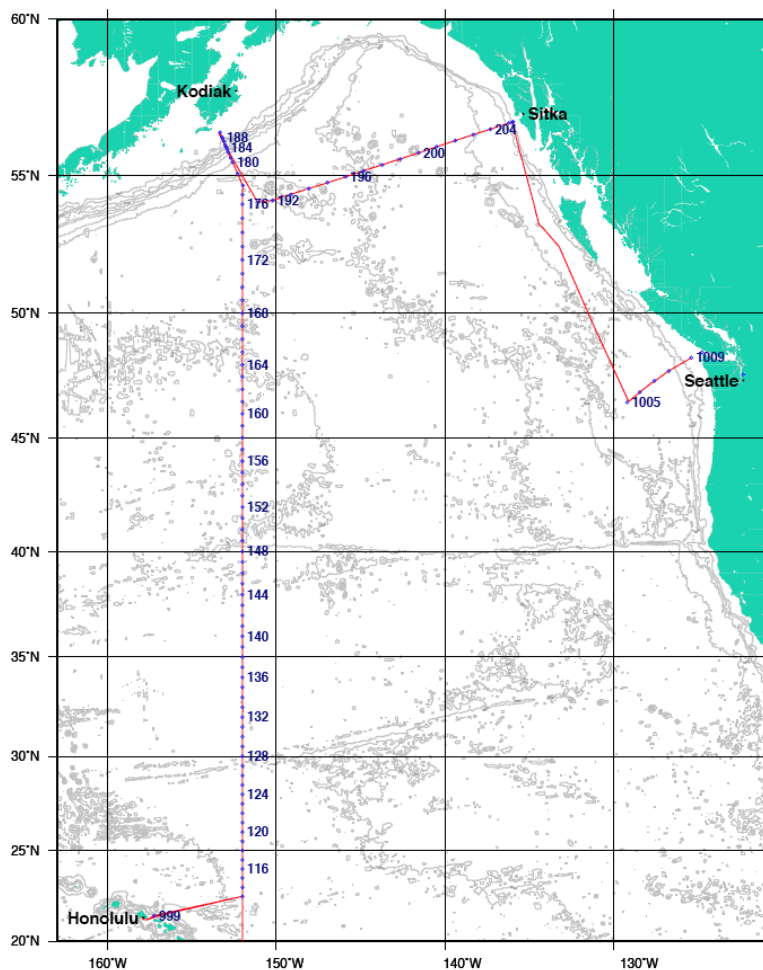


CRUISE REPORT: P16N

(Updated AUG 2015)



Highlights

Cruise Summary Information

Section Designation	P16N
Expedition designation (ExpoCodes)	33RO20150525
Chief Scientist	Alison Macdonald / WHOI
C0-Chief Scientist	Sabine Mecking / UW/APL
Dates	25 May 2015 – 27 June 2015
Ship	NOAAS Ronald H. Brown
Ports of call	Honolulu, Hawaii – Seattle, Washington
Geographic Boundaries	56° 47.40' N 153° 20.39' W 135° 57.03' W 22° 29.96' N
Stations	95
Floats and drifters deployed	5 Argo floats were deployed.
Moorings deployed or recovered	0

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Links To Select Topics

Shaded sections are not relevant to this cruise or were not available when this report was compiled.

Cruise Summary Information	Hydrographic Measurements
Description of Scientific Program	CTD Data:
Geographic Boundaries	Acquisition
Cruise Track (Figure): PI CCHDO	Processing
Description of Stations	Calibration
Description of Parameters Sampled	Temperature Pressure
Bottle Depth Distributions (Figure)	Salinities Oxygens
Floats and Drifters Deployed	Bottle Data
Moorings Deployed or Recovered	Salinity
	Oxygen
Principal Investigators	Nutrients
Cruise Participants	Carbon System Parameters
	CFCs
Problems and Goals Not Achieved	Helium / Tritium
Other Incidents of Note	Radiocarbon
Underway Data Information	References
Navigation Bathymetry	CFCs
Acoustic Doppler Current Profiler (ADCP)	Oxygen
Thermosalinograph	Dissolved Inorganic Carbon
XBT and/or XCTD	pH
Meteorological Observations	Total Alkalinity
Atmospheric Chemistry Data	Nutrients
	Underwater Vision Profiler
Lowered Acoustic Doppler Current Profiler (LADCP)	Bottle Quality Codes and Comments
Data Processing Notes	Acknowledgments

GO-SHIP CLIVAR/Carbon P16N Leg 2

NOAAS Ronald H. Brown
25 May 2015 – 27 June 2015
Honolulu, Hawaii – Seattle, Washington

Chief Scientist:
Dr. Alison Macdonald
Woods Hole Oceanographic Institution

Co-Chief Scientist:
Dr. Sabine Mecking
University of Washington, APL

Preliminary Cruise Report
27 June 2015

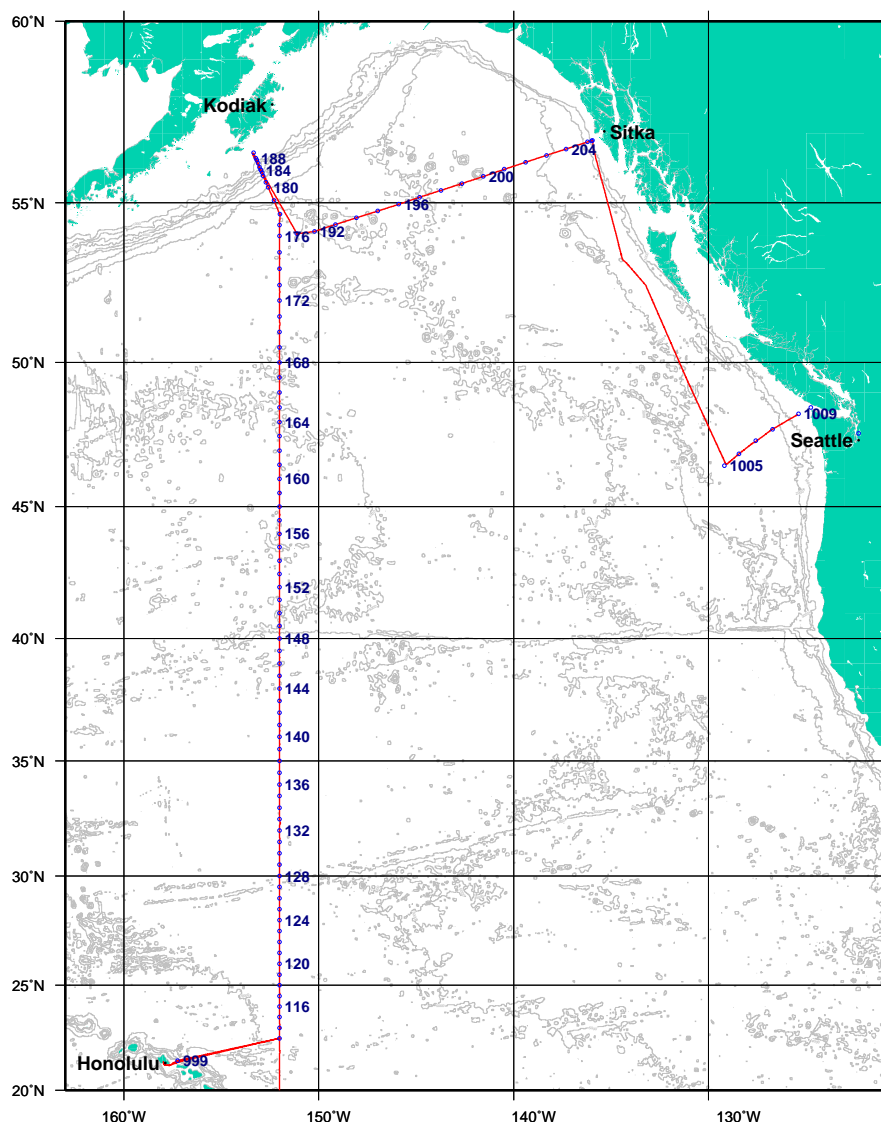
CTD Data Submitted by:

Kristene E. McTaggart
National Oceanic and Atmospheric Administration, PMEL
Seattle, WA
And
James Hooper
National Oceanic and Atmospheric Administration, AOML
Miami, FL

Bottle Data Submitted by:

Courtney Schatzman
Shipboard Technical Support/Oceanographic Data Facility
Scripps Institution of Oceanography/UC San Diego
La Jolla, CA

P16N Leg 2 Cruise Track



Cruise Narrative

Abstract

The GO-SHIP repeat occupation of the pre-WOCE 1984, WOCE 1991 and CLIVAR 2006 P16N/Leg 2 along 152°W between Hawaii and Kodiak Island was successfully completed aboard the NOAA ship Ronald H. Brown from 25 May, 2015 to 27 June, 2015. The cruise also included a repeat of one segment of the 1993 P17N section. Academic institutions, NOAA research laboratories, as well as some NSF funded scientists and students participated in P16N/Leg 2. This project was one of a number of decadal reoccupations of hydrography sections jointly funded by NOAA-COD/CPO (Climate Observation Division of the Climate Program Office) and NSF-OCE (National Science Foundation Division of Ocean Sciences) as part of the GO-SHIP (Global Ocean Ship-Based Hydrographic Investigation Program) /CO2/hydrography/tracer program.

More details on the program can be found at the websites:

<http://ushydro.ucsd.edu> and www.go-ship.org/

Data from this cruise are available from CCHDO at:

http://cchdo.ucsd.edu/data_access/show_cruise?ExpoCode=33RO20150525

The informal "blog" that recounted some of the cruise highlights can be found at:

<http://clivarp16n2015.blogspot.com/>

and will also be accessible through the US Hydro website at:

<http://ushydro.ucsd.edu/outreach/content/2015/04/18/p16n-2015-blog/>

The GO-SHIP Repeat Hydrography Program focuses on the need to monitor inventories of CO₂, heat and freshwater and their transports in the ocean, and provides the only available high quality, multi-variable, basin-scale time-series of the full water column. It provides an observational framework to monitor long-term trends as well as decadal variability. Together with the results of the earlier CLIVAR, WOCE and JGOFS programs, GO-SHIP observations are used to assess changes in the ocean's physical and biogeochemical cycles through the continued re-occupation of a set of hydrographic transects with full water column measurements over the global ocean to support: heat, freshwater and carbon system studies, deep and shallow water mass and ventilation studies, calibration of autonomous sensors, and model calibration and validation.

Track

Leg 2 of the 2015 P16N transect (henceforth referred to as Leg 2), which started out from Honolulu, HI and ended in Seattle, WA, was the third component of GO-SHIP's full P16 line. P16S along 150°W, 67°S to 15°S was occupied spring 2014. P16N/Leg 1, occupied between 11 April and 11 May, 2015 began just south of where P16S left off at 16.5°S, along 152°W to 22.5°N (P16N stations 1 to 112). Leg 2 extended the line from 22.5°N to 54.66°N along 152°W (P16N stations 113 to 176) before turning northwestward to cross perpendicular to the bathymetric contours of the Alaskan Slope onto the Alaska Shelf (stations 177 to 189 at 56.44°N, 153.34°W), including one station in the center of the Aleutian Trench (station 181 at 55.60°N, 155.70°W, 5382m depth). Station 190 occupied the same position as station 184 in the Alaskan Current (55.95°N, 152.98°W), but placed a focus on bottle samples in the deep and bottom waters. The cross-gyre section is made up of station 176 (56.44°N, 152°W) and stations 191 (54.07°N, 151.11°W) to 207 (56.79°N, 135.95°W) running northeastward across the Alaskan Gulf along a line similar to the WOCE P17N section in 1993. Nominal stations spacing for Leg 2 was 30 nm (0.5° latitude) along 152°W, with closer spacing over the slope and shelf. The cross-gyre section used a nominal 40 nm spacing. Eighteen stations west of 152°W that would have provided further sampling of the shelf and a second crossing of the northern slope following the track of WOCE P17N line were planned, but removed before the cruise began due to a delay in the departure out of Hawaii (see below).

Bottle Sampling Program

At each of the 95 Leg 2 stations the 24-bottle rosette was sent down to within approximately 10 m of the bottom. At all, except the shallowest slope/shelf locations, all bottles were fired. At 20 of these locations, the rosette was sent down a second time to approximately 1000 m to collect samples for later cesium analysis. Again all 24 bottles were fired. Three rotating staggering schema each were used to fully measure the water on both the full water column and the thousand meter casts.

This produced a collection of 2740 water samples for analyses of a variety of parameters including: salinity, dissolved oxygen, nutrients (phosphate, silicate, nitrate and nitrite), chlorofluorocarbons (CFCs), sulfur hexafluoride (SF₆), dissolved inorganic carbon (DIC), total alkalinity, two types of pH measurements, radiocarbon (DI¹⁴C), dissolved organic carbon (DOC and DO¹⁴C), chromophoric dissolved organic material (CDOM), particulate organic carbon (POC), chlorophyll, tritium, helium, black carbon, cesium (¹³⁴Cs and ¹³⁷Cs), strontium (⁹⁰Sr) and iodine (¹²⁹I).

The rosette also carried a CTDO system (conductivity, temperature, pressures, oxygen), a transmissometer, fluorometer, Under Water Vision Profiler (UVP), upward and downward looking Lowered Acoustic Doppler Profilers (LADCP), as well as a pair of upward and downward looking chi-pods. At all stations where cesium sampling occurred, a surface sample was also taken from the ship's seawater intake. At each station where CDOM sampling occurred, surface samples for phytoplankton pigments (HPLC) and particulate absorption spectra (AP) were also taken from the ship's seawater intake. Once a day, when a hydrographic station was occupied around

midday a light profiling spectro-radiometer was deployed. Over the course of Leg 2 these casts occurred 32 times. Once a night, when a station occurred around midnight, bongo nets were deployed to collect pteropods for later analysis testing in vivo adaptation strategies to rising CO₂ levels (29 net tows in all). Five Argo floats were deployed. Underway data collection included upper-ocean current measurements from the shipboard ADCP, surface oceanographic (temperature, salinity, fluorescence, chlorophyll pigments, and carbon dioxide) and meteorological parameters from the ship's underway systems and bathymetric data and atmospheric measurements.

Successes and Challenges

Prior to the P16N cruise, Leg 2 stations were categorized as being part of the primary objective (the 152°W reoccupation), the secondary objective (the Alaskan Shelf and Gyre reoccupation of some of the P17N stations) or supplemental (11 stations providing closer spacing on the shelves and slopes). During the in-port in Hawaii between legs 1 and 2, after a variety of repair attempts, the Brown's engineers and local service personnel determined that one of the ship's air conditioning units required replacement. With so many aspects of the cruise dependent upon good air conditioning (from the z-drive to science) it was considered imprudent to head out without both the large air conditioning units working. A refurbished compressor was shipped overnight from the east coast and the service company doing the installation and Brown's engineers worked through the Memorial Day holiday weekend to have the ship ready to leave on Monday, May 25 from Pearl Harbor (instead of May 19 as originally planned). This delay took 6 days of the 38 days-at-sea allotted to Leg 2. Two days were returned to give a total of 34 days-at-sea, moving our arrival date in Seattle from June 25, as originally planned, to June 27. To account for the loss of 4 days, the secondary objective shelf/slope P17N repeat stations were removed from the cruise plan. The delayed return into Seattle also meant that one member of the science party could not participate, and a substitute data processor from SIO flew in from San Diego on short notice.

Generally speaking, the CTD, along with the many instruments on the package, behaved well. Effective water conservation practices meant that in spite of the large number of samples being taken, everyone was able to get the water they needed for analysis. In spite of a few sensor, plumbing, and battery issues with individual instruments on the rosette (see individual instrument sections), no major technical difficulties occurred. Those on the deck and in the winch house mastered the coordinated use of wires from both the aft (rosette package) and forward (bongo net) winch blocks. There was one incident when the package connected with the side of the ship as it swung out of the water, but no issues with the instrumentation occurred afterward. The greatest technical challenge came when the need arose to switch the rosette from the aft winch block to the forward winch block.

Throughout the voyage the ship was quite concerned about the lifetime of the aft winch wire, which at only 2 months old was already showing signs of rust, first below 4000 m and then below 5000 m. Although the wire was lubed on leg 1, this lubing was done on one cast and the wire was immediately deployed (and hence rinsed) on the next cast. The manufacturer suggested a particular applicator (purchased while in port in Hawaii) and a two-day soak period before using the wire again for the next lubrication. It made sense to do the lubing on a deeper cast. Short term science goals made lubing the wire undesirable due to loss of time switching blocks, reterminating the forward wire, and the possible effects on organics measurements. On the other hand, knowing the need for GO-SHIP cruises to be possible on the Brown well into the future, it was recognized that wire maintenance was necessary. In an effort to impact the science as little as possible, the forward wire was prepared ahead of time and the decision was made to give up bongos for two nights. The lubing was performed on station 141 (5844 m depth). The last 500 m of wire were not lubed.

On the next station (142), deployment of the package on the forward winch saw multiple modulo and modem errors on the 1000 m cesium cast. Although, it appeared all bottles had fired properly on the short cast, the sheer number of errors that occurred early in the subsequent full cast required that the cast be aborted. Keeping focus on the primary objective of completing the occupation the 152°W line, rather than moving on, it was decided to stay on station and reterminate. Modem errors continued on ensuing casts until the junction box connections and slip rings were changed. However, throughout this period, the data from the package appeared reasonable and all bottles fired as expected. Upon return to the aft winch similar problems were encountered, and were dealt with in a similar manner (although no reterminations were necessary). In the end, only about 3 hours were lost due to the extra retermination, along with some further time associated with slower deployments and recoveries on the unfamiliar forward winch (which required an air tugger to place the rosette on its platform upon recovery) and another 45 minutes due to an unrelated mishap with LADCP that required that the battery be changed out. The DO¹⁴C group moved one of their sampling positions slightly further north to avoid contamination, and DOC was measured on the two stations after

the lubing to see whether any effect would be visible. Further details on particular sensor issues encountered during the cruise are provided later in this document.

With only a few days of mild rain and choppy waters, throughout most of the cruise, the weather was very comfortable for sampling operations. Two days were more than excellent with bright sunshine and complete calm. On the trips northward and eastward through the Gulf of Alaska the lengthening of the day to midsummer was made less apparent by the thick fog that enshrouded the ship, reduced visibility and caused incessant sounding of the ship's horn. The fog did not, however, impede the progress of sampling. Although the calm waters were an asset the fog did not make for ideal conditions for the spectro-radiometer casts, which continued nevertheless.

One item we do wish to report concerns the multi-beam bathymetric recorder. Perhaps those with greater familiarity with these instruments would have known better, but we report the following experience as a cautionary tale for GO-SHIP cruises which regularly run the multi-beam underway while steaming at full speed. While running at more than 11.5 knots in 4000 m of water, the CTD watch glanced up to see a huge circular crater more than 6000 m deep on the multi-beam display. The ship steamed straight across the center of this feature. A couple of days later, a similar feature was seen with the ship's track skirting the edge of a seemingly circular 6000+ m drop off. The bathymetric map said it was a seamount. After the station 4 nm away, time was taken to go back for a second look with all bathymetric readers running at the recommended survey speed of 8 knots. No crater was found, only the seamount. The suspicion is that this is a multi-beam glitch that occurs when the gates are set for a specific depth range and suddenly a much shallower feature appears. On the display black dropouts surrounding the deeper values indicate the problem.

All over-the-side operations were completed on the morning of 23 June. Once out of Canadian EEZ waters on our steam to Seattle, underway measurements and in particular, underway surface cesium sampling resumed. On P16N/Leg 2, all the planned stations (barring the shelf loop removed during our delay in Hawaii) and 2 extra, for a total of 95 stations (not including the test station) were completed. At these locations the rosette was lowered with CTD & oxygen sensors, transmissometer, LADCP, UVP, and chi-pods in and out of the water 115 times. We performed bongo operations every night, except for the 2 nights when the lubrication was soaking into the wire (29 in total), C-Ops occurred every day there was any chance of getting results (32 times), and 5 Argo floats were deployed.

Table P16N Argo Float Deployment

Float S/N	Date/Time Deployed	Lat	Lon	CenterBeam Depth
ARGO 462	2015-06-02 23:41	32 N	152 W	5436
ARGO 463	2015-06-04 06:15	35 N	152 W	5714
ARGO 464	2015-06-11 06:01	46 N	152 W	5341
ARGO 466	2015-06-13 04:28	49 N	152 W	5023
ARGO 467	2015-06-14 22:23	52 N	152 W	5107

Along the way, analysis of the observations began, in particular the examination of thermocline and deep changes since the previous P16N occupation in 2006. Quality control through the checking for systematic offsets between the two occupations was also continuously performed. One feature that has drawn much public attention, the elevated sea surface temperatures in the northeastern North Pacific (aka "the blob") that have been affecting Pacific Northwest climate, is clearly visible in 2015 underway SST data. We look forward to all the efforts that will analyze and synthesize our new P16N data in a larger context.

Acknowledgements

The successful completion of the cruise relied on dedicated assistance from many individuals on shore and on the NOAA ship Ronald H. Brown. Funded investigators in the project and members of the GO-SHIP Repeat Hydrography program were instrumental in planning and executing the cruise. We would like to thank everyone who has participated in 2015 GO-SHIP P16N repeat, onboard and on land, and who has helped make this cruise a success. The collaboration between leg 1 and leg 2 participants began in the planning stages and was strong on all fronts. All Leg 2 cruise participants displayed dedication and camaraderie throughout their 34 days at sea as well as during the initial week delay.

Officers and crew of the Ronald H. Brown exhibited a high degree of professionalism and assistance to accomplish the mission and to make us feel at home during the voyage. The crew was an enormous help with all aspects of our operations, especially in orchestrating the dance among the CTD, Bongo and C-ops. The Brown's engineers worked tirelessly to keep the ship running. The mess crew kept us well fed and provided thrice-daily doses of humor. Our winch operators took us to the bottom of the ocean and back again 115 times. The Brown's operations officer Lt. Adrienne Hopper started early providing the co-chiefs of both legs with an onshore connection to the ship, answering questions and assisting in the definition of the cruise instructions. Onboard Lt. Hopper provided an open, responsive and always positive connection between the science party and crew. The CO Robert Kamphaus led operation safety meetings during the cruise with the co-chiefs six days a week that were not only informative, but also further strengthened the crew/science party relationship. Other individuals we wish to thank include: Electronics Technician Jeff Hill and Bosun Bruce Cowden, who together with the science party's CTD-processor/ET Jay Hooper and salt analyst/ET Andy Stefanick provided a wealth of troubleshooting experience to get us out of all logistical, technical and mechanical difficulties. Although many on the Brown bring a long history of experience to their jobs, Leg 2 began with new crew members on the bridge, in the winch house, and on the deck working alongside numerous first timers in the science party. It is only through the combined efforts of all parties that safe and efficient progress was made. It was the team spirit among scientists, officers, and crew that made the cruise particularly enjoyable. We would like to acknowledge and thank all of them.

On land, CDR Thomas Pelzer provided much needed help with both the writing of the cruise instructions and the connection to the Brown. The US Repeat Hydrography / CO2 Program is sponsored by NOAA's Office of Climate Observation. In particular, we wish to thank program managers Kathy Tedesco (NOAA), Eric Itsweire (NSF/OCE) and Donald Rice (NSF/OCE) for their financial and moral support of the effort.

P16N Leg 2 Participating Institutions

Abbreviation	Institution
AOML	Atlantic Oceanographic and Meteorological Laboratory - NOAA
APL	Applied Physics Laboratory - UW
CIMAS	Cooperative Institute for Marine and Atmospheric Studies - RSMAS/UM
JISAO	Joint Institute for the Study of the Atmosphere and Ocean - UW
LDEO	Lamont-Doherty Earth Observatory - Columbia University
MIT	Massachusetts Institute of Technology
MPL	Marine Physical Laboratory - SIO
ODF	Oceanographic Data Facility (Shipboard Technical Support) - SIO
PMEL	Pacific Marine Environmental Laboratory - NOAA
RSMAS	Rosenstiel School of Marine and Atmospheric Science - UM
SIO	Scripps Institution of Oceanography
UAF	University of Alaska Fairbanks
UCI	University of California, Irvine
UCSB	University of California, Santa Barbara
UCSD	University of California, San Diego
UM	University of Miami
UW	University of Washington
WHOI	Woods Hole Oceanographic Institution

Principal Programs of P16N Leg 2

Analysis	Institution	Principal Investigator	email
CTDO	NOAA/PMEL NOAA/AOML	Gregory Johnson Molly Baringer	Gregory.C.Johnson@noaa.gov Molly.Baringer@noaa.gov
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Transmissometer	TAMU	Wilford Gardner	wgardner@ocean.tamu.edu
Underwater Vision Profiler (UVP)	UAF	Andrew McDonnell	amcdonnell@alaska.edu
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³ He / Neon / Tritium	WHOI	William Jenkins	wjenkins@whoi.edu
Dissolved O ₂	RSMAS NOAA/AOML	Chris Langdon Molly Baringer	clangdon@rsmas.miami.edu Molly.Baringer@noaa.gov
Total CO ₂ (DIC) / UW pCO ₂	NOAA/PMEL NOAA/AOML	Simone Alin Rik Wanninkhof	Simone.R.Alin@noaa.gov Rik.Wanninkhof@noaa.gov
Total Alkalinity/pH	SIO/MPL	Andrew Dickson	adickson@ucsd.edu
¹³ C / ¹⁴ C-DIC	PU WHOI	Robert Key Ann McNichol	key@princeton.edu amcnichol@whoi.edu
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DO ¹⁴ C / Black Carbon	UCI/ESS	Ellen Druffel	edruffel@uci.edu
CDOM / POC / Chlorophyll a UW HPLC Pigments / AP Spectroradiometry / AP	UCSB/ERI	Norm Nelson	norm@eri.ucsb.edu
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Salinity	NOAA/AOML NOAA/PMEL	Molly Baringer Gregory Johnson	Molly.Baringer@noaa.gov Gregory.C.Johnson@noaa.gov
¹³⁷ Cs / ¹³⁴ Cs / ⁹⁰ Sr / ¹²⁹ I	WHOI	Ken Buesseler	kbuesseler@whoi.edu
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ARGO Floats	NOAA/PMEL	Gregory Johnson	Gregory.C.Johnson@noaa.gov
Shipboard ADCP	UH UH	Eric Firing Jules Hummon	efiring@hawaii.edu hummon@hawaii.edu

P16N Leg 2 Scientific Personnel

Duties	Name	Affiliation	email
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CTD/Salinity/LADCP/ET	Andrew Stefanick	AOML	andrew.stefanick@noaa.gov
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Nutrients	Eric Wisegarver	PMEL	eric.wisegarver@noaa.gov
DIC/underway pCO2	Robert Castle	AOML	robert.castle@noaa.gov
DIC	Brendan Carter	JISAO	brendan.carter@noaa.gov
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pH	Michael Fong	UCSD	mbfong@ucsd.edu
Helium/Tritium	Zoe Sandwith	WHOI	zsandwith@whoi.edu
CDOM	Erik Stassinis	UCSB	eriks@eri.ucsb.edu
CDOM	Kelsey Bisson	UCSB	kbiss0990@gmail.com
Chipod	Bryan Kaiser	WHOI/MIT	bryankais@gmail.com
UVP/Bongo	Jessica Turner	UAF	jessie.turner@alaska.edu
DO14C/black carbon	Brett Walker	UCI	Brett.walker@uci.edu
DOC/TDN	Benjamin Granzow	UM	b.granzow@umiami.edu
Cesium Isotopes	Steven Pike	WHOI	spike@whoi.edu

P16N Leg 2 Ship's Crew

Crew Member	Position	Crew Member	Position
CAPT Robert Kamphaus	Commanding Officer	CB Bruce Cowden	Chief Bosun
LCDR Nicole Manning	Executive Officer	BGL Reggie Williams	Bosun Group Leader
ENS David Owen	Navigation Officer	AB Vicky Carpenter	Able-Bodied Seaman
LT Adrienne Hopper	Operations Officer	AB William Sutton	Able-Bodied Seaman
ENS Dustin Picard	Safety Officer	AB Mike Lastinger	Able-Bodied Seaman
3M David Owen	Third Mate	AB James Deeton	Able-Bodied Seaman
LCDR James McEntee	Medical Officer		
CME Frank Dunlop	Chief Engineer	CS Michael Smith	Chief Steward
1AE Mike Ryan	1st Asst. Engineer	CC Orcino Tan	Chief Cook
2AE Ray Zarzycki	2nd Asst. Engineer	2C Emir Porter	Second Cook
3AE Avery Edson	3rd Asst. Engineer	GVA George Washington	General Vessel Asst.
JUE Mike Robinson	Jr. Unlicensed Engineer		
EU Mike Johnston	Engine Utilityman		
CET Jeff Hill	Chief Electronics Tech.	ST Scott Allen	Survey Tech.
		ST Mark Bradley	Survey Tech.

Measurement Program Summary

A 24-position, 11-liter Bullister bottle rosette frame (NOAA/AOML) was used to collect data. The distribution of the bottle samples during the cruise can be seen in Figures 1 and 2 below.

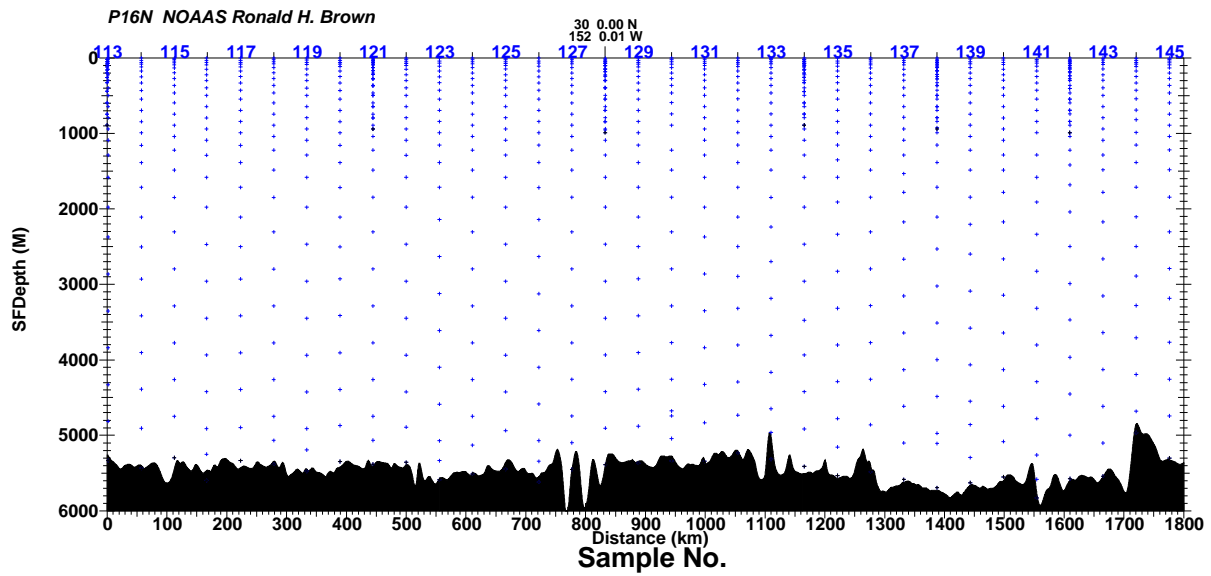


Figure 1 P16N Leg 2 Sample distribution, stations 113-145.

