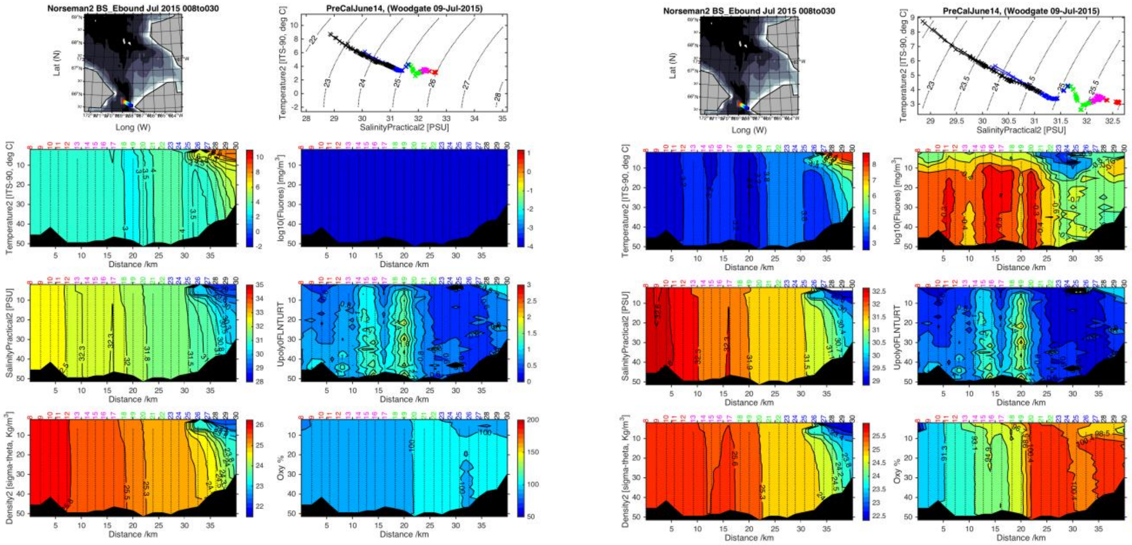
Many physical features are of interest and require further investigation, e.g.,

- bottom layer water temperatures are warmer than last year;
- limited extent of the Alaskan Coastal Current, which (data suggest) was only just arriving in the strait as we left);
- frequent 3-layer structure to the water column;
- presence of cold, fresh water overlaying warmer waters (suggestive perhaps of ice melt);
- deviations from the traditional pattern of warm, fresh waters at the surface;
- remarkable homogeneity of the water column in many places.

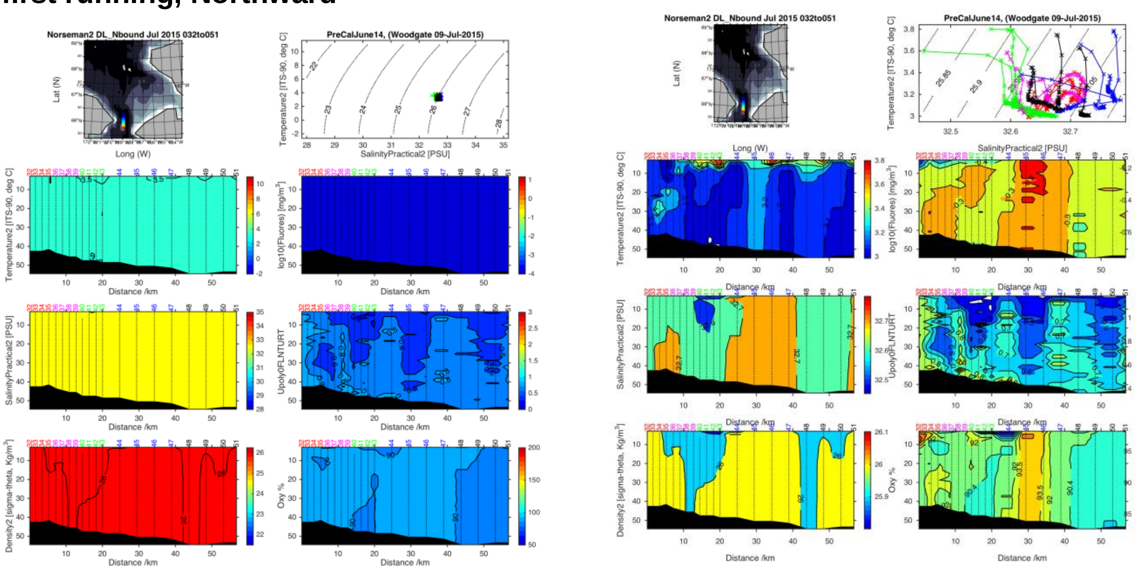
ACTION ITEM: Investigate

Also noteworthy in these data are the relationships between fluorescence, oxygen and turbidity, with suggestions of different ages of blooms, and possible fall out of blooms to the benthos. **ACTION ITEM: Investigate.** Oxygen values are calculated by Seabird software and are reported here in % saturation, with highest values being over 170%. Note we have no bottle samples with which to verify these data. **ACTION ITEM: Investigate.**

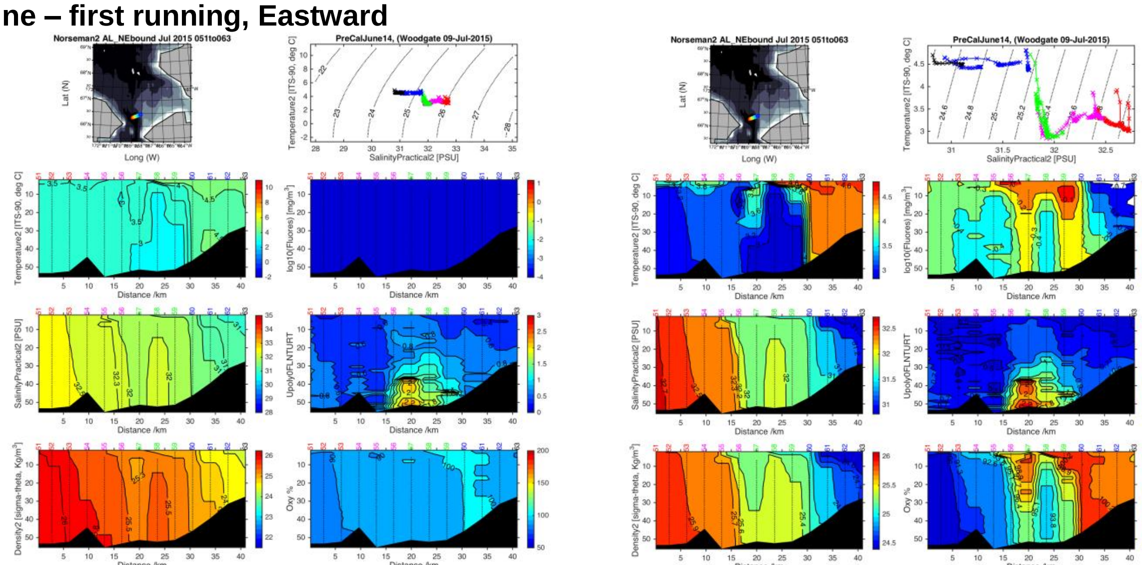
1) Bering Strait line – first running, Eastward



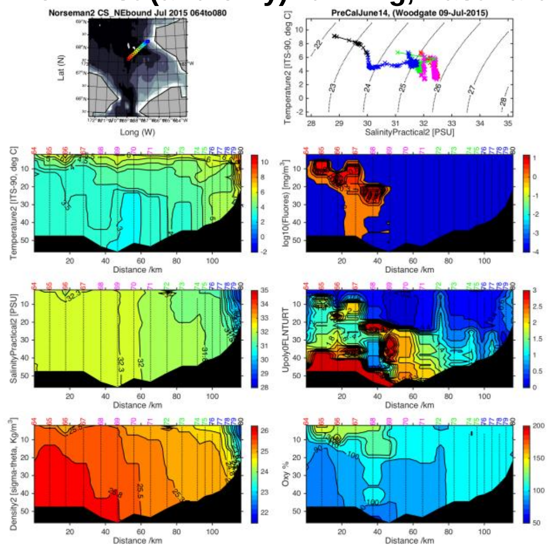
2) DL – first running, Northward

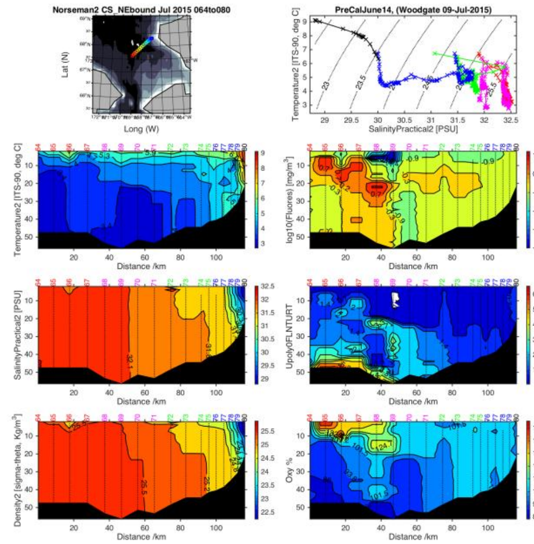


3) Al Line – first running, Eastward

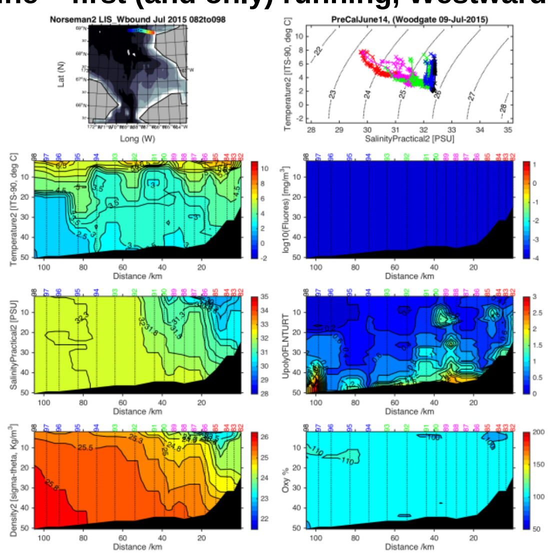


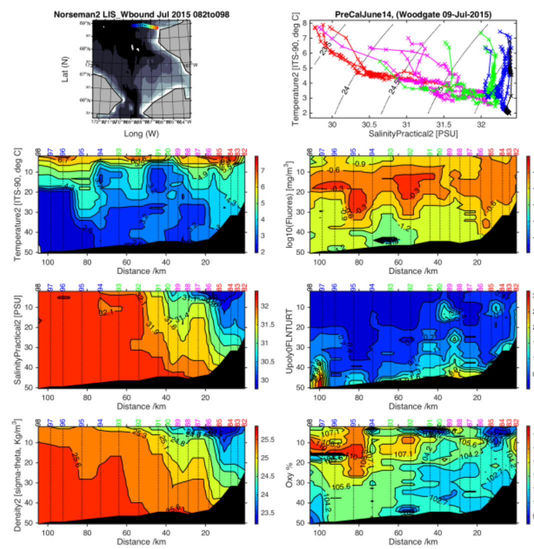
4) CCL line – first (and only) running, Eastward



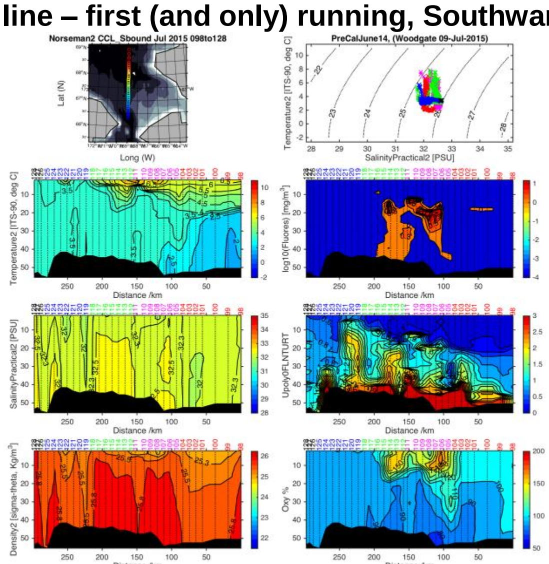


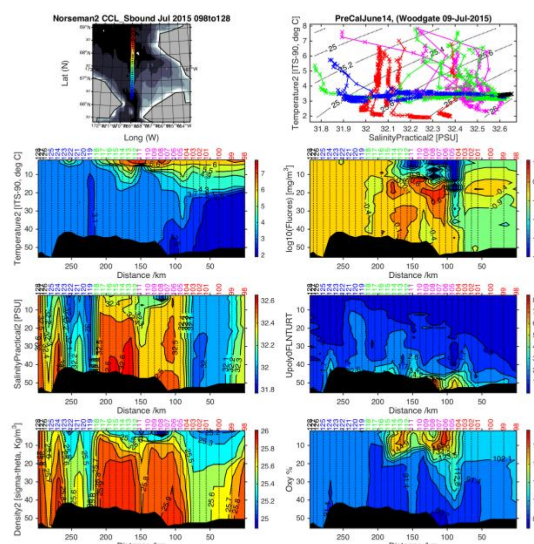
5) LIS line – first (and only) running, Westward



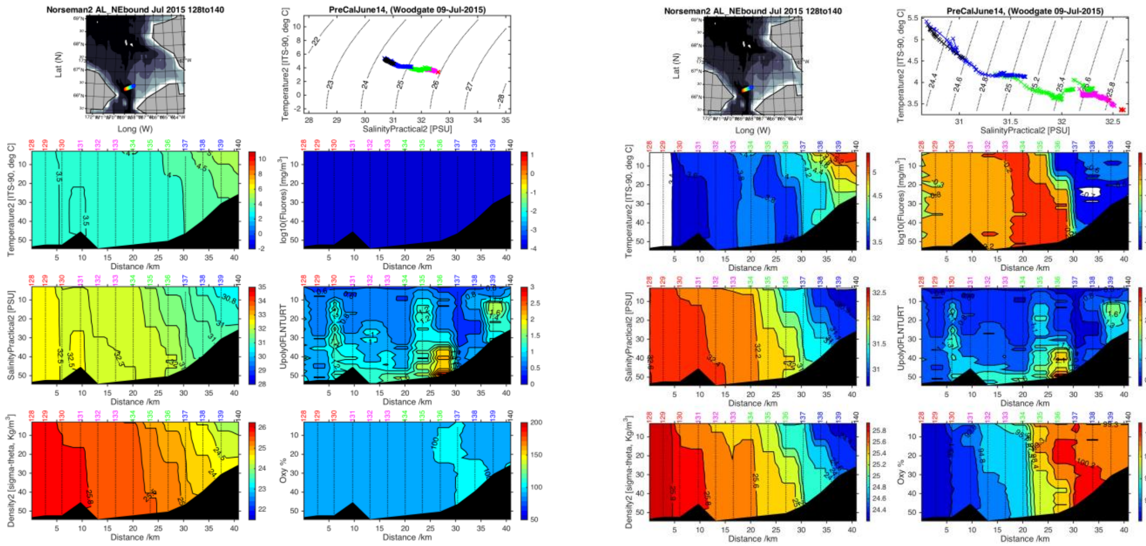


6) CCL line – first (and only) running, Southward

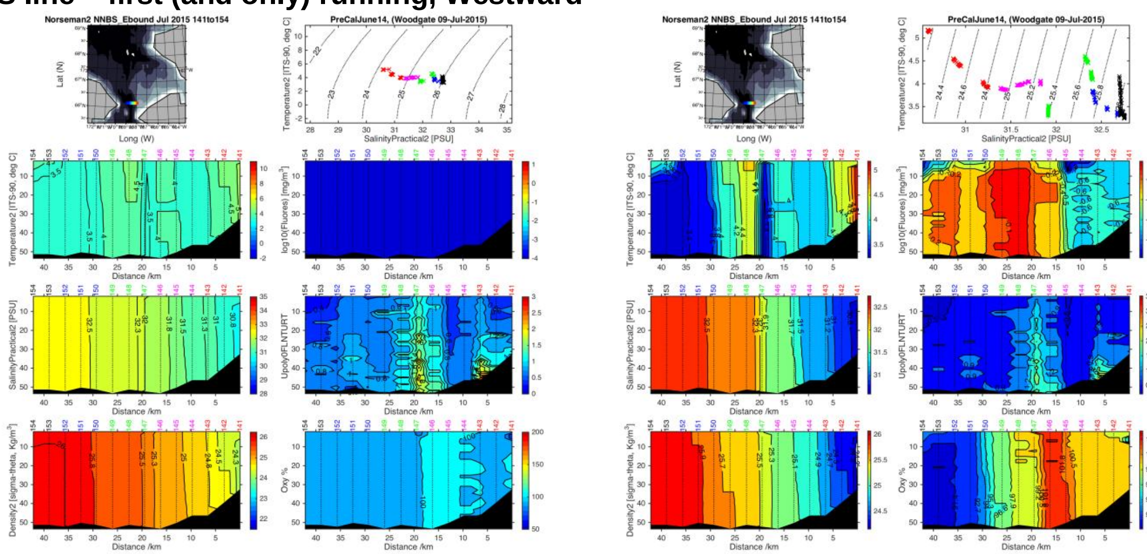




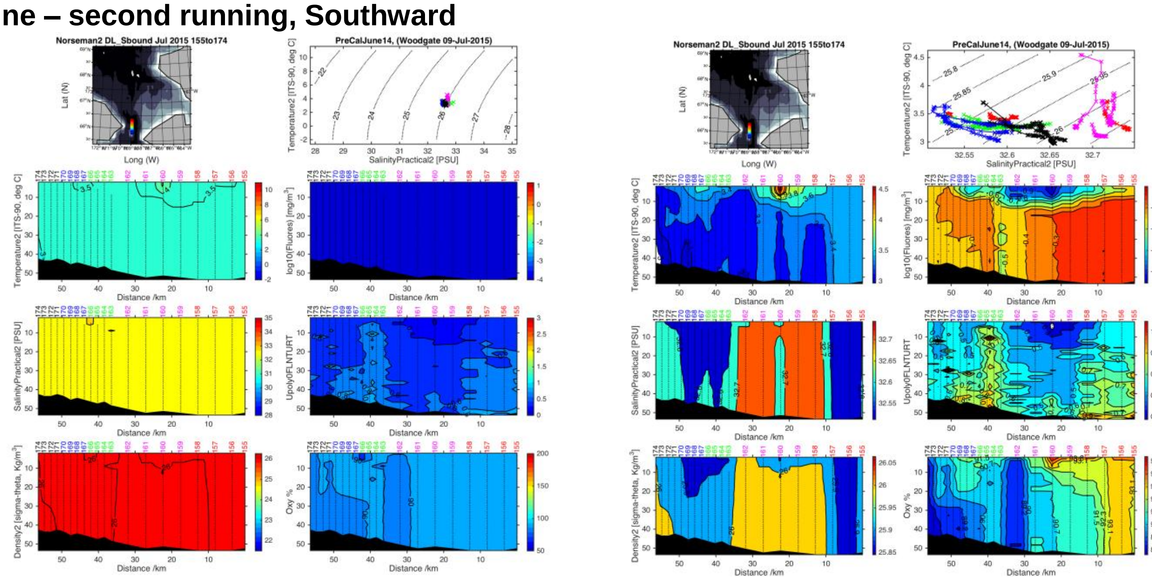
7) AL line – second running, Eastward



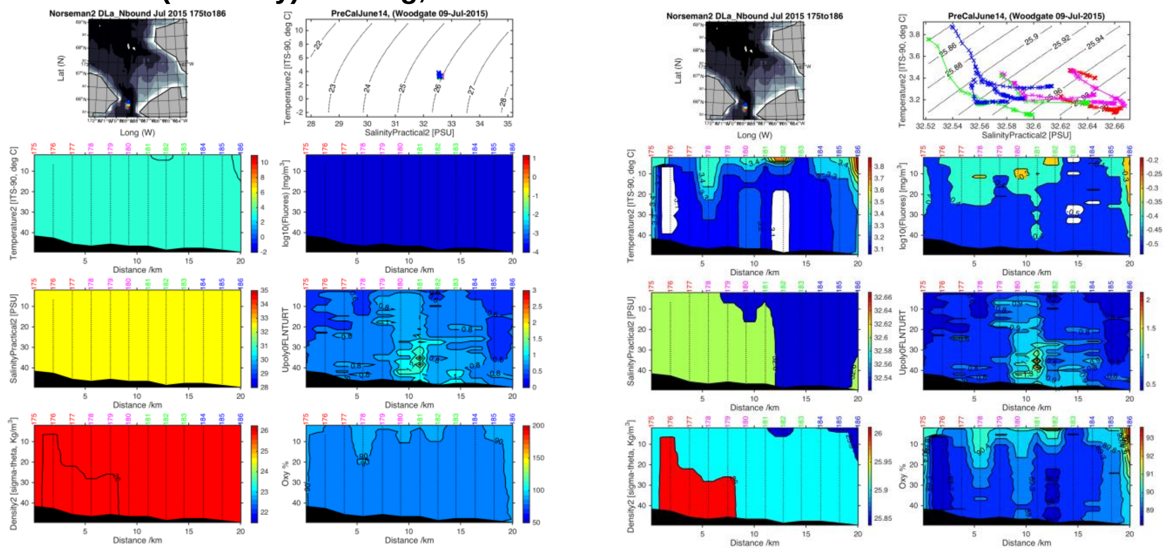
8) NNBS line – first (and only) running, Westward



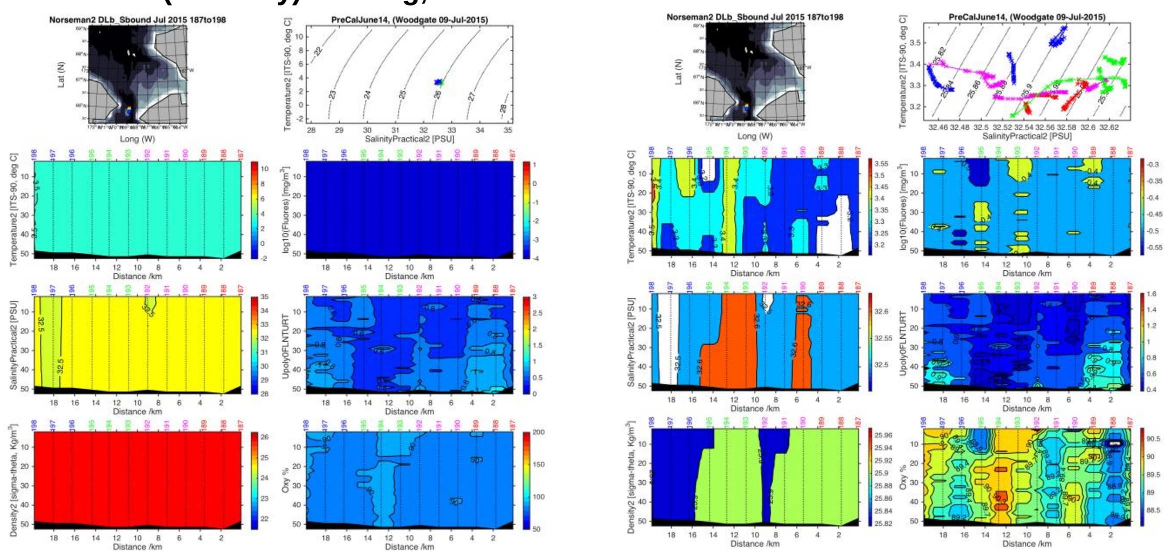
9) DL line – second running, Southward



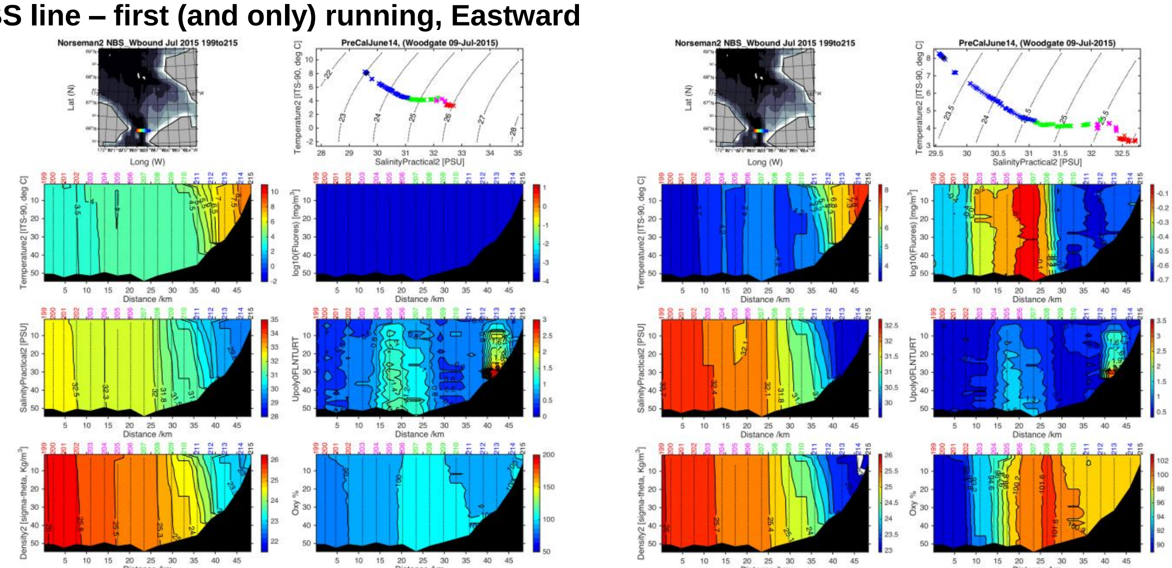
10) DLa line – first (and only) running, Northward



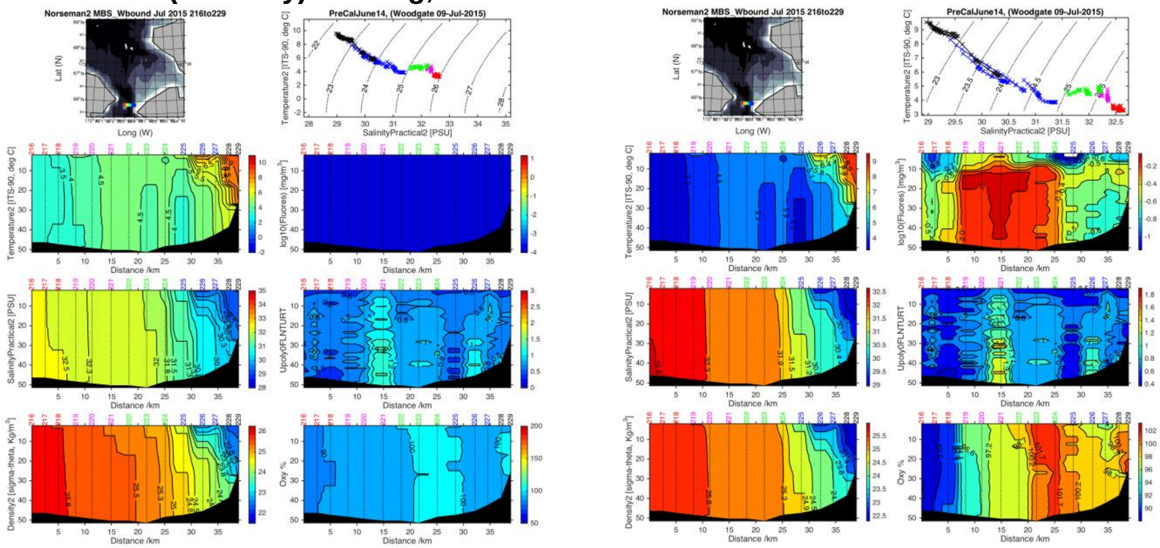
11) DLb line – first (and only) running, Southward



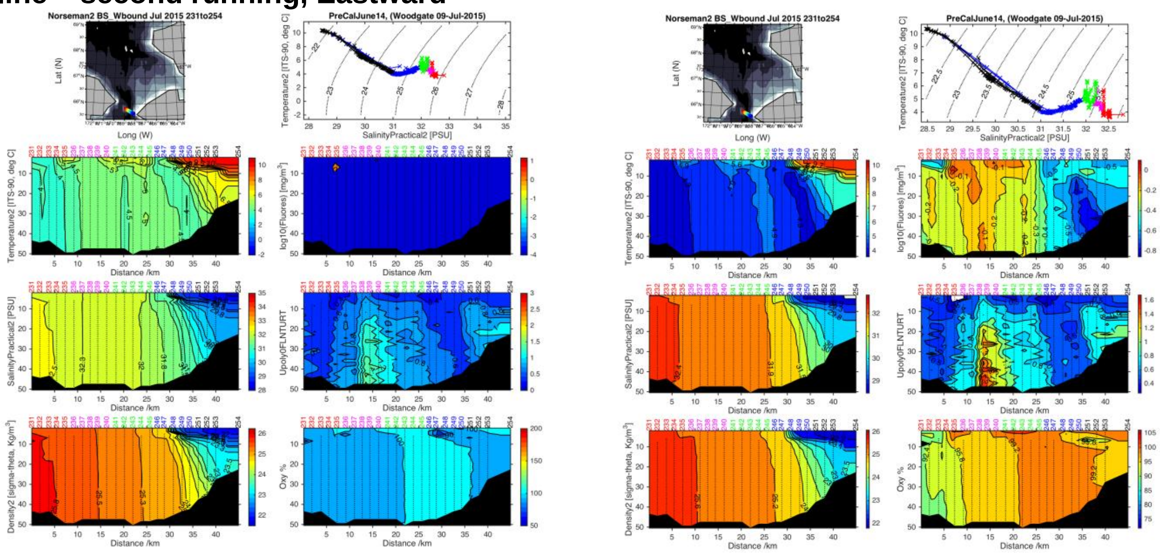
12) NBS line – first (and only) running, Eastward



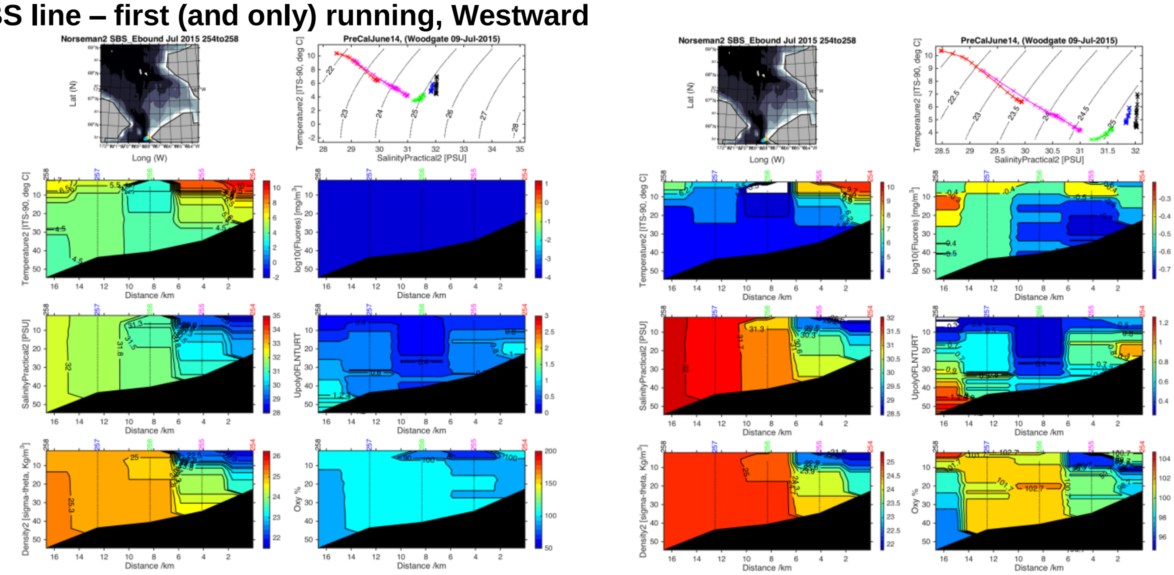
13) MBS line – first (and only) running, Eastward



14) BS line – second running, Eastward



15) SBS line – first (and only) running, Westward



OCEAN ACIDIFICATION REPORT FROM OSU – Maggie Buktenica

Maggie Buktenica from OSU participated in the Bering Strait mooring cruise (July 1-9 2015). The purpose of Maggie's participation was to deploy a set of sensors (SAMI-pH SN: 0076, SAMI-CO2 SN: 0036, and SBE-37 SN: 2945000) at the mooring site A4-15 for one year at a target depth of ~44m. The sensors were successfully deployed at ~2:45 GMT on July 4th 2015, contained in a cylindrical metal frame that was incorporated in the A4-15 mooring. The two SAMI sensors were set to sample every two hours for 380 days starting at 3:00 GMT on July 4th, while the SBE-37 was set to sample temperature (T) and salinity (S) every half hour until its batteries were depleted (should be ~5 years after deployment). The SAMI sampling interval was chosen to maximize sampling frequency, while preserving enough battery power and reagents to sample the whole year.

The SAMI-CO2 and SAMI-pH were included to obtain year round spectrophotometric measurements of the partial pressure of dissolved carbon dioxide (pCO2) and pH, respectively. The combination of these measurements should allow year-round tracking of the fluctuations in the speciation of inorganic carbonate chemistry and ocean acidification some waters of the Bering Strait region represented by the A4 site.

In addition to the mooring deployment, water samples were collected at the A4-15 mooring site (~44 m) for measurement of pCO2, total dissolved inorganic carbon (DIC), and total alkalinity. Since the cruise CTD did not include a water sampling rosette, calibration samples for the mooring instruments were collected using a messenger Niskin attached to the CTD cable ~ 2m above the CTD system. The CTD was lowered to the near bottom as per our standard protocol. Then, instead of returning immediately to the surface, the CTD package was left near the bottom while the messenger was sent down the CTD wire to trip the bottle which was ~ at the depth of the moored instrument. It was found that irregularities on the CTD wire were enough to prevent the standard messenger reaching the Niskin – the messenger jammed at some random depth on the wire (Cast 6). To prevent this, the bore of the messenger was drilled out to a greater diameter, and this was sufficient to allow the messenger to traverse the full distance to trip the bottle. By keeping one hand on the wire, we were able to confim the bottle had tripped by feeling the vibration of the strike transmitted up the CTD wire. Note that, since the Niskin bottle was ~ 2m above the CTD package, to obtain the relevant in situ parameters from the CTD one must consider the measurements taken on the down or up cast (preferably the down cast since the CTD sweeps water up with it as it returned to the surface) rather than the CTD values at the bottom**. ACTION ITEM: If this process is to be repeated in subsequent years, be sure to take modified messenger.**

One water sample was collected (in a beer bottle) from CTD cast 7 directly after deployment (~03:15 GMT July 4th 2015), and two additional samples (in 32oz jam jars) were collected from CTD cast 230 on July 9th 2015 at ~00:51 GMT.

Each sample was poisoned with mercury chloride, and the temperature measured using a hand held sensor, before sealing the sample for transport. These samples and the accompanying CTD data will be used to check the initial calibration of the deployed sensors. Calibration samples will be processed at OSU as soon as possible after arrival of the shipment from Nome AK (cruise end point) in Corvallis OR.

Maintenance and Calibration of Instrumentation Prior to Deployment

The SAMI-CO2 was refurbished in February of 2014 by Sunburst Sensors LLC, followed by re-calibration by Sunburst Sensors LLC in June of 2015.

The SAMI-pH was refurbished in May of 2013 by Sunburst Sensors LLC. In July of 2015 the calibration of the SAMI-pH was checked against a Tris buffer prepared by Maggie Buktenica (agreed within 0.01 pH units). Additionally, the SAMI-pH was deployed in the Newport harbor and its calibration checked against a series of discrete surface samples (one sample every half hour for 8 hours). These calibration samples were collected in beer bottles and processed as described above (data not available).

The SBE-37 was serviced by Sea-Bird electronics then stored until deployment.

BERING STRAIT 2015 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 2 crew at the start of the cruise. **ACTION ITEM: Pre-cruise, develop checksheets for the set up 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 4m bins. 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. Note that, due to a setup error, no bottom track data were collected during the cruise. **ACTION ITEM: Ensure next year that bottom tracking is turned on.** Thus, it is necessary to use ship's navigation to correct the ADCP data. **ACTION ITEM: 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: Meteorological data (including wind speed and direction, air temperature, humidity and pressure) were recorded every 15seconds with position, and course, during the cruise. **ACTION ITEM: Check position used for met sensors.** A preliminary plot of these data is given below. No data quality control has yet been applied to these data. Note the low wind speeds (<10-20 knots) for most of the cruise, with the wind turning from northward to southward on JD 186 (5th July 2015). **ACTION ITEM: Check if wind direction needs to be corrected for magnetic declination.** Relative humidity is high, consistent with the dominantly foggy conditions. While air temperature values are broadly consistent with a human assessment of the temperature, there are many curious peaks in the record, with changes often coincident with changes in the ship's course. **ACTION ITEM: Check air temperature record to ensure it is not being contaminated with warm air from the ship.**

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 (but unfortunately, not depth). **ACTION ITEM: Ensure next year depth is 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.**

The calibration file used while at sea was the 2013 calibration, even though the system was calibrated in 2015. The post processing presented here uses the 2015 calibration. **ACTION ITEM: Ensure the most recent calibration is used in the field. (Differences are 2e-4deg C and 0.02 psu).**

Curiously the time base logged in the .hex file appears to be erroneous. The SBE data suggest the SBE is recording every 10seconds, however the NMEA data string suggests instead the data are being recorded every 3 seconds. Assuming a uniform 3 sec data interval through the cruise gives better alignment with the meteorological and other data sets, although appears to leave the SBE data 1min off. **ACTION ITEM: Investigate. Also when processing data, beware of this 1minute offset.**

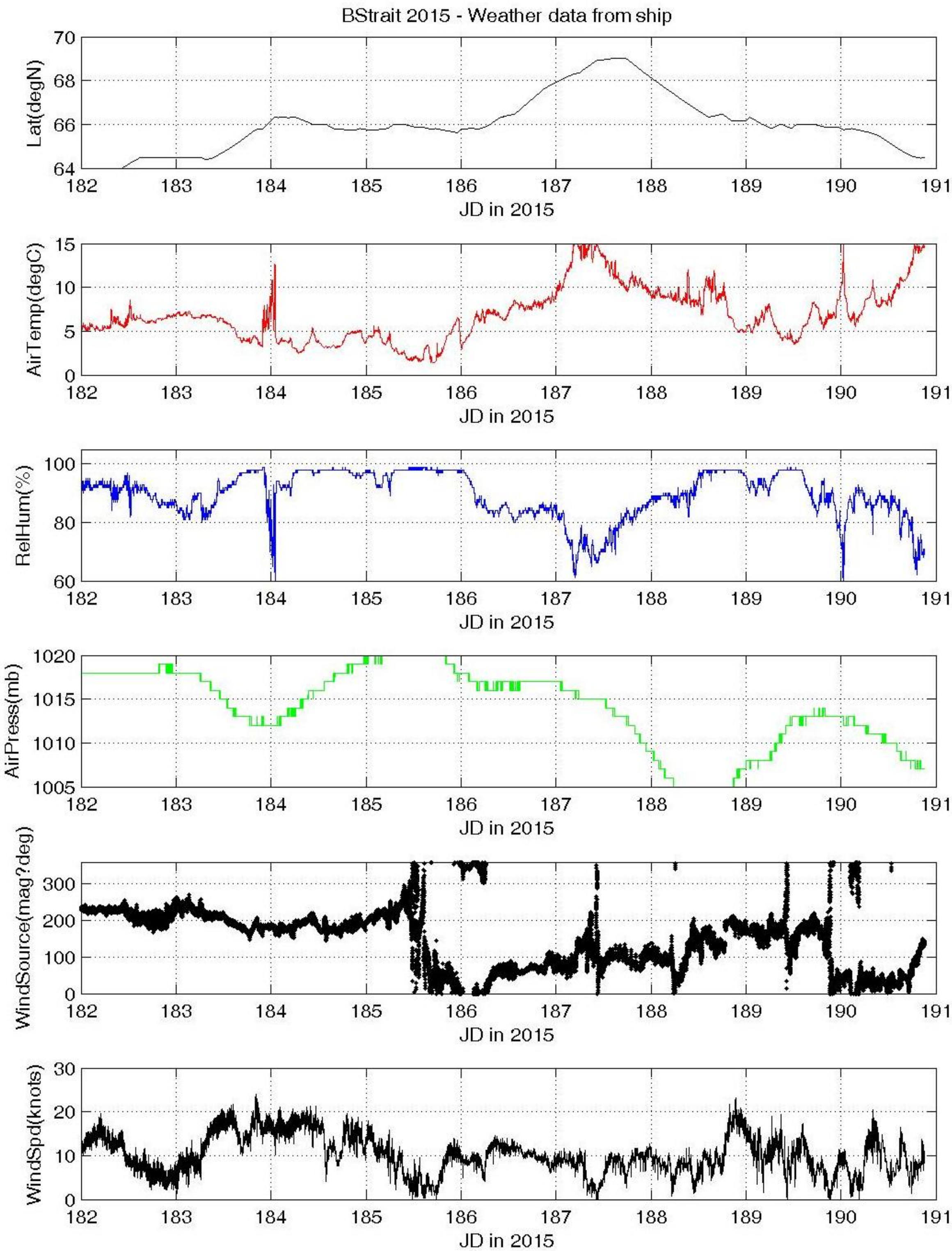
Preliminary plots of the underway temperature and salinity data are given below. Salinity data are obtained from SBEData processing (values 1e-3psu fresher than the usual data conversion).