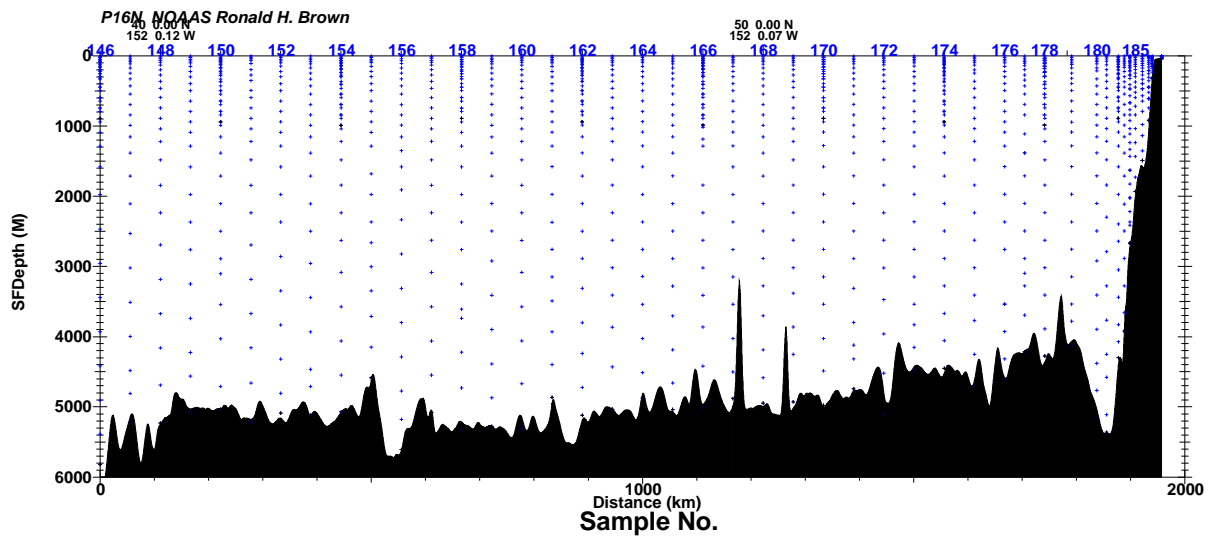


Figure 2 P16N Leg 2 Sample distribution, stations 146-190.

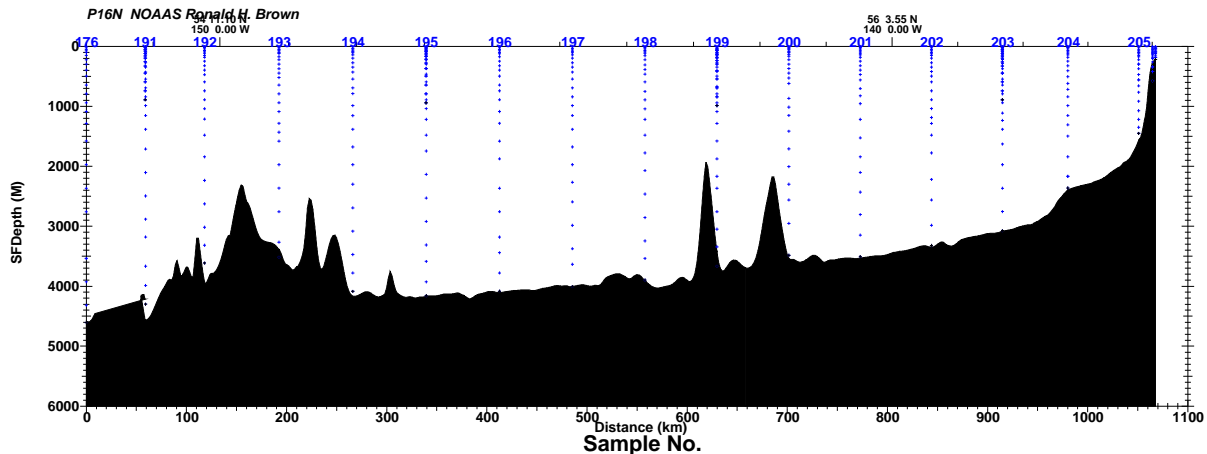


Figure 3 P17E Leg 2 Sample distribution, stations 176 191-205.

Ship's Underway Data Acquisition

Navigation data were acquired at 1-second intervals from the ship's Furuno GP150 P-Code GPS receiver by the SIO/ODF Linux system from the start of the cruise. In addition, centerbeam depth data, with a correction for hull depth included in each data line, were acquired directly from the ship's Seabeam/Kongsberg EM122 system. These data were used to connect the timestamps for each cruise deployment with position and ocean depth information.

The centerbeam depths were also continuously displayed, and data were manually recorded at cast start/bottom/end on CTD Cast Logs.

Etopo2 bathymetry data were merged with navigation time-series data after each cast and used for bottle-depth sections shown elsewhere in this report.

Various underway data were sent from the ship's computer systems to a serial feed on the Linux system. These data were stored at 1-second intervals:

Column	Data Type and units
1	Winch payout (uncorrected meters)
2	Winch speed (meters/minute)
3	Winch tension (pounds)
4	Multibeam Bottom Depth (meters to tenths) - corrected for Sound Velocity but not for hull depth (approx. 5.8m more)
5	UTC Julian Date (day of year in 2015)
6	UTC Time (hh:mm:ss) (hh=hours, mm=minutes, ss=seconds)
7	GPS Latitude (ddmm.mmmH) (d=degrees, m=minutes to 4 places, H=Hemisphere)
8	GPS Longitude (dddmm.mmmH)
9	TSG Sea Surface Temp (SST - degrees Celsius)
10	TSG Sea Surface Salinity (last calibrated 7-Jan-2015)
11	True Wind Speed (knots) - divide by 1.9438445 to get m/sec
12	True Wind Direction (compass degrees)
13	Barometer - Sea Level (millibars)
14	Relative Humidity (%)
15	Air Temperature (degrees Celsius)

Underwater Electronics Package

A Sea-Bird Electronics SBE9plus CTD was connected to a 24-place SBE32 carousel, providing for two-conductor sea cable operation. Two conducting wires in the 0.322 sea cable were soldered to their counterparts in the end termination: black for signal, and white for ground; the third (red) wire was cut back/unused. Power to the CTD and

sensors, carousel and most instruments attached to the CTD was provided through the sea cable from an SBE11*plus* deck unit in the computer lab.

The CTD supplied a standard SBE-format data stream at a data rate of 24 Hz. The CTD provided pressure plus dual temperature, conductivity and dissolved oxygen channels. The CTD system also incorporated an altimeter, transmissometer, fluorometer, and Underwater Vision Profiler (UVP). A Lowered Acoustic Doppler Profiler (LADCP) and Chipods were also mounted on the rosette frame; both were powered separately and collected data internally.

The CTD system was outfitted with dual pumps. Primary temperature, conductivity and dissolved oxygen were plumbed into one pump circuit; and secondary temperature, conductivity and oxygen were plumbed into the other. The CTD and sensors were deployed vertically. The primary temperature and conductivity sensors were used for reported CTD temperatures and salinities on all casts. The secondary temperature and conductivity sensors were used as calibration checks.

Table P16N Underwater Package Configuration

Manufacturer/Model	Serial No.	Calib.Date	Stations Used
Markey DESH-5 Winch	AFT	n/a	999, 113-141, 146-207
	FWD	n/a	142-145
Electrical and Mechanical Reterminations Before These Stations			142/2
Sea-Bird SBE11 <i>plus</i> Deck Unit	11P9852-0367 11P111660		999, 113-185, 187-207 186
Sea-Bird SBE32 Carousel Water Sampler (24-place)	1032	n/a	999, 113-207
Sea-Bird SBE35RT Reference Temperature	0072	03-Jan-2012	999, 113-207
Sea-Bird SBE9 <i>plus</i> CTD Paroscientific Digiquartz Pressure	0489 0489-67264	05-Sep-2014	999, 113-207
Primary Sea-Bird Sensors:			
SBE3 <i>plus</i> Temperature (T1)	03P-4341	20-Jan-2015	999, 113-207
SBE4C Conductivity (C1)	04-3157	21-Jan-2015	999, 113-207
	43-1835	03-Feb-2015	999, 113-163
SBE43 Dissolved Oxygen	43-2934	02-Aug-2014	163-165
	43-0315	06-Feb-2015	166-207
SBE5 Pump	05-5855 05-5946	n/a	999, 113-162 163-205
Secondary Sea-Bird Sensors:			
SBE3 <i>plus</i> Temperature (T2)	03P-4193	20-Jan-2015	999, 113-207
SBE4C Conductivity Sensor (C2)	04-3068	22-Jan-2015	999, 113-207
	43-0312	05-Mar-2015	999, 113-149, 151-207
SBE43 Dissolved Oxygen	43-1890	15-Jan-2015	150/2
	43-0313	03-Feb-2015	150/3
	05-3481	n/a	999, 113-162/1
SBE5 Pump	05-5946 05-5855	n/a n/a	162/2 163-207
Other Devices Connected to CTD:			
Valeport VA500 Altimeter	47972 47973	n/a n/a	999, 113-176 177-207

Manufacturer/Model			Serial No.	Calib.Date	Stations Used
HYDROPTIC UVP5 Underwater Vision Profiler			009	12-Sep-2013	999, 113-207 (internally recorded)
WETLabs C-Star Transmissometer			CST-1636DR	08-Oct-2013	113-207
Teledyne RDI WHM150-1-UG15 LADCP					
150KHz Downlooker/Master			19394		999, 113-117, 134-207
300KHz Downlooker/Master			12243		118-133
300KHz Uplooker/Slave			13330		113-171
300KHz Uplooker/Slave			12243		172-207
Chipod Serial Nos. (OSU-assembled - no Mfr)					
Up/Down Looker	Logger Board	Pressure Case	Sensor	Sensor Holder	Stations Used
Up	2015	Ti44-6	14-26D	1	113-207
Up	2016	Ti44-1	14-28D	4	113-146
Up	2014	Ti44-8	14-28D	4	147-207
Down	2010	Ti44-5	11-23D	2	113-207
Down	2019	Ti44-3	14-27D	6	113-142
Down	2013	Ti44-3	14-27d	6	143-180,182-207

Underwater Electronics Package Challenges

The *NOAAS Ronald H. Brown* has two Markey DESH-5 winches. The AFT winch was used for most casts on P16N. The FWD winch was used for stations 142-148. Reterminations of the winch wires are listed in the first part of the table preceeding this section.

The CTD was switched over to the forward winch after lubricating the aft winch cable during station 141. Several modulo and unsupported modem errors where seen in stations 142 and 143. The slip ring was replaced by Jeff Hill on the forward winch, which resolved the issues.

Station 150 had large oxygen differences during the surface soak. The secondary oxygen sensor, 312, was replaced with s/n 1890 for the cast two and then s/n 0313 for cast two, both of which still had large differences. Returned to s/n 312 where differences returned to acceptable values.

Station 162 had large differences in the sensors. Replaced secondary pump s/n 0819 with s/n 3481, which was also bad, and then s/n 5446 which resolved the differences issue.

Station 163 primary oxygen sensor s/n 1835 was replaced with s/n 2943 after differences of approximately 80 umol/kg during the surface soak. Reversed the pump configuration to address oxygen sensor spiking issues. Did not resolve the issue, but the configuration was kept the rest of the cruise.

Station 166 replaced primary oxygen s/n 2943 with s/n 0315 after continued oxygen spikes and large oxygen differences. Primary oxygen cable was replaced and resolved the large oxygen spikes at depth.

Station 186 deck unit s/n 11P9852 - 0367 would no longer initialize the NMEA feed and was swapped with s/n 1P111660. Large spikes were seen in the voltage channels.

Station 187 determined that the replacement deck unit s/n 1P111660 was causing the voltage spikes across all voltage channel and replaced with s/n 11P9852 - 0367 and the NMEA feed went through the computer on COM 4.

Water Sampling Package

All rosette casts were lowered to within 8-12 meters of the bottom, using the multibeam center depth value plus the altimeter on the rosette to determine distance. Three sampling schema were used in rotation to stagger standard sampling depths for consecutive stations. There were occasional exceptions made to the order of the schema or to capture a feature in the water column.

Rosette maintenance was performed on a regular basis. O-rings were changed and lanyards repaired as necessary. Bottle maintenance was performed each day to ensure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed. Periodic leaks were noted on sample logs. These are documented in the quality comments section of the Appendix.

Bottle Sampling

At the end of each rosette deployment water samples were drawn from the bottles in the following order:

- Chlorofluorocarbons(CFCs) /N₂O /SF₆
- ³Helium / Neon
- Dissolved O₂
- Dissolved Inorganic Carbon (DIC)
- Total pH
- Total Alkalinity (TAlk)
- ¹³C / ¹⁴C-DIC
- Dissolved Organic Carbon / Total Dissolved Nitrogen (DOC/TDN)
- DO ¹⁴C
- Colored Dissolved Organic Matter (CDOM)
- POC
- Chlorophyll a
- Tritium
- Neon
- Nutrients
- Salinity
- ¹³⁷Cs / ¹³⁴Cs / ⁹⁰Sr / ¹²⁹I
- Black Carbon

The correspondence between individual sample containers and the rosette bottle position was recorded on the sample log for the cast. This log also included any comments or anomalous conditions noted about the rosette and bottles. One member of the sampling team was designated the *sample cop*, whose sole responsibility was to maintain this log and insure that sampling progressed in the proper drawing order.

Normal sampling practice included opening the drain valve and then the air vent on the bottle, indicating an air leak if water leaked. This observation together with other diagnostic comments (e.g., "lanyard caught in endcap", "valve left open") that might later prove useful in determining sample integrity were routinely noted on the sample log. Drawing oxygen samples also involved taking the draw temperature from the bottle. The temperature was noted on the sample log and was sometimes useful in determining leaking or mis-tripped bottles.

Once individual samples had been drawn and properly prepared, they were distributed for analysis. On-board analyses were performed on computer-assisted analytical equipment networked to the data processing computer for centralized data management.

Bottle Data Processing

Water samples collected and properties analyzed shipboard were managed centrally in a relational database (PostgreSQL-8.1.23-10) run on a CentOS-5.11 Linux system. A web service (OpenACS-5.3.2-3 and AOLServer-4.5.1-1) front-end provided ship-wide access to CTD and water sample data. Web-based facilities included on-demand arbitrary property-property plots and vertical sections as well as data uploads and downloads.

Shipboard CTDO data were re-processed automatically at the end of each deployment using SIO/ODF CTD processing software v.5.1.6-1. The CTDO data and bottle trip files acquired by SBE SeaSave on the Windows 7

workstation were copied onto the Linux database and web server system. Pre-cruise calibration data were applied to CTD Pressure, Temperature and Conductivity sensor data, then the data were processed to a 0.5-second time series. A 1-decibar down-cast pressure series was created from the time series.

CTD up-cast data at bottle trips were extracted and added to the bottle database to use for CTD Pressure, Temperature and Salinity data in the preliminary bottle files. Pre-cruise calibration data were applied to these three parameters, in addition to PMEL preliminary shipboard conductivity corrections.

Time-series CTDO data from both down- and up-casts were matched along isopycnals to upcast trip data, then fit to bottle O₂ data using the SIO/ODF CTD processing software. The coefficients from these fits were applied, then CTD Oxygen data were extracted from the time-series up-cast data files and added to the database for quality control of bottle Dissolved O₂ data.

The NOAA/PMEL final PTSO data will replace the preliminary SIO/ODF CTD data in the bottle files after submission to CCHDO.

Cast Log and Sample Log information plus any diagnostic comments were entered into the database once sampling was completed. Quality flags associated with sampled properties were set to indicate that the property had been sampled, and sample container identifications were noted where applicable (e.g., oxygen flask number).

Analytical results were provided on a regular basis by the various analytical groups and incorporated into the database. These results included a quality code associated with each measured value and followed the coding scheme developed for the World Ocean Circulation Experiment (WOCE) Hydrographic Programme (WHP) [Joyc94].

Various consistency checks and detailed examination of the data continued throughout the cruise. Log notes were cross referenced with sample data values and quality coded. A summary of Cast Log and Sample Log comments, mis-trips, bottle lanyard issues and associated quality codes can be found in the Appendix.

Collected Samples

Table P16N Samples Collected and/or Analyzed On-Board

Samples Analyzed On-Board	Samples Collected (Not Analyzed)
Chlorofluorocarbons(CFCs)/SF ₆ /N ₂ O	³ He / Neon / Tritium
Dissolved O ₂	¹³ C / ¹⁴ C-DIC
Total CO ₂ (DIC)	DOC / TDN
Total Alkalinity/pH/pH Dye	DO ¹⁴ C / Black Carbon
Chlorophyll a	CDOM / POC
Nutrients	¹³⁷ Cs / ¹³⁴ Cs / ⁹⁰ Sr / ¹²⁹ I
Salinity	

Ship-Board Collection Analysis

The following figures are interpolated cross sections of samples collected and analyzed or calculated through out P16N Leg 2.

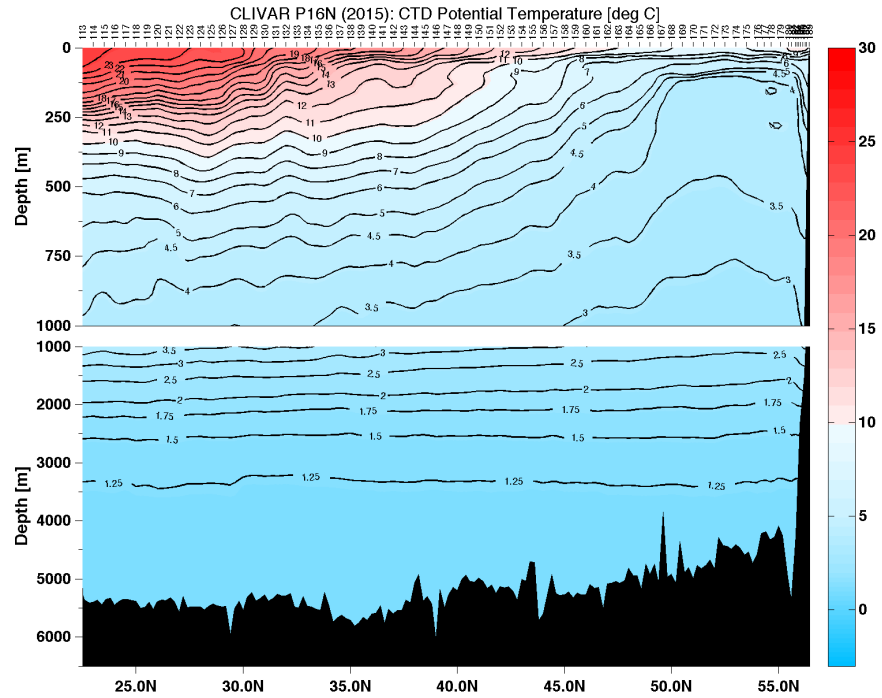


Figure P16N Leg 2 Potential Temperature Cross Section.

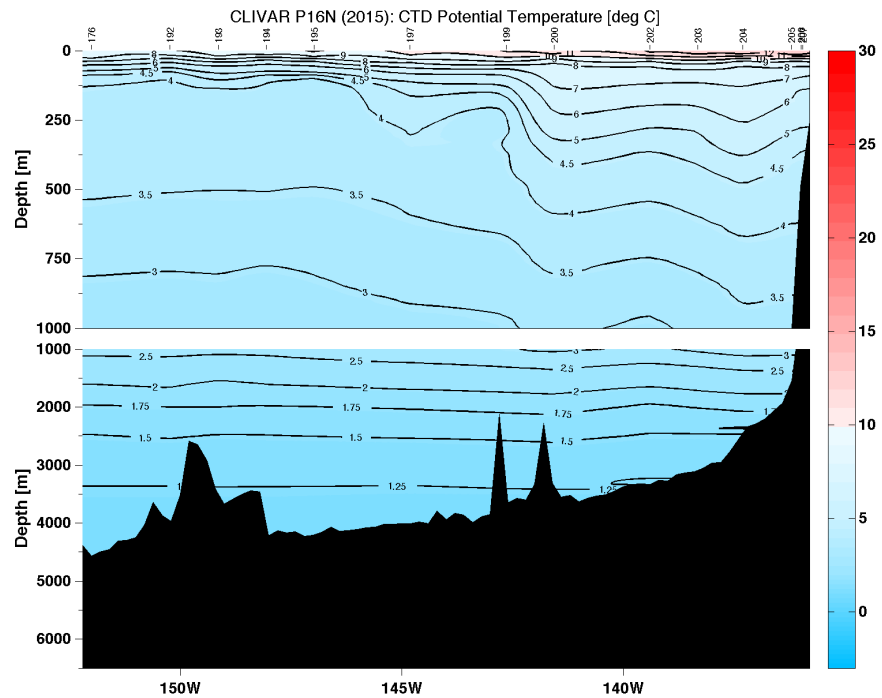


Figure P16N Leg 2 Potential Temperature Cross-Gyre Section.

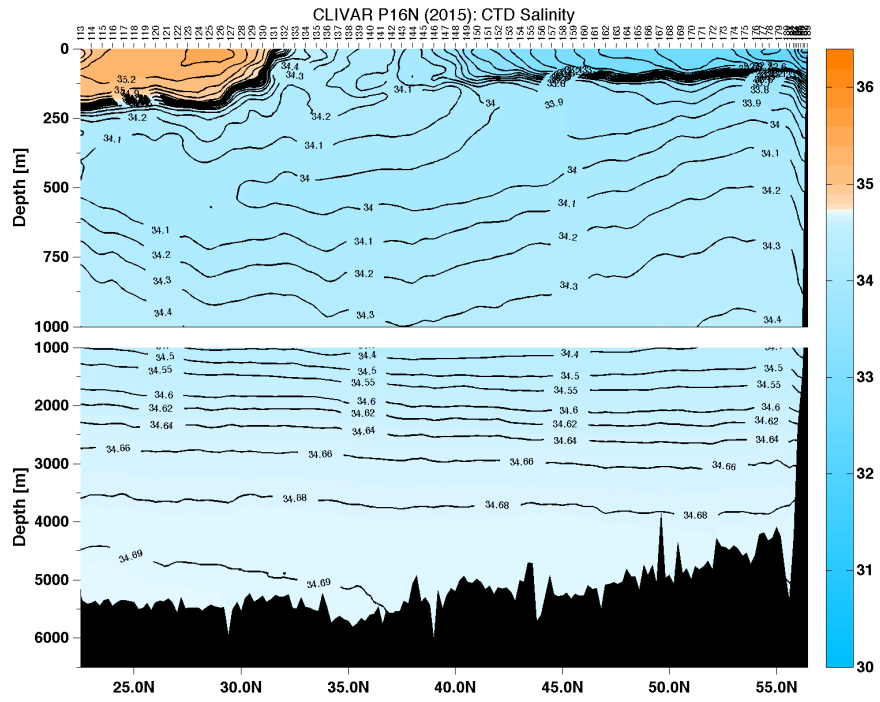


Figure P16N Leg 2 Salinity Cross Section.

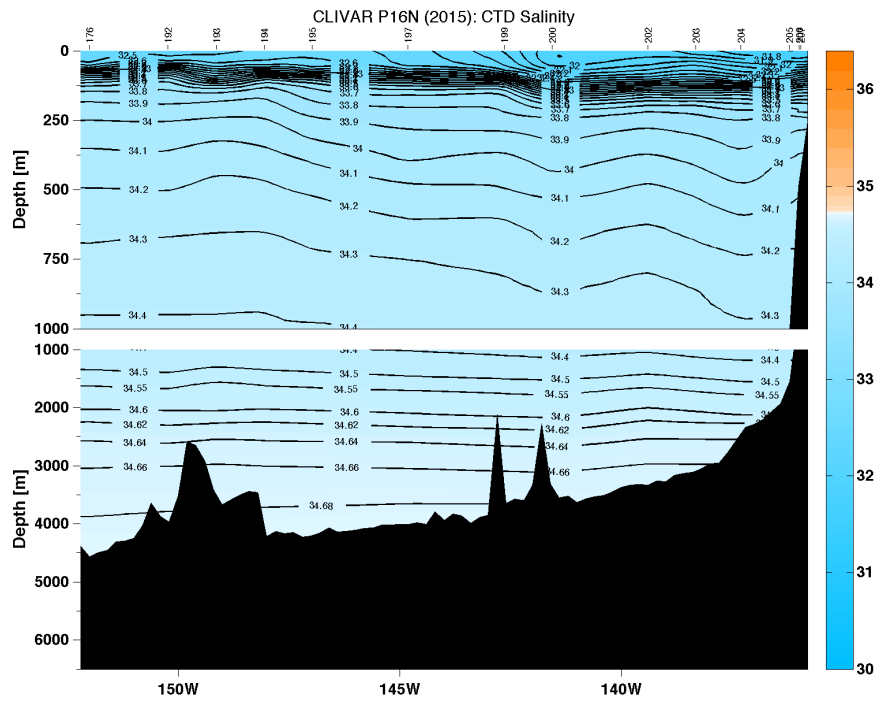


Figure P16N Leg 2 Salinity Cross-Gyre Section.

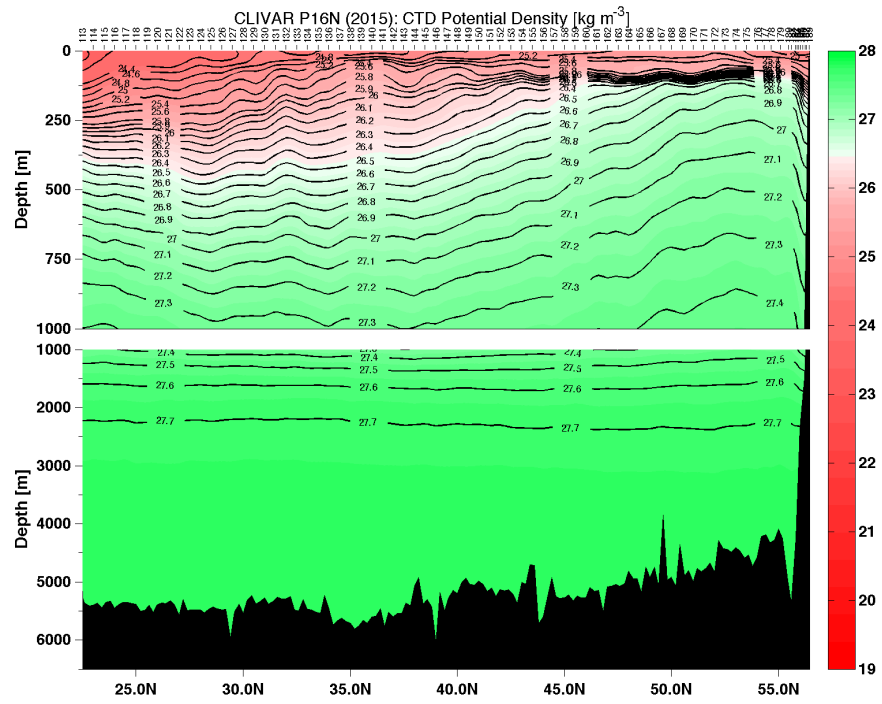


Figure P16N Leg 2 Potential Density Cross Section.

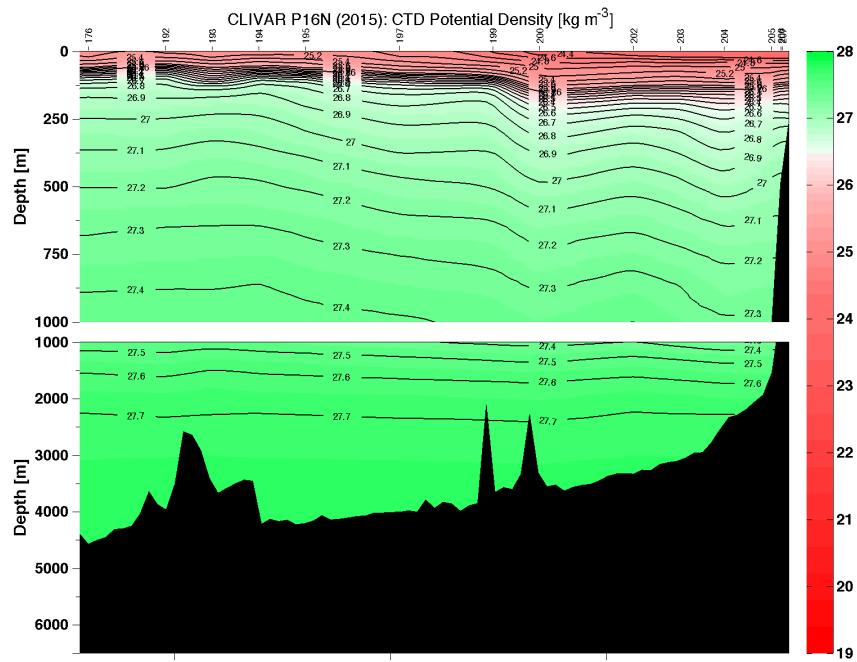
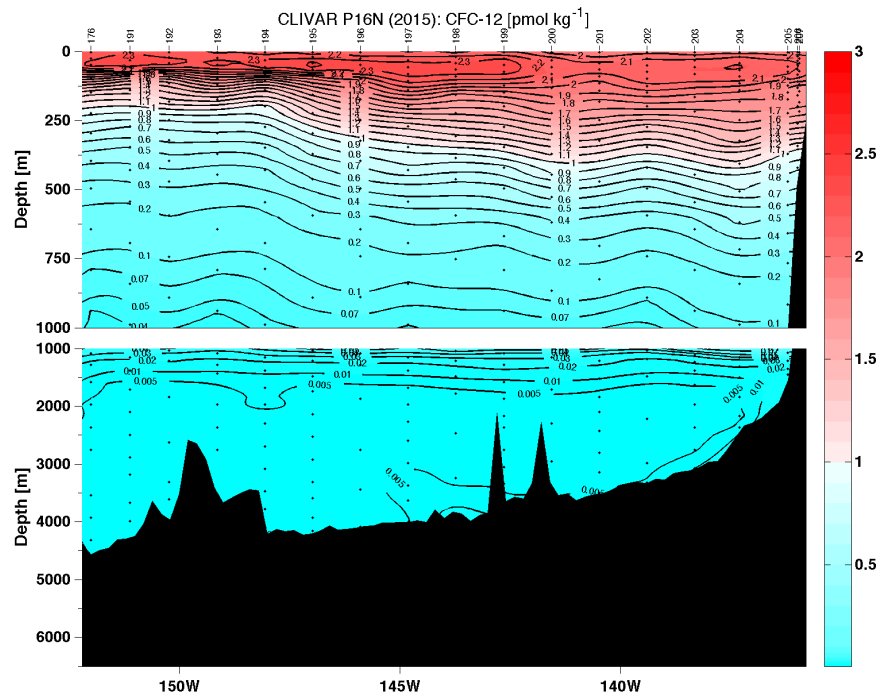
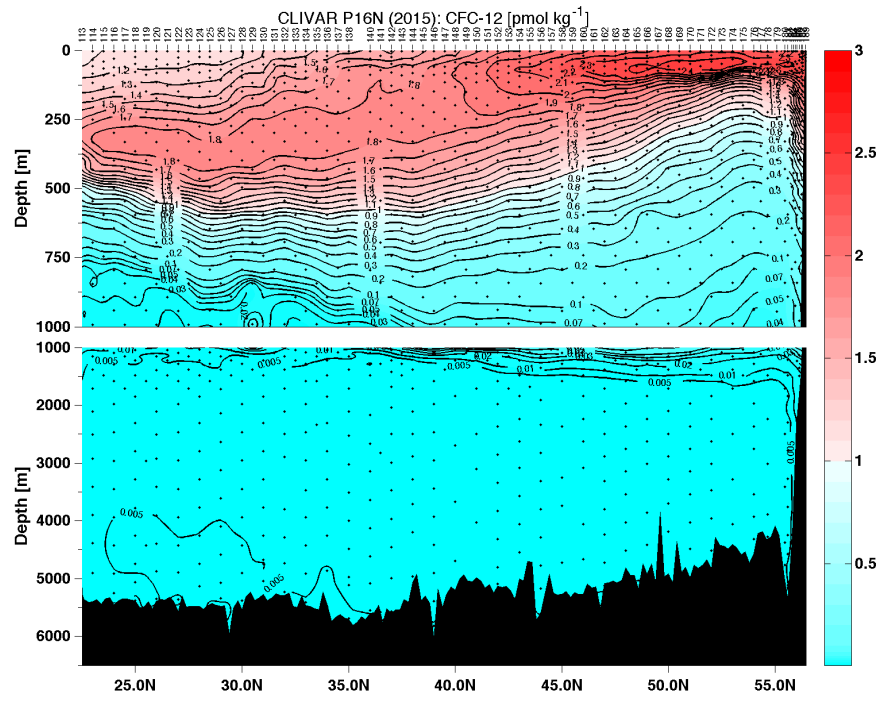


Figure P16N Leg 2 Potential Density Cross-Gyre Section.



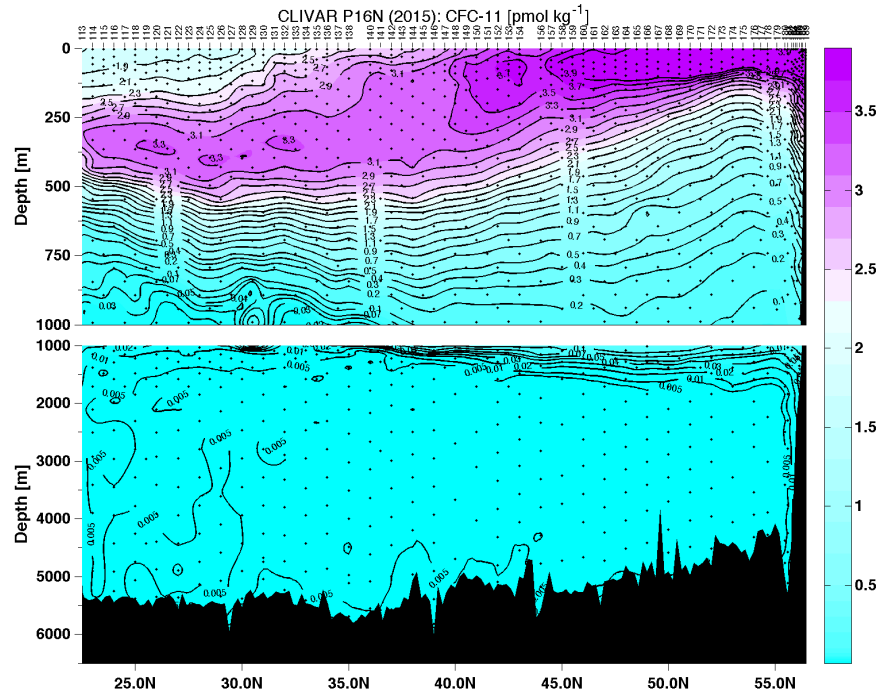


Figure P16N Leg 2 CFC11 Cross Section.

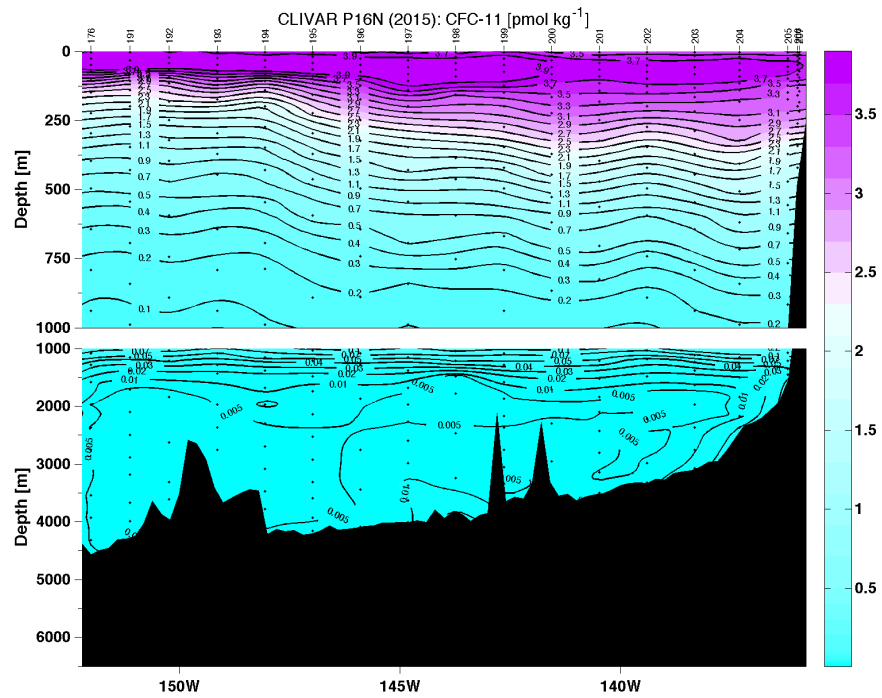


Figure P16N Leg 2 CFC11 Cross-Gyre Section.

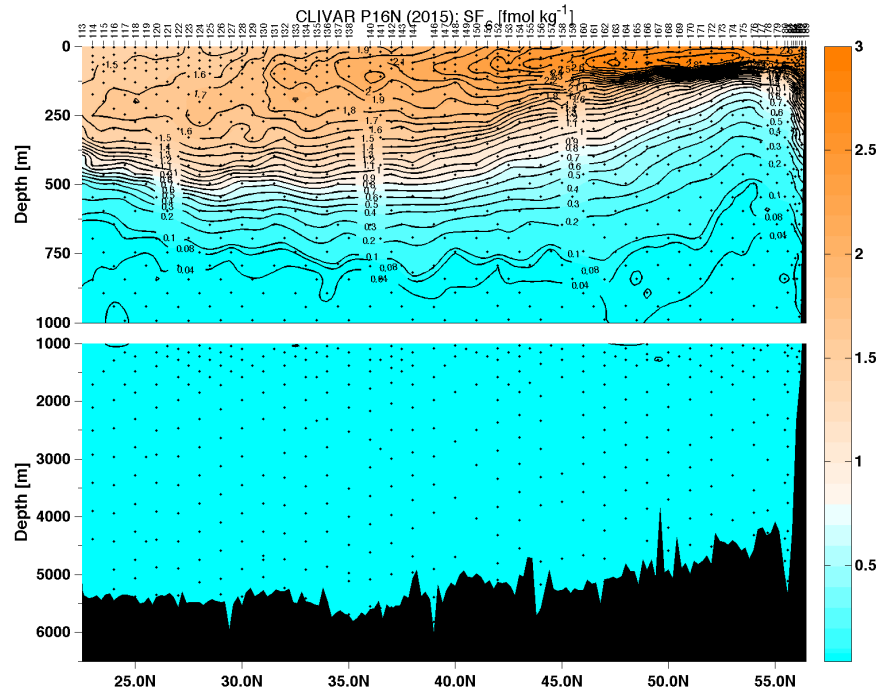


Figure P16N Leg 2 SF₆ Cross Section.

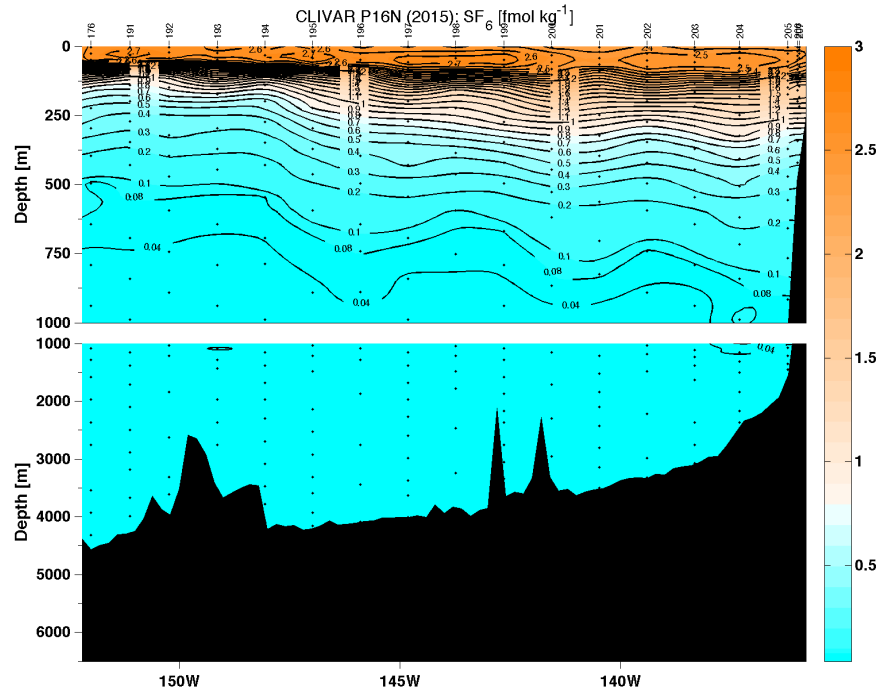


Figure P16N Leg 2 SF₆ Cross-Gyre Section.

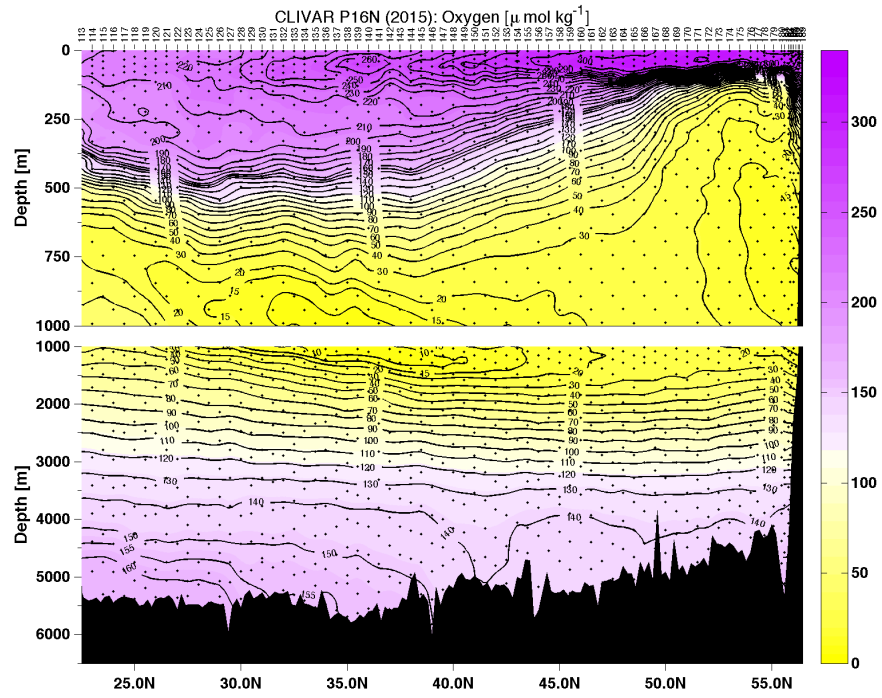


Figure P16N Leg 2 Oxygen Cross Section.

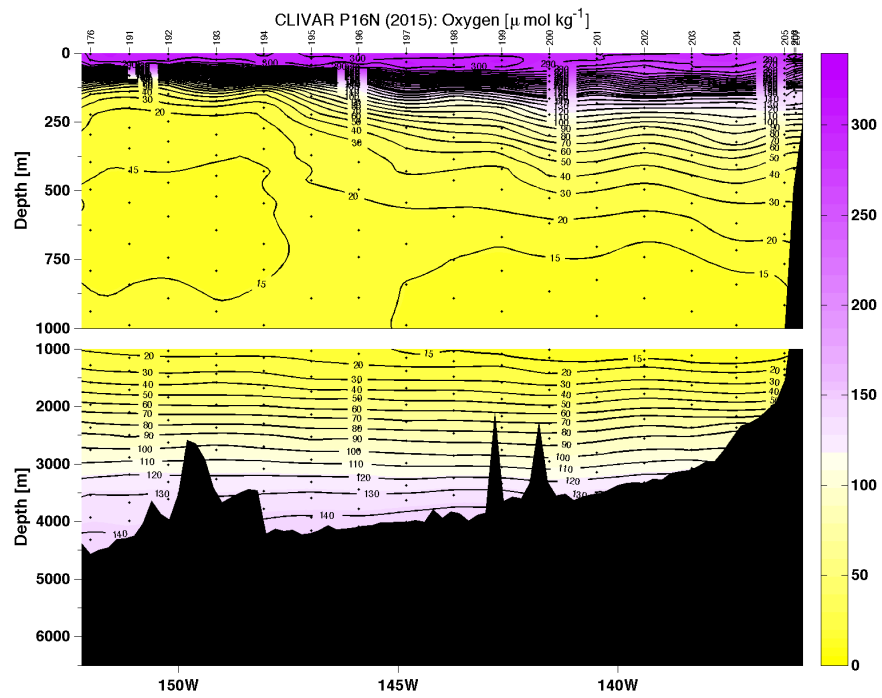


Figure P16N Leg 2 Oxygen Cross-Gyre Section.

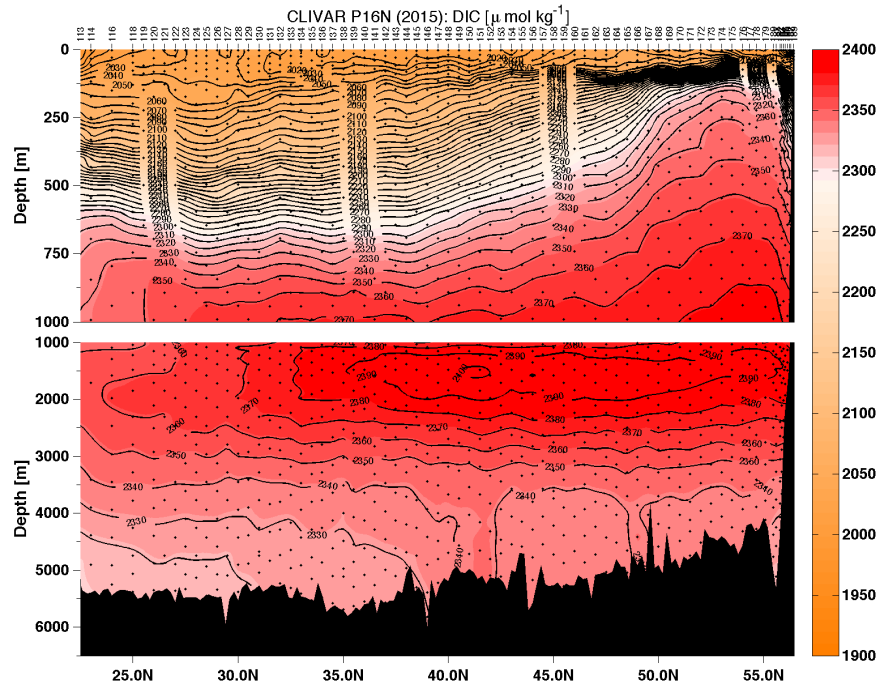


Figure P16N Leg 2 DIC Cross Section.

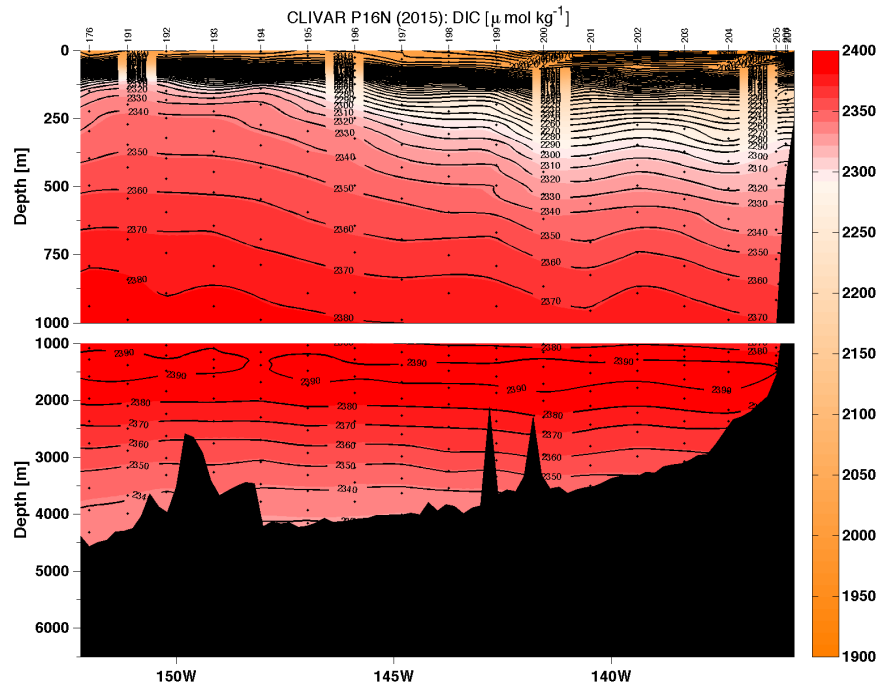
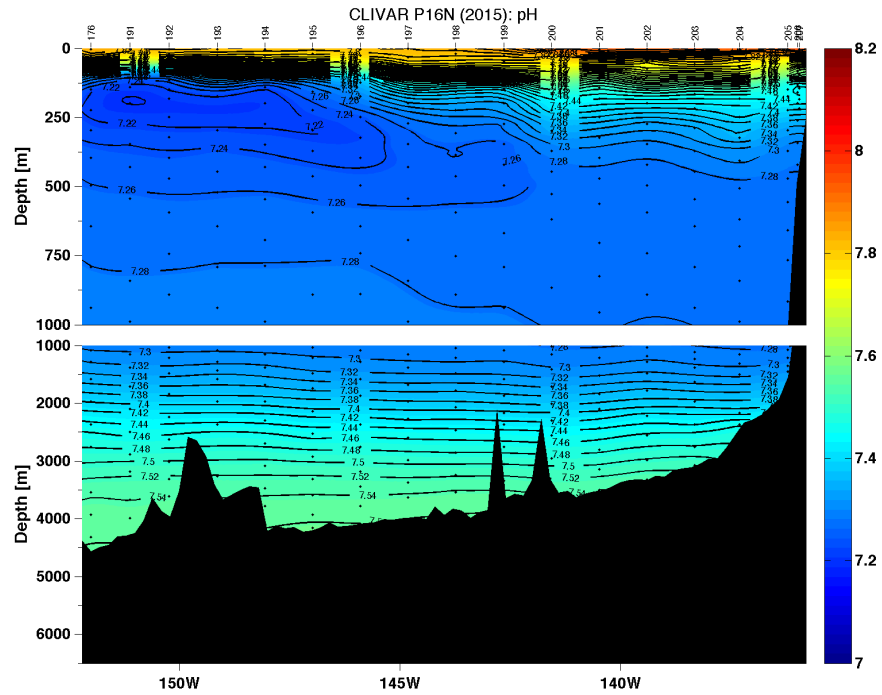
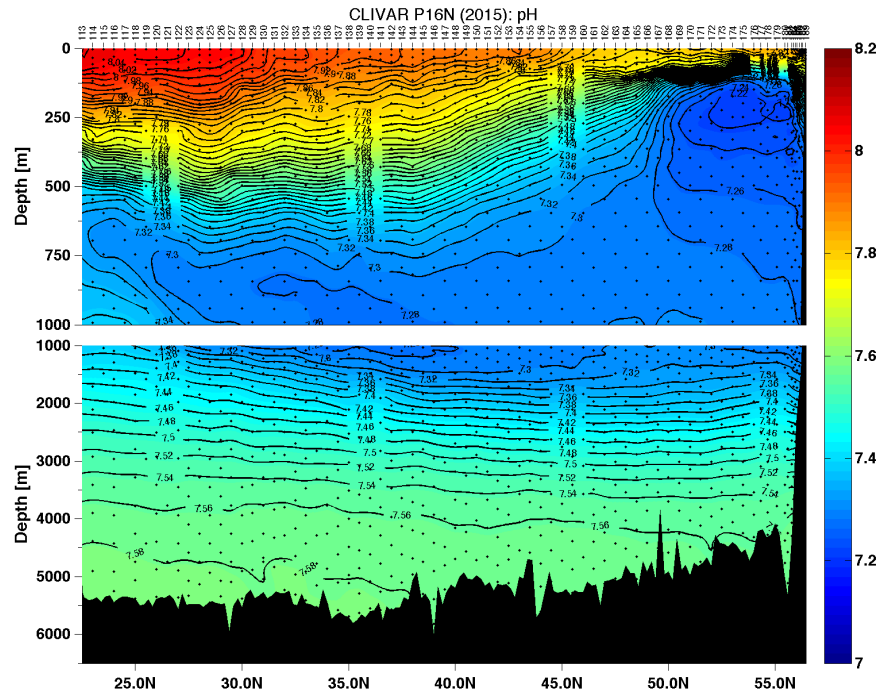


Figure P16N Leg 2 DIC Cross-Gyre Section.



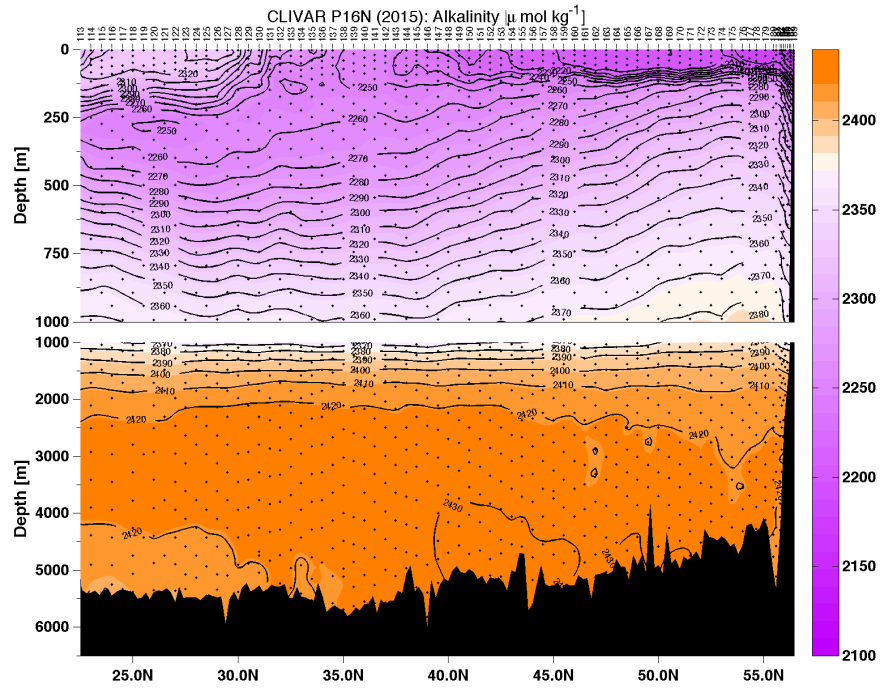


Figure P16N Leg 2 Total Alkalinity Cross Section.

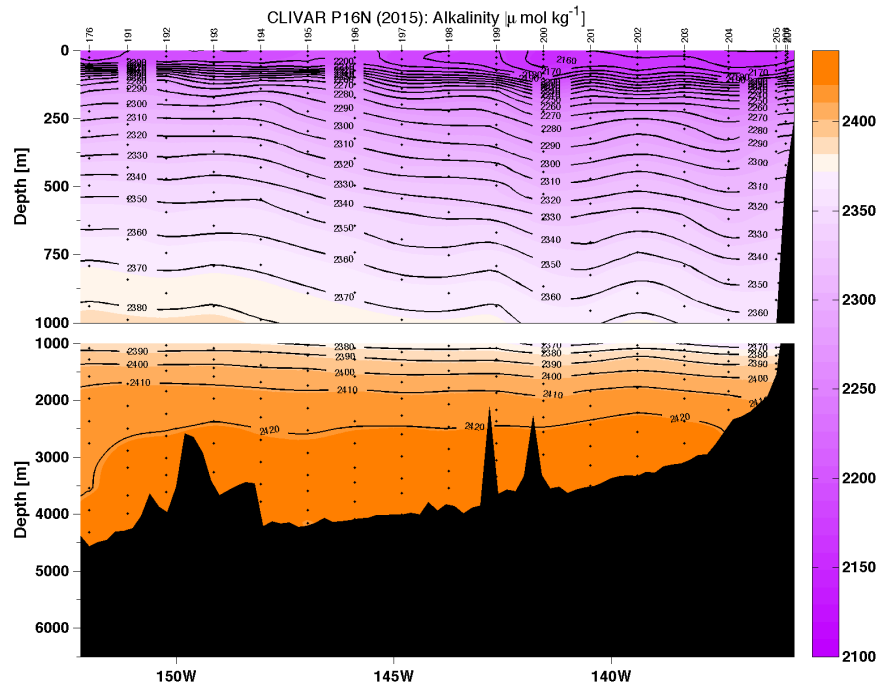


Figure P16N Leg 2 Total Alkalinity Cross-Gyre Section.

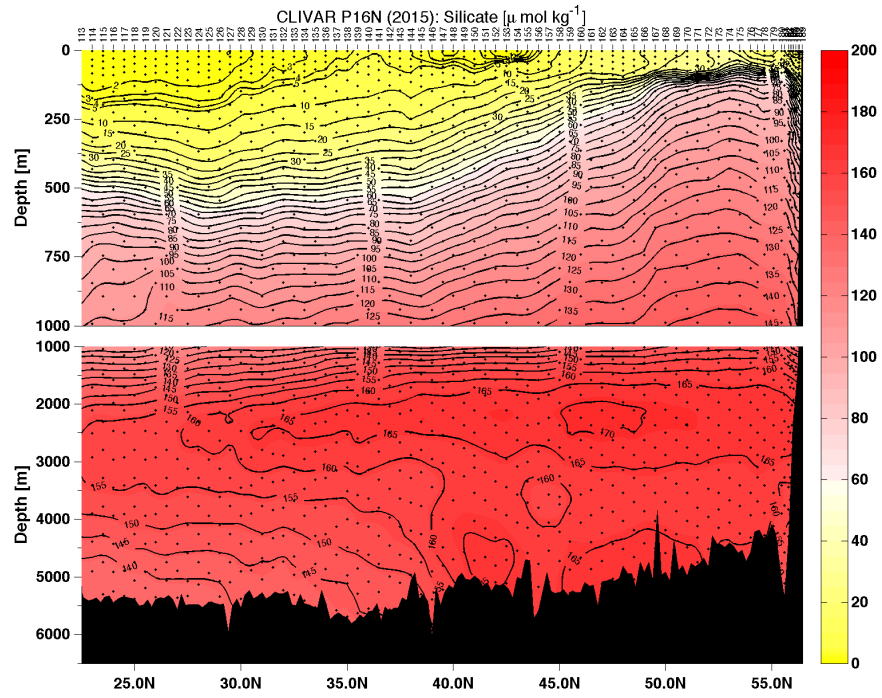


Figure P16N Leg 2 Silicate Cross Section.

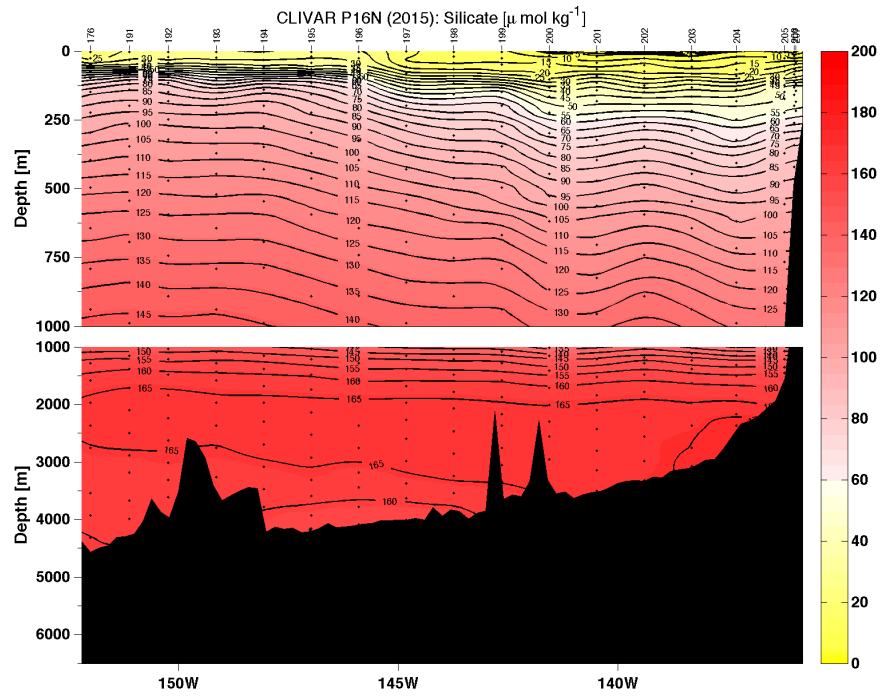


Figure P16N Leg 2 Silicate Cross-Gyre Section.

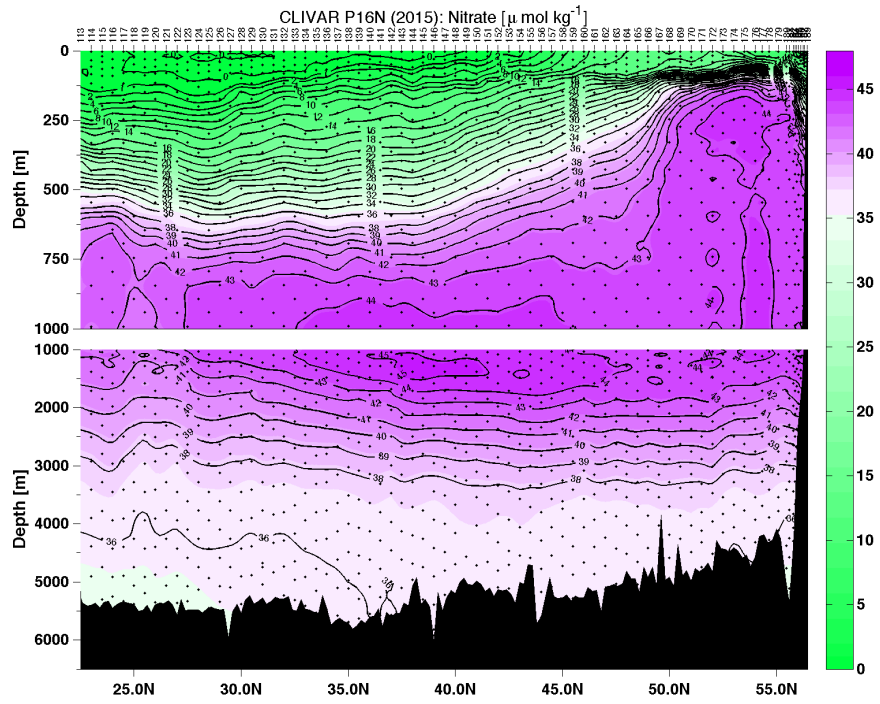


Figure P16N Leg 2 Nitrate Cross Section.

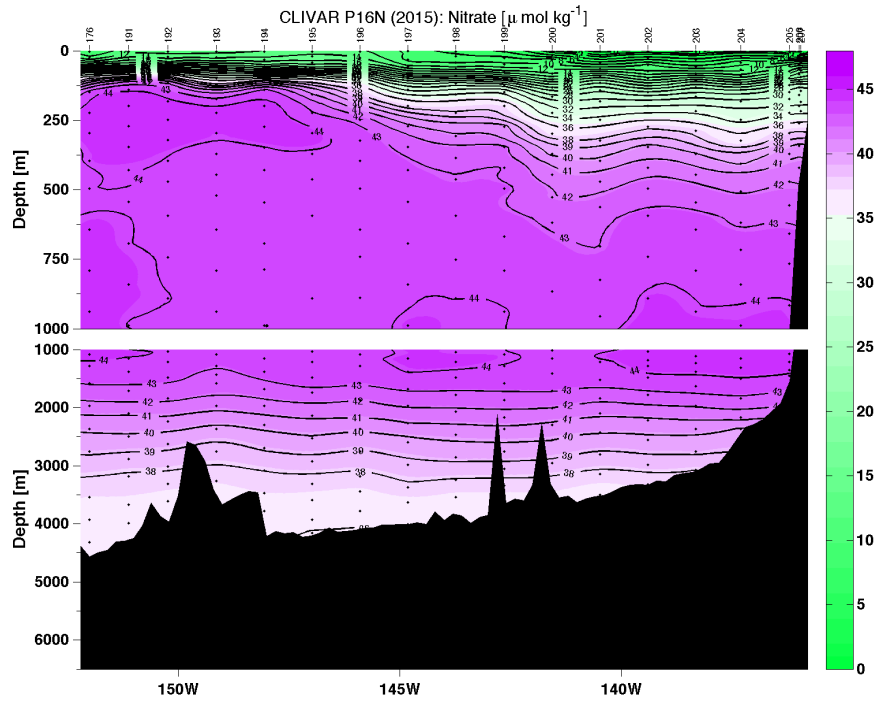


Figure P16N Leg 2 Nitrate Cross-Gyre Section.