The typical pattern of waters being warmer and fresher near the Alaskan coast is evident in these data. However, in stark comparison to 2013 (which recorded salinities of 20psu), the lowest underway salinities recorded were ~ 29psu (in the strait, and off Point Hope), slightly fresher than last year (~ 30psu).

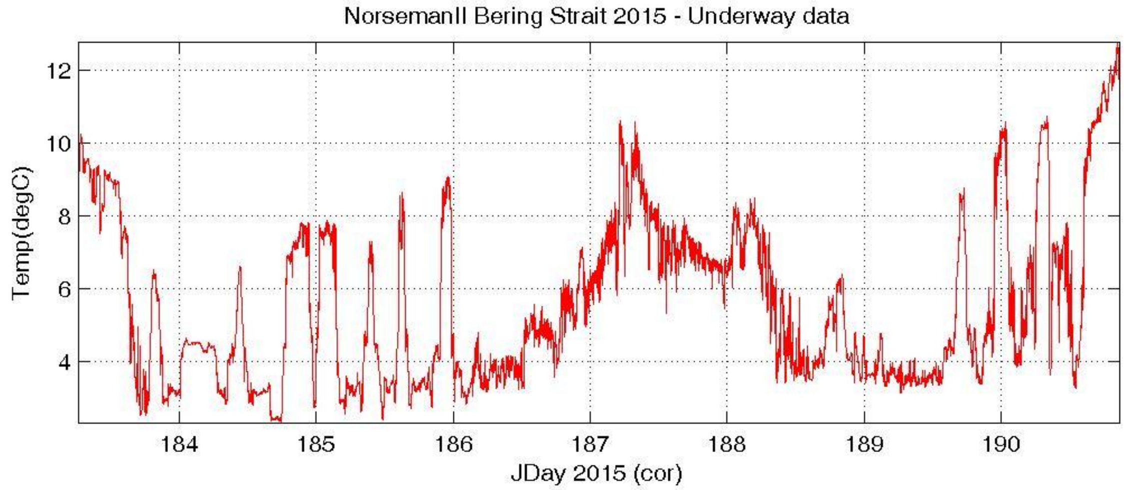
Note that warmer waters are also found in the north of the study area, as per the last two years. Our hypothesis is that this is evidence of local solar heating since these waters are warmer than in the strait itself. **ACTION ITEM: Examine ice records.**

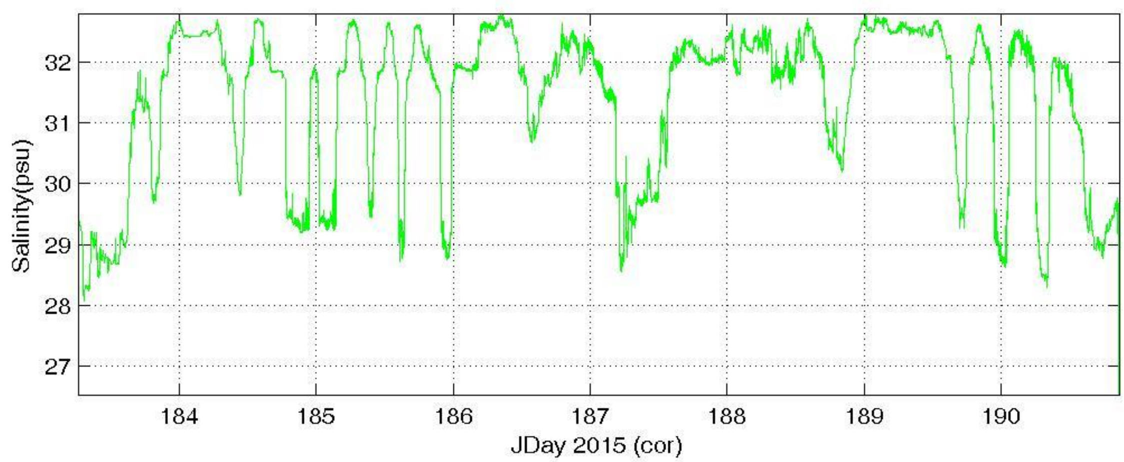
It is very important to remember when interpreting these data, that they are not synoptic, as is evidenced by the plots of the various crossings of the Bering Strait also shown below. These plots suggest the arrival of the warm Alaskan Coastal Current in the strait during the cruise, although the typical salinity signal is less clear in these data. **ACTION ITEM: Examine surface salinities and temperatures, especially in conjunction with prior data.**

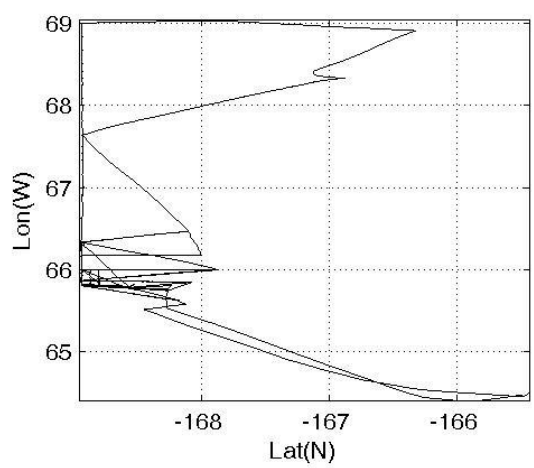
BERING STRAIT 2015 METEOROLOGICAL DATA

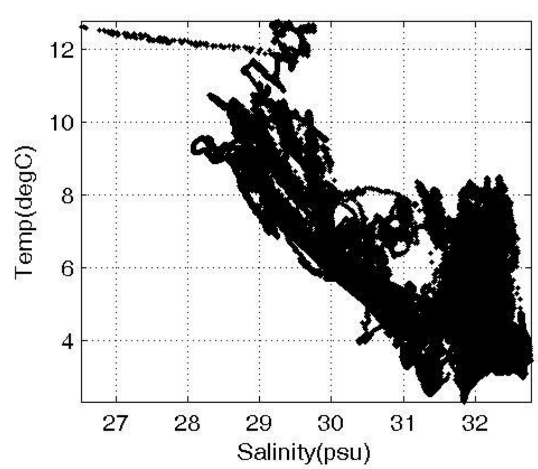


BERING STRAIT 2015 UNDERWAY TEMPERATURE SALINITY DATA



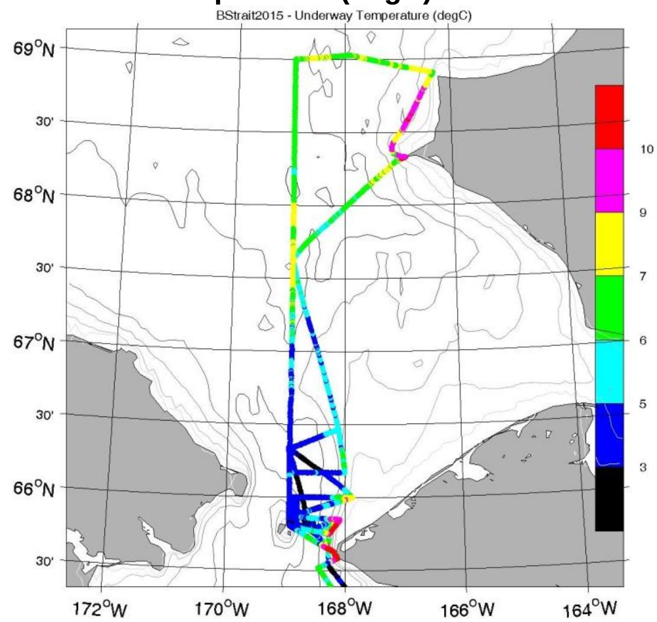




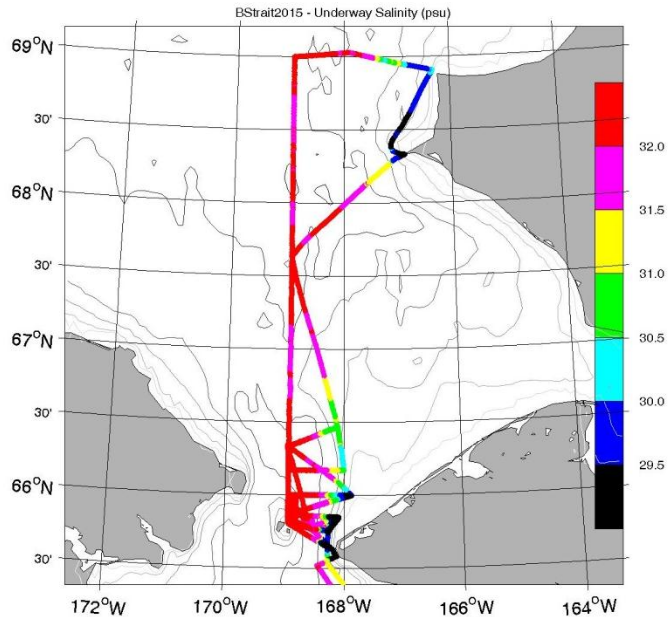


BERING STRAIT 2015 UNDERWAY TEMPERATURE SALINITY DATA (continued)

Temperature (degC)



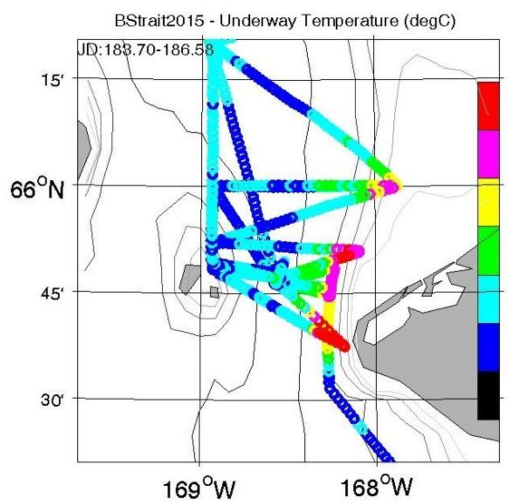
Salinity (psu)

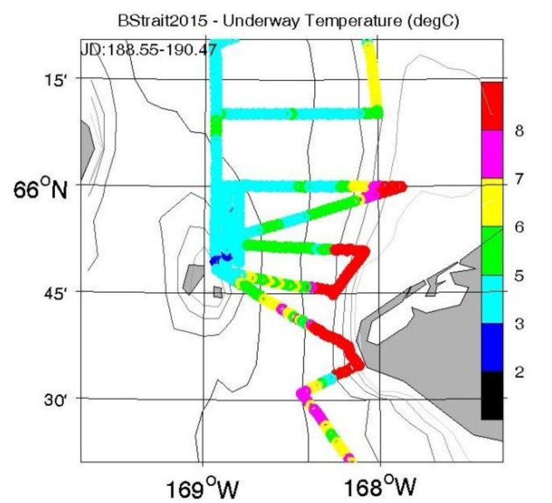


First half of Cruise

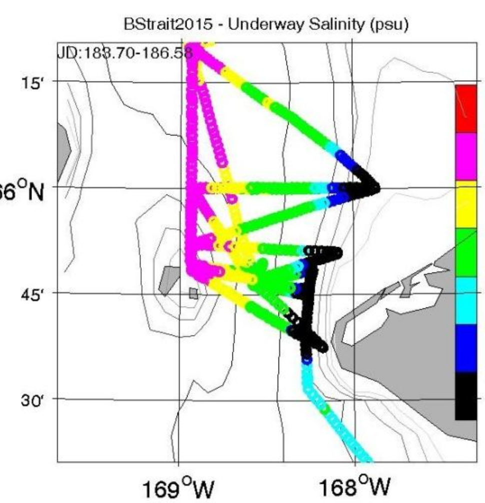
Second half of cruise

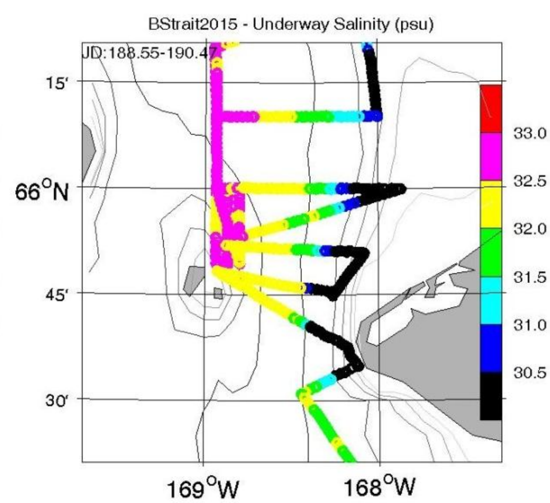
Underway Temperature (DegC)





Underway Salinity (psu)





MARINE MAMMAL AND BIRD REPORT, Kate Stafford, UW

Marine mammal hydrophones

During the Bering Strait mooring cruise 2015, 3 hydrophone packages were recovered from sites A2 (65.78N 168.57W), A4 (65.75N 168.25W) and A3 (66.327N 168.965W). Three hydrophones were deployed at sites A2 (65.78N 168.57W), A4 (65.75N 168.25W) and A3 (66.327N 168.965W). All three instruments deployed in 2014 were programmed to start on 10 July 2014 and sampled for 20 minutes every hour at a sample rate of 8192 Hz. All three instruments were still recording upon recovery and sampled throughout the year. No analysis of these data has occurred to date but a cursory exam of all three instruments showed that the following species were recorded on each: humpback whale, bowhead whale, beluga whale, walrus, and bearded seal. Instruments deployed in 2015 were on the same duty cycle and sample rate as 2014 but were programmed to start on 1 July 2015.

Marine mammal bridge watch survey

In order to document marine mammal species seen along the trackline of the R/V Norseman II during the 2015 mooring cruise, a marine mammal watch was kept on the bridge from ~0700-2200 daily. The watch was halted during mooring operations, sea states greater than Beaufort 5, and heavy fog. Watches consisted of one person stationed primarily on the port side of the bridge (to stay out of the way of bridge operations), scanning roughly 60° to either side of the bow with a pair of Steiner 10 x 50 binoculars. When sightings were made the time, location, species and number of animals as well as any notes on observations were logged (Table 1).

The first few days of the cruise coverage was spotty as mooring operations were in full swing. Once the marine mammal hydrophones were recovered and redeployed, the visual survey was conducted from 0700-~2200 daily. There were many hours of fog. Overall, there were many fewer sightings than in past years despite relatively good sighting conditions from 5-8 July 2015. A total of 33 sightings of 74 individual animals were obtained representing 7 species (Table 1).

Table 1. Marine mammal sightings by species.

Species	#sightings	number animals
Harbor porpoise	7	8
Phoca spp	5	25
Gray whale	10	15
Ringed seal	6	7
Killer whale	1	14
Unid baleen whale (1 probable fin)	2	2
Walrus	2	3
sum	34	74

Bird Sightings

Although a formal survey was not conducted, the following species were identified during the cruise:

Least auklet	Parakeet auklet	Crested auklet
Common murre	Thick-billed murre	
Pigeon guillemot	Black guillemot	
Pomarine jaeger	Parasitic jaeger	
Short-tailed shearwater		
Red phalarope		
Northern fulmar		
Brant geese		
Glaucous gull		
Black-legged kittiwake		
King eider	Common eider	
Horned puffin	Tufted puffin	

BERING STRAIT 2015 TARGET CTD POSITIONS

The following lists give the positions of the CTD lines taken in US waters in the Bering Strait region in the last decade as part of the Bering Strait mooring cruises. Stations taken on this 2015 cruise are included in the full event log later in this cruise report.

```
%=========================================================
% Stations for BStrait Mooring Cruise 2015 NorsemanII
%=========================================================
%
% 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.
%=========================================================
%
%=========================================================
% *****   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 2014
%-------------------------------------------
%NAME        Lat(N)          Long (W)      Water   Top
%            deg min         deg min       depth   Float
% A3-14     66  19.59      168  57.06     58m     15m
% A2-14     65  46.85      168  34.09     56m     15m
% A4-14     65  44.72      168  15.82     49m     15m
%----------------------------------
% DEPLOYMENTS for this 2015 cruise
%----------------------------------
% Target same as 2012 positions.
%NAME      Lat(N)         Long (W)      Water
%          deg min        deg min       depth
% A3-15    66  19.61      168  57.05     58m
% A2-15    65  46.86      168  34.07     56m
% A4-15    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 11 historic CTD lines here.
% 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 the 2015 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 %     BS11J Jim
65.788     168.86     65    47.26 168   51.62 %     BS12
65.780     168.827    65    46.8  168   49.63 %     BS12AJ     AJ
65.772     168.794    65    46.33 168   47.64 %     BS13
65.764     168.758    65    45.81 168   45.47 %     BS13Z Zack
65.755     168.721    65    45.28 168   43.29 %     BS14
65.747     168.692    65    44.82 168   41.55 %     BS14J Jorin
65.739     168.663    65    44.35 168   39.8  %     BS15
65.731     168.627    65    43.82 168   37.63 %     BS15J Jack
65.722     168.591    65    43.29 168   35.46 %     BS16
65.713     168.556    65    42.76 168   33.37 %     BS16J Jim
65.704     168.521    65    42.23 168   31.28 %     BS17
65.695     168.486    65    41.7  168   29.16 %     BS17S Scotty
65.686     168.449    65    41.18 168   26.94 %     BS18
65.679     168.42     65    40.77 168   25.19 %     BS18J Joanne
65.672     168.391    65    40.35 168   23.44 %     BS19
65.664     168.355    65    39.82 168   21.27 %     BS19H Harry
65.655     168.318    65    39.29 168   19.09 %     BS20
65.649     168.284    65    38.91 168   17.03 %     BS20J John
65.642     168.25     65    38.53 168   14.97 %     BS21
65.634     168.214    65    38.01 168   12.8  %     BS21A Andy
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 A3-15, 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
%-----------------------------------------------------
% Lat (N) Long (W)   Lat (N)      Long (W)     Name
%                    deg min      deg   min
   66.327  168.951   66  19.61    168   57.05  % A3-14
% *** Adjust this first position to be safe distance (300m?) from A3-15
   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  % A3-13
% *** Adjust this position to be safe distance (300m?) from A3-13
%
%
%=======================================
% 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 (new)
%=====================================
% 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
%
%
%========================================================
%========================================================

*************************************************
New lines added during the cruise
*************************************************

Revised CCL line - July 2015
===============================
%==============================
% 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    25.0      168  56.0   % CCL18.5   NEW
0 0     68    20.0      168  56.0   % CCL18 + Net
0 0     68    15.0      168  56.0   % CCL17.5   NEW
0 0     68    10.0      168  56.0   % CCL17
0 0     68    05.0      168  56.0   % CCL16.5   NEW
0 0     68    00.0      168  56.0   % CCL16
0 0     67    55.0      168  56.0   % CCL15.5   NEW
0 0     67    50.0      168  56.0   % CCL15
0 0     67    45.0      168  56.0   % CCL14.5   NEW
0 0     67    38.1      168  56.0   % CCL14 (same as CS10US) + Net + Prod
%
0 0     67    35.0      168  56.0   % CCL13.5   NEW
0 0     67    30.0      168  56.0   % CCL13
0 0     67    25.0      168  56.0   % CCL12.5   NEW
0 0     67    20.0      168  56.0   % CCL12
0 0     67    15.0      168  56.0   % CCL11.5   NEW
0 0     67    10.0      168  56.0   % CCL11
0 0     67    05.0      168  56.0   % CCL10.5   NEW
0 0     67    00.0      168  56.0   % CCL10 + Net
0 0     66    55.0      168  56.0   % CCL9.5   NEW
0 0     66    50.0      168  56.0   % CCL9
0 0     66    45.0      168  56.0   % CCL8.5   NEW
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  % A3-13
% *** Adjust this position to be safe distance (300m?) from A3-13
%


% NEW  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
%----------------------------------
% Run for the first time - 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


%============================================
SBS South Bering Strait section
%============================================

           Lat        Lon
           Deg   Min   Deg   Min
           65    34.91 168   7.00  % SBS1  (Same as BS24)
           65    33.93 168   11.85 % SBS2
           65    32.95 168   16.70 % SBS3
           65    31.96 168   21.55 % SBS4
           65    30.98 168   26.40 % SBS5
           65    30.00 168   31.26 % SBS6
           65    29.02 168   36.11 % SBS7
           65    28.03 168   40.96 % SBS8
           65    27.05 168   45.81 % SBS9
           65    26.07 168   50.66 % SBS10
           65    25.09 168   55.51 % SBS11
```