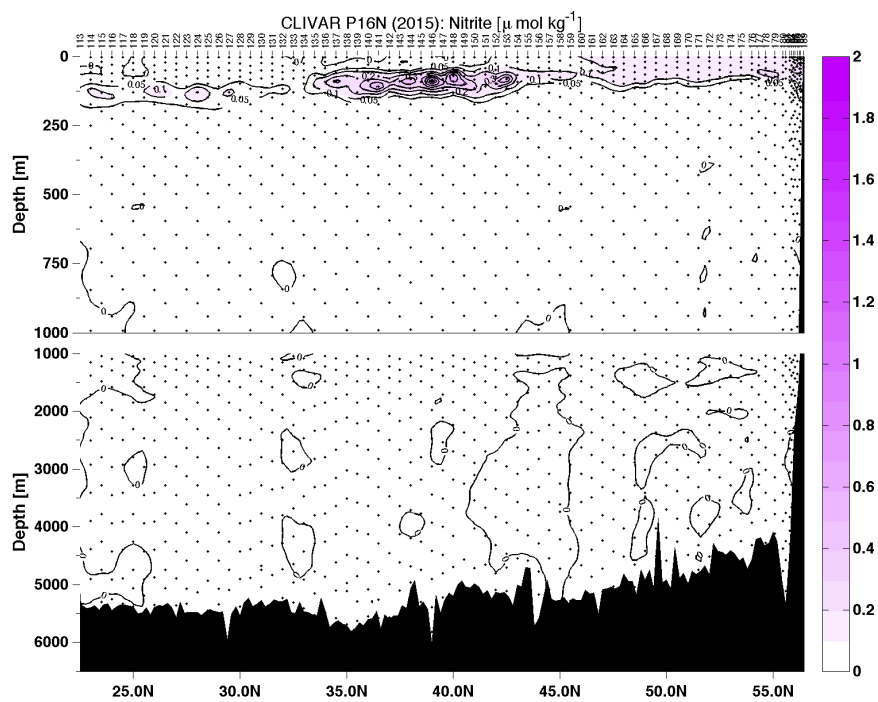


Figure P16N Leg 2 Nitrite Cross Section.

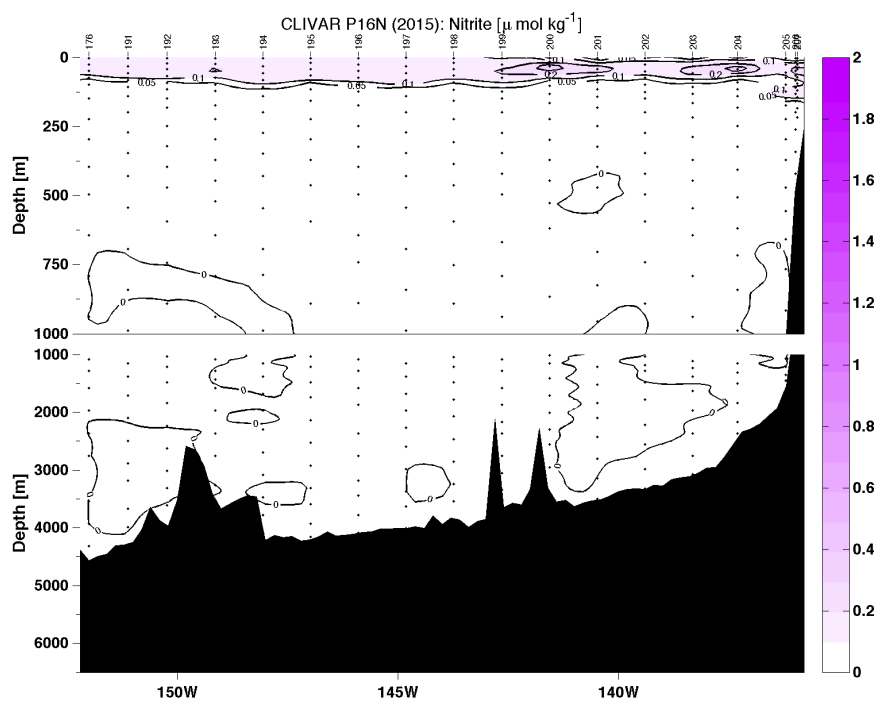


Figure P16N Leg 2 Nitrite Cross-Gyre Section.

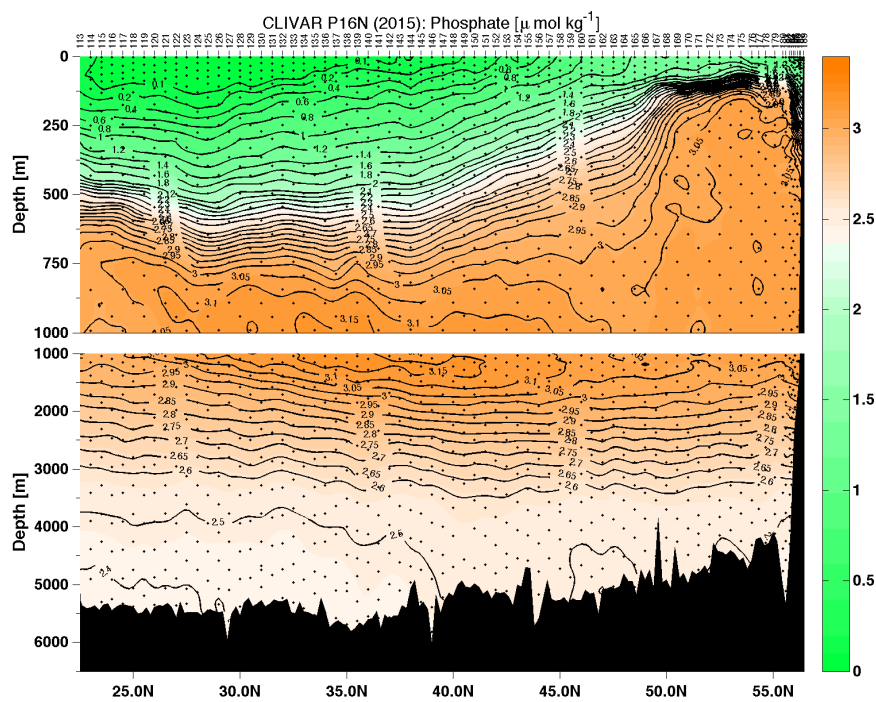


Figure P16N Leg 2 Phosphate Cross Section.

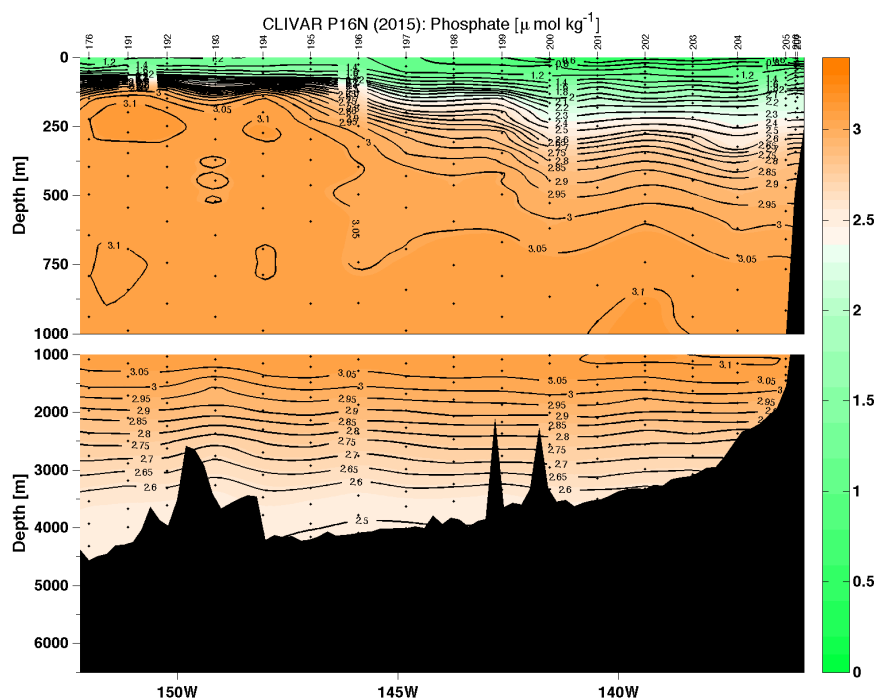


Figure P16N Leg 2 Phosphate Cross-Gyre Section.

CHLOROFLUOROCARBON (CFC) AND SULFUR HEXAFLUORIDE (SF₆) MEASUREMENTS ON GO-SHIP P16N Leg 2

PI: John Bullister

Analysts: David Wisegarver
Sophia Wensman

Chlorofluorocarbon (CFC) and Sulfur Hexafluoride (SF₆)

A PMEL analytical system (Bullister and Wisegarver, 2008) was used for CFC-11, CFC-12, sulfur hexafluoride (SF₆) and nitrous oxide analyses on the CLIVAR P16N expedition. Greater than 1800 samples of dissolved CFC-11, CFC-12 and SF₆ ('CFC/SF₆') were analyzed.

In general, the analytical system performed well for CFC-12, SF₆ and nitrous oxide during the cruise. There were some analytical problems with CFC-11. Typical dissolved SF₆ concentrations in modern surface water are ~1-2 fmol kg⁻¹ seawater (1 fmol = femtomole = 10⁻¹⁵ moles), approximately 1000 times lower than dissolved CFC-11 and CFC-12 concentrations. The limits of detection for SF₆ were approximately 0.03 fmol kg⁻¹ on this cruise. SF₆ measurements in seawater remain extremely challenging. Improvements in the analytical sensitivity to this compound at low concentrations are essential to make these measurements more routine on future CLIVAR cruises.

Water samples were collected in bottles designed with a modified end-cap to minimize the contact of the water sample with the end-cap O-rings after closing. Stainless steel springs covered with a nylon powder coat were substituted for the internal elastic tubing provided with standard Niskin bottles. When taken, water samples collected for dissolved CFC-11, CFC-12 and SF₆ analysis were the first samples drawn from the bottles. Care was taken to coordinate the sampling of CFC/SF₆ with other samples to minimize the time between the initial opening of each bottle and the completion of sample drawing. Samples easily impacted by gas exchange (dissolved oxygen, ³He, DIC and pH) were collected within several minutes of the initial opening of each bottle. To minimize contact with air, the CFC/SF₆ samples were drawn directly through the stopcocks of the bottles into 250 ml precision glass syringes equipped with three-way plastic stopcocks. The syringes were immersed in a holding tank of clean surface seawater held at ~10°C until ~20 minutes before being analyzed. At that time, the syringe was placed in a bath of surface seawater heated to ~32°C.

For atmospheric sampling, a ~75 m length of 3/8" OD Dekaron tubing was run from the CFC van, located on the fantail, to the bow of the ship. A flow of air was drawn through this line into the main laboratory using an Air Cadet pump. The air was compressed in the pump, with the downstream pressure held at ~1.5 atm, using a backpressure regulator. A tee allowed a flow of ~100 ml min⁻¹ of the compressed air to be directed to the gas sample valves of the CFC/SF₆ analytical systems, while the bulk flow of the air (>7 l min⁻¹) was vented through the backpressure regulator. Air samples were analyzed only when the relative wind direction was within 60 degrees of the bow of the ship to reduce the possibility of shipboard contamination. Analysis

of bow air was performed at ~10 locations along the cruise track. At each location, at least five air measurements were made to increase the precision of the measurements.

Concentrations of CFC-11, CFC-12 and SF₆ in air samples, seawater, and gas standards were measured by shipboard electron capture gas chromatography (EC-GC) using techniques modified from those described by Bullister and Weiss (1988) and Bullister and Wisegarver (2008), as outlined below. For seawater analyses, water was transferred from a glass syringe to a glass-sparging chamber (volume ~200 ml). The dissolved gases in the seawater sample were extracted by passing a supply of CFC/SF₆ free purge gas through the sparging chamber for a period of 6 minutes at ~200 ml min⁻¹. Water vapor was removed from the purge gas during passage through a Nafion drier. Carbon dioxide was removed with an 18 cm long, 3/8" diameter glass tube packed with Ascarite and a small amount of magnesium perchlorate desiccant. The sample gases were concentrated on a cold-trap consisting of a 1/16" OD stainless steel tube with a 2.5 cm section packed tightly with Porapak Q, a 15 cm section packed with Carboxen 1000 and a 2.5 cm section packed with MS5A. A Neslab Cryocool CC-100 was used to cool the trap to ~-70°C. After 6 minutes of purging, the trap was isolated, and it was heated electrically to ~170°C. The sample gases held in the trap were then injected onto a precolumn (~61 cm of 1/8" O.D. stainless steel tubing packed with 80-100 mesh Porasil B, held at 80°C) for the initial separation of CFC-12, CFC-11, SF₆ from later eluting peaks.

After the SF₆ and CFC-12 had passed from the pre-column and into the second pre-column (26 cm of 1/8" O.D. stainless steel tubing packed with MS5A, 160°C) and into the analytical column #1 (174 cm of 1/8" OD stainless steel tubing packed with MS5A + 60 cm Porasil C held at 80°C), the outflow from the first pre-column was diverted to the second analytical column (180 cm 1/8" OD stainless steel tubing packed with Porasil B, 80-100 mesh, held at 80°C). The gases remaining after CFC-11 had passed through the first pre-column, were backflushed from the pre-column and vented. After CFC-12 had passed through the second pre-column, a flow of Argon-Methane (95:5) was used to divert the N₂O to a third analytical column (30 cm of MS5A, 150°C). Column #3 and the second pre-column were held in a Shimadzu GC8 gas chromatograph with an electron capture detector (ECD) held at 330°C. Columns #1, and the first pre-column were in another Shimadzu GC8 gas chromatograph with ECD. The column #2 was also in a Shimadzu GC8 gas chromatograph with the ECD held at 330°C.

The analytical system was calibrated frequently using a standard gas of known CFC/SF₆ composition (PMEL-WRS-72611). Gas sample loops of known volume were thoroughly flushed with standard gas and injected into the system. The temperature and pressure was recorded so that the amount of gas injected could be calculated. The procedures used to transfer the standard gas to the trap, pre-columns, main chromatographic column, and ECD were similar to those used for analyzing water samples. Four sizes of gas sample loops were used. Multiple injections of these loop volumes could be made to allow the system to be calibrated over a relatively wide range of concentrations. Air samples and system blanks (injections of loops of CFC/SF₆ free gas) were injected and analyzed in a similar manner. The typical analysis time for seawater, air, standard or blank samples was ~11 minutes. Concentrations of the CFC-11 and CFC-12 in air, seawater samples, and gas standards are reported relative to the SIO98 calibration scale (Cunnold et al., 2000; Bullister and Tanhua, 2010). Concentrations of SF₆ in air, seawater samples, and gas standards are reported relative to the SIO-2005 calibration scale (Bullister and Tanhua, 2010). Concentrations in air and standard gas are reported in units of mole fraction CFC in dry gas, and are typically in the parts per trillion (ppt) range. Dissolved CFC concentrations are given in units

of picomoles per kilogram seawater (pmol kg^{-1}) and SF_6 concentrations in fmol kg^{-1} . CFC/ SF_6 concentrations in air and seawater samples were determined by fitting their chromatographic peak areas to multi-point calibration curves, generated by injecting multiple sample loops of gas from a working standard (PMEL cylinder WRS72611) into the analytical instrument. The response of the detector to the range of moles of CFC/ SF_6 passing through the detector remained relatively constant during the cruise. Full-range calibration curves were run at several times during the cruise and partial curves were run as frequently as possible, usually while sampling. Single injections of a fixed volume of standard gas at one atmosphere were run much more frequently (at intervals of ~ 90 minutes) to monitor short-term changes in detector sensitivity.

The purging efficiency was estimated by re-purging a high-concentration water sample and measuring the residual signal. At a flow rate of 200 cc min^{-1} for 6 minutes, the purging efficiency for SF_6 and both CFC gases was $> 99\%$. The efficiency for N_2O was about 97% .

On this expedition, based on the analysis of more than 150 pairs of duplicate samples, we estimate precisions (1 standard deviation) of about 1% or $0.003 \text{ pmol kg}^{-1}$ (whichever is greater) for dissolved CFC-12 and 1% or $0.005 \text{ pmol kg}^{-1}$ for CFC-11 measurements. The estimated precision for SF_6 was 2% or $0.03 \text{ fmol kg}^{-1}$, (whichever is greater). Overall accuracy of the measurements (a function of the absolute accuracy of the calibration gases, volumetric calibrations of the sample gas loops and purge chamber, errors in fits to the calibration curves and other factors) is estimated to be about 2% or $0.004 \text{ pmol kg}^{-1}$ for CFC11 and CFC-12 and 4% or $0.04 \text{ fmol kg}^{-1}$ for SF_6 .

A small number of water samples had anomalously high CFC-12 and/or SF_6 concentrations relative to adjacent samples. These samples occurred sporadically during the cruise and were not clearly associated with other features in the water column (e.g., anomalous dissolved oxygen, salinity, or temperature features). This suggests that these samples were probably contaminated with CFCs/ SF_6 during the sampling or analysis processes.

Measured concentrations for these anomalous samples are included in the data file, but are given a quality flag value of either 3 (questionable measurement) or 4 (bad measurement). Less than 2% of samples were flagged as bad or questionable during this voyage. A quality flag of 5 was assigned to samples which were drawn from the rosette but never analyzed due to a variety of reasons (e.g., leaking stopcock, plunger jammed in syringe barrel, etc).

A small number of peaks on the SF_6 /CFC-12 channel were lost due to RF interference and were flagged as bad (4).

Some nitrous oxide samples had very high restrips in low oxygen zones and were not used in the determination of the stripper efficiency corrections. In addition, the nitrous oxide stripper blanks increased with time and to reduce the blank, the stripper frit was periodically washed with $10\% \text{ HCl}$.

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HELIUM AND TRITIUM

PI: William Jenkins

Sampler: Zoe Sandwith

Helium Sampling

Helium and Tritium samples were collected roughly every three degrees on CLIVAR P16N Leg 2, for a total of 13 stations. A total of 194 helium samples were taken on Leg 2, which included 7 duplicates.

At each station sampled, 16 copper tube helium samples were drawn from the upper 2000m of the water column. Generally, at every other station sampled, a duplicate helium sample was drawn from a random depth in the upper 2000m. On the last station sampled, the profile was very shallow and only a surface sample was collected.

The copper tube used was 5/8" dehydrated refrigeration copper tube manufactured by Mueller Industries Inc. (Fulton, MS) and supplied in 50ft rolls. These rolls were stored in the air-conditioned and low humidity bio-analytical lab in order to limit corrosion and exposure risk. Poor quality copper can result in seal failure so great care is necessary in the handling of the copper in all stages of preparation, sampling, storage, and transport.

Approximately 1.5 hours before sampling a cast, the copper tubes were rolled out and cut into 30" sections. These sections were then flattened slightly so that after sampling and sealing of the copper tube samples, they could be re-rounded in order to create a small headspace allowing for expansion of the seawater inside as it warmed.

In order to sample from the rosette with the copper tubes, they were attached to the Niskins using Tygon tubing with a small silicon tubing adaptor at the nipple end. Tubing would be attached to both ends of the copper tube, with the inlet tube coming in the bottom of the copper tube. Both pieces of Tygon tubing had plastic tubing clamps on them.

Water was drawn through the copper tube while gently knocking the tube with a thumper in order to remove any and all bubbles along the inside of the tubes. When satisfied that all bubbles had been cleared, and at least 2 volumes of water had flushed through, the sample was ready for sealing. The 2 plastic clamps were closed and the Tygon removed from the Niskin for transport to the hydraulic sealing jaws. The jaws run at 8000psi, press the copper together and cut it, creating a knife-edge seal and a gas tight sample chamber. Immediately after sealing, the tubes were re-rounded to create expansion space. After all samples were taken they were rinsed thoroughly with fresh water and dried before storing.

The only major issue encountered during Leg 2 was that for the first portion of the cruise the ship's air conditioner reheaters for the room were not functioning, resulting in a steady drop in room temperature as we steamed north. At its worst, the room temperature

was down to 50°F, which was becoming unworkable. This was resolved midway through the cruise and the room temperature brought up to 60°F. It is unclear whether the reheaters were functioning or not on Leg 1, since the problem only became apparent as the cooling water temperature dropped in the northern latitudes. Other than that, the only problem was a failed hydraulic footpump, which was swapped out for a spare.

Tritium Sampling

A total of 194 tritium samples were taken, including 7 duplicates during Leg 2 of P16N. Tritium samples were drawn from the same stations and bottles as those sampled for helium. Duplicate tritium samples were drawn on the same stations that duplicate helium samples were taken. Due to water budgets, the duplicate tritium was taken on a different Niskin than the helium.

Tritium samples were taken using Tygon tubing to fill 1 liter glass jugs. Prior to the cruise, the jugs were baked in an oven, and backfilled with argon, then the caps were taped shut. While filling, the jugs were placed on the deck and filled to about 2 inches from the top of the bottle, taking care to not spill the argon gas out. Caps were replaced and taped shut with electrical tape before being packed for shipment back to WHOI. Tritium samples will be degassed in the lab at WHOI and stored for a minimum of 6 months before mass spectrometer analysis.

Dissolved Oxygen (discrete)

Maria Arroyo and Chris Langdon, Uni. of Miami
(PIs: Chris Langdon, RSMAS, Molly Baringer, AOML)

Equipment and Techniques

Dissolved oxygen analyses were performed with an automated titrator using amperometric end-point detection [Langdon, 2012]. Sample titration, data logging, and graphical display were performed with a PC running a LabView program written by Ulises Rivero of AOML. Lab temperature was maintained at 19.5-25.4 °C. The temperature-corrected molarity of the thiosulfate titrant was determined as given by Dickson [1994]. Thiosulfate was dispensed by a 2 ml Gilmont syringe driven with a stepper motor controlled by the titrator. The whole-bottle titration technique of Carpenter [1965], with modifications by Culbertson et al. [1991], was used. Three to four replicate 10 ml iodate standards were run every 3-4 days ($SD < 1 \mu L$). The reagent blank was determined as the difference between V1 and V2, the volumes of thiosulfate required to titrate 1-ml aliquots of the iodate standard, was determined at the beginning and end of the cruise.

Sampling and Data Processing

Dissolved oxygen samples were drawn from Niskin bottles into calibrated 125-150 ml iodine titration flasks using silicon tubing to avoid contamination of DOC and CDOM samples. Samples were drawn by counting while the flask was allowed to fill at full flow from the Niskin. This count was then doubled and repeated thereby allowing the flask to be overflowed by two flask volumes. At this point the silicone tubing was pinched to reduce the flow to a trickle. This was continued until a stable draw temperature was obtained on the Oakton meter. These temperatures were used to calculate $\mu mol/kg$ concentrations, and provide a diagnostic check of Niskin bottle integrity. 1 ml of $MnCl_2$ and 1 ml of $NaOH/NaI$ were added immediately after drawing the sample was concluded using a Re-pipetor. The flasks were then stoppered and shaken well. DIW was added to the neck of each flask to create a water seal. 24 samples plus two duplicates were drawn at each station. The total number of samples collected from the rosette was 2350.

The samples were stored in the lab in plastic totes at room temperature for 30-40 minutes before analysis. The data were incorporated into the cruise database shortly after analysis.

Thiosulfate normality was calculated for each standardization and corrected to the laboratory temperature. This temperature ranged between 20.5 and 25.1 C.

Reagent blanks were run at the beginning ($1.4 \pm 0.3 \mu L$), middle ($1.6 \pm 0.8 \mu L$) and end of the cruise ($3.4 \pm 2.2 \mu L$). Standards were May 25 708.2, May 29 713.3, June 2 712.2, June 3 710.7, June 9 706.4, June 16 705.92 and June 22 706.9.

Volumetric Calibration

The dispenser used for the standard solution (SOCOREX Calibrex 520) and the burette were calibrated gravimetrically just before the cruise. Oxygen flask volumes were determined gravimetrically with degassed deionized water at AOML. The correction for buoyancy was applied. Flask volumes were corrected to the draw temperature.

Duplicate Samples

Duplicate samples were drawn at two depths on every cast. The Niskins selected for the duplicates and hence the oxygen flasks were changed for each cast. A total of 170 sets of duplicates were run. The average standard deviation of all sets was 0.27 $\mu\text{mol/kg}$.

Quality Coding

Preliminary quality code flags have been assigned to the oxygen data. Eighty-three were coded bad based on Niskin mis-trips. Eighteen were flagged based on comparison with the preliminary calibrated CTD oxygen profiles.

O2 quality flag	Number	Note
3	15	Sample value high for profile and adjoining casts. Code questionable
4	16	Sample value low for profile. Top end cap not closed properly or leaking from the bottom. Assumed contaminated sample.
5	6	Sample value not reported a problem occurred during the titration (spilled, overshoot endpoint).

Problems

The change in the code applied after leg 1 to fix the problem with titrating samples with extremely low oxygen ($<10 \mu\text{mol/kg}$) worked flawlessly on the leg 2. Five oxygen flasks were either broken or deemed to have lost stoppers during the cruise and were replaced as follows:

56 > 16

59 > 23

62 > 24

68 > 18

69 > 19

Cross-over comparisons

None this cruise.

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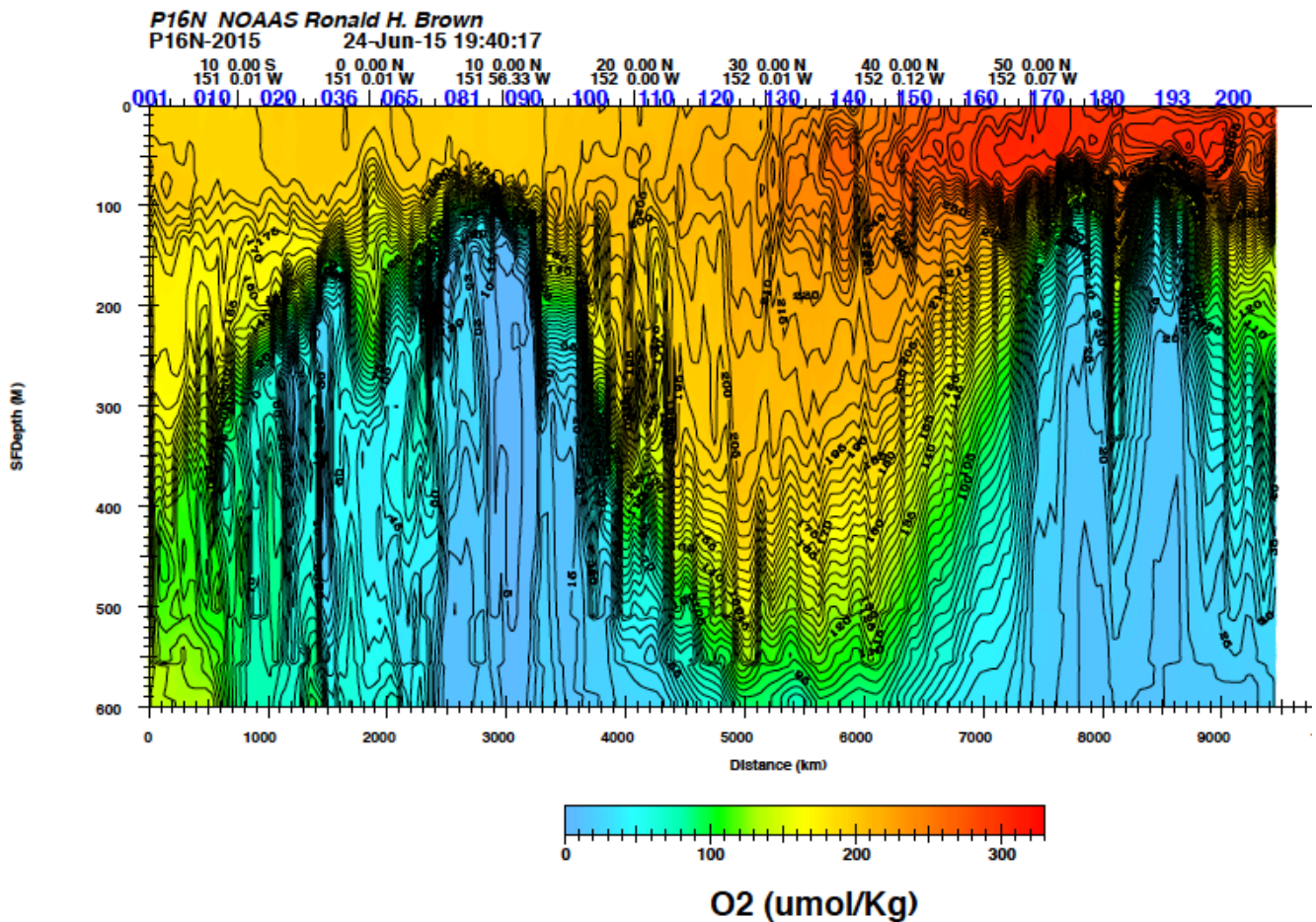


Figure 1 Vertical section showing the detail of the oxygen field in the upper 600 m of the water column.

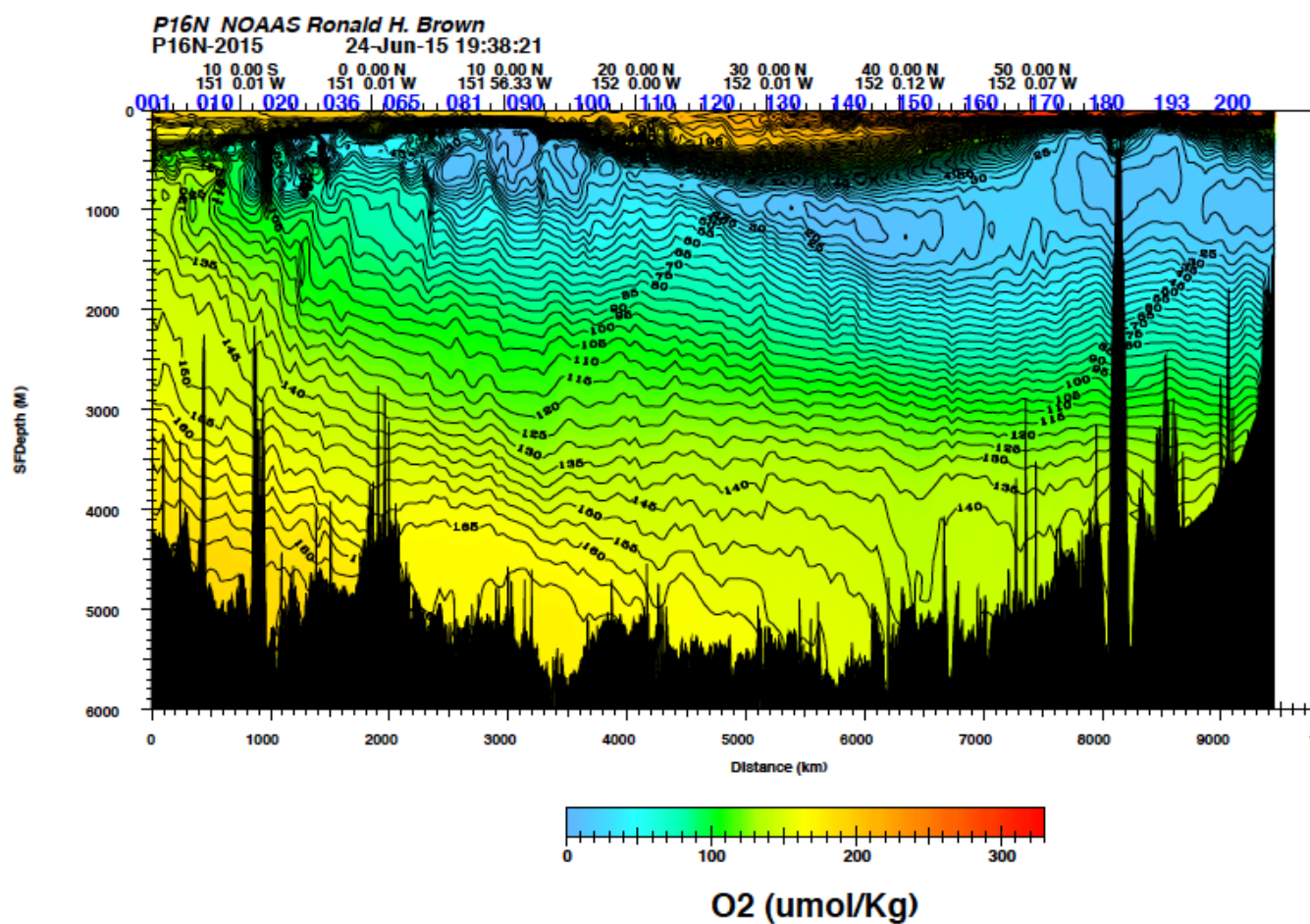


Figure 2 Full depth vertical section of dissolved oxygen structure along 152W (P16N line).

DISSOLVED INORGANIC CARBON (DIC)
PI: Richard A. Feely and Rik Wanninkhof
Technicians: Robert Castle and Brendan Carter

Sample collection:

Samples for DIC measurements were drawn (according to procedures outlined in the PICES Publication, *Guide to Best Practices for Ocean CO₂ Measurements*) from Niskin bottles into 310 ml borosilicate glass flasks using silicone tubing. The flasks were rinsed once and filled from the bottom with care not to entrain any bubbles, overflowing by at least one-half volume. The sample tube was pinched off and withdrawn, creating a 6 ml headspace, followed by the addition of 0.12 ml of saturated HgCl₂ solution, which was added as a preservative. The sample bottles were then sealed with glass stoppers lightly covered with Apiezon-L grease.

Equipment:

The analysis was done by coulometry with two analytical systems (PMEL1 and PMEL2) used simultaneously on the cruise. Each system consisted of a coulometer (CM5015 UIC Inc) coupled with a Dissolved Inorganic Carbon Extractor (DICE). The DICE system was developed by Esa Peltola and Denis Pierrot of NOAA/AOML and Dana Greeley of NOAA/PMEL to modernize a carbon extractor called SOMMA (Johnson et al. 1985, 1987, 1993, and 1999; Johnson 1992).

The two DICE systems (PMEL1 and PMEL2) were set up in a seagoing container modified for use as a shipboard laboratory on the aft main working deck of the *R/V Ronald H. Brown*.

Calibration, Accuracy, and Precision:

The stability of each coulometer cell solution was confirmed three different ways.

- 1) Gas loops were run at the beginning and end of each cell;
- 2) CRM's supplied by Dr. A. Dickson of SIO, were measured near the beginning; and
- 3) Samples from the same Niskin were run throughout the life of the cell solution.

Each coulometer was calibrated by injecting aliquots of pure CO₂ (99.999%) by means of an 8-port valve (*Wilke et al., 1993*) outfitted with two calibrated sample loops of different sizes (~1ml and ~2ml). The instruments were each separately calibrated at the beginning of each cell with a minimum of two sets of these gas loop injections and then again at the end of each cell to ensure no drift during the life of the cell.

The accuracy of the DICE measurement is determined with the use of standards (Certified Reference Materials (CRMs), consisting of filtered and UV irradiated seawater) supplied by Dr. A. Dickson of Scripps Institution of Oceanography (SIO). The CRM accuracy is determined manometrically on land in San Diego and the DIC data reported to the database have been corrected to this batch 143 CRM value. The CRM certified value for this batch is 2017.75 $\mu\text{mol/kg}^1$.

The precision of the two DICE systems can be demonstrated via the replicate samples. Approximately 13% of the Niskins sampled were duplicates taken as a check of our precision.

These replicate samples were interspersed throughout the station analysis for quality assurance and integrity of the coulometer cell solutions. The average absolute difference from the mean of these replicates is 0.75 $\mu\text{mol/kg}$ - No major systematic differences between the replicates were observed².

Summary

The overall performance of the analytical equipment was good during the cruise. For the first four days, PMEL 2 was not working properly and samples from stations 115, 117 and 119 were bad. After replacing a bad lamp, a disconnected gas line was discovered during the analysis of samples from station 119. After fixing it, the rest of the samples from station 119 gave good results. Beginning with station 120, all Niskins were sampled and analyzed except for 3 Niskins from the close-spaced shelf stations.

Including the duplicates, over 2,400 samples were analyzed for dissolved inorganic carbon (DIC). With the loss of the three stations (115, 117 & 119) mentioned above and a slightly less than full profile on station 121, there is a DIC value for approximately 97% of the Niskins tripped. The DIC data reported to the database directly from the ship are to be considered preliminary until a more thorough quality assurance can be completed shore side.

Calibration data during this cruise:

UNIT	L Loop	S Loop	Pipette	Ave CRM ¹	Std Dev ¹	Dupes ²
PMEL1	1.9842 ml	1.0006 ml	27.571 ml	2013.72, N= 55	1.42	0.71
PMEL2	1.9885 ml	0.9857 ml	26.363 ml	2015.83, N = 48	1.80	0.79

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Discrete pH Analyses

PI: *Dr. Andrew Dickson*

Cruise Participant: *Michael B. Fong*

Sampling

Samples were collected in 250 mL Pyrex glass bottles and sealed using grey butyl rubber stoppers held in place by aluminum-crimped caps. Each bottle was rinsed two times and allowed to overflow by one additional bottle volume. Prior to sealing, each sample was given a 1% headspace and poisoned with 0.02% of the sample volume of saturated mercuric chloride (HgCl_2). Samples were collected only from Niskin bottles that were also being sampled for both total alkalinity and dissolved inorganic carbon in order to completely characterize the carbon system. This resulted in an overall coverage of greater than 75%. Additionally, two duplicate samples were collected from each station for quality control purposes.

Analysis

pH was measured spectrophotometrically on the total hydrogen scale using an Agilent 8453 spectrophotometer and in accordance with the methods outlined by Carter et al., 2013. A Kloehe V6 syringe pump was used to autonomously fill, mix, and dispense sample through the custom 10cm flow-through jacketed cell. A Thermo NESLAB RTE-7 recirculating water bath was used to maintain the cell temperature at 25.0°C during analyses, and a YSI 4600 precision thermometer and probe were used to monitor and record the temperature of each sample immediately after the spectrophotometric measurements were taken. The indicator meta-cresol purple (mCP) was used to measure the absorbance of light measured at two different wavelengths (434 nm, 578 nm) corresponding to the maximum absorbance peaks for the acidic and basic forms of the indicator dye. A baseline absorbance was also measured and subtracted from these wavelengths. The baseline absorbance was determined by averaging the absorbances from 725-735nm. The ratio of the absorbances was then used to calculate pH on the total scale using the equations outlined in Liu et al., 2011. The salinity data used was obtained from the conductivity sensor on the CTD. The salinity data was later corroborated by shipboard measurements.

Reagents

The mCP indicator dye was made up to a concentration of approximately 2.0mM and a total ionic strength of 0.7 M. A total of 4 batches were used during Leg 2 of the cruise. The pHs of these batches was adjusted with 0.1 M solutions of HCl and NaOH (in 0.6 M NaCl background) to approximately 7.5-7.8, measured with a pH meter calibrated with NBS buffers. The indicator was purified using the HPLC technique described by Liu et al., 2011.

Data Processing

An indicator dye is itself an acid-base system that can change the pH of the seawater to which it is added. Therefore it is important to estimate and correct for this perturbation to the seawater's pH for each batch of dye used during the cruise. To determine this correction, multiple bottles from each station were measured twice, once with a single addition of indicator dye and once with a double addition of indicator dye. The measured absorbance ratio (R) and an isosbestic absorbance (A_{iso}) were determined for each measurement, where:

$$R = (A_{578} - A_{\text{base}}) / (A_{434} - A_{\text{base}}) \text{ and}$$

$$A_{\text{iso}} = (A_{488} - A_{\text{base}}).$$

The change in R for a given change in A_{iso} , $\Delta R / \Delta A_{\text{iso}}$, was then plotted against the measured R -value for the normal amount of dye and fitted with a linear regression. From this fit the slope and y-intercept (b and a respectively) are determined by:

$$\Delta R / \Delta A_{\text{iso}} = bR + a$$

From this the corrected ratio (R') corresponding to the measured absorbance ratio if no indicator dye were present can be determined by:

$$R' = R - A_{\text{iso}} (bR + a)$$

Standardization/Results

The precision of the data was assessed from measurements of duplicate analyses, replicate analyses (two successive measurements on one bottle), certified reference materials (CRMs) from Batch 143 (provided by Dr. Andrew Dickson, UCSD), and TRIS buffer Batch 26 (provided by Dr. Andrew Dickson, UCSD). CRMs were measured twice a day and bottles of TRIS buffer were measured about twice a week over the course of the cruise.

The overall precision determined from duplicate analyses was ± 0.00039 ($n=185$). The overall precision determined from replicate analyses was ± 0.00056 ($n=187$). Additionally, 108 measurements were made on 54 bottles of Certified Reference Materials and found to have a pH of 7.9201 ± 0.0018 ($n=108$) and a within-bottle standard deviation of ± 0.0005 ($n=54$). Furthermore, 20 measurements were made on 11 bottles of TRIS buffer solution and the pH was found to be 8.0913 ± 0.0017 ($n=20$).

Problems

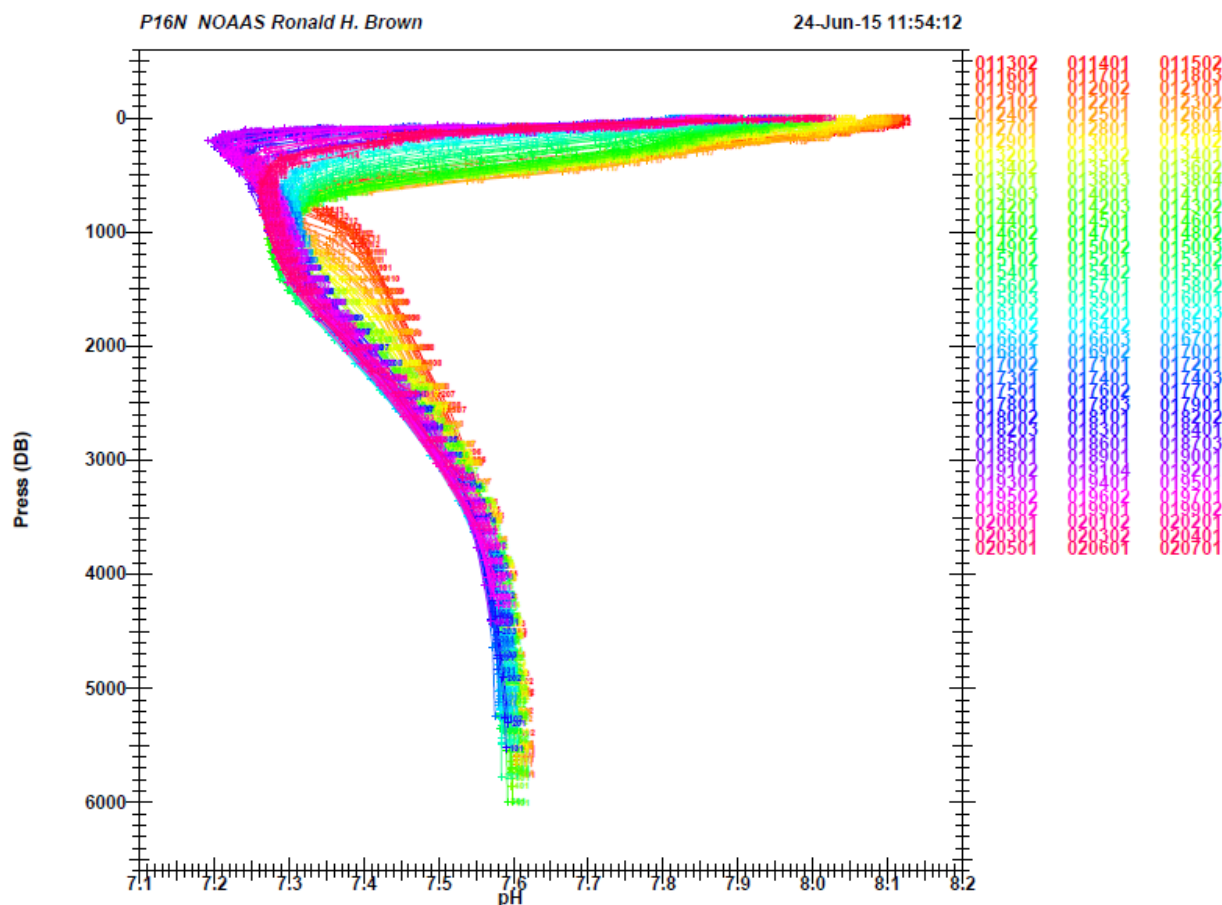
The high standard deviation of the TRIS pH's appear to be due to unusually high and low values measured on two days. If data from these two days are removed, the standard deviation improves to 0.0007. The temperature of the system appeared to be in control. Further investigation will be required to determine the cause of the unstable TRIS pH's.

Some of our bottles were quite fragile and cracked from the warming and expansion of the sample after collection. This resulted in the loss of a few samples. Some bottles also broke at the neck when crimping and sealing the sample.

Typically, the precision from duplicates and replicates should be similar and around ± 0.0004 . However, the replicate precision from Leg 2 was slightly high and greater than the duplicate precision. The poorer replicate precision seemed to be caused by a handful of measurements with extremely poor repeatability (exceeding the control limit of 0.0017 difference in replicate measurements). Most of these outliers were from samples with low pH (< 7.6), and the second measurements almost always had a higher pH. This might suggest that some CO_2 loss occurred,

despite precautions to minimize gas exchange (i.e., threading the sampling tube through a rubber stopper so that the bottle can be capped during measurement). I tried inverting the bottles a few times prior to opening to evenly distribute any gradients that might exist in the bottles. It is unclear whether this helped.

Our HgCl_2 dispenser became clogged towards the end of the cruise, and we were unable to unclog it. We therefore poisoned our samples using the DIC group's supply of HgCl_2 . The DIC group dispenses 120 μL of HgCl_2 into their samples as opposed to the 60 μL we use for our samples. Our samples from Station 187 onwards were poisoned with double our usual amount of HgCl_2 .



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Discrete pH Analyses—“pH Dye”

PI: *Dr. Andrew Dickson*

Cruise Participant: *Michael B. Fong*

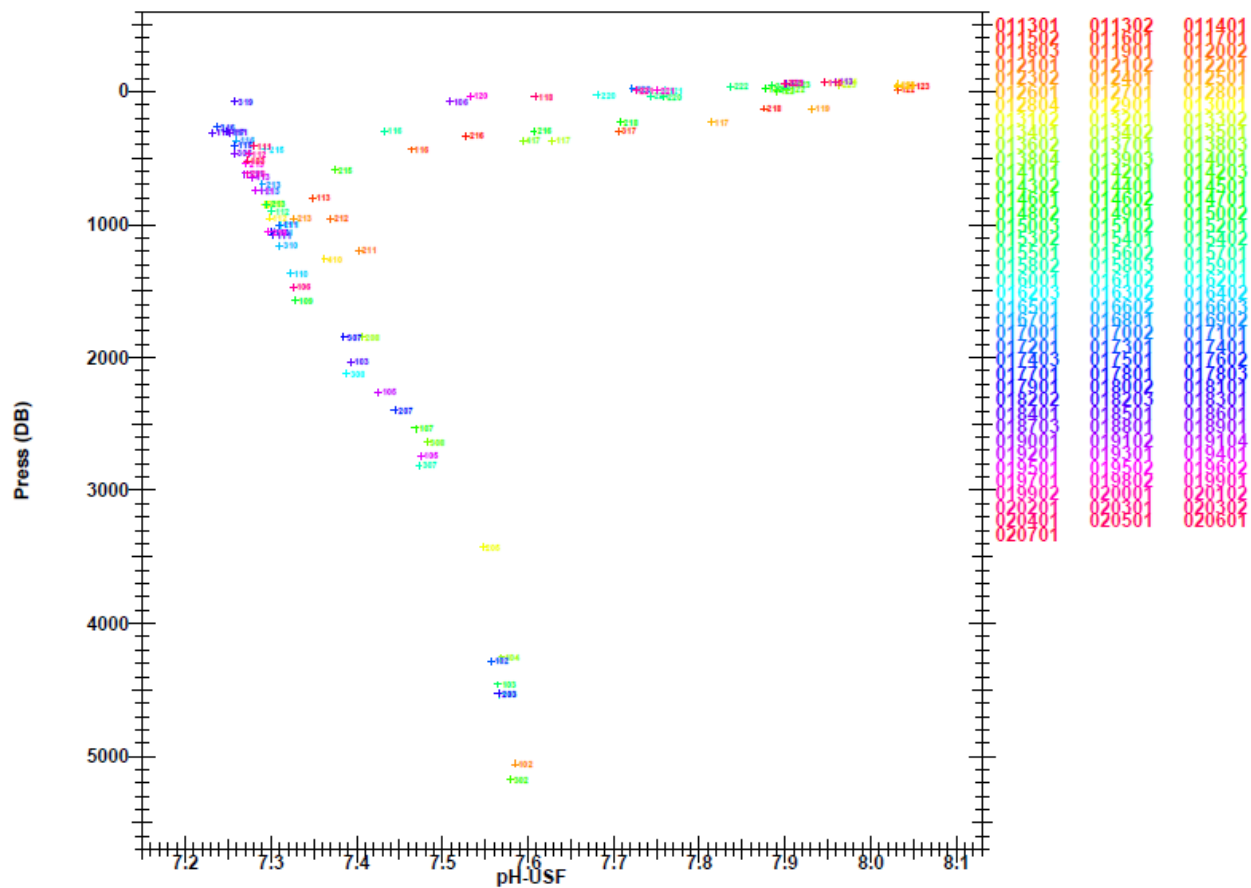
In addition to the regular 250 mL pH samples, one 500 mL sample was collected every station from a random Niskin. A larger volume sample was collected so that up to four pH measurements at different indicator dye concentrations can be made on a single bottle. The purpose of these samples was to gather more data to better characterize the perturbation effects of the dye on the sample pH.

The “pH Dye” samples were collected in a used CRM bottle (500 mL glass bottle) with a ground glass stopper, sealed with grease and secured with a band and clip. Initially, these samples were not collected according to standard pH sampling procedures. Instead, the bottles were merely filled with water. Toward the end of the cruise, when we were confident that there was sufficient water in the Niskins, the pH Dye samples were collected according to standard pH protocol—rinsing twice and overflowing the bottle by one volume. The headspace was adjusted by pipetting off the excess water with an Eppendorf pipette (as is done with the pH samples), and the samples were poisoned with twice the amount of HgCl_2 used for the 250 mL pH samples. The samples were measured spectrophotometrically, following the same procedures described in the Discrete pH Analyses section.

The data reported for pH Dye samples are not dye-corrected and are simply reported as the average of the four measurements on a single bottle.

Problems:

The pH of the pH Dye samples are not always comparable to the values measured in the 250 mL samples. Even in the samples collected following standard pH protocol, the difference between the pH Dye and regular pH samples can be as large as 0.003. This was probably due to the difficulty in adjusting the headspace. Using the same size pipette as for the regular pH samples, it was necessary to pipette multiple times to achieve a 1% headspace, but this was not always reproducible.



P16N Leg 2 - 2015 – Total Alkalinity

PI: Andrew G. Dickson – Scripps Institution of Oceanography

Technicians: David Cervantes and August Pereira

Total Alkalinity

The total alkalinity of a sea water sample is defined as the number of moles of hydrogen ion equivalent to the excess of proton acceptors (bases formed from weak acids with a dissociation constant $K \leq 10^{-4.5}$ at 25°C and zero ionic strength) over proton donors (acids with $K > 10^{-4.5}$) in 1 kilogram of sample.

Total Alkalinity Measurement System

Samples were dispensed using a Sample Delivery System (SDS) consisting of a volumetric pipette, various relay valves, and two air pumps controlled by LabVIEW 2012. Before filling the jacketed cell with a new sample for analysis, the volumetric pipette was cleared of any residual from the previous sample with the aforementioned air pumps. The pipette was then rinsed with new sample and filled, allowing for overflow and time for the sample temperature to equilibrate. The sample bottle temperature was measured using a DirecTemp thermistor probe inserted into the sample bottle. The volumetric pipette temperature was measured using a DirecTemp surface probe placed directly on the pipette. These temperature measurements were used to convert the sample volume to mass for analysis.

Samples were analyzed using an open cell titration procedure using two 250 mL jacketed cells. One sample was undergoing titration while the second was being prepared and equilibrating to 20°C for analysis. After an initial aliquot of approximately 2.3-2.4 mL of standardized hydrochloric acid (~0.1M HCl in ~0.6M NaCl solution), the sample was stirred for 5 minutes while air was bubbled into it at a rate of 200 scc/m to remove any liberated carbon dioxide gas. A Metrohm 876 Dosimat Plus was used for all standardized hydrochloric acid additions. After equilibration, ~19 aliquots of 0.04 ml were added. Between the pH range of 3.5 to 3.0, the progress of the titration was monitored using a pH glass electrode/reference electrode cell, and the total alkalinity was computed from the titrant volume and e.m.f. measurements using a non-linear least-squares approach (Dickson, et.al., 2007). An Agilent 34970A Data Acquisition/Switch Unit with a 34901A multiplexer was used to read the voltage measurements from the electrode and monitor the temperatures from the sample, acid, and room. The calculations for this procedure were performed automatically using LabVIEW 2012.

Sample Collection

Samples for total alkalinity measurements were taken at all P16N Leg 2 Stations (113-207). All 24 Niskin bottles were sampled for analysis whenever possible. For every 12 Niskin bottles, one duplicate sample was taken for quality control analyses. Using silicone tubing, the total alkalinity samples were drawn from Niskin bottles into 250 mL Pyrex glass bottles, making sure to rinse the bottles and Teflon sleeved glass stoppers at least twice before the final filling. A headspace of approximately 5 mL was removed and 0.06 mL of saturated mercuric chloride solution was added to each sample for preservation. After sampling was completed, each sample's temperature was equilibrated to approximately 20°C using a Thermo Scientific RTE water bath.

Problems and Troubleshooting

During instrument set up for Leg 2, it was discovered that the Pipette A SDS board was dispensing less than the calibrated volume that was determined back on shore. This was confirmed by running titrations using a calibrated manual pipette to dispense reference seawater of known total alkalinity and measuring the correct total alkalinity. The Pipette A SDS board was providing incorrect total alkalinity values with the same reference seawater. As a result, a volume correction was applied to the Pipette A SDS board (from 92.946 mL to 92.853 mL) to account for the shift in its dispensing volume. After this correction was made, the CRM average remained precise and accurate for the remainder of the cruise (see Quality Control section for Reference Material data).

About one week into Leg 2, communication issues began to occur with our instruments. The computer was failing to consistently communicate with the Dosimat and therefore not adding acid when commanded by the computer. This eventually led to replacement of the NI USB 6501 box that connects the Dosimat to the computer. One week later, the computer began failing to recognize and communicate with the Agilent 34970A Data Acquisition/Switch Unit. The Switch Unit was replaced but produced the same result. Once the computer was replaced, all instrumental communication issues ceased for the remainder of the cruise.

0.06 mL of saturated mercuric chloride solution is normally added to each 250mL sample for preservation. On Station 186, the Dispensette succeeded to dispense mercuric chloride for samples 1-5 but failed for the rest of the station. After sample 5, the Dispensette from the DIC group was used. This new Dispensette delivered 0.120 mL instead of 0.06 mL. After some minor cleaning, the TA Dispensette began working properly to begin Station 187. However, this only lasted for the first three samples and the DIC provided Dispensette (and mercuric chloride volume) was used for the remainder of Leg 2. Mercuric chloride volume corrections were applied to all samples for the accurate amount of mercuric chloride added.

2160 total alkalinity values were submitted out of 2162 sampled Niskin bottles. While analyzing samples from Station 122, there was an SDS malfunction and sample 9 was lost. SDS Pipette Board A continued to draw from bottle 9 without stopping like it normally would. By the time this was noticed by the analyst, not enough sample remained in the bottle for measurement. In addition, the Dosimat communication issue mentioned above resulted in the loss of sample 16 from Station 139. Therefore, no total alkalinity values are reported for these two samples and each is flagged as a 5.

Quality Control

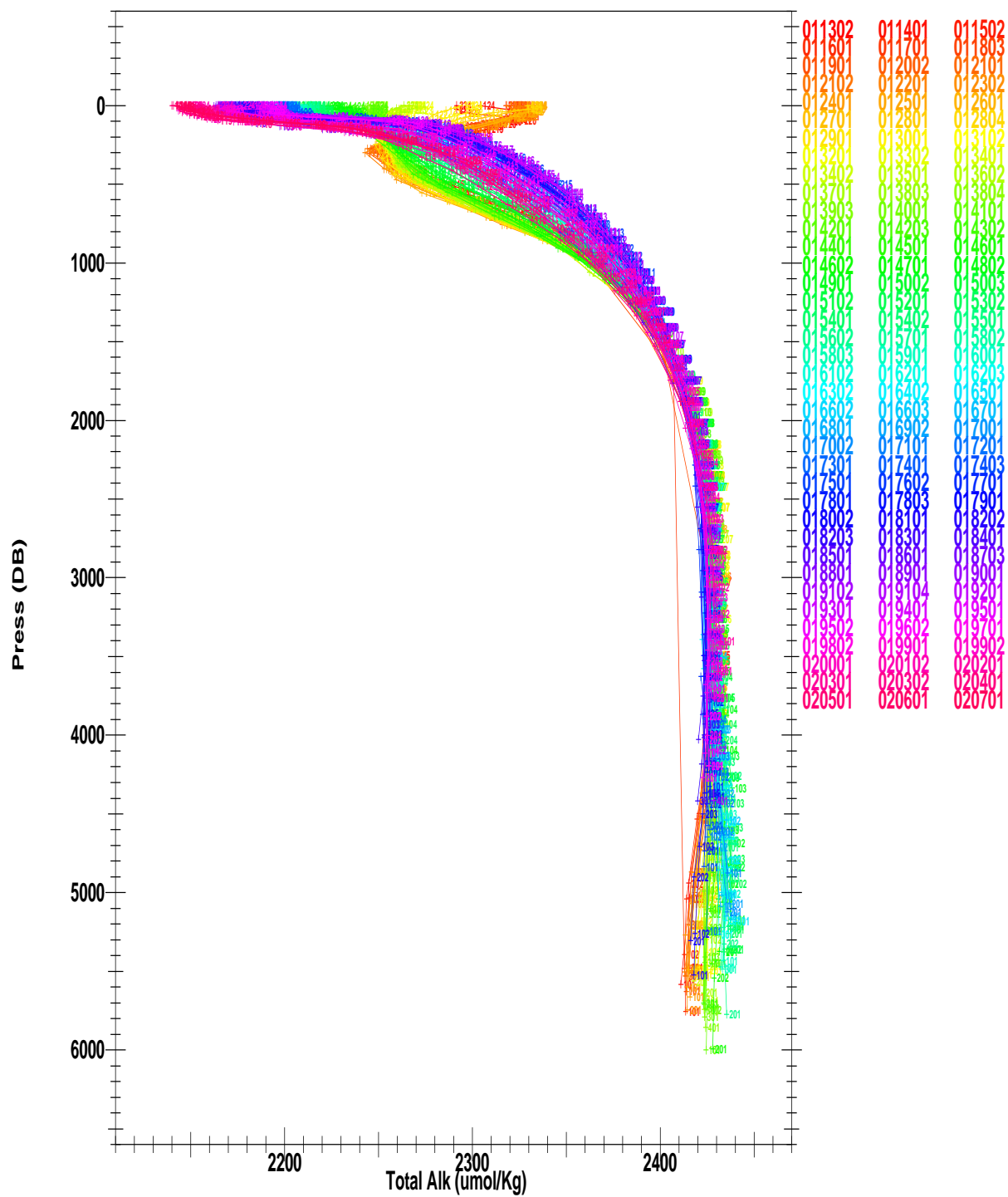
Dickson laboratory Certified Reference Material (CRM) Batch 143 was used to determine the accuracy of the total alkalinity analyses. The certified total alkalinity value for Batch 143 is $2241.04 \pm 0.84 \mu\text{mol kg}^{-1}$. This reference material was analyzed 163 times throughout P16N Leg 2. The preliminary B143 measured value average for P16N Leg 2 is 2241.40 ± 1.10 . A correction of 0.99984 will be applied to all samples.

For every ~12 Niskin bottles, one duplicate sample was taken for quality control analyses. A total of 186 Niskins were sampled for duplicate analyses and gave a pooled standard deviation of $0.92 \mu\text{mol kg}^{-1}$.

Throughout P16N Leg 2, empty pre-weighed glass bottles with rubber stoppers and aluminum caps were filled with deionized water from the SDS and then crimped shut. These sealed bottles will be weighed again once they return to shore to detect any possible or suspected shifts in volume dispensing throughout the cruise that could have caused reference material, and therefore sample, value shifts.

All of the P16N 2015 station's total alkalinity measurements were compared to measurements taken from the neighboring P16N 2015 stations and the P16N 2006 stations of similar if not identical coordinates.

2162 Niskin bottles were sampled for total alkalinity analyses. 2160 total alkalinity measurements were submitted. 2 samples were lost. Corrections have already been applied for the Certified Reference Material measurement comparison and also for the mercuric chloride volume additions. A normalized total alkalinity plot was analyzed to aid in identifying any possible bad measurements. Although most corrections have been made and it is unlikely that additional ones will need to be performed, this data should be considered preliminary since the correction for any shifts in total volume dispensed per sample has to be checked, confirmed and applied. This assessment cannot be accomplished until the pre-weighed bottles of filled deionized water are reweighed back on land. Attached is a plot of total alkalinity versus pressure for all of the stations occupying P16N Leg 2 2015.



Reference

Dickson, Andrew G., Chris Sabine and James R. Christian, editors, "Guide to Best Practices for Ocean CO₂ Measurements", Pices Special Publication 3, IOCCP Report No. 8, October 2007, SOP 3b, "Determination of total alkalinity in sea water using an open-cell titration"

Carbon Isotopes in seawater ($^{14}/^{13}\text{C}$)

PI: Ann McNichol

Samplers: Bryan Kaiser, Zoe Sandwith, Maria Arroyo

Along the 152°W line, a total of 516 samples were collected from 26 stations, plus 6 duplicate samples. At 18 of the stations, the full profile was sampled; at 6 of the stations, samples were collected from $\sigma_\theta \approx 27.2$ to the bottom of the mixed layer, plus the surface Niskin. During the Alaskan Gyre transect, the surface Niskin was sampled at every station. Samples were collected in 500 mL airtight glass bottles.

Using silicone tubing, the flasks were overflowed 1.5 times the fill time with seawater from the Niskin bottle while keeping the tubing at the bottom of the flask. Once the sample was taken, 5-10 ml of water was poured off to create a headspace and 120 μL saturated mercuric chloride solution was added in the sampling bay. In order to avoid contamination, gloves were used during all collection, handling, and storage processes. Sample handling was done on a clean table covered with plastic. After all samples were collected from a station, the glass stoppers were dried and greased with Apiezon-M grease to ensure an airtight seal. The stoppers were secured with a rubber band. The samples were stored in AMS boxes inside the ship's bio-analytical laboratory during the cruise, then transferred to the WHOI shipping container at the end of the leg. The samples will be shipped to WHOI for analysis. The radiocarbon/DIC content of seawater (DI^{14}C) is measured by extracting the inorganic carbon as CO_2 gas, converting the gas to graphite, then counting the number of ^{14}C atoms in the sample directly using an accelerator mass spectrometer (AMS). Radiocarbon values will be reported as ^{14}C using established procedures modified for AMS applications. The $^{13}\text{C}/^{12}\text{C}$ of the CO_2 extracted from seawater is measured relative to the $^{13}\text{C}/^{12}\text{C}$, a CO_2 gas standard calibrated to the PDB standard using an isotope radio mass spectrometer (IRMS) at NOSAMS.

Dissolved Organic Carbon (DOC)

PI: Dennis Hansell

Sampler: Benjamin Granzow

Dissolved Organic Carbon (DOC) samples were taken from every Bullister (aka Niskin) bottle at every other station (odd stations). Samples were also taken from stations 130, 148, 188, and 195-207. Duplicates were taken on the first (deepest) 12 bottles on every station except for stations 185-189 and stations 204-207. 1936 samples were taken from 57 stations in total. All samples from depths of 300m and shallower were filtered through GF/F filters using in-line filtration. Samples from deeper depths were not filtered. Samples were taken in polycarbonate 60 ml bottles and duplicates were taken in 40mL glass vials. The polycarbonate bottles were pre-cleaned with 10% HCl and rinsed with Mili-Q water. Both the glass duplicate vials and GF/F filters were combusted at 450 °C overnight. Filter holders and silicone tube were cleaned with 10% HCl and rinsed with Mili-Q water before sampling.