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Norseman Maritime Charters (NMC)

BERING STRAIT MOORINGS 2015 Cruise Blog
Norseman II

1st - 9th July 2015, Nome to Nome,
(Cruise website)

NSF (National Science Foundation)
Polar Programs PLR-1416920 and ARC-1107106.
Part of the AON (Arctic Observing Network)

***An NSF-supported collaboration between University of Washington (UW)** (lead PI: Rebecca Woodgate),*
***Massachusetts Institute of Technology (MIT)** (Co PIs: Patrick Heimbach, An Nguyen),*
*with links also to **Oregon State University (OSU)** (lead PI: Laurie Juranek and Burke Hales)*

Back to Bering Strait Home Page
Back to High Latitude Dynamics

Who are we?

Rebecca Woodgate, UW,
Physical Oceanographer

Jim Johnson, UW,
Field Engineer

Kate Stafford, UW,
Marine Mammal Acoustics

An Nguyen, MIT,
Physical Oceanographer

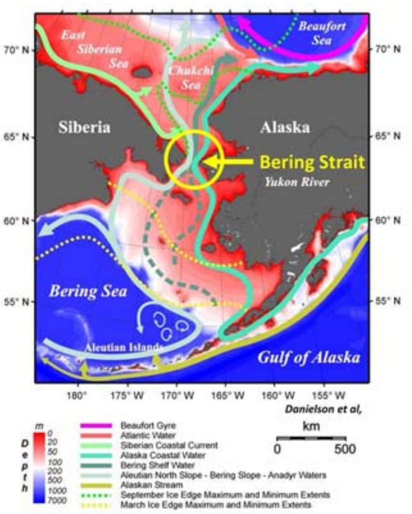
Melania Guerra, UW,
Marine Mammal Acoustics

Maggie Buktenica, OSU,
Chemical Oceanographer

Max Showalter, UW,
Biological Oceanographer

Robert Daniels, UW,
Physical Oceanographer

What are we doing?



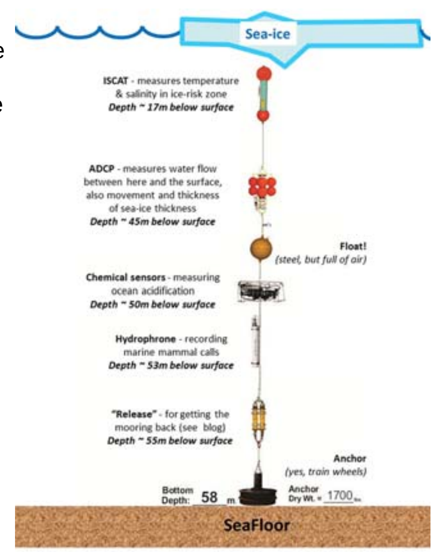
Schematic of the currents in the Bering Strait region. We will work mainly within the yellow circle.

The Bering Strait is the only oceanic link between the Pacific and the Arctic Oceans. The flow through the strait brings heat (which melts ice) and nutrients (which feed Arctic ecosystems) into the Arctic. Since 1990, we have been measuring the properties of the flow through the strait to establish the effects of this flow, and see how it is changing.

We do this using instruments which we deploy reaching from the sea floor (about 150ft/50m) deep to near the surface. We combine instruments into moorings (strings of instruments, with an anchor at the bottom and floats at the top - see Figure right). These instruments record data every hour throughout the year. Every year we have to recover the instruments to get the data. Then we redeploy them for the next year. We also do a survey of the waters of the region, to check that our moorings are measuring the major properties of the flow.

The purpose of this cruise is to recover (and then redeploy) three moorings which have been in the water since summer 2014. Because the region is covered in sea-ice in winter, we have to do this in the summer, when the region is ice-free. The top float of the mooring must be below the surface, as otherwise it would be destroyed by the sea-ice. Thus, we need a way of finding the moorings without being able to see them.

How do we do this? - follow our daily adventures

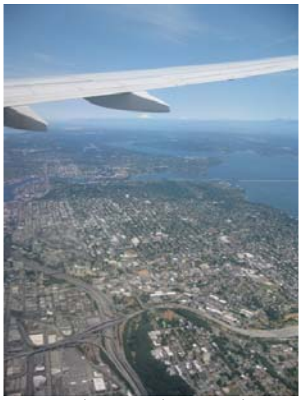


Schematic of Bering Strait mooring

(below) to find out!

Day 1 - Arrival in Nome

Saturday 27th June 2015



Leaving "snowless Seattle"

The science team for this cruise comes from Seattle (WA), Corvallis (OR) and Cambridge (MA), but we join the ship in Nome, the closest port to the Bering Strait. We fly into Nome some days before the ship, so we can prepare instruments ready to deploy.

Nome, originally a gold rush town, has a population of ~ 4000 with "downtown" Nome about 1.5 miles long and 0.5 mile wide, quite a contrast to the 3.6 million people in the Seattle metropolitan area. Nome is at a latitude of ~ 64.5N. This is below the Arctic Circle, but in summer the days are still very long - sunset is now ~ 1:40am, and sunrise only ~ 3 hrs later (4:30am).

Arriving "snowless Nome" some 9hrs later (18hrs later from Boston)

We arrive too late to start work that night, but stretching our legs along the beach, we find it covered with hundreds of ~ 6inch long sardine-like fish (see picture). A local explained these are called "Hooligan" or "Cigar" fish. (The name is actually a corruption of Eulachon - try saying that!) and are caught by the children, dipped in flour and fried and eaten whole. They are also called Candle fish, as they are rich in oil and burn well, indeed the oil was traded far along the coast to California. However, we are not quite that hungry.

"Cigar" fish on beach in Nome with toe of boot for scale

Day 2/3/4 - Preparing for Sea

Sunday/Monday/Tuesday 28th/29th/30th June 2015

"Traveling light!" Shipping container partially filled with instrumentation and hardware transported from Seattle WA to Nome AK

Turning on and programing instruments in preparation for deployment

When working in remote regions like the Bering Strait, a first challenge is getting all required oceanographic gear to the shipping port. For this cruise, all major instruments and hardware (all 12,000 lbs of it!, see picture on left) were sent in a shipping container by ocean barge to Nome ahead of time. These types of shipments are only possible once a month making it necessary for the scientific team to prepare and ship their equipment well in advance of the cruise (the container left Seattle at the end of April, 2 months ago).

Once in Nome, we unpack our shipment and sort through the gear in preparation for deployment. Since both time and space are limited on the ship, it is important to get as much work done before leaving port. In our first three days in Nome, we perform final checks on the instruments, program them to start recording (see lower left picture), and install them in the frames in which they will be deployed (see pictures on right). We then repack the container, so everything can be easily transported to the dock for loading into the ship.

And now we wait for the ship. You can track the ship's position HERE. She is currently just past St. Lawrence Island, 100 nautical miles (115 land miles) off Nome and due in Wednesday morning.

Preparing instrumentation for deployment

Preparing upper instrument and floatation for deployment

Another important part of any research project is to share our research goals and findings with local communities. Tonight (6:30pm), Dr. Kate Stafford will give a public presentation at the University of Alaska, Fairbanks, Northwest Campus here in Nome - "Climate Change and Whales in the Arctic". Come if you can!

Day 5 - Departure from Nome
Wednesday 1st July 2015

Today, the *Norseman II* arrives in Nome. With the ship docking in harbor, we move our equipment down to the dock in preparation for loading.

The bow of the Norseman II.


Landing the container that holds our equipment at the dock in Nome

We hoist our 12,000 pounds of equipment onto the ship with the help of the crew. Once everything (and everyone!) is on board, we listen to a briefing on safety protocols and practice an abandon-ship drill. Having all freshly trained last Tuesday on cold-water safety, we are able to climb into our survival suits (jokingly called 'Gumby suits') in almost no time. Hopefully, we never have to use our training.

After our safety drill, we jump right into getting our instruments up and running. We are ready to set sail, strengthened by a tasty BBQ prepared by the *Norseman II*'s cook. Bellies full, we say goodbye to Nome and head off towards the Bering Strait for the first sea day of mission. By morning, we should be at our first mooring site.

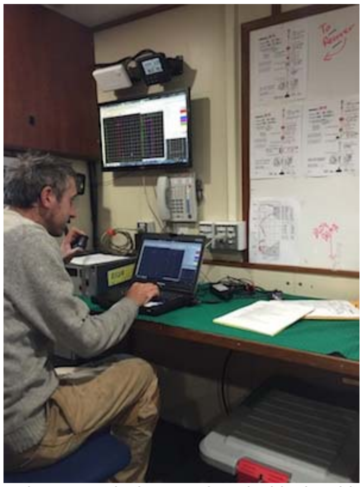

Getting the instrumentation up and running as the ship gets underway


"Flying" an instrument from the container onto the ship


The view leaving Nome Harbor at 10:30 PM.

Day 6 - CTDs in the Mist
Thursday 2nd July 2015

A view of the Bering Strait out the porthole of the Norseman II



Robert controls the CTD from inside the ship

We arrive at our mooring station this morning and are greeted by heavy fog. Because the mooring recovery requires visibility, it is too risky to attempt the mooring recovery until the fog burns off. As we wait, we take several "*CTD*" casts to characterize the water column at the mooring sites.

The *CTD,* an instrument that measures **c**onductivity, **t**emperature, and **d**epth, is the workhorse of oceanography. Temperature is (obviously!) the temperature of the water. Conductivity (the ability of a material to pass an electric current) and temperature allow us to calculate ocean salinity (how salty the water is), while pressure serves as a measure of depth.

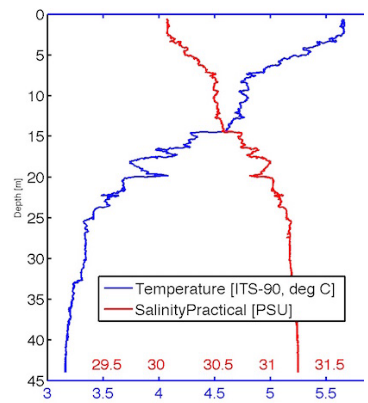
The sensors of salinity, temperature, and pressure (which compose the CTD) are typically attached to a metal frame (see picture right) to protect them as they are lowered toward the seafloor. Often times, "niskin bottles" (open ended canisters which can be shut by a signal from the ship) are also connected to this metal frame (called a *rosette*) to collect water samples and return them to the ship. A scientist sits on the ship at a computer connected to the instruments and tells the crew on the deck when to lower or raise the CTD. From the ship we can see this data on a computer screen in real time, which appears as plots of salt content, temperature, and pressure plotted against depth in the water (see example below right for the data from this morning).

Data collected from CTDs are used to characterize the properties of the water. Physical oceanographers, for example, may use this information to determine where the water is coming from in the form of currents, while those studying marine mammal acoustics need to know these properties of the water in order to understand how sound waves propagate in the sea. A biological oceanographer might deploy a CTD to study if conditions are right for an algal bloom, while chemical oceanographers use the data to support chemical analysis of water samples (e.g., as you will see later, to measure ocean acidification).

Wait .. maybe the fog is clearing .....

A hitch-hiking Crested Auklet (Aethia cristatella) joins us aboard the ship

A lonely CTD sits on the aft deck of the ship in fog



A CTD plot shows temperature and salini measurements with depth - straight from this morning's cast

Day 7 - A Tale of Two Moorings

Friday 3rd July 2015

The crew hooks the mooring out of the sea

Using the winch, the mooring is lifted from the water onto the deck

Last night, the fog cleared to reveal a beautifully sunny evening. Working late into the Arctic midnigh successfully completed our first mooring retrieval of the cruise. Today, our spirits are high in the new mor experience a feeling of *deja vu* - as the day starts, we're once again surrounded by fog and forced to wai weather.

As we mentioned before, our moorings rest below the sea surface to prevent collision with the thick (covers the Bering Strait in the winter. Now, in the summer, the water is still cold (about 3 degC), but with time to recover moorings. Because we cannot see the moorings under the water's surface, we use GPS locate them. Once we are in position, we release the mooring from its anchor with an instrument called a *release*. Acoustic releases utilize sound waves to communicate with us on board the ship: an operator se the mooring to break its connection to the anchor (the standard anchor in oceanography is an old train w acoustic release receives and executes this command. This allows the instruments to rise to the surface connected to some big floats) so we can spot them. Even though the instruments are large and brightly p still be difficult to see them in the waves of the sea, so we have all eyes on deck to look for the floats as t surface.

Later into the afternoon, the fog begins to clear and we forge onward with recovering our second mo without an exciting challenge. The first release reports a problem and fails to release. The second releas function is so critical, we always use two releases) - confirms it has released, but still the mooring does n suspect that the very strong currents we are experiencing (4 knots, ~ 4 times the average current) have s jammed the mechanism. Our only option is to try and knock the mooring free. We lower hooks and wei floor. Then paying out ~ 300m of wire and with all eyes on the water, we steam in circles around the moo trying to snag the anchor. The strong current repeatedly pushes us off course. Our hopes rise every tim snags on something, but to no avail. The fog hovers near the horizon. Hours pass, until suddenly, witho mooring breaks the surface to relief all round. However, just minutes later, the wire snags on something now must free the wire, without losing sight of the drifting mooring. Some intense deck operations ensue snagged an old mooring anchor, weighing ~ 800kg, which is now hung up on the hooks. But finally, we f and recover it, bringing up also a stowaway sea star (below right), and we can return to the recovery of th itself.

Once the mooring has been spotted, the ship pulls along side it. Crew members hook the floating ins top) and connect it to a rope line. The crew then uses the rope line to pull the mooring at the *stern* (back ship, where it can be attached to the winch. We use the winch to pull the mooring onto the ship (left botto left), and returning to us instruments which have been (we hope) recording data for the last year.

Before reading the data, we first have to clean the instruments off. Any surface put into open water by sea life, and our moorings are no exception. Barnacles, algae, and other small creatures attach to the grow in a process known as *biofouling*. One oceanographer's noise is another oceanographer's signal. T among us catalog the organisms growing on the moorings, and then scrape them off and return them to t

(left) The recovered mooring is lowered to the deck
(center) Barnacles (~5cm long) and algae cover the moorings
(right) Our stowaway sea star joins us on deck

Day 8 - A Mooring a Day...
Saturday 4th July 2015

The sun struggling through the fog causes a "fogbow" (similar to a rainbow) - one consolation of CTDing in fog.

This morning, we are eager to recover our last mooring ... however, we are yet again thwarted by fog. Our experience yesterday underlines that we must have good visibility to attempt recovery. But we don't have it. So instead, pushing away haunting worries about the fog remaining for the whole cruise, we collect CTD data, hoping the fog will clear later in the day.

We run the first of our CTD "sections" (a collection of casts taken in a line - think of it as a vertical slice through the ocean). This section is ~22 nautical miles (~24 land miles) long, crossing the US half of the strait (the remaining half of the strait is in Russian waters, where we do not have permission to work). Stopping every nautical mile to take a cast, for the next ~ 5 hours we work (through fog) from the Diomede Islands in the center of the strait eastward toward the US coast. There, we find the Alaskan coast is clear of fog, and even though the strait is still fogged in, we head hopefully back to the mooring site (midway between the Islands and the US coast). As we go, miraculously the fog starts to lift and a view of the full strait slowly emerges - stretching from the Russian coast in the west to the US cape, Prince of Wales, in the east, with the two beautiful Diomede islands in the middle (see photo collage below). Keeping an eye on the remaining fog, we set to recovering our last mooring - and this time, the mooring releases exactly to plan, and soon we have the mooring safely on board the ship.

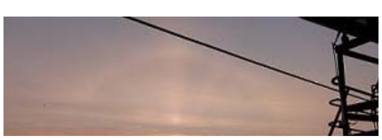
Steps for deploying a mooring - harder than it looks.

As we have been recovering moorings, we have also been redeploying to continue the data collection for another year (see photo collage left). Though the process looks simple, details are essential, as one small mistake in assembly can result in the mooring being lost during its year in the water. Every joint between instruments has a second safety mechanism to secure it. To reduce corrosion, components of different metals must be electrically isolated from each other.reduce corrosion, components of different metals must be electrically isolated from each other. Extra grab-points are included to make the mooring easier to recover. And meticulous details are kept of all this, especially of the instruments (which we will describe in later blogs). When all is checked and rechecked, we are ready to deploy. With the ship steaming slowly towards the desired location, we use the ship's winch to lower the top of the mooring into the water, letting the mooring stream out on the surface behind the ship. Finally, the ship's winch lifts the anchor into the water as well. As we reach the desired deployment site, a final tug on a rope frees the anchor from the ship's crane, the anchor plunges to the sea-floor drawing the mooring down with it, and we lose sight of it ...

Photo collage of the Diomede Islands, finally clear of fog in the evening. This view is from the north, looking south. From left to right - the smaller Little Diomede (in US waters) is ~ 3 nautical miles from the larger Big Diomede (in Russian waters). To the far right of Big Diomede, the coast of Russia (~ 20 nautical miles away) can just be seen low on the horizon.

Day 9 - A well "Orca-strated" Whale Watch

Sunday 5th July 2015



With the mooring recoveries and deployments accomplished, our remaining tasks are the downloading (and initial quality control) of the data we have recovered from the moorings and supporting surveys of the Bering Strait region, including the southern portion of the Chukchi Sea.