Bottles were rinsed three times with the seawater before collecting 50 - 60 mL of sample at each Bullister bottle. Duplicate vials were rinsed three times with seawater before collecting 30 – 40 mL of sample from the first twelve Bullister bottles. Additionally, atmospheric blanks were collected on stations 113, 177, and 200. To collect these blanks, 50 mL of Mili-Q water were placed in a 60 mL polycarbonate bottle and left uncapped during sampling. The blank was capped at the end of the sampling and frozen.

Samples taken in polycarbonate were frozen upright for 18 hours before being put into bags labeled by station. Duplicate vials were stored in boxes at room temperature in the dark. The frozen samples and duplicates were shipped back to The Rosenstiel School of Marine and Atmospheric Science in 4 coolers and 5 crates for laboratory analysis by High Temperature Combustion (HTC). Gloves were used during all processes of collection, and all samplers taking water at the rosette prior to DOC wore gloves.

Problems: While sampling we would encounter grease on some Niskin spigots, which would dirty the ends of the tubing used. Each dirty spigot was wiped with Kimwipes before sampling. Dirty tubes were replaced before the next station.

CLIVAR P16N Leg 2

Dissolved organic carbon ^{14}C , Black carbon ^{14}C , Ultrafiltered dissolved organic carbon ^{14}C

PI: Ellen R.M. Druffel, Earth System Science, University of California, Irvine

Sample Collection: Brett D. Walker, Earth System Science, University of California, Irvine.

7x Black Carbon and 56x 1L total DO ^{14}C and 4x ultrafiltered DO ^{14}C samples were taken.

Samples were taken at 10 stations on Leg 2 of the P16N cruise. Stations sampled were #128 (30°N, 152°W), #129 (30.5°N, 152°W), #130 (30°N, 152°W), #154 (43°N, 152°W), #155 (43.5°N, 152°W), #174 (53°N, 152°W), #175 (53.5°N, 152°W), #181 (55.5°N, 152°W), #204 (56.5°N, 137.5°W) and #205 (56.5°N, 136°W).

PROJECT SUMMARY:

DOC is the largest pool of organic carbon in the ocean, comparable to the total carbon content in the atmosphere. Knowing the carbon isotopic signatures of DOC is important for understanding the biogeochemistry and dynamics of DOC cycling, and is essential for the C cycle modeling community. This study addresses fundamental gaps in our knowledge of the global carbon cycle and the dynamic nature of DOC in the ocean. These results will provide much needed, quantitative information on the timescale of DOC cycling in the ocean. These results will also help to determine the amount of terrestrially derived organic carbon (e.g. black carbon) in the open ocean. DOC may serve as a sink for excess carbon dioxide produced from fossil fuel and biomass burning. Most of this excess carbon will end up in the ocean, and it is critical to improve our understanding of the processes that are important for its long-term storage. Results of this research will be made available for use in models that assess present and future concentrations of atmospheric CO₂.

The average radiocarbon (^{14}C) age of dissolved organic carbon (DOC) in the deep ocean ranges from 4000 – 6500 ^{14}C years. However, the data set used to estimate this range is based on only a few sites in the world ocean. The main objective of this research is to determine the ^{14}C signatures of DOC in seawater from low and high latitude regions of the Pacific for which there is no data. High-precision $\Delta^{14}\text{C}$ measurements will be performed on samples using AMS (accelerator mass spectrometry) of DOC in water samples from detailed profiles at each site. Another objective of this effort is to isolate black carbon from DOC and determine the ^{14}C and ^{13}C signatures of this recalcitrant DOC fraction. As a test we are also collecting 4x samples of size-fractionated DOC to determine the size-age structure of DOC in the ocean. We are testing three hypotheses:

- (1) ^{14}C of bulk DOC in the low latitude regions of the Pacific Ocean are similar to those in the south and north Pacific.
- (2) Black carbon constitutes a significant amount of DOC in open ocean water, and its ^{14}C age is greater than 10,000 ^{14}C years.
- (3) Ultrafiltered DO ^{14}C will reveal the molecular size-age structure of the DOC pool in the ocean.

Dissolved Organic Carbon-14 Sampling and Analysis

Dissolved organic carbon-14 samples were taken in pre-combusted (540°C/4hours) 1L borosilicate bottles (amber boston round). We collected 7x DOC samples below 1000m and 7x samples above 1000m at each station. Samples above 400m depth were filtered using pre-combusted GFF filters and acid cleaned silicone tubing/stainless steel filter manifolds. Samples were immediately frozen after collection and stored at -20°C until analysis at UCI. Once in the lab, CO₂ will be evolved from DOC via UVoxidation and vacuum line extraction. This CO₂ will then be graphitized and its radiocarbon content measured via accelerator mass spectrometry at the KCCAMS facility at UCI.

Size fractionated (ultrafiltered) DOC was collected from the surface (<20m) and deep (~3000m) depths from 2x stations along the transect. Collection and analysis is identical to that for DO¹⁴C, except 1L seawater volumes will be ultrafiltered in the lab prior to ¹⁴C analysis.

Black Carbon-14 Sampling

Due to extremely low concentrations of Black carbon in seawater (<5% of the DOC pool), 4x 4 gallon filtered surface samples were collected from stations #128-129, 154, 174 204, while 3x 8 gallon deep samples were collected from stations #128-129, 154, and 204/205. The concentration and carbon isotopes (¹⁴C and ¹³C) of black carbon in this sample (and all others collected from Repeat Hydrography cruises) will be measured using the benzene polycarboxylic acid (BPCA) method, and these data will be used to estimate the abundance and source of black carbon in oceanic DOC. Individual BPCAs will be isolated using a preparative column gas chromatograph (PCGC). These fractions will be combusted to CO₂ gas, graphitized and radiocarbon content measured.

POTENTIAL CONTAMINATION ISSUES:

Several observations were made on Leg 2 that could possibly influence our natural abundance DOC D¹⁴C measurements, and DOM measurements from other groups (UCSB: CDOM, and UM: DOC/TN). These are summarized below:

- 1) Wire grease in the form of large oil slick plumes were observed immediately after using StranCore at Station 148. These plumes were documented to be present during casts for at least 1.5 weeks. Samples were taken to evaluate the presence of StranCore grease in seawater samples, which may contribute gross isotopic contamination of our surface and deep samples.
- 2) Leaking Z-drive also input significant hydrocarbon oils into the surface ocean near the ship and rosette.
- 3) Anomalous foaming bubbles (grey water discharge?) were present for several days if not one week surrounding the ship. This could also have potentially contaminated our surface samples.

Unlike Leg 1, no grease was observed to be present on the Niskin bottles at least during the stations we sampled. All science parties were exceptionally vigilant in their use of cleaned SiO₂ tubing to sample the rosette. Preliminary tests of DOC concentrations from Leg 1 suggest that the wire grease is not an immediate issue, however, our isotopic D¹⁴C are far more sensitive and future testing will be required to see if our samples have been compromised. We recommend in the future that wire grease be applied at the end of the cruise, or immediately after a DO¹⁴C station (of which there were only four on Leg 2) to minimize impact on our scientific program.

P16N Cruise Report for Nutrients

Equipment and Techniques

Dissolved nutrients (phosphate, silicate, nitrate and nitrite) were measured by using a Seal Analytical AA3 HR automated continuous flow analytical system with segmented flow and colorimetric detection.

Detailed methodologies are described by Gordon et al. (1992).

Silicic acid was analyzed using a modification of Armstrong et al. (1967). An acidic solution of ammonium molybdate was added to a seawater sample to produce silicomolybdic acid. Oxalic acid was then added to inhibit a secondary reaction with phosphate. Finally, a reaction with ascorbic acid formed the blue compound silicomolybdous acid. The color formation was detected at 660 nm. The use of oxalic acid and ascorbic acid (instead of tartaric acid and stannous chloride by Gordon et al.) were employed to reduce the toxicity of our waste stream.

Nitrate and Nitrite analysis were also a modification of Armstrong et al. (1967). Nitrate was reduced to nitrite via a copperized cadmium column to form a red azo dye by complexing nitrite with sulfanilamide and N-1-naphthylethylenediamine (NED). Color formation was detected at 540 nm. The same technique was used to measure nitrite, (excluding the reduction step).

Phosphate analysis was based on a technique by Bernhart and Wilhelms (1967). An acidic solution of ammonium molybdate was added to the sample to produce phosphomolybdate acid. This was reduced to the blue compound phosphomolybdous acid following the addition of hydrazine sulfate. The color formation was detected at 820 nm.

Sampling and Standards

Nutrient samples were drawn in 50ml HDPE Nalgene sample bottles that had been stored in 10% HCl. The bottles are rinsed 3-4 times with sample prior to filling. A replicate was normally drawn from the deep Niskin bottle at each station for analysis to reduce carry over. Samples were then brought to room temperature prior to analysis. Fresh mixed working standards were prepared before each analysis. In addition to the samples, each analysis consisted of 3 replicate standards, 3 DIW blanks and 3 Matrix blanks placed at the beginning and then repeated at the end of each run. Also, one mixed working standard from the previous analytical run was used at the beginning of the new run to determine differences between the two standards. Samples are analyzed from deep water to the surface. Low Nutrient Seawater (LNSW) was used as a wash, base line carrier and medium for the working standards.

The working standard was made by the addition of 0.2ml of primary nitrite standard and 15.0 ml of a secondary mixed standard (containing silicic acid, nitrate, and phosphate) into a 500ml calibrated volumetric flask of LNSW. Working standards were prepared daily.

Dry standards of a high purity were pre-weighed at PMEL. Nitrite standards were dissolved at sea. The secondary mixed standard was prepared by the addition of 30ml of a nitrate - phosphate primary standard to the silicic acid standard.

Nutrient concentrations were reported in micromoles per liter. Lab temperatures were recorded for each analytical run. All the pump tubing was replaced at least four times during the P16N cruise.

Approximately 2200 samples were analyzed.

Reference:

Armstrong, F.A.J., Stearns, C.R. and Strickland, J.D.H. (1967) The measurement of upwelling and subsequent biological processes by means of the Technicon AutoAnalyzer and associated equipment. *Deep-Sea Res.* 14:381-389.

Bernhard, H. and Wilhelms, A. (1967) The continuous determination of low level iron, soluble phosphate and total phosphate with AutoAnalyzer. *Technicon Symposia*, I. pp.385-389.

Gordon, L.I., Jennings Jr., J.C., Ross, A.A. and Krest, J.M. (1993) A suggested protocol for the continuous automated analysis of seawater nutrients (phosphate, nitrate, nitrite and silicic acid) in the WOCE Hydrographic program and the Joint Global Ocean Fluxes Study, WOCE Operations Manual, vol. 3: The Observational Programme, Section 3.2: WOCE Hydrographic Programme, Part 3.1.3: WHP Operations and Methods. WHP Office Report WHPO 91-1; WOCE Report No. 68/91. November 1994, Revision 1, Woods Hole, MA., USA, 52 loose-leaf pages.

Discrete Salinity Sampling

Preparation

Two Guildline Autosol's, model 8400B salinometers (S/N 61668, nicknamed Dallas and S/N 60555, nicknamed Debbi), located in the salinity analysis room, were used for all salinity measurements. The salinometer readings were logged on a computer using Ocean Scientific International's logging hardware and software. The Autosol's water bath temperature was set to 24°C, which the Autosol is designed to automatically maintain. The laboratory's temperature was also set and maintained to 23°C, to help further stabilize reading values and improve accuracy. The temperature of the room was monitored by a thermostat as well as spot checked daily with a handheld thermistor to confirm accuracy of the unit and verify that the room was staying at or below 24°C. Salinity analyses were performed after samples had equilibrated to laboratory temperature. After spot checking sample temperatures using a thermistor probe, it was concluded that the wait time for this particular cruise for samples to come up to temperature should be around 24 hours because of the colder nature of the sampled water. The salinometer was standardized for each group of samples analyzed (usually 2 casts and up to 52 samples) using two bottles of standard seawater: one at the beginning and end of each set of measurements. The salinometer output was logged to a computer file. A accessory peristaltic pump was used inline with the normal sample introduction tubing to draw the sample water from the sample bottle during analysis. The software prompted the analyst to flush the instrument's cell and change samples when appropriate. Prior to each run a sub-standard flush, approximately 200 ml, of the conductivity cell was conducted to flush out the DI water used in between runs. For each calibration standard, the salinometer cell was initially flushed 6 times before a set of conductivity ratio reading was taken. For each sample, the salinometer cell was initially flushed at least 3 times before a set of conductivity ratio readings were taken.

IAPSO Standard Seawater Batch P-157 was used to standardize all casts up to station 196 and the remaining stations used Batch P-155.

Sampling

The salinity samples were collected in 200 ml Kimax high-alumina borosilicate bottles that had been rinsed at least three times with sample water prior to filling. The bottles were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. Prior to sample collection, inserts were inspected for proper fit and loose inserts replaced to insure an airtight seal. PSS-78 salinity [UNES81] was calculated for each sample from the measured conductivity ratios. The offset between the initial standard seawater value and its reference value was applied to each sample. Then the difference (if any) between the initial and final vials of standard seawater was applied to each sample as a linear function of elapsed run time. The corrected salinity data was then incorporated into the cruise database. Two duplicate samples were drawn from each cast to determine total analytical precision. When duplicate measurements were deemed to have been collected and run properly, they were averaged and submitted with a quality flag of 6. On P16N, 2384 salinity measurements were taken, including 188 duplicates, and approximately 110 vials of standard seawater (SSW) were used.

Analysis

The running standard calibration values and duplicates are below. Through the course of the 33 day cruise, the autosol standards changed by ~ 0.0012 in conductivity ratio, about 0.024 in salinity for Dallas and ~ 0.0003 in conductivity ratio, about 0.005 in salinity for Debbi (Figure 1). The duplicates taken during the cruise showed a median precision of $2.24 \times 10^{-4} \pm 0.0016$ psu (Figure 2).

Problems

Dallas showed small gradual increase in variability and instability through the first 48 stations and was swapped out for Debbi at station 161, which showed better stability.

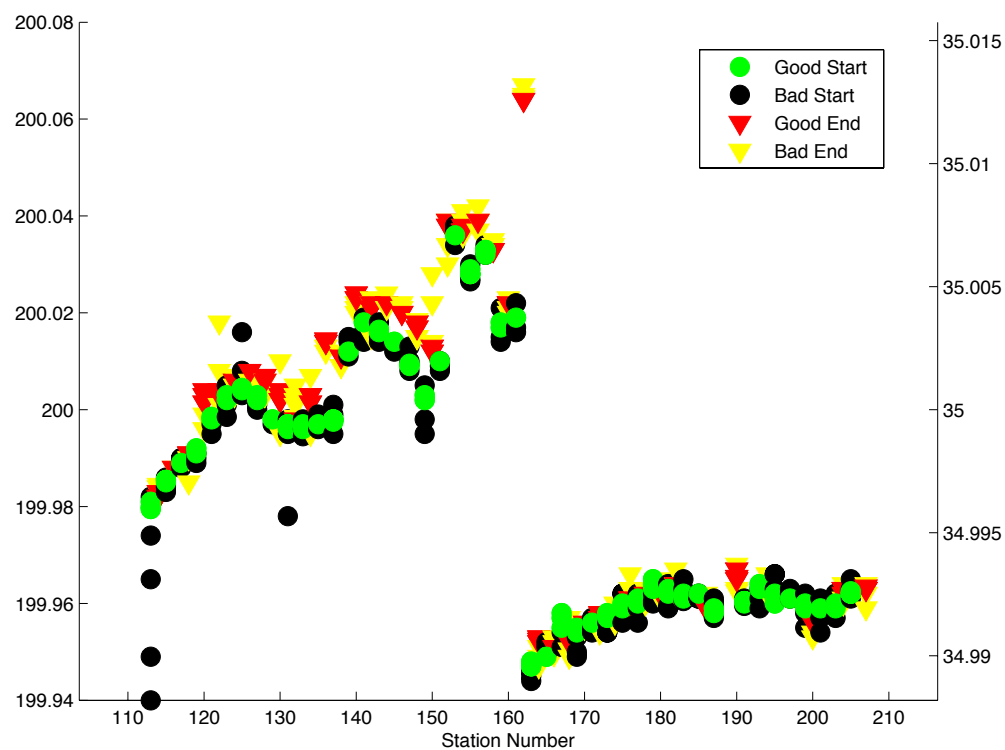


Figure 1: Standard vial calibrations throughout the cruise.

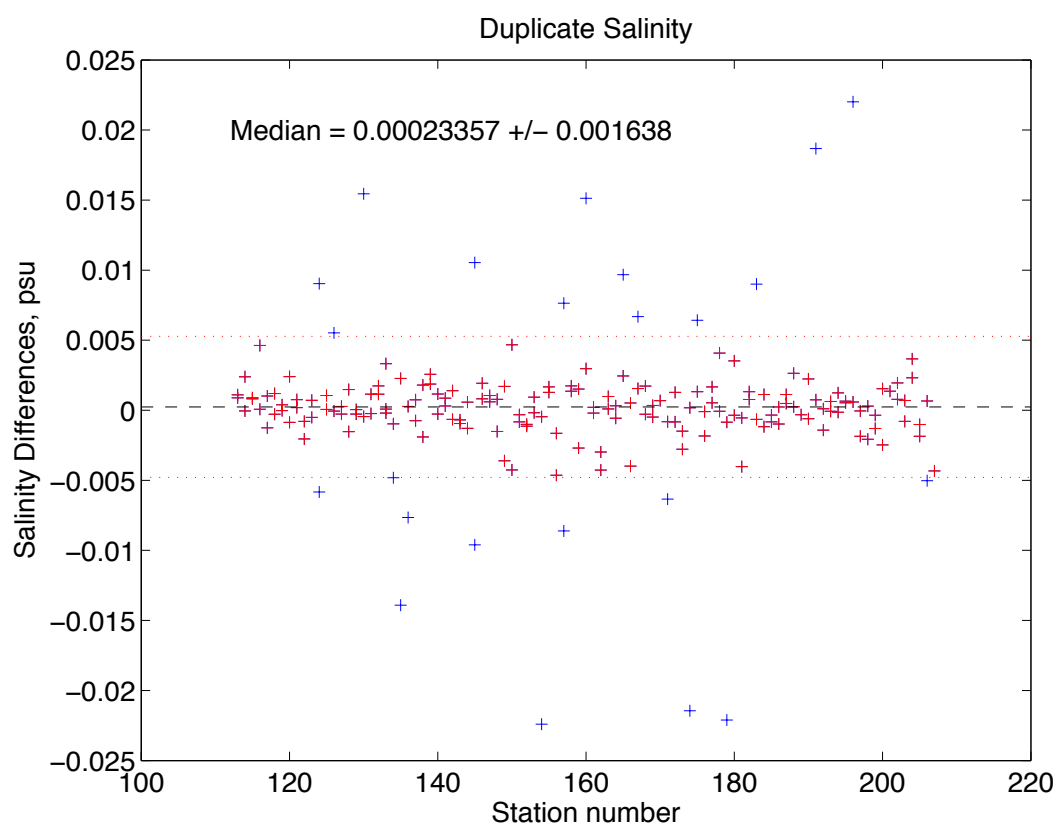


Figure 2: Salinity residuals of the duplicate samples.

GO-SHIP P16N Cesium Sampling

Alison Macdonald (PI)

Steven Pike (Sampler)

The goal of this project is to investigate the pathways, mixing and transport of water in the North Pacific Ocean. In particular, we are seeking to understand the timescales associated with the gyre transport of water mixed down by winter storms in the western Pacific, as well as mixing and dispersion along the transport pathways as observed using the radionuclide tracers ^{137}Cs (~30 year half-life) and ^{134}Cs (2 year half-life).

Sampling: Each sample is taken in a 20 L plastic cubitainer. The cubitainers were filled with unfiltered seawater (<0.1% of Cs is particulate). No rinsing was required. As the samples are so large, all samples come from multiple Niskins. Each cubitainer is approximately 10 inches tall – making each 0.5” of water equivalent to 1 L. For the integrated samples drawn from multiple Niskin’s the height of the water after the addition of water from each Niskin was recorded so that later the fraction from each pressure contributing to the sample could be ascertained.

On leg 2 there were five different types of samples taken (each sample = 1 cubitainer):

- 1) Integrated upper layer samples from Niskins within the range: ~100 - 300 dbar
 - 2) Integrated deeper samples taken within the range: ~300 – 600 dbar
 - 3) Profiles to ~1000 m with 12 samples (sample= 2 Niskins fired at the same pressure)
 - 4) Shorter integrated profiles made up of left over water from multiple Niskins in varying pressures ranges above 1000 dbar.
 - 5) Seawater Intake Surface samples (SIS)
- 15 Upper layer (type 1) samples were taken at stations: 116, 124, 130, 136, 144, 152, 160, 168, 176, 184, 192, 194, 197, 200 and 202.
 - 15 Deeper (type 2) samples were taken at stations: 119,126,132, 140, 148, 156, 164, 172, 180, 186, 193, 196, 198,201 and 204.
 - 20 Cesium-only Profiles with 12 samples each were taken at stations: 113, 121, 128, 134, 148, 142, 146, 150, 154, 158, 162, 166, 172, 176, 182, 191, 195, 199, 203.
 - 29 Integrated profile samples (type 4) were taken at 6 stations: 187, 188, 189, 204, 206 and 207.
 - 71 SIS samples were taken (type 5) were drawn; one at each station sampled using types 1-4, and 15 SIS samples drawn along our cruise track (outside the Canadian EEZ) on our return to Seattle.
 - All told 370 cesium samples were drawn on Leg 2.

Some of the cesium samples were stored; others were filtered to reduce the volume of water shipped back to the lab where analysis will occur. To filter, the sample water was pumped slowly through a 5-ml volume KNiFC-AMP resin column. The resin is transferred to a counting vial for analysis in one of several high purity germanium well detectors at WHOI. Time was the main factor limiting the amount of filtering that could occur onboard. While in port in Hawaii, the 27 Leg 1 samples were filtered. On Leg 2, half of the samples from the cesium-only cast profiles (type 3) were filtered, the other half of the samples were stored. All upper layer, deeper

layer and SIS (1,2,5) samples were stored unfiltered. Subsamples of some the unfiltered waters will later be used to analyze for ^{129}I and ^{90}Sr as well as the primary isotopes, ^{134}Cs and ^{137}Cs .

A set of staggering schemes for varying the pressures at which cesium profile samples were taken was used in a rotation of 3. The filtered and unfiltered samples were also staggered. For each set of 6 cesium casts the pressures at which the Niskins were fired, the bottles that go into each sample, and whether the samples are filtered (F) or not (U), is described in Tables 1-3.

Table 1: Sampling scheme for first 6 stations. In the columns following the pressures F implies that the sample will be filtered, U implies that samples will be stored in the cubitainer, unfiltered. Station 7 will look like station 1, 8 like 2 etc.

Stagger→	A		B		C		A		B		C	
Niskins	Sta. 1		Sta. 2		Sta. 3		Sta. 4		Sta. 5		Sta. 6	
23-24	20	F	30	U	40	F	20	U	30	F	40	U
21-22	50	U	60	F	70	U	50	F	60	U	70	F
19-20	80	F	90	U	105	F	80	U	90	F	105	U
17-18	120	U	130	F	145	U	120	F	130	U	145	F
15-16	160	F	170	U	185	F	160	U	170	F	185	U
13-14	200	U	220	F	240	U	200	F	220	U	240	F
11-12	260	F	280	U	300	F	260	U	280	F	300	U
9-10	330	U	370	F	410	U	330	F	370	U	410	F
7-8	450	F	500	U	550	F	450	U	500	F	550	U
5-6	600	U	650	F	700	U	600	F	650	U	700	F
3-4	750	F	800	U	850	F	750	U	800	F	850	U
1-2	900	U	950	F	1000	U	900	F	950	U	1000	F
Intake	Surface	U	Surface	U	Surface	U	Surface	U	Surface	U	Surface	U

Table 2: Repeating scheme for Unfiltered samples for first 6 stations (subset of Table 1).

A	B	C	A	B	C
Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta.
Surface	Surface	Surface	Surface	Surface	Surface
50	30	70	20	60	40
120	90	145	80	130	105
200	170	240	160	220	185
330	280	410	260	370	300
600	500	700	450	650	550
900	800	1000	750	950	850

Table 3: Repeating scheme for Filtered samples for first 6 stations (subset of Table 1).

A	B	C	A	B	C
Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta.
20	60	40	50	30	70
80	130	105	120	90	145
160	220	185	200	170	240
260	370	300	330	280	410
450	650	550	600	500	700
750	950	850	900	800	1000

Chipods

PI: Jonathan Nash

Sampler: Bryan Kaiser

System Configuration and Sampling

Four Chipods were mounted on the rosette to measure temperature (T), its time derivative (dT/dt), and x and z (horizontal and vertical) accelerations at a sampling rate of 50 Hz. Two chipods were oriented such that their sensors pointed upward (circled in green in the figure below), and are referred to as *uplookers*. The other two pointed downwards and are referred to as *downlookers* (circled in green at the bottom of the rosette in the figure below). The chipod pressure case, containing the logger board and batteries, is circled in red in the figure below.

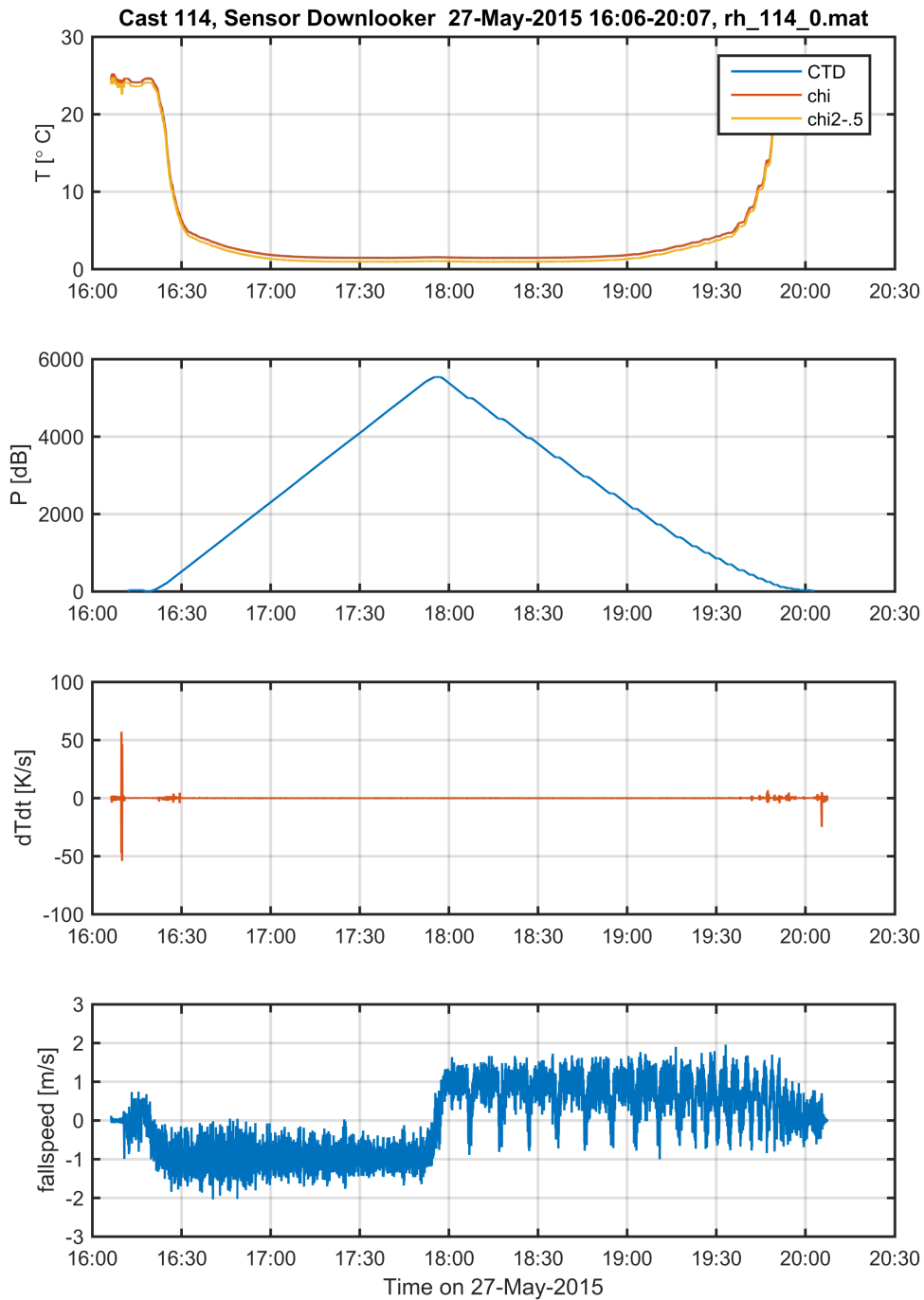


The uplooking sensors were positioned higher than the Niskin bottles on the rosette in order to avoid measuring turbulence generated by the firing of Niskin bottles. The downlooking sensors were positioned an inch above the base of the rosette at a distance of about six inches away from the frame. This ensured that the rosette could rest on its frame (and not on the downlooking sensors) and ensured that the downlooking sensors were as far from the frame as possible and as close to the leading edge of the rosette during descent as possible to avoid measuring turbulence generated by the rosette frame.

Data processing

To plot vertical profiles of turbulent kinetic energy dissipation (epsilon) and dissipation of thermal variance (chi), chipod temperature and temperature derivatives measurements must be collocated with pressure profiles. The chipods do not have a pressure sensors so vectors of doubly-integrated vertical acceleration (i.e. displacement) are fit to the pressure profiles from the CTD. Epsilon and chi as a function of pressure can be estimated by fitting the vertical temperature gradient (dT/dz) spectrum, computed using the temperature time derivative (dT/dt) and chipod descent rate, to the theoretical temperature gradient spectrum, by using an iterative procedure demonstrated by Moum and Nash (2009).

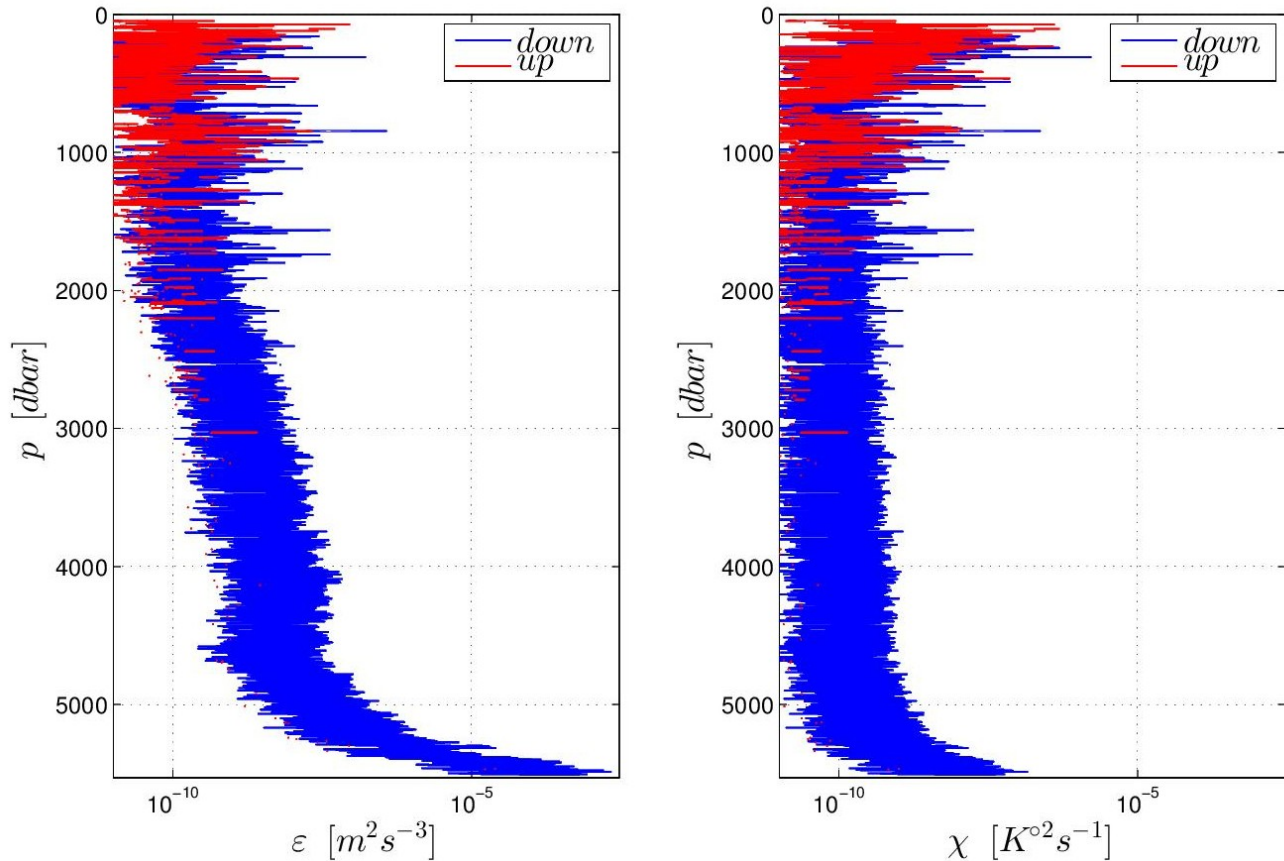
The [figure below](#) shows typical cast measurements from a downlooker. The high signal on the temperature derivative (dT/dt) record during the upcast is produced by the wake turbulence behind the rosette. The time record for the uplooker is similar; wake turbulence is recorded by the uplooker measurements as the rosette descends. However, there is a stronger wake turbulence signal for the uplooker because the uplooker sensors protrude beyond the top of the rosette frame. In addition, uplooker measurements on the upcast may be affected turbulence associated with the stops to fire the Niskin bottles.