Sounds fr

Brief extracts from hydro

we recover

A ship at sea never sleeps. Like the ship's crew, we split into shifts to take CTD data around the clock - those now working "nights" being compensated, when the fog lifts, by glorious midnight sun effects (left), as we are now north of the Arctic circle.

Walrus in the Bering

Bearded Seal in the Be

Today's sighting of orcas

Not Nessie - but a harbor

One of the instruments on our moorings is a hydrophone - an underwater microphone. This instrument "eavesdrops" on the underwater environment of the Bering Strait by recording the sounds that are made by marine animals, sea-ice, wind and ships. These data can provide information on the timing of migration of marine mammals that move between the Bering and Chukchi Sea or identify animals that stay in the Bering Strait region all winter, even under heavy ice and 24 hours of darkness. The data are used to study, for example, the singing behavior of bowhead whales, how sea-ice influences the occurrence of bearded seals, and how often ships move through the Bering Strait on their way to and from the Arctic. Integrating the oceanographic information obtained from other instruments on the moorings allows us to determine which environmental factors influence the presence of marine mammals.

Although we just retrieved our hydrophones, we've already found some interesting sounds from walrus and bearded seals - you can listen to these by clicking the links on the right.

Though again hindered by the fog, we are also making visual observations of marine mammals species (and birds). Our marine mammal experts man the bridge from 7am to 11pm, recording numbers, species and behavior in a certain area around the ship. We might expect both "summer whales", those that come to the Arctic only in the summer (e.g., fin, gray, minke and humpback whales), and "winter whales", those who live year-round in the Arctic. Of particular interest is the baleen (filter-feeder) bowhead whale, so-called as they have a large hump (bow) on their heads, with which they push up sea-ice (up to 1-m thick) to create an air pocket in which to breathe! Marine mammal sightings have been few this cruise so far, not unusual in July, but today we passed a pod of about 12 orcas (killer whales, see right). Orcas have been more abundant in the Arctic in recent years, possibly due to sea-ice retreat as their prey also move north. Here again, the mooring data allow a year-round assessment of "who" is in the Arctic when.

Birds are our almost constant companions. Bird species seen thus far include: Least, parakeet, and crested auklet; common and thick-billed murres; pigeon and black guillemots; pomarine and parasitic jaegers; short-tailed shearwaters; red phalaropes; northern fulmars; Brant geese; glaucous gulls; black legged kittiwakes; king and common eiders; and horned and tufted puffins. But our crested Auklet has left us, probably prefering company his own size.

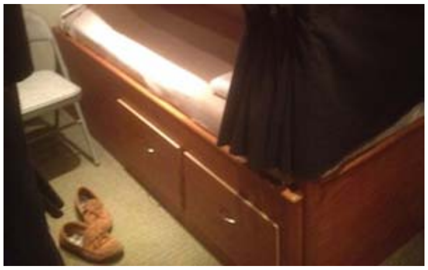
Some examples of birds sighted this trip (Left: Common Murres; Middle: Pomarine Jaeger; Right: Horned Puffin)

Day 10 - A Day in the Life of a Research Ship

Monday 6th July 2015

A research ship is a unique environment when compared to land: its crew must function round the clock in limited space, often on unforgiving seas. For this reason, protocol dictates certain behaviors at sea to ensure a safe and productive cruise.

A scientist on day shift starts her morning at 0600 (6:00 AM), drawing back the black-out curtains on her bed in a shared cabin (bedroom). She heads up to the main deck as breakfast and coffee is set on the table at 0630. What is a morning meal for her is a late night snack for the night watch, who transfers over any important information of what



happened over the previous 12 hours to the incoming rotation. Sitting down at the computer, she radios to the deck to prepare for the next CTD cast. Elsewhere aboard, the rest of the day shift takes their respective posts performing data quality control, mammal watch, and biofouling analyses, (or blog writing).

Old maritime tradition gives us many of the terms we use at sea, including the rooms and equipment aboard a ship. One sleeps in a **stateroom** (photo left), while a bathroom is referred to as the **head.** The captain drives the ship from the **bridge**, while the cook works in the **galley**. At the front of the ship is the **bow**, and at the **aft** (back) of the ship is the **stern**. Aboard the Norseman II and other research vessels there is also a science lab where instrumentation is prepared for deployment and data are monitored.

Actually, many nautical terms have made their way back to land. For example, to measure speed in old times, a **line** (rope) was tied to a log, which was then tossed off the back of a ship. As the rope was pulled off deck, one counted the passage of knots which had been tied into the rope at regular intervals, giving rise to the nautical unit of speed over water (**knots**). So, every time you "log on" to a computer, you harken back to the maritime tradition of writing these log-based speeds in a "log book."

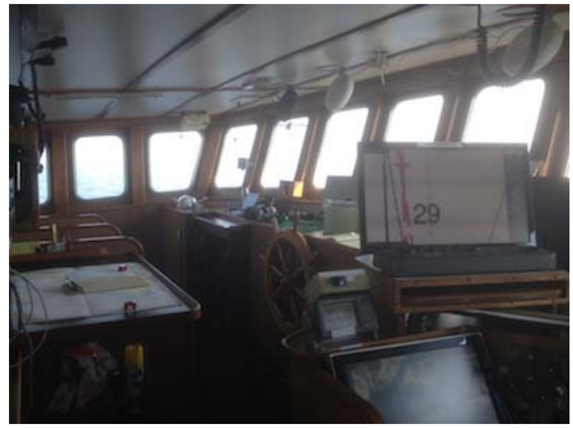
Back in the science lab, after several hours driving the CTD, the day shift scientist receives lunch relief at 1130 - another scientist fills in for her while she eats, so CTD operations can continue uninterrupted. At the lunch table, and indeed everywhere on the ship, any loose object must be tied down, Velcroed, or placed on a non-slip surface. Cups, plates, and flatware could all turn into dangerous projectiles in rough seas. People, too, must be cognizant of the roll of the ship and develop "sea-legs"- a safety paradigm of being at sea is "one hand for yourself, one hand for the ship", i.e., always keep one hand free to steady yourself against the ship's motion.

Of course, the ship's operations could not proceed without the dedicated efforts of the Norseman II's crew members. The Captain (**The Old Man**), with the help of his First Officer (**Mate**), directs course and heading, as well as oversees all ship's operations. In the engine room, the Chief Engineer (**Chief**) ensures functioning mechanical, electrical, and plumbing systems. One **Bosun** and two able-bodied seamen (**AB**s) carry out deck operations, while from a tiny galley the Chief Steward (**Cook**), assisted by the 2nd Cook, prepares 4 meals a day (breakfast, lunch, dinner and **Midrats**) for the whole crew of 16 people aboard the *Norseman II*. As the daytime scientist ends her shift, she sits down to dinner from 1730 to 1830 (5:30 PM to 6:30 PM). Done with her day, she transfers her watch over to the night shift, who, along with the ship's night shift, maintains continuous operations of data collection and the ship.

And so the days roll round ...

(above, a stateroom of the Norseman II)

The Galley of the Norseman II , from which comes great food.



The Bridge of the Norseman II, from which comes great direction

The Lab of the Norseman II, from which comes great science

Day 11 - If it moves, it's biology; if it smells, it's chemistry ...
Tuesday 7th July 2015

The primary mission of this research is to investigate the physical oceanography of the Bering Strait, but all disciplines of oceanography benefit from interactions with others; chemical and biological oceanography represent important elements to any oceanic study. As well as having interdisciplinary sensors on the moorings, on this cruise, we also have representatives of these disciplines to investigate oceanic nutrients and acidification, and biofouling communities, as well as to help us recognize and capitalize on moments of opportunistic science.

Recovered interdisciplinary instruments will tell us about the year-round variation in **nutrients** (i.e., food for ecosystems) in the water. Newly deployed instruments (see left) should yield the first year-round quantification of **ocean acidification** in the strait. One of the many consequences of the increasing CO2 in the atmosphere is an increase in the concentration of CO2 in our oceans. Once dissolved in the ocean, CO2 reacts with the water increasing the acidity of the ocean. Increased acidity inhibits the ability of marine organisms to form shells, and the speed with which ocean acidity is increasing makes it hard for organisms to adapt. Many of these vulnerable organisms are a vital food source for the rest of the food chain, and more research is need to predict how the system will adapt. This is not just an Arctic problem - think about oyster beds off our coast in Washington. However, the particular (cold, fresh) properties of Arctic waters make them more susceptible to acidification, and we are seeing the effects here sooner - a bellwether for the global ocean.

Biofouling, as previously mentioned, is the process by which organisms colonize and disrupt surfaces. Marine biofouling is especially problematic on ships, piping, marine structures, and instrumentation (such as moorings). Since the advent of seafaring, humans have made attempts to circumvent biofouling through various means - on wooden ships, a thin copper plating was common, while on more modern iron vessels (which would be corroded by copper), ***organotin*** (tin-based poisons) paints, especially the harsh chemical *tributyltin oxide* (TBT), were common until their ban in 2001. Today, antifouling research focuses on non-corroding copper-based paints, as well as biomimetic (bio-mimicing) materials that seek to emulate the natural antifouling qualities of, for example, shark skin.

Tiny organic particles are the first elements of biofouling - they are attracted to surfaces by electrostatic ***Van der Waals forces*** (the same forces which allow you to stick a rubber balloon to the wall once you have rubbed it on your sweater). Once the surface is coated with these tiny organic particles, bacteria ***chemotax*** (swim in response to a chemical/nutrient gradient) toward the surface and begin attaching as a ***biofilm*** (a population of stationary bacteria held together by an exuded organic glue). Algae join the bacteria, giving rise to a green or brown slimy layer, followed by larger, more recognizable creatures: barnacles, sea sponges, sea slugs, *etc*.. We characterize the members of this ***fouling community*** (see left) to give us a sense of how organisms are responding to changing environmental conditions in the Bering Strait over the years.

While we are on deck transferring the CTD in and out of the water, we also keep a watch for marine life that drifts by the ship during the cast. Our most common oceanic visitors have been ***ctenophores*** ("comb-jellies", looking like small, ~ 5cm clear jellyfish of various forms, see right) and ***salps*** (clear filter-feeding swimmers, again ~ 5cm long), with also frequent sightings of up to 1m long peach-colored jellyfish. The small, simple organisms can create dazzling displays in the water as they float by in great number.

But with the winds increasing to strengths NOAA disturbingly calls "Small Craft Advisory", our time on deck is more focused on safely catching the CTD and getting as many stations done as we can, in case the seas come up.

(Above, top) The ocean acidification assembly from our mooring

(Above, bottom) A sample of biofouling organisms collected from a mooring, which included an annelid worm, anemones, barnacles, algae, and hydroids

Above: examples of the diversity of ctenophores

Image top: NOAA photo gallery, via Wikimedia commons

Image bottom: OAR/National Undesea Research Program (NURP), via Wikimedia commons

The Chukchi Sea at 2am, reflecting the setting sun

Day 12 - Filling the unforgiving minute .. with CTDs

Wednesday 8th July 2015

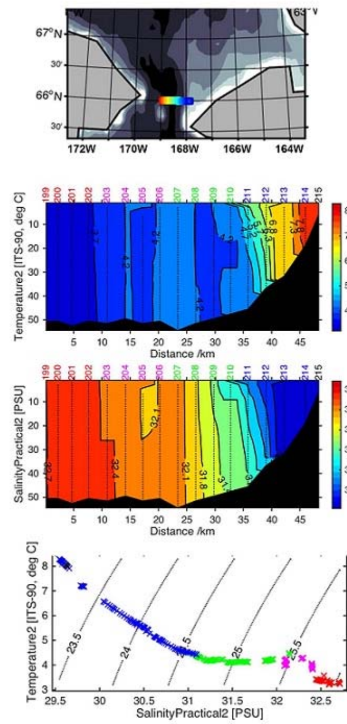
It is 1am, and we have just brought the CTD on board for the final time, and are now steaming to Nome for offloading tomorrow. While most of the team sleeps to be ready for final packing in the morning, the remainder run through the final data collection tasks, backing up all the data, performing initial quality control, and quickly plotting up the preliminary data to see what we have "caught". The temptation is too great not to - we can sleep tomorrow!

CTDing off Wales, in the eastern side of the Bering Strait, looking south along our route home.

Over the last few days, we have taken 258 casts. As each cast is taken, it is carefully scrutinized for any technical problems. Sediment and biology in the water can jam the pumps on the CTD, compromising the data unless quickly identified. We have had tiny stones and likely jellyfish caught in parts of the CTD, but in each case have quickly been able to fix the system (see left) without data loss.

Tending to the CTD - the operation was a success

Our focus has been on running sections (see example right). These are data we took this morning, along the line shown in color on the map at the top of the figure (right). The two panels below show slices through the ocean (as if you were looking north) of the temperature and the salinity of the water.

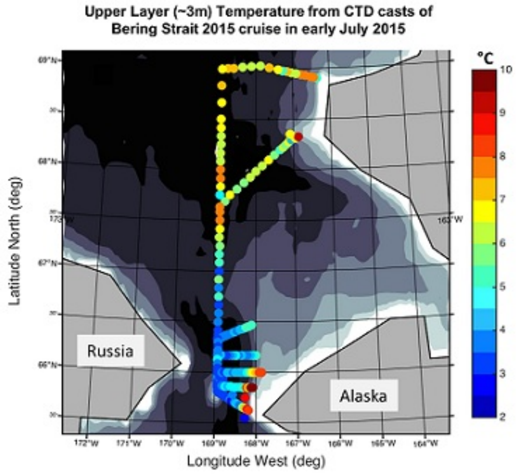


Sections of temperature and salinity taken this morning in the northern Bering Strait. Top shows the line on the map. Second and third panels show slices through the ocean as if you were looking north. The final panel is plotting temperature against salinity, a technique which allows oceanographers to identify where waters are from. In this final panel, the blue crosses indicate waters of the Alaskan Coastal Current, while the red dots show waters that have come from the Russian side of the Bering Sea.

Temperature and salinity measurements are the mainstay of physical oceanography. Firstly (and very remarkably) together they tell you where waters are from - you can think of them as the "accent" of sea-water, identifying the waters' origin even after a journey around half the globe. In our section (right), the warm, fresh waters on the eastern (right hand side) of the plot are from the Alaskan Coast, and form the **Alaskan Coastal Current**. Though small in volume (only about 1/10th of the flow through the strait), this current carries ~1/12th of ALL the freshwater entering the Arctic Ocean.

A pair of walrus spotted today by our marine mammal observers. A grey whale was also sighted by the Diomede Islands.

Secondly, from temperature and salinity, you can calculate the density of the water and, from that, gain information about the currents that are flowing. All this information, combined with data from our moorings and also measurements of water flow we are taking from the ship during our sections, allows us to estimate not just the total volume of water, but also the amount of heat and other properties that are being carried with the water. For example, our prior work has shown that the **amount of heat carried into the Arctic through the Bering Strait has doubled between 2001 and 2011**. While 1/3rd of this change seems to be due to changes in the local winds, one of our goals is to find out what is causing the rest of the change.



The Alaskan Coastal Current is a seasonal current, and our data suggest that it has arrived in the strait in the 5 days we have been here. This map (right) shows not only the regions we have sampled, but also the temperature in the upper layers of the ocean. The heat within this current is thought to influence the retreat of Arctic sea-ice. The data we have collected from the moorings should elucidate the causes and timing of these changes and will advance our understanding of how the Arctic works.

But for now (and for many days ahead of us), we must focus on securing the highest quality of the data we have collected, and ensure that these data are available quickly and permanently (though national data archives) for use of scientists for years to come.

We are homeward bound, and tomorrow will disperse to our own institutions - but with a wealth of in the role of the Bering Strait, the Pacific Gateway to the Arctic.

Bye Bye Bering Strait - sunset, looking east towards the Diomede Islands, as we finally leave the Strait and head back to Nome.

For use of any of these figures, please contact Rebecca Woodgate (woodgate@apl.washington.edu)

Who's following us?

Count:

0611

Location:

We gratefully acknowledge financial support for this work the National Science Foundation (NSF).

[Back to Bering Strait Homepage](#)
[Back to High Latitude Dynamics Homepage](#)

% Bering Strait 2014 NORSEMAN2 log CTD

%Date	Time	1	Cast NO	Down	Depth (m)	Lat (deg)	Lat (min)	Lon (deg)	Lon(min)	Altimeter	%	StationID	Windspeed	Winddir	Operator	Comments

%Please fill in all data for every event (CTD/net tow) %
%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 % THIS YEAR WE ONLY HAVE TYPE 1
%#,Number is consecutive for that event type %
%In/out (I/O): 1=In / 2=Out %
%Dep=waterdepth(m) from Furuno readout by CTD which is depth below keel, keel is 3m (10ft
%LatD and LatM are Latitude Degrees and Minute and are positive N %
%LonD and LonM are Longitude Degrees and Min and are positive W %
%St is the name of the station (Line ID then station number) %
% SS = CTD operator estimate of sea state (Beaufort Scale)
%WSp=wind speed in m/s; WD=Wind direction from bridge
%Op=CTD operator
% when 3 lines for NET, dep indicates wire out for net
% Altimeter = 0 if complete rubbish, 0.5 if some good readings, 1 if good both up and dowr
%Fill in any comments if needed. %

%Date	Time	1	Cast NO	Down	Depth (m)	Lat (deg)	Lat (min)	Lon (deg)	Lon(min)		%	StationID	Windspeed	Winddir	Operator	Comments
20150702	1840	1	1	1	42	65	33.186	168	16.038	0	%	wet test	14.5	161	RJD	wet test cast
20150702	1845	1	1	2	42.3	65	33.312	168	16.12	0	%	wet test	12.5	163	RJD	
20150702	2024	1	2	1	46	65	45.015	168	15.787	0	%	A4-14			MG	Lots of current, deployment at high angle,altimeter did no report
20150702	2028	1	2	2	46	65	45.367	168	15.601	0	%	A4-14			MG	
20150702	2143	1	3	1	53.6	65	46.925	168	33.823	0	%	A2-14	16.6	178	MB	Altimeter not working
20150702	2149	1	3	2	54.2	65	47.09	168	33.889	0	%	A2-14	12.5	174	MB	moved altimeter down 0.25inch
20150703	113	1	4	1	54.3	66	19.712	168	57.145	0	%	A3-14	13.9	164	GMS	winch issue before start
20150703	116	1	4	2	54.1	66	19.824	168	57.089	0	%	A3-14	17.4	171	GMS	
20150703	555	1	5	1	54.5	66	19.703	168	57.061	0	%	A3-15	18.5	184	atn	
20150703	600	1	5	2	54.2	66	19.846	168	57.113	0	%	A3-15	15.5	178	atn	
20150704	257	1	6	1	45.6	65	45.055	168	15.644	0	%	A4-15	10.2	203	GMS	niskin bottle sample
20150704	301	1	6	2	45.6	65	45.119	168	15.585	0	%	A4-15	9.4	221	GMS	7:03 local dropped another messenger
20150704	314	1	7	1	45.7	65	45.143	168	15.715	0	%	A4-15 try 2	11.4	216	GMS	niskin bottle sample try two - fired at scai
20150704	319	1	7	2	45.5	65	45.357	168	15.573	0	%	A4-15 try 2	9.1	215	GMS	
20150704	1735	1	8	1	44.9	65	48.363	168	55.908	0	%	BS11	3.4	92	RJD	
20150704	1744	1	8	2	44.8	65	48.36	168	55.5	0	%	BS11	1.7	38	RJD	
20150704	1750	1	9	1	45.1	65	47.796	168	53.783	0	%	BS11J	3.3	39	RJD	Jelly fish
20150704	1755	1	9	2	45.3	65	47.8	168	53.8	0	%	BS11J	2.1	24	RJD	
20150704	1800	1	10	1	41.8	65	47.309	168	51.709	0	%	BS12	3.3	28	RJD	back into fog
20150704	1806	1	10	2	44.2	65	47.28	168	51.1	0	%	BS12	2.7	40	RJD	
20150704	1813	1	11	1	46.8	65	46.3	168	49.62	0	%	BS12AJ	8.7	40	RJD	
20150704	1818	1	11	2	47.1	65	46.463	168	49.675	0	%	BS12AJ	2.9	45	RJD	
20150704	1826	1	12	1	49.9	65	46.336	168	47.773	0	%	BS13	4.9	50	RJD	
20150704	1832	1	12	2	49.7	65	46.443	168	47.72	0	%	BS13	5.3	26	RJD	
20150704	1841	1	13	1	50.4	65	45.77	168	45.47	0	%	BS13Z	5.8	27	RJD	salps? And on all cast beforehand.
20150704	1846	1	13	2	50.8	65	45.913	168	45.559	0	%	BS13Z	5.4	29	RJD	
20150704	1855	1	14	1	50.6	65	45.317	168	42.253	0	%	BS14	4.4	19	RJD	
20150704	1900	1	14	2	50.6	65	45.45	168	43.283	0	%	BS14	6	39	RJD	
20150704	1916	1	15	1	49.7	65	44.843	168	41.657	0	%	BS14J	5.6	37	MG	Man overboard drill prior to this cast
20150704	1920	1	15	2	50	65	44.915	168	41.696	0	%	BS14J	4.7	49	MG	
20150704	1932	1	16	1	49.7	65	44.429	168	39.794	0	%	BS15	7.3	48	MG	
20150704	1936	1	16	2	49.6	65	44.501	168	39.798	0	%	BS15	8.4	32	MG	
20150704	1945	1	17	1	49.4	65	43.898	168	37.64	0	%	BS15J	7.9	40	MG	
20150704	1949	1	17	2	49.5	65	43.987	168	37.64	0	%	BS15J	7.9	38	MG	
20150704	2001	1	18	1	49.6	65	43.285	168	35.466	0	%	BS16	9	45	MG	
20150704	2005	1	18	2	49.7	65	43.381	168	35.407	0	%	BS16	9.2	43	MG	
20150704	2016	1	19	1	50.2	65	42.799	168	33.424	0	%	BS16J	8.9	41	RW	
20150704	2019	1	19	2	50.2	65	42.861	168	33.491	0	%	BS16J	8.3	53	RW	
20150704	2032	1	20	1	52.8	65	42.32	168	31.334	0	%	BS17	11.7	53	MG	
20150704	2035	1	20	2	52.5	65	42.386	168	31.335	0	%	BS17	11.1	47	MG	
20150704	2047	1	21	1	51.7	65	41.746	168	29.147	0	%	BS17S	11	55	MG	
20150704	2050	1	21	2	51.5	65	41.831	168	29.214	0	%	BS17S	11.4	66	MG	
20150704	2101	1	22	1	51.8	65	41.243	168	27.007	0	%	BS18	11	52	MG	
20150704	2105	1	22	2	51.8	65	41.339	168	27.088	0	%	BS18	11.2	50	MG	