Summary

The [figure below](#) shows a typical vertical profile of the turbulent kinetic energy dissipation (epsilon) and the dissipation of temperature variance as a function of pressure for both uplookers and downlookers. Both sets of profiles are of measurements at station 114 located at 23 $^{\circ}\text{N}$, and 152 $^{\circ}\text{W}$. In the profiles, local maximums near the surface indicate the presence of a weak mixed layer and weak mixing near the base of the summer thermocline (at approximately 800m), and a global maximum in the benthic

boundary layer. In order to obtain better estimates, the data obtained from all four chipods at each station need to be considered together, and the rosette-generated turbulence must be filtered out of the signal. Therefore, further data processing is needed.



Known Problems

Chipods proved to be quite independent, and easy to manage during the cruise. There were, however, a couple of issues encountered during the cruise. These issues will be described in order of encounter frequency below, starting from the most common problem.

Mini-logger freezing when downloading data

A very common issue I found when working with Chipods came from the mini-logger while recording data.

Symptom: The most common symptom was data recorded during the cast would look gibberish, unphysical. In the best-case scenario, the file would just read gibberish, but

the Chipod would continue recording and the next files would look perfectly normal. The first time this happened was during the second cast. You will notice the casts 001-003 contain very little useful data. But starting from cast 004 and on they all looked *good*.

The worst-case scenario: Mini logger (program on laptop) would freeze and become non-responding. I would then force quit the program and in a couple of times, the Chipod would stop recording at all. The first time that this happen was on cast 024. 3 out of 4 chipods did the exact same thing. Solution: Over the course of the cruise, I found out that there were different ways to un-freeze the chipod. The most simple was to simply disconnect the Pressure case from the sensor. I don't know why, but it worked. In the absolute worst case scenario, where this didn't work and the Chipod would still be un-responsive, I remove the chipod from the CTD, opened it and removed the memory chip form the mini-logger board. After I put back the memory chip into its place, the Chipod then became responsive and began functioning normally.

CTD hitting bottom

This wasn't really common at all, but I feel it's a common situation, external to the Chipods. It hit once during our cruise, on station 027, going down at 60 m/min. I double checked everything, as I normally would do, and upon close inspection I found in the time record for the temperature derivative, there was a lot of noise, more so than in the downcast. I replaced both downlooking sensors for new ones. I wrote the Series number on the Chipod recovery logs, and you can find that info in the table below summarizing all changes made on the configuration of the Chipods.

Sensor Deterioration

Towards the end of the trip (cast 100 out of 112) significant sensor deterioration was observed in one of the Chipods (uplooking, SN2014). The symptom was values after looking at the SA output, for the values in the temperature derivative were very low (usually there are between 45000 and 55000 when connected to a sensor, that time they were around 4200 and below). I changed both pressure case (along with its mini-logger SN2014 and everything inside) and put a new one. The values were equally low. Then I changed the sensor (thermistor) for a new one and the values came up significantly, no normal ones. While removing the thermistor (sensor) I noticed something like a white substance on it, possibly indicating corrosion. I didn't perform further tests on the Chipod SN 2014. It may still very well be functional, since it looks like the problem was with the thermistor (uplooking sensor). The sensor holder, and the cables connecting the Chipod together were still the same.

At the last station, it looked like the other thermistor was showing the same signs: low values of the temperature and its derivatives when looking at the SA output. I did not

change it. My recommendation is to have it replaced.

Chipods malfunction?

I replaced Chipod with Minilogger SN2013, towards the end of the cruise (stations 106-112, which comprises two recoveries) for a new one, because it was giving me serious trouble when trying to connect to it. When connecting to it, through the Minilogger program, after hitting USB connect, the screen would then start displaying crazy symbols, not stop. It would not respond to anything, and just kept on displaying weird characters filling the screen, non-stop. I replaced the unit for a new one, the 4th replacement available with SN 2019. It turns out, however, that the new chipod unit (SN2019) did not record any file. All values displayed were working well, and it actually was bench tested by June and me in Papeete, but just wouldn't record anything. Being the last recovery when I realized that, I did not try to fix the problem since the cruise reached to an end. The Chipod unit is still mounted on the CTD.

CTD Malfunction prompts interruption during cast

There were a few casts where the CTD, during a single cast, needed to be re-booted in order to appropriately fire water bottles. This issue was external to the Chipods, but affected the amount of data that can be processed during the cruise. When this happened, the CTD would produce more than just one raw file (XXX.hex) for the same cast. The Chipod code used to process the data is written to read just one XXX.hex file and from there, determine the time interval (and date I guess) where the specific cast was done. In the situation where there are more than one file, the code doesn't work appropriately. The cast where this happen are: 033, 037 and 040. There are other (more common) cases where there are more than one xxx.hex ctd files, but where one of them was produced where the CTD was still onboard (prior a deployment). Such is the case, for example, of cast #111. In such cases, which are pretty common, I just used the 2nd xxx.hex file for the same cast (that is the longest file). In such cases there is no problem.

Below is a table with all the info regarding the Chipod configuration used, along with the component's serial numbers. But first a little intro: In total, before sailing, we had 6 working chipods, with minilogger serial numbers listed below (2013, 2014, 2016, 2018, 2019, 2020). Unit SN 2020 was used to replaced a downlooking unit (when I mean unit, I mean the cylindrical pressure case with its own batteries and minilogger) just for cast 025 (unit with SN2016, after most of the chipods froze), while trying to figure out a solution to the problem. Unit with minilogger SN2020 was then used again to replace an uplooker for good (unit with SN 2014) for the last casts 100-112.

Unit with SN2019 was used to replace unit with SN 2013, after this one went "crazy"!

This was done the last 6 casts, from 106-112.

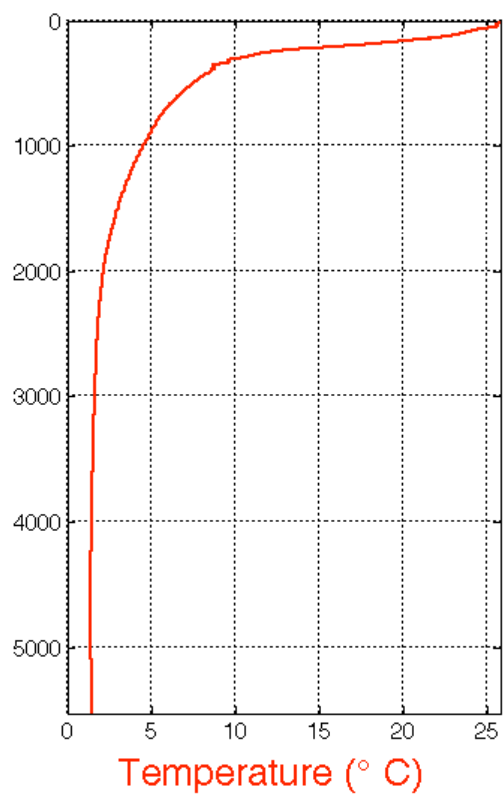
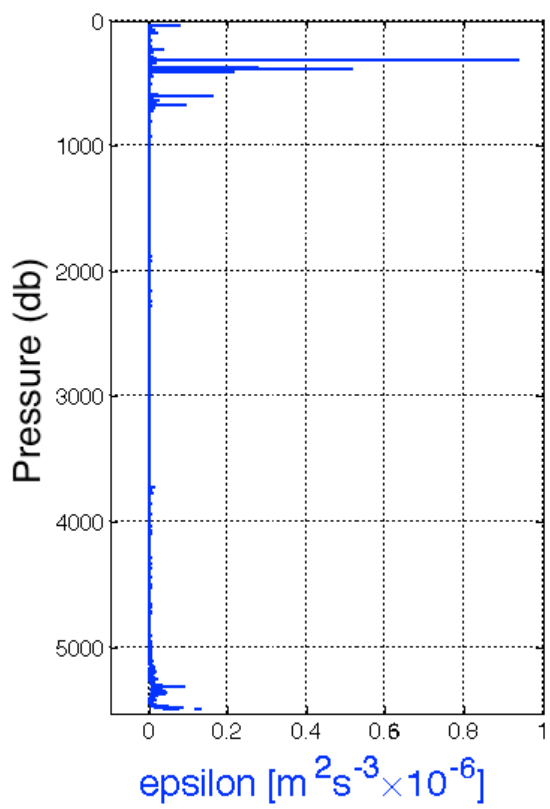
In total three now sensors (thermistors) where replaced, although it is recommended that a 4th one (uplooker, connected to unit 2019) needs to be replaced.

Logger Board SN	Pressure Case SN	Sensor SN	Sensor Holder SN	Up/Down looker	Cast used
2013	Ti44-7	14-26d	1	Up	001-106
2014	Ti44-8	14-24d*	4	Up	001-099
2016	Ti44-1	14-25d*	6	Down	001-024, 026- 112
2018	Ti44-3	11-25d*	2	Down	001-012
2019	Ti44-6	14-26d*	1	Up	106-112
2020	Ti44-5	14-28d	4	Up	100-112
2020	Ti44-5	14-25d	6	Down	025

Several replacements were made during the cruise. For example, the Pressure case + logger board with serial numbers **Ti44-1** and **2016** respectively, were replaced with the Pressure case + logger board with serial numbers **Ti44-5** and **SN 2020** respectively, during cast 025, oriented downwards. After the cast, the original configuration was mounted back again. Then after cast 099, the logger board (**SN 2014**), pressure case (**Ti44-8**) and sensor (**SN 14-24d**) were replaced with the logger board (**SN 2020**), pressure case (**Ti44-5**) and sensor (**SN 14-28d**), this time as an uplooker. That is why logger board **SN 2020** appears twice in the table. Similarly, the logger board **SN 2013** and pressure case **SN Ti44-7** were replaced by logger board **SN2019** and pressure case **SN Ti44-6** starting at cast 106.

Summary

Figure X shows a typical vertical profile of the turbulent kinetic energy dissipation (epsilon) and mean temperature as a function of pressure. The profile represents the cast 100, located at 16° 30 N, and 152° W. It can be appreciated that there exists an absolute maximum near the base of the thermocline, and a local maximum near the bottom topography. These **figures** were made from the data coming from one of the downlooking Chipods. In order to obtain better estimates, the data obtain from all chipods at each station need to be consider together, taking into account whether the signal is coming from false turbulence, such as that produced in an uplooker at the downcast, or a downlooker in the upcast. For that, further processing needs to be applied to the data.



2015 CLIVAR P16N leg 2 LADCP Cruise Report

D.C. McKee (LDEO; Participant), A.M. Thurnherr (LDEO; PI), and A. Stefanick (AOML)

Introduction

LADCP data were collected during the full-depth CTD cast at all stations. Additionally, LADCP data were collected during the secondary shallow casts for the cesium group until it became apparent that the back-to-back casts provided too much of a strain on the battery pack (data collected at stations 121, 128, 134, 138). Preliminary processing and QC was performed onboard by McKee. Questionable profiles were sent to Thurnherr for shore-based processing and comparison of results. A full QC will be carried out after the cruise.

LADCP System Configuration

An AOML custom 48V lead acid rechargeable battery pack was used for all deployments. Instruments and battery pack were interfaced using a standard RDI star cable. Custom AOML deck leads were used for communications and charging between casts. The battery pack was periodically vented manually to prevent pressure build up. Battery power was periodically checked to ensure proper charge level of 52V was being maintained before deployments. Both the battery pack and the ADCP's were affixed to the CTD package using custom tabbed brackets aligned on horizontal cross-members of the package. The upward ADCP was positioned between niskin bottles 1 and 24 towards the outer ring, while the downward ADCP was affixed in the middle of the package about 4 inches from the bottom ring. The configuration is shown in [photo 01](#).

The power supply and data transfer were handled independently from any CTD connections. While on deck, a communications and power cable was connected to a cable in the staging bay that ran into the wet lab. This cable connected to a battery charger located in the wet lab for power and to an acquisitions computer via USB connection for data download. The LADCP acquisitions computer clock was synced to the master clock in the computer lab via network.

Model	Serial Number	Stations used
Teledyne RDI WHM150	19394	113-117; 134-207 (DL)
Teledyne RDI WHM300	13330	113-171 (UL)
Teledyne RDI WHM300	12243	118-133 (DL); 172-207 (UL)

Table 01: Instruments used on cruise. DL = downlooker, UL = uplooker.

Three different ADCP instruments were used during this cruise (*table 01*). WHM150 #19394 was 'constructed' by Stefanick and McKee before leg 2 began. This instrument contains the transducers and pressure housing of WHM150 #16283 and the circuit boards of WHM150 #19394 (it was found on leg 1 that #16283 had functioning beams but yielded biased data; #19394 on the other hand yielded good data but had a failed beam -- since this hybrid instrument uses the electronics of #19394, we refer to it by that serial number). The other two instruments used are model WHM300.

Initial configuration consisted of the WHM150 #19394 as downlooker and the WHM300 #13330

as uplooker. Command files for both instruments used 16 m bins, 32 m pulse length, and 0 m blanking. These choices were made to exploit maximal range in a region of low scattering. Staggered pinging was used to avoid previous ping interference. This instrument configuration was used for stations 113-117. To acquire a benchmark of comparison for the new #19394 downlooker and command files, the downlooker was switched out for WHM300 #12243 and that instrument was used for stations 118-133. The quality of profile as assessed by the root mean square (rms) difference between the SADC data and the LADC data unconstrained by SADC data ([figure 01](#)) suggested that data collected with the WHM150 downlooker were of better quality. Therefore WHM150 #19394 was reinstalled before station 134.

During the full-depth cast on station 138 following a cast for the cesium group, the two instruments recorded multiple files, indicating a likely battery failure. Though the battery was charged between casts, Stefanick suggested that the short interval between them (about 15 minutes) was insufficient to fully charge the battery. Voltage was measured before the following casts and was adequate (~51 V), although on station 141 multiple files were again recorded. CTD problems at station 142 afforded an additional 2.5 hours of trickle charge. This seemed to completely recharge the battery, and complete profiles were recorded through station 145. At station 146, arcing occurred while checking voltage and so the battery pack was swapped out.

Configuration was not changed until station 172, where the uplooker was replaced with the other WHM300, #12243. It was noticed that two beams on #13330 were performing at or below 90% while all four beams on #12243 were known to perform near 100%. Though beam performance was not nearly weak enough to prompt a warning from the software, the UVP was off the rosette for maintenance making this switch convenient.

By station 173 it became apparent that data in the far bins (> 9) of the downlooker ensemble profiles were contaminated, as indicated by coherent structure in the velocity bias. While the bias is large, Thurnherr was not severely concerned about overall profile quality since the LADC-SADC rms error has been good. McKee re-processed the data while excluding these contaminated bins. This improved the LADC-SADC rms agreement ([figure 02](#)), suggesting that while the bias is affecting profile quality, good profiles are likely retrievable. A problematic profile is shown in [figure 03](#) and shown re-processed in [figure 04](#). WHM150 #19394 recorded data with similar contamination during leg 1 and it was hypothesized that the bias was exaggerated on leg 2 due to the longer pulses used (32 m). To test this, on station 178 the downlooker #19394 was programmed with the command file used on leg 1, station 90, though the condition did not improve. Therefore original command files were used again beginning at station 179. It was preferred to keep the current instrument configuration and restrict bins in processing since the WHM300 as downlooker - the only other option - tends to yield only about < 9 bins of quality data anyway.

LADC Operation

ADC programming and data acquisition were carried out using the LDEO Acquire software running on a Mac computer. Communications between the acquisitions computer and the ADCs took place across two parallel RS232 connections via a Keyspan USA-49WG 4-port USB-to-RS232 adapter. There were no significant communications issues throughout the entire

cruise. After sending the corresponding command files to the instruments prior to each cast, communication between the computer and the instrument was terminated, the battery charger was turned off, the deck cables were disconnected, and all connections were sealed with dummy plugs and secured. Silicone spray was applied to all plugs once daily. After the CTD was brought back on deck following a cast, the data and the power supply cable were rinsed with fresh water and reconnected to the computer and battery charger via the deck cables. The battery charger was then powered on. Data acquisition was terminated and the data were downloaded using the Acquire software. The battery charger remained on from the time of data download until the time the instrument was prepared for the next cast. Log files were kept for each cast to ensure that all the steps were completed.

Data Processing and Quality Control

The LADCP data were processed by McKee at least once per day on a Windows 7 laptop using the Matlab-based LDEO IX_10 processing software¹. This software principally uses the velocity inversion method, constrained by SADCP, GPS, and bottom-track data, to obtain a full-depth velocity profile. It also calculates a shear-based solution and compares the two, which, under ideal conditions, should agree. Each processed profile was inspected for realistic values and compared to the constraining data sources. Further, any warnings issued by the software were addressed. The processing figures produced by the software for each cast were inspected, which included checking the realism of final profile values, checking for any biased shear, examining the agreement between aligned CTD/LADCP time series, and monitoring beam strength and range. Thurnherr was either sent data or consulted when questionable profiles were observed.

In addition to the output from the processing software, a log was kept of the rms difference between the SADCP profiles and the LADCP profiles unconstrained by SADCP data during processing. This is one measure of profile quality. As soon as far-bin-contaminated velocity values were observed, a second log of rms difference was kept where far bins were ignored in processing.

Preliminary best processing omits bins > 9 for all profiles using WHM150 #19394 as downlooker. These re-processed profiles tend to have more realistic (i.e., smaller) abyssal values. Including [excluding] the contaminated bins in processing, about 25% [17%] of all samples deeper than 2000 m had velocity > 7 cm/s. For reference, in the 2006 occupation of P16N, about 16% of all samples deeper than 2000 m had velocity components that large. By [figure 02](#), these re-processed data are indeed of better quality, at least in the upper ocean. Preliminary data are shown as gridded sections in [figure 05](#).

Post-cruise processing is necessary and will be conducted at LDEO. At that point it will be determined which profiles are of sufficient quality for inclusion in the final CLIVAR ADCP archives.

1 http://www.ldeo.columbia.edu/cgi-bin/ladcp-cgi-bin/hgwebdir.cgi/LDEO_IX/

Photo 01: Instruments and battery pack on rosette. UVP is not mounted in this photo.

Figure 01: Root-mean-square difference between SADCP velocities and LADCP velocities that were unconstrained by the SADCP data in the inversion.

Figure 02: As in *figure 01*, except only near-bins were used in processing.

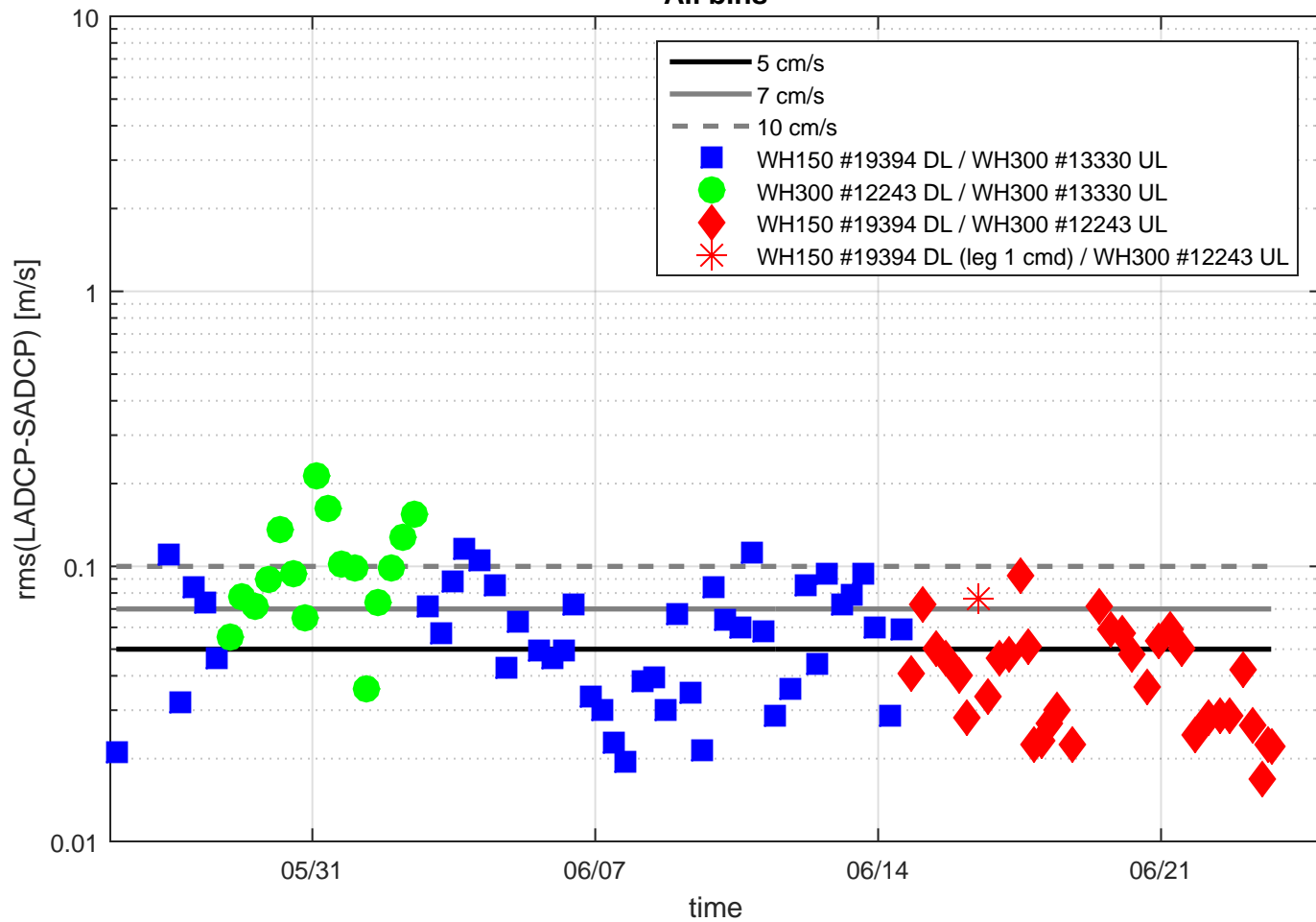
Figure 03: Inversion residuals (left - time/depth space; middle - bin-averaged) and velocity time series (right) for a profile with far-bin velocity bias. The left panels should be approximately random but instead indicate structure (bias) in the far bins.

Figure 04: As in *figure 03*, but with far bins ignored in processing.

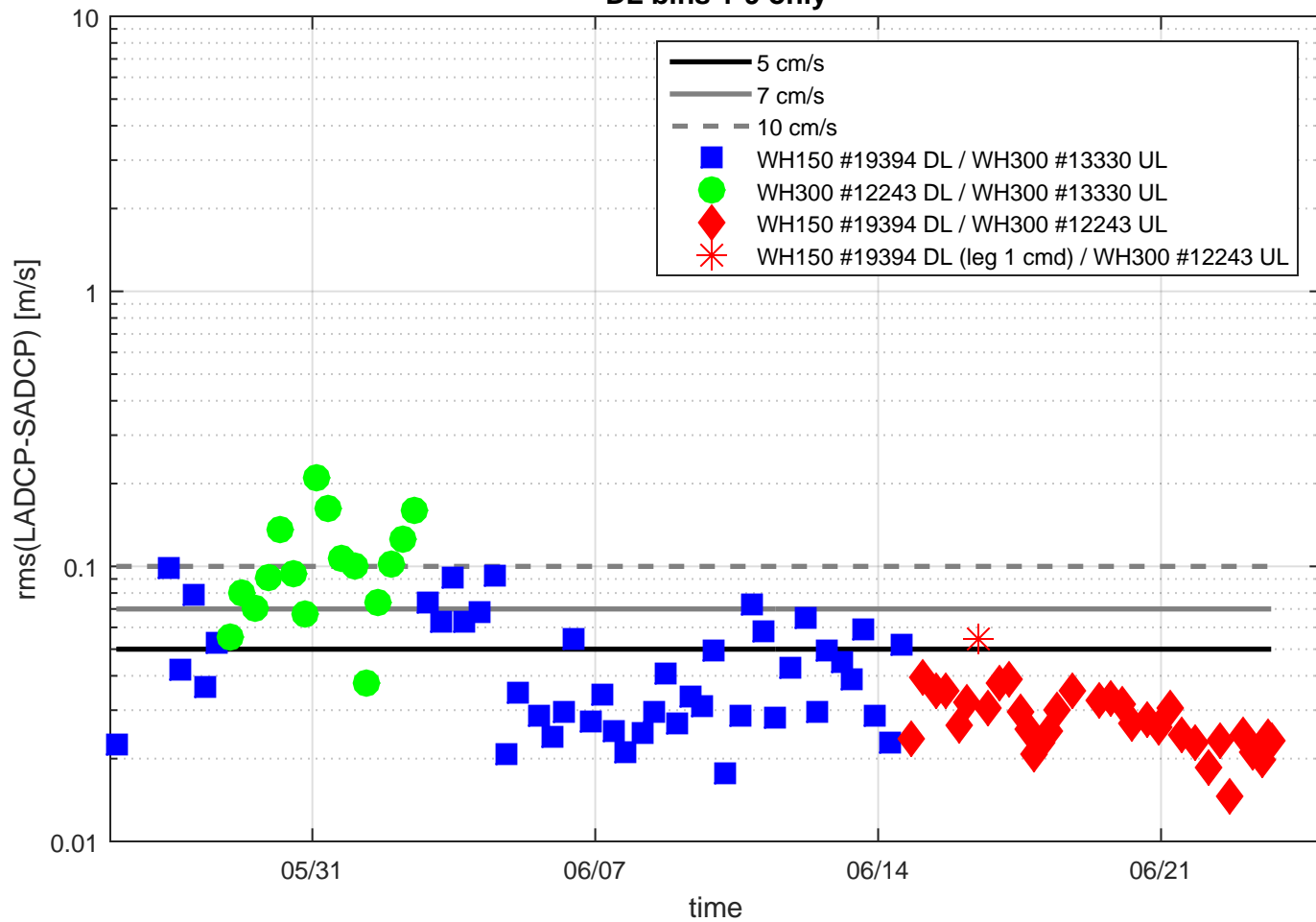
Figure 05: Smoothed sections gridded with a Gaussian weighting function. Color bar is saturated. Wedges indicate profile locations and solid black line indicates 0 m/s contour.