20150704	2115	1	23	1	50.8	65	40.825	168	25.21	0 %	BS18J	10.2	43 MG	
20150704	2118	1	23	2	51.1	65	40.894	168	25.255	0 %	BS18J	11.6	56 MG	
20150704	2129	1	24	1	50	65	40.398	168	23.478	0 %	BS19	12.4	42 MG	
20150704	2133	1	24	2	50.3	65	40.472	168	23.517	0 %	BS19	11.7	43 MG	
20150704	2143	1	25	1	48.8	65	39.915	168	21.45	0 %	BS19H	11	31 MG	Experimented with turning power off before pump off - directed by RW
20150704	2146	1	25	2	48.8	65	40.006	168	21.477	0 %	BS19H	8.5	28 MG	
20150704	2200	1	26	1	47.2	65	39.387	168	19.236	0 %	BS20	11.2	32 MG	Implementing kill power after upcast
20150704	2204	1	26	2	47	65	39.519	168	19.237	0 %	BS20	12.1	28 MG	
20150704	2216	1	27	1	44.7	65	39.004	168	17.183	0.5 %	BS20J	13.1	31 MG	
20150704	2219	1	27	2	44.6	65	39.111	168	17.235	0.5 %	BS20J	11.3	MG	
20150704	2232	1	28	1	40.8	65	38.636	168	15.109	1 %	BS21	11.6	19 MG	
20150704	2235	1	28	2	41	65	38.756	168	15.178	1 %	BS21	10.3	20 MG	
20150704	2249	1	29	1	37.2	65	38.091	168	12.913	1 %	BS21A	10.5	23 MG	
20150704	2252	1	29	2	37.2	65	38.196	168	12.947	1 %	BS21A	11.1	15 MG	
20150704	2305	1	30	1	30.2	65	37.528	168	10.764	1 %	BS22	11.9	14 MB	
20150704	2307	1	30	2	30.5	65	37.587	168	10.831	1 %	BS22	11.1	21 MB	End of BS line
20150705	411	1	31	1	52.2	65	46.931	168	33.997	0 %	A2-15	9	1 GMS	Deployment calibration cast
20150705	415	1	31	2	53	65	47.003	168	33.96	0 %	A2-15	9.1	2 GMS	
20150705	522	1	32	1	45.4	65	49.273	168	55.918	0 %	DL1	7.2	318 GMS	Start of DL line
20150705	526	1	32	2	45.4	65	49.308	168	55.825	0 %	DL1	6.8	337 GMS	
20150705	533	1	33	1	45.2	65	50.122	168	56.165	0 %	DL2	6.3	333 GMS	
20150705	537	1	33	2	44.9	65	50.109	168	56.289	0 %	DL2	6.6	315 GMS	
20150705	545	1	34	1	45.8	65	51.089	168	56.192	0 %	DL3	4.6	341 GMS	
20150705	548	1	34	2	45.8	65	51.061	168	56.24	0 %	DL3	6.4	305 GMS	
20150705	557	1	35	1	43.8	65	52.069	168	56.253	0 %	DL4	4.4	332 GMS	
20150705	601	1	35	2	43.6	65	52.113	168	56.286	0 %	DL4	5.1	317 GMS	
20150705	609	1	36	1	45.7	65	53.105	168	56.221	0 %	DL5	8.7	8 GMS	
20150705	612	1	36	2	45.9	65	53.128	168	56.334	0 %	DL5	8	359 GMS	
20150705	620	1	37	1	46.8	65	54.091	168	56.228	0 %	DL6	11.2	23 GMS	
20150705	623	1	37	2	46.8	65	54.141	168	56.321	0 %	DL6	10.3	20 GMS	
20150705	631	1	38	1	47.1	65	55.083	168	56.25	0 %	DL7	11.3	24 GMS	
20150705	634	1	38	2	47.1	65	55.125	168	56.38	0 %	DL7	11	19 GMS	
20150705	642	1	39	1	47.6	65	56.078	168	56.186	0 %	DL8	11.5	31 GMS	
20150705	646	1	39	2	47.6	65	56.168	168	56.32	0 %	DL8	10	17 GMS	
20150705	653	1	40	1	48.6	65	57.02	168	56.303	0 %	DL9	11.3	27 GMS	
20150705	656	1	40	2	48.8	65	57.075	168	56.456	0 %	DL9	11.6	25 GMS	
20150705	704	1	41	1	49.7	65	58.015	168	56.217	0 %	DL10	12.2	30 GMS	
20150705	706	1	41	2	49.7	65	58.076	168	56.284	0 %	DL10	11.3	31 GMS	
20150705	715	1	42	1	50	65	59.023	168	56.17	0 %	DL11	11.8	35 GMS	
20150705	717	1	42	2	50	65	59.09	168	56.22	0 %	DL11	10.7	31 GMS	
20150705	725	1	43	1	50.4	66	0	168	56.227	0 %	DL12	11.8	41 GMS	
20150705	728	1	43	2	50.4	66	0.05	168	56.322	0 %	DL12	12	44 GMS	
20150705	745	1	44	1	50.9	66	2.537	168	56.213	0 %	DL13	11.3	43 GMS	
20150705	747	1	44	2	50.9	66	2.588	168	56.286	0 %	DL13	12.2	46 GMS	
20150705	805	1	45	1	52.7	66	5.075	168	56.059	0 %	DL14	8.8	53 GMS	
20150705	807	1	45	2	52.7	66	5.067	168	56.106	0 %	DL14	11.9	56 GMS	
20150705	826	1	46	1	52.3	66	7.647	168	56.178	0 %	DL15	12.8	53 GMS	
20150705	828	1	46	2	52.6	66	7.713	168	56.233	0 %	DL15	12.8	57.1 GMS	
20150705	846	1	47	1	53.2	66	10.166	168	56.171	0 %	DL16	12.1	51 GMS	
20150705	849	1	47	2	53.3	66	10.238	168	56.33	0 %	DL16	12.1	47 GMS	
20150705	908	1	48	1	55.1	66	12.775	168	56.273	0 %	DL17	12.2	55 atn	
20150705	911	1	48	2	55.2	66	12.853	168	56.342	0 %	DL17	13.1	60 atn	
20150705	928	1	49	1	55.3	66	15.284	168	56.23	0 %	DL18	11.6	60 atn	
20150705	933	1	49	2	55	66	15.616	168	56.304	0 %	DL18	12.7	67 atn	
20150705	948	1	50	1	54.5	66	17.846	168	56.207	0 %	DL19	10.8	60 atn	
20150705	952	1	50	2	54.5	66	17.943	168	56.29	0 %	DL19	11.5	64 atn	End of DL line
20150705	1007	1	51	1	54.2	66	19.769	168	57.105	0 %	A3-15	12.5	65 atn	Start of AL line
20150705	1011	1	51	2	54.2	66	19.853	168	57.222	0 %	A3-15	12.9	64 atn	
20150705	1023	1	52	1	54.2	66	20.366	168	53.838	0 %	AL13	14.2	69 atn	
20150705	1027	1	52	2	54.4	66	20.467	168	53.943	0 %	AL13	13.2	67 atn	
20150705	1041	1	53	1	53.5	66	21.019	168	49.434	0 %	AL14	12.3	75 atn	
20150705	1045	1	53	2	53.4	66	21.121	168	49.546	0 %	AL14	12.3	68 atn	
20150705	1059	1	54	1	45.9	66	21.692	168	45.015	0 %	AL15	13.5	67 atn	
20150705	1102	1	54	2	45.5	66	21.769	168	45.108	0 %	AL15	13.1	65 atn	

20150705	1117	1	55	1	55.9	66	22.445	168	40.795	0 %	AL16	11.4	69	atn			
20150705	1120	1	55	2	55.7	66	22.519	168	40.949	0 %	AL16	11.1	67	atn			
20150705	1135	1	56	1	54.1	66	23.167	168	36.579	0 %	AL17	13.7	70	atn			
20150705	1139	1	56	2	53.7	66	23.255	168	36.786	0 %	AL17	13	64	atn	interesting warm kink in T at 25m		
20150705	1154	1	57	1	51.6	66	23.844	168	32.24	0 %	AL18	12	69	atn			
20150705	1158	1	57	2	51.7	66	23.903	168	32.398	0 %	AL18	11.7	65	atn	the sun did not set!! Sat on horizon this past 2 hrs, now rising back up		
20150705	1213	1	58	1	52.4	66	24.57	168	27.919	0 %	AL19	12.1	70	atn	changed lattitude to 66, 24.57		
20150705	1216	1	58	2	52.4	66	24.654	168	28.027	0 %	AL19	11	60	atn			
20150705	1230	1	59	1	51.1	66	25.327	168	23.611	0 %	AL20	11.8	71	atn	nice warm and fresh layer at surface		
20150705	1234	1	59	2	51.1	66	25.445	168	23.731	0 %	AL20	11.4	66	atn			
20150705	1248	1	60	1	46.6	66	26.006	168	19.26	0 %	AL21	13	72	atn			
20150705	1251	1	60	2	46.5	66	26.085	168	19.36	0 %	AL21	12.7	72	atn			
20150705	1306	1	61	1	39.6	66	26.753	168	14.966	0 %	AL22	12	64	atn			
20150705	1309	1	61	2	39.7	66	26.846	168	15.032	0 %	AL22	11.8	68	atn	fresh layer at surface		
20150705	1323	1	62	1	32.3	66	27.366	168	10.543	0 %	AL23	13.2	67	atn			
20150705	1326	1	62	2	32.3	66	27.439	168	10.609	0 %	AL23	12.4	60	atn			
20150705	1339	1	63	1	26	66	28.091	168	6.238	0 %	AL24	11.8	73	atn			
20150705	1343	1	63	2	26.1	66	28.187	168	6.479	0 %	AL24	10.3	63	atn	End of AL line		
20150705	2113	1	64	1	48.4	67	37.97	168	55.92	0 %	CS10US	9.7	69	MG	Start of CS line		
20150705	2116	1	64	2	48.4	67	38.002	168	55.896	0 %	CS10US	9.7	68	MG			
20150705	2148	1	65	1	48.1	67	41.616	168	48.369	0 %	CS10.5	8.1	88	MG			
20150705	2150	1	65	2	48.1	67	41.644	168	48.314	0 %	CS10.5	8.2	95	MG			
20150705	2222	1	66	1	48.1	67	45.248	168	40.064	0 %	CS11	6.8	91	MG			
20150705	2225	1	66	2	48.1	67	45.267	168	39.964	0 %	CS11	7.1	110	MG			
20150705	2300	1	67	1	48.8	67	48.913	168	29.532	0 %	CS11.5	7.4	85	MG			
20150705	2303	1	67	2	49	67	48.941	168	29.443	0 %	CS11.5	8.3	96	MG			
20150705	2337	1	68	1	54.3	67	52.448	168	19.037	0 %	CS12	9.1	73	MB			
20150705	2340	1	68	2	54.3	67	52.444	168	18.962	0 %	CS12	9.1	85	MB			
20150706	14	1	69	1	57.1	67	55.873	168	9.34	0.5 %	CS12.5	7.7	71	MB	Altimeter worked on downcast		
20150706	17	1	69	2	57.1	67	55.904	168	9.287	0.5 %	CS12.5	8.9	101	MB			
20150706	50	1	70	1	52.9	67	59.272	167	59.695	0.5 %	CS13	9.5	82	MB	Altimeter worked on downcast		
20150706	53	1	70	2	53	67	59.326	167	59.629	0.5 %	CS13	9	74	MB	changed longitude to 167 from 168		
20150706	126	1	71	1	52.1	68	2.672	167	49.957	1 %	CS13.5	8.7	62	MB	Altimeter worked on downcast, PUMP ONE BUST?		
20150706	130	1	71	2	52.1	68	2.725	167	49.498	1 %	CS13.5	8.8	67	MB	may have hit bottom, up S cast v different in both sensors, some grit in exit of sensor		
20150706	204	1	72	1	51	68	6.059	167	40.16	1 %	CS14	9.7	71	MB	S up and down casts very different PUMP ONE BUST?		
20150706	210	1	72	2	51	68	6.118	167	40.255	1 %	CS14	10.3	76	MB	cleaned vents on both systems after this case with syringe .. Tested pumps. That on 48		
20150706	242	1	73	1	46.9	68	9.052	167	30.853	1 %	CS14.5	9.3	60	MB	Suspect pump on system one, pumps turned on at surface after cast, PUMP ONE BUST		
20150706	248	1	73	2	47	68	9.15	167	31.064	1 %	CS14.5	9.7	56	MB	UW SS 31.8		
20150706	319	1	74	1	46.4	68	12.058	167	21.433	1 %	CS15	1.8	10.1	MB	UW SS 31.46 PUMP ONE BUST>		
20150706	323	1	74	2	46.4	68	12.111	167	21.676	1 %	CS15	10.1	69	MB			
20150706	340	1	75	1	44.4	68	13.6	167	16.937	1 %	CS15.5	10.7	78	MB	PUMP ONE BUST?		
20150706	343	1	75	2	44.1	68	13.69	167	17.083	1 %	CS15.5	9.5	63	MB	PUMP ONE BUST?		
20150706	400	1	76	1	43.3	68	14.94	167	12.133	1 %	CS16	8.4	87	MB	PUMP ONE BUST?		
20150706	402	1	76	2	43.1	68	15.009	167	12.269	1 %	CS16	8.1	77	MB	PUMP ONE BUST?		
20150706	420	1	77	1	40	68	16.594	167	7.621	1 %	CS16.5	9.5	84	GMS	PUMP ONE BUST?		
20150706	423	1	77	2	40	68	16.659	167	7.752	1 %	CS16.5	8.3	81	GMS	PUMP ONE BUST?		
20150706	439	1	78	1	36.4	68	18	167	2.955	1 %	CS17	9.03	83	GMS	PUMP ONE BUST? - altered psa to sensors 2		
20150706	442	1	78	2	36.6	68	18.085	167	3.1	1 %	CS17	8	85	GMS	PUMP ONE BUST?		
20150706	459	1	79	1	32.3	68	18.841	166	57.6	1 %	CS18	7.2	72	GMS	PUMP ONE BUST?		
20150706	501	1	79	2	32.3	68	18.911	166	57.734	1 %	CS18	7.9	89	GMS	PUMP ONE BUST?		
20150706	526	1	80	1	25.3	68	19.84	166	52.441	1 %	CS19	8.5	138	GMS	PUMP ONE BUST?		
20150706	528	1	80	2	25.4	68	19.886	166	52.635	1 %	CS19	8.1	129	GMS	PUMP ONE BUST? Pulled a stone out of the pump after this line		
20150706	601	1	81	1	35.3	68	21.235	167	5.291	1 %	Test Cast	11.1	139	GMS	test to confirm functional pump	off Point Hope	originally called BS15t
20150706	604	1	81	2	35.3	68	21.294	167	5.47	1 %	test Cast	9.2	142	GMS	test to confirm functional pump	off Point Hope	originally called BS15t
20150706	1018	1	82	1	26.3	68	54.394	166	19.817	1 %	LIS1	1.7	299	atn			
20150706	1021	1	82	2	26.3	68	54.386	166	19.845	1 %	LIS1	1.4	294	atn	data looks ok, so looks like pump is working ok		
20150706	1035	1	83	1	30.9	68	54.785	166	24.974	1 %	LIS2	0.6	156	atn			
20150706	1038	1	83	2	31	68	54.842	166	24.843	1 %	LIS2	0.6	9	atn			
20150706	1054	1	84	1	32.5	68	55.233	166	30.276	1 %	LIS3	3.1	59	atn			
20150706	1056	1	84	2	32.3	68	55.223	166	30.175	1 %	LIS3	2.7	69	atn			
20150706	1120	1	85	1	39.5	68	55.842	166	38.488	1 %	LIS4	3.9	89	atn			
20150706	1123	1	85	2	39.3	68	55.849	166	38.402	1 %	LIS4	3.8	76	atn	altimeter working beautifully		
20150706	1146	1	86	1	44.2	68	56.441	166	46.498	1 %	LIS5	4.5	81	atn			
20150706	1149	1	86	2	44.2	68	56.429	166	46.373	1 %	LIS5	4	72	atn			

20150706	1212	1	87	1	44.6	68	56.995	166	54.497	0.5 %	LIS6	5.6	87	atn	
20150706	1215	1	87	2	44.6	68	56.955	166	54.453	0.5 %	LIS6	4.7	83	atn	
20150706	1235	1	88	1	45.1	68	57.591	167	1.872	0 %	LIS6.5	8.4	91	atn	
20150706	1238	1	88	2	45	68	57.537	167	1.883	0 %	LIS6.5	6.5	88	atn	
20150706	1258	1	89	1	45	68	58.201	167	9.287	0 %	LIS7	7.9	95	atn	
20150706	1301	1	89	2	45	68	58.25	167	9.277	0 %	LIS7	8.2	96	atn	
20150706	1321	1	90	1	45.3	68	58.87	167	16.613	0 %	LIS7.5	9	102	atn	
20150706	1324	1	90	2	45.3	68	58.84	167	16.671	0 %	LIS7.5	9.8	104	atn	
20150706	1343	1	91	1	45.8	68	59.415	167	23.922	0 %	LIS8	9.9	108	atn	
20150706	1346	1	91	2	45.7	68	59.4	167	23.923	0 %	LIS8	10.2	104	atn	
20150706	1422	1	92	1	46.7	69	0.622	167	38.4	0 %	LIS9	9.1	103	RJD	
20150706	1465	1	92	2	46.9	69	0.575	167	38.584	0 %	LIS9	7	106	RJD	
20150706	1501	1	93	1	47.6	69	1.802	167	53.158	0 %	LIS10	9.8	103	RJD	Jelly fish
20150706	1506	1	93	2	47.5	69	1.786	167	53.291	0 %	LIS10	8.6	104	RJD	
20150706	1537	1	94	1	48.3	69	1.336	168	7.679	0 %	LIS11	8.4	104	RJD	Jelly fish
20150706	1543	1	94	2	48.2	69	1.364	168	7.716	0 %	LIS11	9.7	107	RJD	
20150706	1614	1	95	1	48.6	69	0.973	168	22.071	0.5 %	LIS12	8.9	115	RJD	
20150706	1620	1	95	2	48.9	69	0.914	168	22.411	0.5 %	LIS12	7.8	107	RJD	
20150706	1653	1	96	1	50	69	0.433	168	36.947	0.5 %	LIS13	9.4	102	RJD	
20150706	1659	1	96	2	50.1	69	0.445	168	37.008	0.5 %	LIS13	7.9	107	RJD	
20150706	1721	1	97	1	50.3	69	0.236	168	46.437	0 %	LIS14n	6.1	115	RJD	
20150706	1725	1	97	2	50.7	69	0.251	168	46.481	0 %	LIS14n	5.8	115	RJD	
20150706	1747	1	98	1	50.8	69	0.001	168	56.002	0 %	CCL22n	4.4	94	RJD	
20150706	1752	1	98	2	51	68	59.983	168	55.985	0 %	CCL22n	5.8	91	RJD	
20150706	1900	1	99	1	51.5	68	50.022	168	55.927	0.5 %	CCL21	6.7	90	RJD	
20150706	1903	1	99	2	52	68	50.029	168	55.955	0.5 %	CCL21	6.5	113	RJD	
20150706	2009	1	100	1	51.1	68	40.049	168	55.926	0.5 %	CCL20	7	77	MG	
20150706	2012	1	100	2	51	68	40.066	168	56.067	0.5 %	CCL20	9.7	101	MG	
20150706	2117	1	101	1	53.1	68	30.048	168	55.887	1 %	CCL19	8	78	MG	
20150706	2121	1	101	2	53.1	68	30.059	168	56.026	1 %	CCL19	8	94	MG	
20150706	2154	1	102	1	53.7	68	25.018	168	55.864	1 %	CCL18.5	10.3	74	MG	
20150706	2157	1	102	2	53.7	68	25.006	168	56.01	1 %	CCL18.5	8	108	MG	
20150706	2234	1	103	1	54.2	68	20.023	168	55.874	1 %	CCL18	10.1	100	MG	From here on read Altimeter in real time, separate rating for up/down cast
20150706	2237	1	103	2	54.2	68	20.028	168	56.152	1 %	CCL18	10.2	118	MG	
20150706	2310	1	104	1	54.9	68	15.014	168	55.803	1 %	CCL17.5	10.8	101	MB	
20150706	2314	1	104	2	55	68	15.013	168	55.956	1 %	CCL17.5	10.5	117	MB	
20150706	2348	1	105	1	55.8	68	10.032	168	55.92	1 %	CCL17	10.5	101	MB	Chl max now at bottom
20150706	2352	1	105	2	55.8	68	10.01	168	56.02	1 %	CCL17	10.9	116	MB	
20150707	26	1	106	1	56.8	68	5.023	168	55.851	1 %	CCL16.5	9.1	100	MB	
20150707	30	1	106	2	56.7	68	5.025	168	56.008	1 %	CCL16.5	9.1	118	MB	
20150707	103	1	107	1	55.7	68	0.03	168	55.832	1 %	CCL16	9	93	MB	
20150707	107	1	107	2	55.6	68	0.039	168	55.962	1 %	CCL16	9.7	122	MB	
20150707	142	1	108	1	51.3	67	54.99	168	55.935	1 %	CCL15.5	6.2	99	MB	
20150707	146	1	108	2	51.2	67	55.014	168	55.989	1 %	CCL15.5	8.5	101	MB	
20150707	219	1	109	1	49	67	50	168	56.056	1 %	CCL15	7.2	100	MB	
20150707	223	1	109	2	49	67	49.936	168	56.016	1 %	CCL15	7.2	98	MB	
20150707	300	1	110	1	48.5	67	45.02	168	56.019	1 %	CCL14.5	7.7	82	MB	
20150707	303	1	110	2	48.5	67	44.959	168	55.954	1 %	CCL14.5	7.2	92	MB	
20150707	350	1	111	1	48.4	67	38.079	168	55.647	1 %	CCL14	5.7	101	MB	
20150707	354	1	111	2	48.4	67	38.086	168	55.474	1 %	CCL14	6.2	98	MB	
20150707	416	1	112	1	48.2	67	35.04	168	55.836	1 %	CCL13.5	8	92	GMS	
20150707	420	1	112	2	48.2	67	35.117	168	55.857	1 %	CCL13.5	7.7	100	GMS	
20150707	457	1	113	1	48	67	30.025	168	56.011	1 %	CCL13	6	121	GMS	
20150707	501	1	113	2	48.1	67	30.05	168	56.123	1 %	CCL13	7.5	105	GMS	
20150707	536	1	114	1	47.9	67	25.029	168	55.869	1 %	CCL12.5	5.4	58	GMS	
20150707	539	1	114	2	47.8	67	25.041	168	55.729	1 %	CCL12.5	4.6	59	GMS	
20150707	614	1	115	1	47.6	67	20.02	168	56.042	1 %	CCL12	6.7	47	GMS	
20150707	617	1	115	2	47.6	67	20.037	168	55.96	1 %	CCL12	7.3	40	GMS	
20150707	653	1	116	1	47.1	67	15.002	168	55.673	0 %	CCL11.5	8.8	50	GMS	
20150707	657	1	116	2	47.1	67	15.075	168	55.663	0 %	CCL11.5	9	48	GMS	
20150707	734	1	117	1	46.7	67	10	168	55.769	0 %	CCL11	9.2	52	GMS	
20150707	737	1	117	2	46.8	67	10.054	168	55.892	0 %	CCL11	9.3	61	GMS	
20150707	813	1	118	1	46.4	67	5.001	168	55.741	0 %	CCL10.5	8.3	68	GMS	
20150707	816	1	118	2	46.5	67	5.061	168	55.713	0 %	CCL10.5	8.3	80	GMS	

20150707	853	1	119	1	46.1	66	59.993	168	55.621	0 %	CCL10	10	87	GMS	
20150707	856	1	119	2	46	67	0.125	168	55.595	0 %	CCL10	9.9	98	GMS	
20150707	936	1	120	1	44.9	66	55.025	168	56.047	0 %	CCL9.5	9.3	129	atn	
20150707	939	1	120	2	44.9	66	55.019	168	55.982	0 %	CCL9.5	9.1	129	atn	
20150707	1016	1	121	1	43.2	66	50.035	168	55.905	0 %	CCL9	7.4	186	atn	
20150707	1019	1	121	2	43.2	66	50.113	168	55.797	0 %	CCL9	6.1	150	atn	
20150707	1059	1	122	1	41.2	66	45.028	168	55.722	0 %	CCL8.5	2.4	172	atn	
20150707	1102	1	122	2	41.1	66	45.124	168	55.699	0 %	CCL8.5	3.5	154	atn	
20150707	1142	1	123	1	42	66	40.026	168	55.798	0 %	CCL8	6.6	141	atn	
20150707	1145	1	123	2	42.1	66	40.148	168	55.827	0 %	CCL8	6.8	149	atn	
20150707	1225	1	124	1	44.3	66	35.006	168	56.038	0 %	CCL7	6.6	116	atn	
20150707	1228	1	124	2	44.3	66	35.055	168	56.226	0 %	CCL7	5.4	134	atn	
20150707	1308	1	125	1	54.9	66	29.997	168	56.113	0 %	CCL6	9.6	167	atn	
20150707	1311	1	125	2	54.6	66	29.99	168	56.214	0 %	CCL6	10.5	163	atn	
20150707	1350	1	126	1	55	66	25.043	168	56.028	0 %	CCL5	10	157	atn	
20150707	1354	1	126	2	55.2	66	25.083	168	56.137	0 %	CCL5	10.2	163	atn	
20150707	1415	1	127	1	53.8	66	22.322	168	55.997	0 %	CCL4	9.8	159	RJD	
20150707	1420	1	127	2	53.6	66	22.392	168	56.135	0 %	CCL4	9.1	158	RJD	
20150707	1440	1	128	1	54.3	66	19.727	168	56.956	0 %	A3-15	1.8	170	RJD	
20150707	1445	1	128	2	54.2	66	29.767	168	57	0 %	A3-15	9.2	155	RJD	
20150707	1457	1	129	1	54.4	66	20.451	168	53.739	0 %	AL13	10	161	MB	
20150707	1500	1	129	2	54.3	66	20.515	168	53.755	0 %	AL13	9	175	MB	
20150707	1513	1	130	1	53.3	66	21.013	168	49.53	0 %	AL14	5.2	127	RJD	
20150707	1518	1	130	2	53.4	66	21.138	168	49.622	0 %	AL14	7.1	147	RJD	
20150707	1531	1	131	1	45.8	66	21.734	168	45.131	0 %	AL15	7.5	139	RJD	
20150707	1538	1	131	2	46.1	66	21.977	168	45.136	0 %	AL15	6.3	145	RJD	
20150707	1550	1	132	1	55.4	66	22.443	168	40.831	0 %	AL16	7	163	RJD	
20150707	1554	1	132	2	55.6	66	22.547	168	40.757	0 %	AL16	6	156	RJD	
20150707	1605	1	133	1	54.4	66	23.111	168	36.544	0 %	AL17	9.1	119	RJD	
20150707	1611	1	133	2	54.2	66	23.303	168	36.468	0 %	AL17	9.7	125	RJD	
20150707	1623	1	134	1	51.7	66	23.888	168	32.151	0 %	AL18	9	106	RJD	
20150707	1628	1	134	2	52.1	66	23.952	168	32.142	0 %	AL18	10.2	111	RJD	
20150707	1641	1	135	1	52.3	66	24.638	168	27.982	0 %	AL19	11.1	122	RJD	Jelly Fish & cteniphores
20150707	1646	1	135	2	52.4	66	24.702	168	28.026	0 %	AL19	10.3	138	RJD	
20150707	1659	1	136	1	51.4	66	25.26	168	23.612	0 %	AL20	8.5	129	RJD	
20150707	1703	1	136	2	51.1	66	25.24	168	23.67	0 %	AL20	8.6	115	RJD	
20150707	1716	1	137	1	46.8	66	26.037	168	19.338	0 %	AL21	8.2	130	RJD	
20150707	1720	1	137	2	46.7	66	26.138	168	19.364	0 %	AL21	8.7	128	RJD	
20150707	1732	1	138	1	40	66	26.72	168	15.022	0 %	AL22	7.9	140	RJD	
20150707	1736	1	138	2	39.9	66	26.771	168	15.083	0 %	AL22	6.9	136	RJD	
20150707	1749	1	139	1	32.2	66	27.358	168	10.414	0 %	AL23	7.2	137	RJD	
20150707	1753	1	139	2	32.4	66	27.4469	168	10.61	0 %	AL23	7.1	128	RJD	
20150707	1805	1	140	1	26.1	66	28.069	168	6.195	0 %	AL24	8.7	132	RJD	
20150707	1809	1	140	2	26.1	66	28.181	168	6.263	0 %	AL24	9.5	126	RJD	
20150707	2027	1	141	1	33.4	66	10.21	167	59.972	0 %	NNBS7.5	17.9	189	MG	sea state coming up
20150707	2030	1	141	2	33.5	66	10.261	168	0.025	0 %	NNBS7.5	18.1	186	MG	
20150707	2043	1	142	1	39.9	66	10.227	168	4.213	0 %	NNBS7	17.1	190	MG	
20150707	2046	1	142	2	39.9	66	10.295	168	4.359	0 %	NNBS7	19.5	187	MG	
20150707	2059	1	143	1	46.7	66	10.164	168	8.592	0 %	NNBS6.5	17.1	184	MG	big jellyfish
20150707	2103	1	143	2	46.8	66	10.249	168	8.806	0 %	NNBS6.5	18.5	183	MG	
20150707	2116	1	144	1	48.9	66	10.161	168	12.925	0 %	NNBS6	21.6	195	MG	more jellyfish
20150707	2119	1	144	2	48.9	66	10.257	168	12.859	0 %	NNBS6	21.3	185	MG	
20150707	2132	1	145	1	51.7	66	10.175	168	17.174	0 %	NNBS5.5	18.4	178	MG	
20150707	2136	1	145	2	51.6	66	10.286	168	17.303	0 %	NNBS5.5	19.7	181	MG	
20150707	2149	1	146	1	55.3	66	10.186	168	21.535	0 %	NNBS5	17.6	179	MG	
20150707	2153	1	146	2	56.8	66	10.279	168	21.655	0 %	NNBS5	17.4	187	MG	
20150707	2206	1	147	1	51.9	66	10.198	168	25.86	0 %	NNBS4.5	14.4	179	MG	
20150707	2209	1	147	2	52.1	66	10.208	168	25.761	0 %	NNBS4.5	19.8	162	MG	
20150707	2224	1	148	1	52.1	66	10.157	168	30.095	0 %	NNBS4	18	183	MG	
20150707	2227	1	148	2	52.1	66	10.244	168	30.006	0 %	NNBS4	17.2	189	MG	
20150707	2241	1	149	1	55.8	66	10.169	168	34.509	0 %	NNBS3.5	17.8	178	MG	
20150707	2244	1	149	2	55.7	66	10.27	168	34.62	0 %	NNBS3.5	17.5	179	MG	
20150707	2258	1	150	1	52.9	66	10.181	168	38.97	0 %	NNBS3	20.5	175	MG	
20150707	2301	1	150	2	53.4	66	10.272	168	39.065	0 %	NNBS3	18.1	174	MG	

20150707	2313	1	151	1	53	66	10.171	168	43.169	0 %	NNBS2.5	16.1	171	MB	
20150707	2316	1	151	2	54.2	66	10.209	168	43.209	0 %	NNBS2.5	18.3	176	MB	
20150707	2329	1	152	1	54.1	66	10.157	168	47.384	0 %	NNBS2	15.1	172	MB	
20150707	2332	1	152	2	53.9	66	10.209	168	47.438	0 %	NNBS2	17.6	170	MB	
20150707	2346	1	153	1	53.5	66	10.166	168	51.829	0 %	NNBS1.5	16.1	180	MB	
20150707	2349	1	153	2	53.4	66	10.218	168	51.822	0 %	NNBS1.5	17.9	176	MB	
20150708	3	1	154	1	53.5	66	10.181	168	56.109	0 %	NNBS1	17.3	184	MB	
20150708	6	1	154	2	53.7	66	10.239	168	56.1	0 %	NNBS1	16.3	169	MB	
20150708	104	1	155	1	54.5	66	19.704	168	57.021	0 %	A3-15	16.3	175	MB	
20150708	107	1	155	2	54.5	66	19.716	168	57.012	0 %	A3-15	16.2	180	MB	wrongly named DL19 in hdr
20150708	123	1	156	1	54.7	66	17.842	168	56.21	0 %	DL19	13.3	179	MB	
20150708	126	1	156	2	54.7	66	17.855	168	56.315	0 %	DL19	12.6	182	MB	wrongly named DL18 in hdr
20150708	146	1	157	1	55.5	66	15.333	168	56.192	0 %	DL18	9.8	171	MB	cleaned S1 vent prior to cast, as older data problem
20150708	150	1	157	2	55.7	66	15.34	168	56.282	0 %	DL18	12.3	178	MB	wrongly named DL17 in hdr
20150708	211	1	158	1	55.2	66	12.769	168	56.14	0 %	DL17	11.9	173	rw	headers correct now
20150708	215	1	158	2	55.4	66	12.796	168	56.197	0 %	DL17	13.5	176	rw	
20150708	235	1	159	1	53.3	66	10.237	168	56.283	0 %	DL16	10	163	MB	
20150708	238	1	159	2	53.6	66	10.351	168	56.398	0 %	DL16	8.9	170	MB	
20150708	259	1	160	1	52.6	66	7.69	168	56.138	0 %	DL15	14.5	153	MB	
20150708	303	1	160	2	52.3	66	7.703	168	56.183	0 %	DL15	14.6	153	MB	
20150708	323	1	161	1	53.2	66	5.147	168	56.229	0 %	DL14	14.6	148	MB	Spike in PSU2, then recovered
20150708	326	1	161	2	53	66	5.213	168	56.13	0 %	DL14	15.2	146	MB	
20150708	348	1	162	1	51.2	66	2.553	168	56.135	0 %	DL13	10.3	162	MB	
20150708	351	1	162	2	51.2	66	2.556	168	56.086	0 %	DL13	9.9	160	MB	
20150708	412	1	163	1	50.8	66	0.036	168	56.245	0 %	DL12	5.5	157	GMS	
20150708	416	1	163	2	50.7	66	0.062	168	56.147	0 %	DL12	6	155	GMS	
20150708	425	1	164	1	50.5	65	59.066	168	56.14	0 %	DL11	7	158	GMS	
20150708	428	1	164	2	50.2	65	59.126	168	55.899	0 %	DL11	9	156	GMS	
20150708	438	1	165	1	50.1	65	58.058	168	56.153	0 %	DL10	10.2	163	GMS	
20150708	442	1	165	2	50.2	65	58.083	168	55.973	0 %	DL10	10.9	167	GMS	
20150708	451	1	166	1	49.2	65	57.078	168	56.105	0 %	DL9	11.1	165	GMS	
20150708	454	1	166	2	49.4	65	57.094	168	55.976	0 %	DL9	11	168	GMS	
20150708	504	1	167	1	47.9	65	56.107	168	56.073	0 %	DL8	9.3	165	GMS	
20150708	507	1	167	2	48.2	65	56.168	168	55.877	0 %	DL8	9.3	154	GMS	
20150708	516	1	168	1	47.4	65	55.099	168	56.23	0 %	DL7	9.3	144	GMS	
20150708	519	1	168	2	47.4	65	55.074	168	56.197	0 %	DL7	9.8	131	GMS	
20150708	528	1	169	1	47.4	65	54.141	168	56.239	0 %	DL6	11.4	166	GMS	
20150708	531	1	169	2	47.3	65	54.122	168	56.329	0 %	DL6	14	158	GMS	
20150708	539	1	170	1	46.2	65	53.133	168	56.236	0 %	DL5	9.7	158	GMS	
20150708	542	1	170	2	46.1	65	53.087	168	56.269	0 %	DL5	10.2	164	GMS	
20150708	550	1	171	1	44.6	65	52.15	168	56.127	0 %	DL4	12.9	193	GMS	
20150708	553	1	171	2	45.2	65	52.171	168	55.994	0 %	DL4	11.4	190	GMS	
20150708	602	1	172	1	46.3	65	51.242	168	56.206	0 %	DL3	9.2	175	GMS	
20150708	605	1	172	2	46.3	65	51.265	168	56.294	0 %	DL3	9.3	178	GMS	
20150708	614	1	173	1	45.8	65	50.248	168	56.138	0 %	DL2	12	192	GMS	
20150708	617	1	173	2	45.9	65	50.239	168	56.048	0 %	DL2	7.2	178	GMS	
20150708	625	1	174	1	45.5	65	49.334	168	56.166	0 %	DL1	8.6	191	GMS	
20150708	628	1	174	2	45.8	65	49.431	168	56.1	0 %	DL1	7.5	194	GMS	
20150708	641	1	175	1	42.2	65	49.248	168	52.2	0 %	DLa1	11.5	176	GMS	
20150708	644	1	175	2	43.6	65	49.214	168	52.12	0 %	DLa1	14	183	GMS	
20150708	652	1	176	1	45.2	65	50.279	168	52.138	0 %	DLa2	11.5	169	GMS	
20150708	655	1	176	2	45.2	65	50.306	168	52.136	0 %	DLa2	11.9	167	GMS	
20150708	703	1	177	1	47.3	65	51.264	168	52.258	0 %	DLa3	12.8	165	GMS	
20150708	706	1	177	2	47.4	65	51.306	168	52.289	0 %	DLa3	12.9	162	GMS	
20150708	713	1	178	1	47.9	65	52.24	168	52.16	0 %	DLa4	12.2	172	GMS	
20150708	717	1	178	2	48	65	52.29	168	52.097	0 %	DLa4	12.9	184	GMS	
20150708	725	1	179	1	48.1	65	53.25	168	52.199	0 %	DLa5	14.6	172	GMS	Accidentally named DLa4 in hex file
20150708	728	1	179	2	48	65	53.293	168	52.221	0 %	DLa5	15.3	166	GMS	
20150708	735	1	180	1	48.1	65	54.181	168	52.173	0 %	DLa6	15.1	176	GMS	
20150708	738	1	180	2	48.1	65	54.238	168	52.108	0 %	DLa6	15.4	179	GMS	
20150708	747	1	181	1	49.5	65	55.208	168	52.238	0 %	DLa7	14.3	162	GMS	
20150708	750	1	181	2	49.3	65	55.252	168	52.267	0 %	DLa7	14	159	GMS	
20150708	800	1	182	1	50.4	65	56.142	168	52.083	0 %	DLa8	12.5	159	GMS	
20150708	803	1	182	2	50.3	65	56.182	168	51.995	0 %	DLa8	12.9	168	GMS	

20150708	812	1	183	1	50.3	65	57.089	168	52.221	0 %	DLa9	8.6	181	GMS	
20150708	815	1	183	2	50.3	65	57.098	168	52.322	0 %	DLa9	9.3	181	GMS	
20150708	824	1	184	1	50.3	65	58.07	168	52.138	0 %	DLa10	13	171	GMS	
20150708	827	1	184	2	50.6	65	58.128	168	52.202	0 %	DLa10	13.8	169	GMS	
20150708	835	1	185	1	50.6	65	59.0458	168	52.285	0 %	DLa11	12.7	170	GMS	
20150708	838	1	185	2	50.6	65	59.107	168	52.4	0 %	DLa11	14.9	168	GMS	
20150708	846	1	186	1	51.3	66	0.026	168	52.189	0 %	DLa12	14	175	GMS	
20150708	849	1	186	2	51.4	66	0.073	168	52.169	0 %	DLa12	15.5	174	GMS	
20150708	902	1	187	1	51.5	65	59.996	168	48.22	0 %	DLb12	12.1	188	GMS	
20150708	905	1	187	2	51.4	66	0.058	168	48.059	0 %	DLb12	12.8	180	GMS	
20150708	915	1	188	1	52.2	65	59.054	168	48.198	0 %	DLb11	10.3	192	atn	
20150708	919	1	188	2	52.3	65	59.07	168	48.206	0 %	DLb11	11.3	191	atn	
20150708	929	1	189	1	51.4	65	58.053	168	48.25	0 %	DLb10	7.3	182	atn	
20150708	932	1	189	2	51.5	65	58.056	168	48.23	0 %	DLb10	7.6	193	atn	
20150708	941	1	190	1	51.5	65	57.095	168	48.234	0 %	DLb09	10.1	165	atn	
20150708	945	1	190	2	51.5	65	57.103	168	48.303	0 %	DLb09	12.1	174	atn	
20150708	955	1	191	1	51.4	65	56.126	168	48.264	0 %	DLb08	5.4	189	atn	
20150708	958	1	191	2	51.5	65	56.129	168	48.207	0 %	DLb08	4.5	210	atn	
20150708	1008	1	192	1	51.6	65	55.119	168	48.199	0 %	DLb07	5.2	272	atn	
20150708	1012	1	192	2	51.6	65	55.168	168	48.36	0 %	DLb07	2.3	146	atn	
20150708	1022	1	193	1	51	65	54.129	168	48.139	0 %	DLb06	1.6	303	atn	
20150708	1025	1	193	2	51.3	65	54.151	168	47.957	0 %	DLb06	1.2	293	atn	
20150708	1034	1	194	1	51	65	53.153	168	48.108	0 %	DLb05	8.6	122	atn	
20150708	1038	1	194	2	51	65	53.183	168	47.941	0 %	DLb05	9.5	131	atn	
20150708	1047	1	195	1	50.2	65	52.236	168	47.964	0 %	DLb04	8	110	atn	
20150708	1050	1	195	2	50.6	65	52.311	168	47.868	0 %	DLb04	7.9	116	atn	
20150708	1100	1	196	1	49.3	65	51.251	168	48.029	0 %	DLb03	6.8	75	atn	
20150708	1104	1	196	2	49.4	65	51.261	168	47.982	0 %	DLb03	6.5	95	atn	
20150708	1112	1	197	1	49.4	65	50.27	168	48.065	0 %	DLb02	4	90	atn	
20150708	1116	1	197	2	49.3	65	50.293	168	48.086	0 %	DLb02	4.4	123	atn	
20150708	1124	1	198	1	48.9	65	49.298	168	48.117	0 %	DLb01	6.8	104	atn	
20150708	1128	1	198	2	49	65	49.349	168	47.958	0 %	DLb01	8.4	127	atn	end of DLb line
20150708	1255	1	199	1	50.7	66	0.11	168	55.878	0 %	NBS1	1.4	157	atn	beginning of NBS line eastbound
20150708	1258	1	199	2	50.8	66	0.201	168	55.943	0 %	NBS1	12.5	160	atn	
20150708	1308	1	200	1	50.8	65	59.987	168	53.004	0 %	NBS1.5	10.5	148	atn	
20150708	1312	1	200	2	51	65	59.969	168	52.899	0 %	NBS1.5	9.3	163	atn	
20150708	1322	1	201	1	51.9	65	59.988	168	49.739	0 %	NBS2	11.9	167	atn	
20150708	1325	1	201	2	51.7	66	0.024	168	49.573	0 %	NBS2	10.9	175	atn	
20150708	1339	1	202	1	51.8	66	0.102	168	45.698	0 %	NBS2.5	11.4	174	atn	
20150708	1343	1	202	2	52.1	66	0.204	168	45.845	0 %	NBS2.5	11.7	167	atn	
20150708	1357	1	203	1	51.4	66	0	168	41.5	0 %	NBS3	11.9	184	atn	
20150708	1400	1	203	2	51.6	66	0.057	168	41.362	0 %	NBS3	13.7	183	atn	
20150708	1411	1	204	1	50.8	66	0.033	168	37.467	0 %	NBS3.5	16.3	179	RJD	
20150708	1416	1	204	2	51.2	66	0.082	168	37.066	0 %	NBS3.5	15.4	185	RJD	
20150708	1427	1	205	1	52	65	59.97	168	33.304	0 %	NBS4	16.6	184	RJD	
20150708	1431	1	205	2	52.3	66	0.09	168	33.125	0 %	NBS4	12.7	175	RJD	
20150708	1443	1	206	1	51.7	65	59.984	168	29.259	0 %	NBS4.5	12.6	176	RJD	
20150708	1447	1	206	2	51.5	66	0.101	168	29.082	0 %	NBS4.5	10.5	176	RJD	
20150708	1459	1	207	1	55.1	65	59.974	168	25.117	0 %	NBS5	13	189	RJD	
20150708	1503	1	207	2	55.3	66	0.131	168	24.952	0 %	NBS5	11.4	179	RJD	
20150708	1515	1	208	1	52	65	59.998	168	20.853	0 %	NBS5.5	13.2	186	RJD	
20150708	1520	1	208	2	52.3	66	0.133	168	20.789	0 %	NBS5.5	10.3	180	RJD	
20150708	1532	1	209	1	50.5	65	59.93	168	16.527	0 %	NBS6	11	180	RJD	
20150708	1537	1	209	2	51	66	0.075	168	16.507	0 %	NBS6	8.9	177	RJD	
20150708	1548	1	210	1	48.1	65	59.964	168	12.627	0 %	NBS6.5	11.4	186	RJD	
20150708	1553	1	210	2	48.4	66	0.1	168	12.604	0 %	NBS6.5	7.8	187	RJD	
20150708	1605	1	211	1	45.9	65	59.944	168	8.556	0 %	NBS7	8.3	174	RJD	Huge jelly fish
20150708	1609	1	211	2	46	66	0.066	168	8.602	0 %	NBS7	6.2	187	RJD	
20150708	1621	1	212	1	37.4	65	59.947	168	4.332	0 %	NBS7.5	7.4	192	RJD	Huge jelly fish
20150708	1624	1	212	2	38	66	0.012	168	4.361	0 %	NBS7.5	8.7	201	RJD	
20150708	1638	1	213	1	32.1	65	59.915	168	0.143	0 %	NBS8	6.9	211	RJD	
20150708	1641	1	213	2	32.1	66	0.012	168	0.0118	0 %	NBS8	6.5	200	RJD	
20150708	1654	1	214	1	19.2	65	59.913	167	55.174	0 %	NBS9	9.3	194	RJD	
20150708	1657	1	214	2	19.2	65	59.94	167	55.166	0 %	NBS9	7.8	197	RJD	

20150708	1707	1	215	1	8.3	65	59.961	167	52.032	0 %	NBS10	5.9	172	RJD	
20150708	1710	1	215	2	8.3	65	59.944	167	52.056	0 %	NBS10	6.1	176	RJD	
20150708	2016	1	216	1	46.5	65	51.997	168	55.888	1 %	MBSn1	4.1	180	MG	
20150708	2019	1	216	2	46.9	65	52.017	168	55.838	1 %	MBSn1	4.7	130	MG	
20150708	2030	1	217	1	47.5	65	51.932	168	52.612	0 %	MBSn1.5	5.5	107	MG	
20150708	2033	1	217	2	47.5	65	52.011	168	52.574	0 %	MBSn1.5	4.5	113	MG	
20150708	2043	1	218	1	49.2	65	51.861	168	49.303	0 %	MBSn2	2	172	MG	
20150708	2048	1	218	2	48.8	65	51.945	168	48.877	0 %	MBSn2	1.7	151	MG	
20150708	2059	1	219	1	50.2	65	51.717	168	45.034	0 %	MBSn2.5	2	150	MG	
20150708	2103	1	219	2	51.1	65	51.816	168	45.036	0 %	MBSn2.5	0.9	171	MG	
20150708	2115	1	220	1	50.7	65	51.628	168	41.021	0 %	MBSn3	0.9	11	MG	little jellyfish
20150708	2119	1	220	2	50.7	65	51.713	168	41.014	0 %	MBSn3	0.2	311	MG	
20150708	2133	1	221	1	51.8	65	51.53	168	36.373	0 %	MBSn3.5	1.7	63	MG	little jellyfish
20150708	2136	1	221	2	51.5	65	51.606	168	36.375	0 %	MBSn3.5	2.8	31	MG	
20150708	2150	1	222	1	51.4	65	51.463	168	31.914	0 %	MBSn4	2.6	16	MG	
20150708	2153	1	222	2	51.3	65	51.557	168	31.873	0 %	MBSn4	2.7	21	MG	
20150708	2206	1	223	1	53.8	65	51.325	168	27.539	0 %	MBSn4.5	3.9	7	MG	
20150708	2209	1	223	2	54	65	51.414	168	27.517	0 %	MBSn4.5	4.6	4	MG	
20150708	2224	1	224	1	50.3	65	51.234	168	23.007	0 %	MBSn5	5.4	27	MG	
20150708	2227	1	224	2	50.2	65	51.34	168	22.932	0 %	MBSn5	6.2	17	MG	
20150708	2240	1	225	1	48.9	65	51.144	168	18.498	0 %	MBSn5.5	5.5	42	MG	
20150708	2243	1	225	2	48.9	65	51.264	168	18.398	0 %	MBSn5.5	6.1	41	MG	
20150708	2257	1	226	1	45.1	65	51.18	168	13.747	0 %	MBSn6	4.4	42	MG	kate reports front at ~ 65 51.14, 168 15.7
20150708	2301	1	226	2	43.8	65	51.166	168	12.67	0 %	MBSn6	6.6	35	MG	
20150708	2311	1	227	1	44.6	65	51.108	168	10.682	1 %	MBSn6.5	6.9	52	MB	
20150708	2314	1	227	2	44.6	65	51.206	168	10.587	1 %	MBSn6.5	9.3	53	MB	
20150708	2326	1	228	1	39.1	65	50.879	168	7.222	1 %	MBSn7	9	49	MB	
20150708	2329	1	228	2	38.9	65	50.944	168	7.186	1 %	MBSn7	10.2	50	MB	
20150708	2336	1	229	1	27.7	65	50.872	168	4.393	1 %	MBSn8	9	34	MB	
20150708	2339	1	229	2	27.6	65	50.911	168	4.898	1 %	MBSn8	9.3	30	MB	Finished MBSn line
20150709	45	1	230	1	45.9	65	44.959	168	15.855	1 %	A4-15	9.8	48	rw	Water Sample ~2mabove bot, scan 6937ish, wetlabs not cleaned
20150709	55	1	230	2	46	65	45.332	168	15.704	1 %	A4-15	9.8	43	rw	waited at 30m on up cast to test transponder
20150709	249	1	231	1	45.3	65	48.311	168	55.814	0 %	BS11	1.1	311	MB	
20150709	252	1	231	2	45.3	65	48.301	168	55.713	0 %	BS11	2.5	335	MB	
20150709	300	1	232	1	45.7	65	47.791	168	53.826	0 %	BS11J	3.8	327	MB	
20150709	304	1	232	2	46.2	65	47.832	168	53.835	0 %	BS11J	4.4	329	MB	
20150709	313	1	233	1	43.5	65	47.314	168	51.486	0 %	BS12	5.4	331	MB	
20150709	317	1	233	2	45.1	65	47.369	168	51.348	0 %	BS12	3.1	339	MB	
20150709	325	1	234	1	47.4	65	46.763	168	49.701	0 %	BS12AJ	5.6	332	MB	
20150709	328	1	234	2	47.3	65	46.798	168	49.832	0 %	BS12AJ	6.7	334	MB	
20150709	337	1	235	1	50.3	65	46.312	168	47.634	0 %	BS13	5.2	337	MB	
20150709	341	1	235	2	49.9	65	46.379	168	47.709	0 %	BS13	5.7	344	MB	
20150709	351	1	236	1	50.7	65	45.88	168	45.294	0 %	BS13Z	4.5	337	MB	
20150709	354	1	236	2	50.7	65	45.984	168	45.37	0 %	BS13Z	5.4	14	MB	
20150709	404	1	237	1	50.6	65	45.268	168	43.358	0 %	BS14	4.8	345	GMS	
20150709	407	1	237	2	50.7	65	45.315	168	42.508	0 %	BS14	4.1	350	GMS	
20150709	416	1	238	1	49.8	65	44.775	168	41.636	0 %	BS14J	4.7	275	GMS	
20150709	419	1	238	2	49.9	65	44.788	168	41.498	0 %	BS14J	5.7	278	GMS	
20150709	428	1	239	1	49.6	65	44.3	168	39.772	0 %	BS15	3	8	GMS	
20150709	431	1	239	2	49.5	65	44.277	168	39.687	0 %	BS15	5.3	1.4	GMS	
20150709	439	1	240	1	49.6	65	43.766	168	37.588	0 %	BS15J	4.9	50	GMS	
20150709	443	1	240	2	49.7	65	43.824	168	37.691	0 %	BS15J	2.6	47	GMS	
20150709	452	1	241	1	49.7	65	43.294	168	35.242	0 %	BS16	6.2	60	GMS	
20150709	456	1	241	2	49.6	65	43.279	168	35.179	0 %	BS16	6.1	79	GMS	
20150709	504	1	242	1	50	65	42.731	168	33.271	0 %	BS16J	3.8	60	GMS	
20150709	507	1	242	2	50.7	65	42.744	168	33.101	0 %	BS16J	3.2	51	GMS	
20150709	515	1	243	1	53	65	42.212	168	31.26	0 %	BS17	3	54	GMS	
20150709	518	1	243	2	52.4	65	42.292	168	31.113	0 %	BS17	2.5	38	GMS	
20150709	527	1	244	1	51.4	65	41.682	168	29.148	0 %	BS17S	3.8	21	GMS	
20150709	531	1	244	2	51	65	41.727	168	29.283	0 %	BS17S	3.8	22	GMS	
20150709	541	1	245	1	51.6	65	41.176	168	26.994	0 %	BS18	6	27	GMS	
20150709	544	1	245	2	51.5	65	41.27	168	27.053	0 %	BS18	6.2	28	GMS	
20150709	553	1	246	1	50.8	65	40.762	168	25.241	0 %	BS18J	8.2	45	GMS	
20150709	556	1	246	2	50.8	65	40.766	168	25.167	0 %	BS18J	8.4	41	GMS	

20150709	603	1	247	1	49.5	65	40.373	168	23.485	0	%	BS19	10.3	43	GMS	
20150709	607	1	247	2	49.9	65	40.505	168	23.41	0	%	BS19	11.5	40	GMS	
20150709	619	1	248	1	48.5	65	39.851	168	21.17	0	%	BS19H	10.9	45	GMS	
20150709	622	1	248	2	48.6	65	39.931	168	21.189	0	%	BS19H	11.6	46	GMS	
20150709	634	1	249	1	46.9	65	39.28	168	19.145	1	%	BS20	12.2	46	GMS	
20150709	637	1	249	2	47	65	39.326	168	19.192	1	%	BS20	12.4	36	GMS	
20150709	647	1	250	1	44.4	65	39	168	17	1	%	BS20J	14.4	37	GMS	
20150709	650	1	250	2	44.5	65	38.946	168	17.252	1	%	BS20J	13.8	36	GMS	
20150709	701	1	251	1	40	65	38.532	168	14.832	1	%	BS21	14.5	43	GMS	
20150709	704	1	251	2	40.1	65	38.606	168	14.887	1	%	BS21	15	39	GMS	
20150709	715	1	252	1	36.9	65	37.976	168	12.786	1	%	BS21A	12.9	44	GMS	
20150709	718	1	252	2	37	65	38.032	168	12.815	1	%	BS21A	14.5	39	GMS	
20150709	730	1	253	1	30.1	65	37.477	168	10.722	1	%	BS22	14.4	38	GMS	
20150709	733	1	253	2	30	65	37.511	168	10.679	1	%	BS22	12.3	25	GMS	
20150709	758	1	254	1	24.4	65	34.87	168	7.059	1	%	BS24	17.5	53	GMS	also SBS1
20150709	800	1	254	2	24.3	65	34.904	168	7.096	1	%	BS24	11.1	32	GMS	SBS1
20150709	816	1	255	1	37	65	33.922	168	11.884	1	%	SBS2	16	24	GMS	
20150709	818	1	255	2	36.8	65	33.964	168	11.979	1	%	SBS2	16.6	13	GMS	
20150709	834	1	256	1	42.3	65	32.969	168	16.836	0	%	SBS3	15.2	35	GMS	
20150709	837	1	256	2	42.4	65	32.991	168	16.832	0	%	SBS3	14.6	21	GMS	
20150709	854	1	257	1	46.5	65	31.931	168	21.61	0	%	SBS4	12.9	22	GMS	
20150709	857	1	257	2	46.5	65	31.956	168	21.867	0	%	SBS4	18	32	GMS	
20150709	912	1	258	1	57.4	65	30.917	168	26.502	0	%	SBS5	11.6	15	GMS	
20150709	916	1	258	2	57.6	65	30.97	168	26.728	0	%	SBS5	16.4	32	GMS	