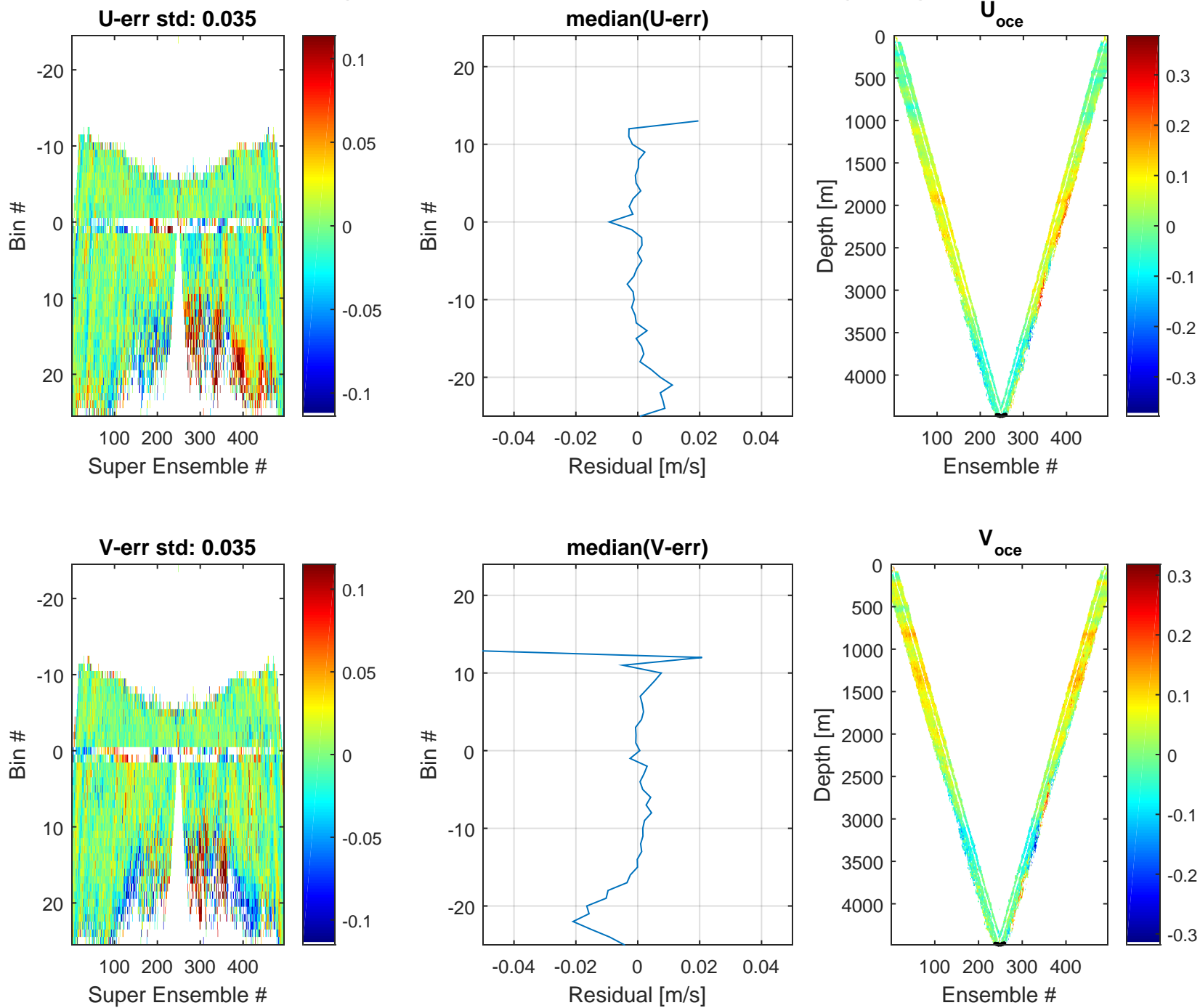
All bins



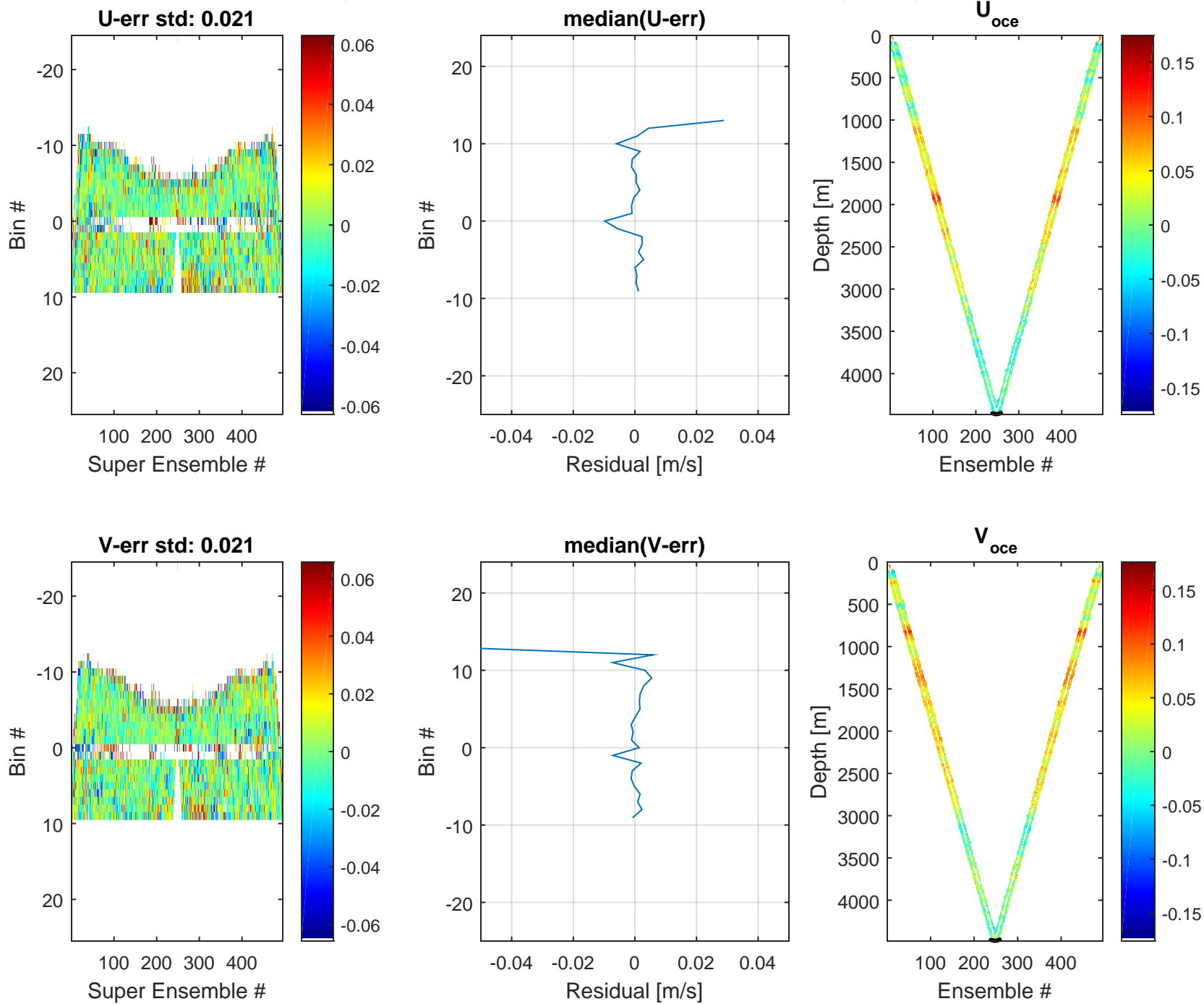
DL bins 1-9 only

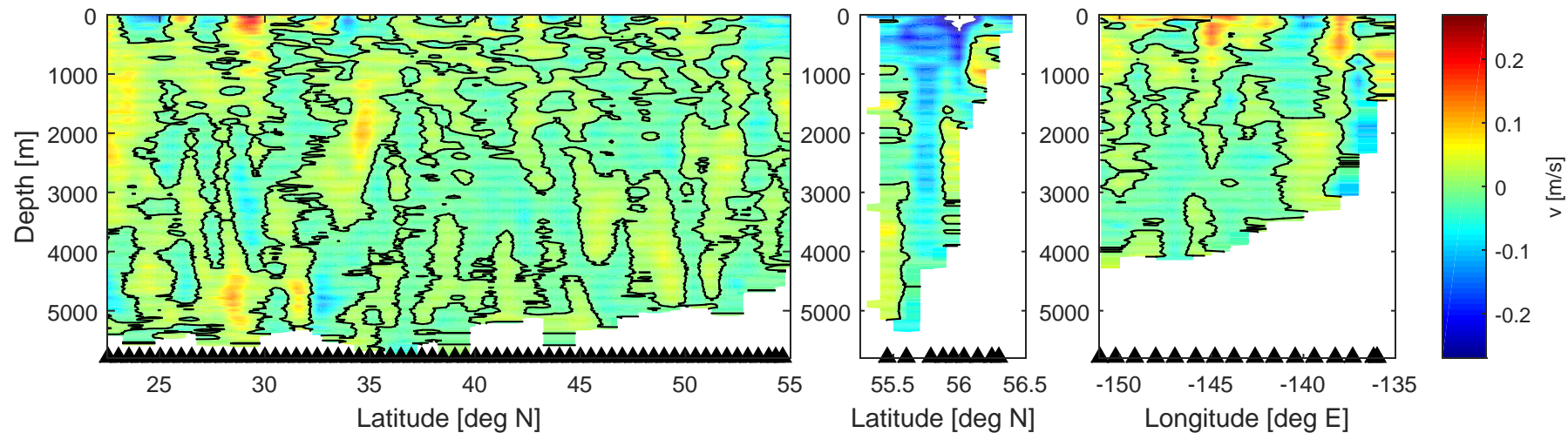
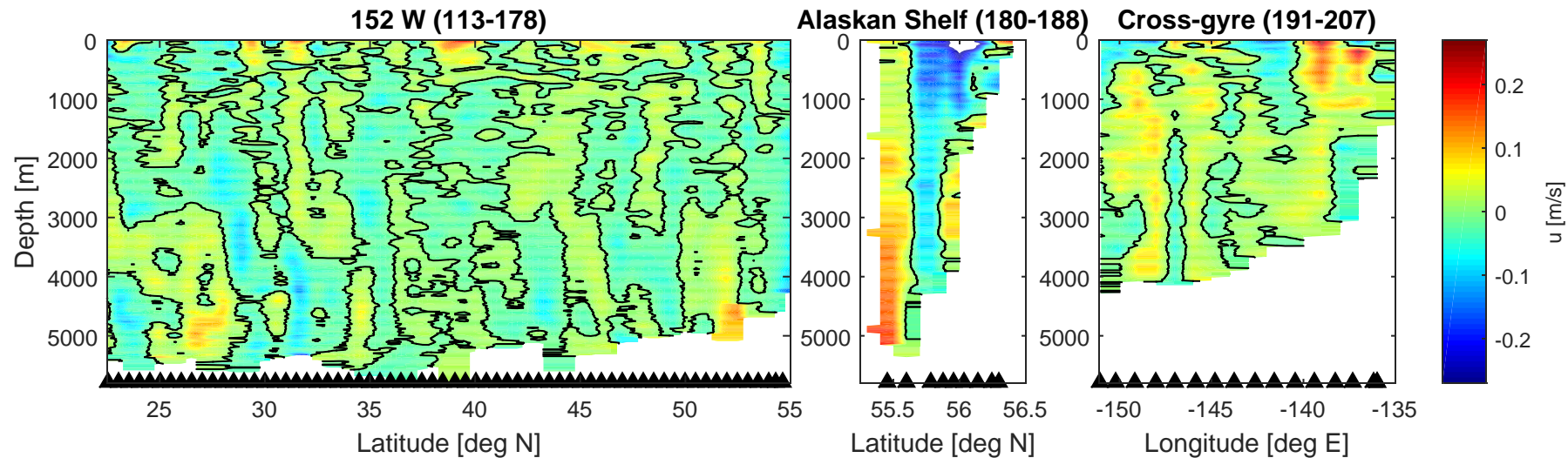


P16N (leg 2) station #173 (cruise processing) Figure 3



P16N (leg 2) station #173 (cruise processing) Figure 3





2015 CLIVAR P16N leg 2 SADCP Cruise Report

Eric Firing (UH; PI) and Jules Hummon (UH, PI)

Sampling

The Ronald H. Brown has a permanently mounted 75 kHz acoustic Doppler current profiler (Teledyne RDI) for measuring ocean velocity in the upper water column. The ADCP is a Phased Array instrument, capable of pinging in broadband mode (for higher resolution), narrowband mode (lower resolution, deeper penetration), or interleaved mode (alternating). On this cruise, data were collected with 8 m broadband pings and 16 m narrowband pings. The depth range achieved depends on weather (bubbles), installation (eg. ship noise), scattering levels, and other factors. Data were recorded during the entire cruise.

Processing

Specialized software developed at the University of Hawaii has been installed on the Brown for the purpose of ADCP acquisition, preliminary processing, and figure generation during each cruise. The acquisition system ("UHDAS", University of Hawaii Data Acquisition System) acquires data from the ADCPs, gyro heading (for reliability), Mahrs and POSMV headings (for increased accuracy), and GPS positions from various sensors. Single-ping ADCP data are automatically edited and combined with ancillary feeds, averaged, and disseminated via the ship's web, as regularly-updated figures on a web page and as Matlab and netCDF files.

Data Quality

The ADCP on board the Ron Brown died during 2014. NOAA worked hard to get another 75kHz instrument installed prior to this field season. We are grateful for their effort, as the ADCP has been functioning well since its installation early in 2015. Attempts were also made to improve the degrading POSMV, but those efforts did not lead to improvement. In fact the POSMV was useless early in the season (100% data loss), but has regained some quality and now functions about 60%-70% of the time. This means we will continue to have to depend on the Mahrs, which is not as accurate an instrument, when the POSMV is not healthy.

Summary

Shipboard ADCP data were collected for the duration of P16N, Leg 2. Data range is typical, 600m-700m in general. The ADCP system and data were monitored remotely. There were no changes or errors noted, beyond the persistent poor performance of the POSMV. Although the Mahrs and the POSMV are supposed to be accurate, neither is perfect and post-processing of the ADCP data will be necessary to obtain best accuracy for data while the ship is steaming. When the ship speed is near zero, heading errors do not cause significant errors in ocean velocity. Therefore the automated at-sea product should be good enough for preliminary use while the ship is on station. With the exception of the POSMV, the instrument, ancillary devices, and acquisition system performed well.

Underwater Vision Profiler (UVP) Report
Jessica Turner (Participant)
Andrew McDonnell (PI)

System configuration and sampling

The Underwater Vision Profiler 5 (UVP5) serial number 009 was mounted on the rosette, programmed, charged, and operated using the exact same procedures as in Leg 1 of the cruise. This optical imaging device obtains in situ concentrations and images of marine particles and plankton throughout the water column, capturing objects sized $0.64\ \mu\text{m}$ to several cm in equivalent spherical diameter. The instrument and data processing are described in Picheral et al. (2010).

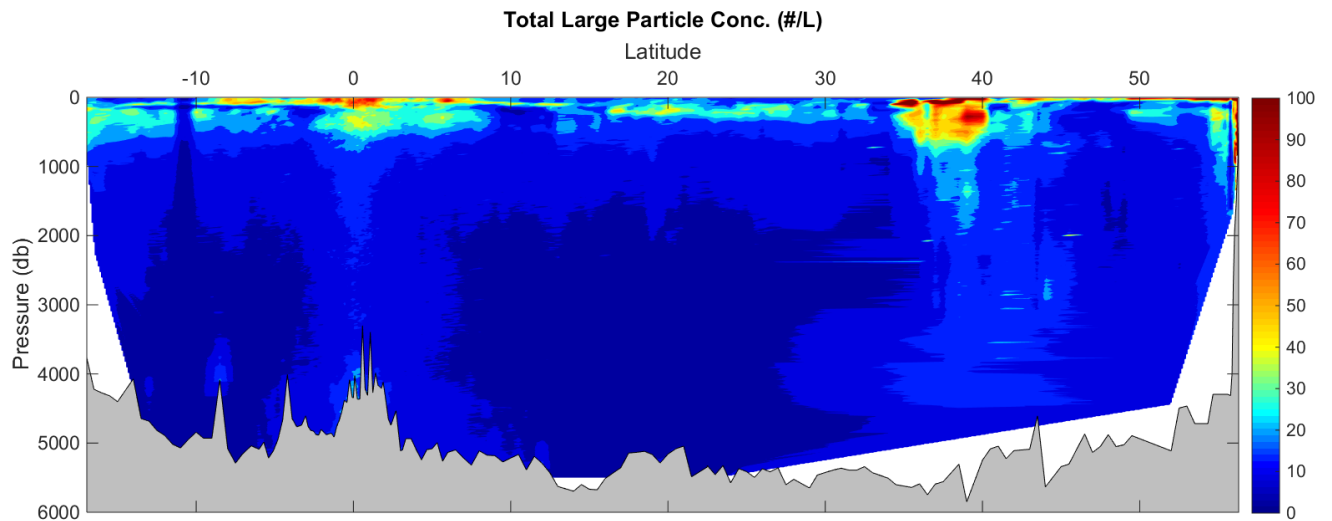


Figure XX. Transect of total particle concentration (number of particles per liter) determined by the UVP5 along the 152° W line.

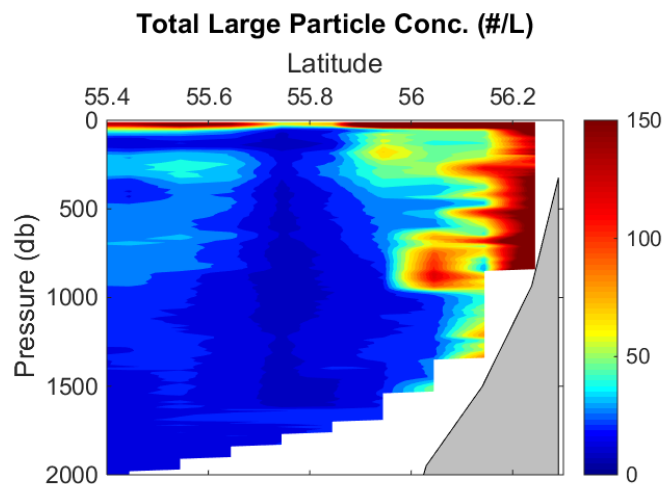


Figure XX. Transect of total particle concentration (number of particles per liter) determined by the UVP5 at the Kodiak shelf stations 179-187.

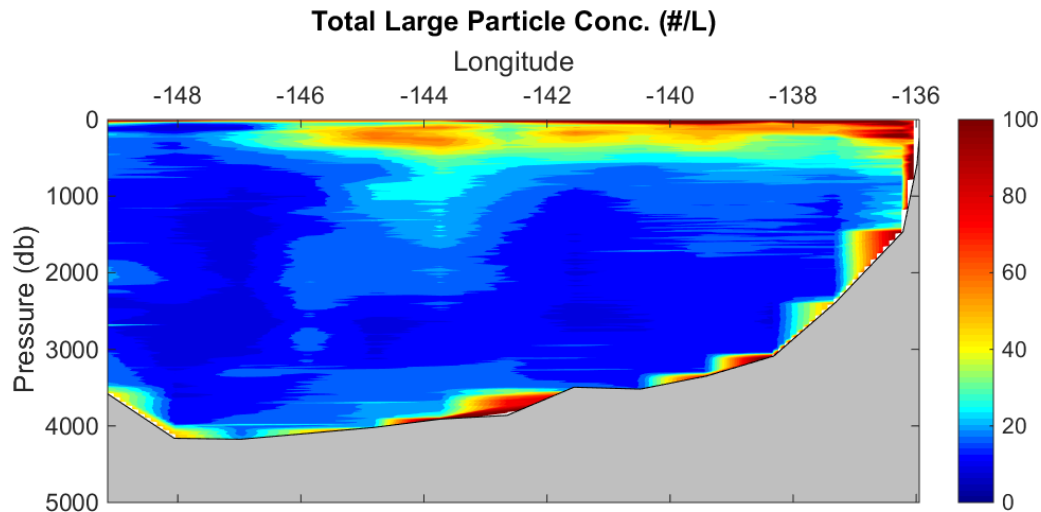


Figure XX. Transect of total particle concentration (number of particles per liter) determined by the UVP5 along the cross-gyre stations 193-207.

Problems

On a few occasions (stations 125,128,135,138,144,147,153) the UVP failed to collect data. The most likely cause was determined to be insufficient charging, or possibly unplugging the power cables before the charging unit had been turned off.

Overall, the performance of the lithium ion battery inside the UVP decreased over the course of Leg 2, with the maximum voltage of the instrument decreasing from 28.5 to 27.4. This caused the UVP to shut off partway through its descent through the water column, so the instrument did not collect full depth casts for many of the Leg 2 stations on the 152°W line. Depths of casts varied between 1500 m and 4000 m.

Battery recharge operations

The first attempt to fix the UVP battery occurred on June 13-14 (skipping UVP data collection for stations 168-171), using a 53W lightbulb to drain the battery and recharge it. The battery could only be drained to a minimum of 22.0 V, however, so the decision was made to recharge it in order to collect data on more casts, albeit shallow profiles. Total discharge time and recharge time took 22 hours and 3 hours, respectively.

During the steam from the end of the 152°W line to the beginning of the cross-gyre line (between stations 189 and 191), the second attempt to fix the UVP battery was carried out using computer fans instead of a lightbulb. This was much more successful, draining the battery almost completely before recharging it to a much higher maximum voltage of 28.7 V. Total discharge time and recharge time took 20 hours and 4 hours, respectively.

Reference:

Picheral, M., Guidi, L., Stemmann, L., Karl, D.M., Iddaoud, G., Gorsky, G., 2010. The Underwater Vision Profiler 5: An advanced instrument for high spatial resolution studies of particle size spectra and zooplankton. *Limnol. Ocean. Methods* 8, 462–473.

Bongo Net Deployment Report

Jessica Turner: participant

Nina Bednarsek - PI

Deployment

The bongo net was connected to the forward winch wire, with the flowmeter and a 60-lb weight suspended from the frame between the two nets. The net was deployed every night of sampling except for two nights, for a total of 26 casts (+ test cast). On those two nights, the main CTD rosette wire (aft wire) was being lubricated, so the rosette was deployed off the forward wire in place of the bongo net. The timing of the cast varied depending on arrival times at stations, but always fell well between the local time of sunrise and sunset. Deployment always occurred at an official P16N station, with timing occurring either before the CTD cast, after the CTD cast, or between the 1000 m cast and the following full cast at the same station.

After connecting the cod ends to the respective ends of the 200 and 300 μ m mesh size nets, the bongo was lifted so that the weight could pass just above the safety line, and the cod ends were lifted over the side before the net was boomed out and lowered to the water. The time the net entered the water was noted by the CTD watchstander on paper and as an event in the ship's log. The net was then lowered to 140 meters of wire out, at a target wire angle of 45⁰, for a target depth of 100 meters. Wire angle was measured with a simple plum-line style inclinometer. Often the wire angle varied throughout the cast between 30⁰ and 55⁰, and the variations were recorded along with how many meters of wire were out when they occurred. Flowmeter readings were recorded before and after each bongo cast by the CTD watch stander.

When recovering the net, the time it emerged from the water was recorded by the CTD watch stander and in the ship's event log. The net was held with the frame ~3 ft above the main deck for a saltwater rinse, then brought onboard by carefully lifting the cod ends over the safety lines as it was boomed in. Once on deck, the lower ends of the net and the outside of the cod ends were rinsed thoroughly with saltwater before the cod ends were detached and brought inside for sample preservation.

Sample Preservation

The samples from each mesh size net were preserved separately. For each cod end, the plankton was poured into a plankton sock, using the seawater squirt bottle to rinse all plankton out of the cod end. While the sample was in the plankton sock, any large (>4 cm) fish or gelatinous organisms were removed from the sample. The plankton sock was then inverted into a jar (or several jars) and rinsed with the ethanol squirt bottle. Ethanol was then dispensed into the jar(s) in an approximate volume ratio of ~3:1 ethanol:plankton. The number of jars collected from a given station varied from 2-8 (1-4 jars from each cod end). The 200 μ m samples were frozen in an extra chest freezer, while the 300 μ m samples were stored at room temperature in the wet lab where they were preserved. 12-24 hours after original sample preservation, samples from each jar were poured into the plankton sock, inverted back into the jars, and fresh ethanol was dispensed for long-term storage.

APPENDIX

Bottle Data Quality Code Summary and Comments

This section contains WOCE quality codes [Joyce94] used during this cruise, and remarks regarding bottle data.

P16N Water Sample Quality Code Summary

Property	1	2	3	4	5	6	7	8	9	Total
Bottle	0	5358	24	9	0	0	0	0	9	5400
CFC-11	0	3206	13	32	37	0	0	0	0	3288
CFC-12	0	3226	12	13	37	0	0	0	0	3288
N ₂ O	0	3240	1	10	37	0	0	0	0	3288
SF ₆	0	3184	25	42	37	0	0	0	0	3288
³ He	471	0	0	1	5	0	0	0	0	477
Neon	471	0	0	1	5	0	0	0	0	477
Dissolved O ₂	0	4750	42	39	6	2	0	0	0	4839
DIC	0	3743	28	48	0	536	0	0	0	4355
pH	0	3171	44	7	3	1133	0	0	0	4358
pH_usf	0	0	0	0	0	95	0	0	0	95
Total Alkalinity	0	3949	21	5	3	380	0	0	0	4358
¹³ C	976	0	0	0	0	0	0	0	0	976
¹⁴ C	976	0	0	0	0	0	0	0	0	976
DOC	2633	0	0	1	0	0	0	0	0	2634
TDN	2633	0	0	1	0	0	0	0	0	2634
DO ¹⁴ C	105	0	0	0	0	0	0	0	0	105
DO ¹⁴ C (Unfilt.)	2	0	0	0	0	0	0	0	0	2
POC	54	0	0	0	0	0	0	0	0	54
Chlorophyll a	0	383	3	2	12	0	0	0	0	400
Tritium	457	0	0	1	0	0	0	0	0	458
Nitrate	0	4030	0	7	11	801	0	0	1	4850
Nitrite	0	4026	0	7	11	805	0	0	1	4850
Phosphate	0	3804	0	267	12	766	0	0	1	4850
Silicic Acid	0	4035	0	7	11	796	0	0	1	4850
Salinity	0	4359	107	13	3	367	0	0	0	4849
¹³⁴ Cs	719	0	0	0	0	0	0	0	0	719
¹³⁷ Cs	719	0	0	0	0	0	0	0	0	719
¹²⁹ I	719	0	0	0	0	0	0	0	0	719
⁹⁰ Cs	719	0	0	0	0	0	0	0	0	719
Black Carbon	53	0	0	0	0	0	0	0	0	53

Quality evaluation of data included comparison of bottle salinity and bottle oxygen data with CTDO data using plots of differences; and review of various property plots and vertical sections of the station profiles and adjoining stations. Comments from the Sample Logs and the results of investigations into bottle problems and anomalous sample values are included in this report. Sample number in this table is the cast number times 100 plus the bottle position number.

P16N Bottle Quality Codes and Comments

Station /Cast	Sample Number	Property	Quality Code	Comment
113/2	218	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sample problems likely.
114/1	121	Bottle	3	Nisk.21 leaking from bottom end cap.
115/2	209	DIC	4	Probable instrument malfunction
115/2	211	DIC	4	Probable instrument malfunction
115/2	212	DIC	4	Probable instrument malfunction
115/2	213	DIC	4	Probable instrument malfunction
115/2	214	DIC	4	Probable instrument malfunction
115/2	215	DIC	4	Probable instrument malfunction
115/2	216	DIC	4	Probable instrument malfunction
115/2	217	Bottle	4	Mis-trip. Parameter values support mis-trip on bottle 17.
115/2	217	DIC	4	Probable instrument malfunction
115/2	217	Nitrite	4	Mis-trip
115/2	217	Nitrate	4	Mis-trip
115/2	217	O2	4	Mis-trip
115/2	217	pH	4	Mis-tripped Niskin bottle
115/2	217	Phosphate	4	Mis-trip
115/2	217	Salinity	4	Mis-trip
115/2	217	Silicate	4	Mis-trip
115/2	218	DIC	4	Probable instrument malfunction
115/2	219	DIC	4	Probable instrument malfunction
115/2	220	DIC	4	Probable instrument malfunction
115/2	221	DIC	4	Probable instrument malfunction
115/2	222	DIC	4	Probable instrument malfunction
115/2	224	DIC	4	Probable instrument malfunction
116/1	101	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.
116/1	121	Bottle	3	Nisk.21 leaking from bottom end cap.
116/1	122	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.
116/1	123	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.
117/1	101	DIC	4	Probable instrument malfunction
117/1	101	pH	3	High baseline absorbance (Ao) due to bubble in cell.
117/1	103	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.
117/1	109	DIC	4	Probable instrument malfunction
117/1	111	DIC	4	Probable instrument malfunction
117/1	112	DIC	4	Probable instrument malfunction
117/1	113	DIC	4	Probable instrument malfunction
117/1	114	DIC	4	Probable instrument malfunction
117/1	115	DIC	4	Probable instrument malfunction
117/1	116	DIC	4	Probable instrument malfunction
117/1	117	DIC	4	Probable instrument malfunction
117/1	118	DIC	4	Probable instrument malfunction
117/1	119	DIC	4	Probable instrument malfunction
117/1	120	DIC	4	Probable instrument malfunction
117/1	121	DIC	4	Probable instrument malfunction
117/1	122	DIC	4	Probable instrument malfunction
117/1	124	DIC	4	Probable instrument malfunction

Station /Cast	Sample Number	Property	Quality Code	Comment
118/3	319	Salinity	3	Does not fit cast profile. No analytical problems noted. High gradient. Code questionable.
118/3	324	O2	3	Does not fit cast profile, adjacent casts or other criteria. High for adjacent surface casts. No analytical problems noted.
119/1	101	DIC	4	Probable instrument malfunction
119/1	104	DIC	4	Probable instrument malfunction
119/1	107	DIC	4	Probable instrument malfunction
119/1	110	DIC	4	Probable instrument malfunction
119/1	113	DIC	4	Probable instrument malfunction
119/1	114	DIC	4	Probable instrument malfunction
119/1	124	DIC	3	Probable instrument malfunction
120/2	219	O2	3	Does not fit cast profile, adjacent casts or other criteria. No problems were noted by the analyst.
121/2	219	Salinity	3	Does not fit cast profile. No problems were noted by the analyst. High gradient. Code questionable.
122/1	109	TALK	5	Instrument malfunction. Sample lost.
122/1	120	Bottle	3	Sample bottle lanyard caught on recovery and water lost on deck. Niskin leaking.
123/2	206	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
123/2	207	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
124/1	106	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
124/1	106	TALK	3	Possibly low? Value confirmed with a rerun.
124/1	108	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
125/1	109	Salinity	3	Does not fit cast profile. No problems were noted by the analyst. Code questionable.
125/1	122	Salinity	3	Does not fit cast profile. No problems were noted by the analyst. Code questionable.
126/1	101	Bottle	4	SLOG: "Temp on 1 high compared to others nearby." CMS: Parameter measurements indicate bottle may did not tripped at intended depth.
126/1	101	Nitrite	4	Mis-trip
126/1	101	Nitrate	4	Mis-trip
126/1	101	O2	4	Mis-trip
126/1	101	pH	4	Mis-tripped Niskin bottle
126/1	101	Phosphate	4	Mis-trip
126/1	101	Salinity	4	Mis-trip
126/1	101	Silicate	4	Mis-trip
126/1	101	TALK	3	Value looks really low. Niskin mis-trip suspected. Value confirmed with a rerun.
126/1	119	Bottle	2	SLOG: Niskin is hard to close and results in water loss from niskin.
127/1	101	Bottle	4	SLOG: "Bottle 1 high temp again." CMS: Parameter measurements indicate bottle may did not tripped at intended depth.
127/1	101	Nitrite	4	Mis-trip
127/1	101	Nitrate	4	Mis-trip
127/1	101	O2	4	Mis-trip
127/1	101	pH	4	Mis-tripped Niskin bottle
127/1	101	Phosphate	4	Mis-trip
127/1	101	Salinity	4	Mis-trip
127/1	101	Silicate	4	Mis-trip
127/1	101	TALK	4	Niskin mis-trip suspected.
127/1	106	Salinity	3	Does not fit cast profile. Possibly mis-sampled. Sample value 6 compares well sample 5 and CTD trip value at 5. Code bad.
128/4	405	O2	4	Does not fit cast profile, adjacent casts or other criteria. Sample or analytical problems likely.

Station /Cast	Sample Number	Property	Quality Code	Comment
128/4	407	TALK	3	Pretty sure this was filled with Niskin 8 water.
128/4	414	Bottle	2	SLOG: Niskin 14 dripping after sampling.
128/4	422	Salinity	3	Does not fit down cast profile. No problems were noted by the analyst. Code questionable.
129/1	119	TALK	3	Possibly high
130/1	104	Bottle	2	SLOG: Niskin fired on the fly.
131/2	206	Salinity	3	Does not fit cast profile. No problems were noted by the analyst. Code questionable.
132/1	122	Refc.Temp.	4	SBE35 value reads high vs CTDT1 & CTDT2. 8 sec delay likely not observed after bottle trip. Code bad.
133/2	203	Salinity	4	Samples may have been run out of order. After correcting sample 3 does not match profile. Code bad.
134/2	201	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
134/2	223	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
135/1	119	O2	3	Does not fit cast profile, adjacent casts or other criteria.
135/1	122	O2	3	Does not fit cast profile, adjacent casts or other criteria.
135/1	123	Refc.Temp.	2	Unstable temperature read in all three sensors. High gradient. Code questionable.
136/2	204	Salinity	4	Analytical samples show slight offset with profile. Debris noted in autosal cell. Code bad.
136/2	205	Salinity	4	Analytical samples show slight offset with profile. Debris noted in autosal cell. Code bad.
136/2	206	Salinity	4	Analytical samples show slight offset with profile. Debris noted in autosal cell. Code bad.
136/2	207	Salinity	4	Analytical samples show slight offset with profile. Debris noted in autosal cell. Code bad.
136/2	208	Salinity	4	Analytical samples show slight offset with profile. Debris noted in autosal cell. Code bad.
136/2	209	Salinity	4	Analytical samples show slight offset with profile. Debris noted in autosal cell. Code bad.
137/1	108	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
138/4	401	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
139/3	306	TALK	3	Low
139/3	316	TALK	5	Instrument malfunction.
142/3	303	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
143/2	209	Salinity	4	Does not fit cast profil. Possibly mis-sampled. Sample value compares better with niskin 8. Code bad.
143/2	224	TALK	3	Possibly high
144/1	111	Salinity	4	Does not fit cast profile, adjacent casts or other criteria. Sampling or analytical problems likely. Code bad.
146/2	204	TALK	3	High
146/2	205	TALK	3	High
146/2	218	chlor	5	KB: Sampling contamination issue. Samples not recorded.
146/2	219	chlor	5	KB: Sampling contamination issue. Samples not recorded.
146/2	220	chlor	5	KB: Sampling contamination issue. Samples not recorded.
146/2	221	chlor	5	KB: Sampling contamination issue. Samples not recorded.
146/2	222	chlor	5	KB: Sampling contamination issue. Samples not recorded.
146/2	223	chlor	5	KB: Sampling contamination issue. Samples not recorded.
146/2	224	chlor	5	KB: Sampling contamination issue. Samples not recorded.
147/1	109	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
149/1	101	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.

Station /Cast	Sample Number	Property	Quality Code	Comment
149/1	103	Nitrite	5	Niskins emptied before nutrients could be samples.
149/1	103	Nitrate	5	Niskins emptied before nutrients could be samples.
149/1	103	Phosphate	5	Niskins emptied before nutrients could be samples.
149/1	103	Silicate	5	Niskins emptied before nutrients could be samples.
149/1	104	Nitrite	5	Niskins emptied before nutrients could be samples.
149/1	104	Nitrate	5	Niskins emptied before nutrients could be samples.
149/1	104	Phosphate	5	Niskins emptied before nutrients could be samples.
149/1	104	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
149/1	104	Silicate	5	Niskins emptied before nutrients could be samples.
149/1	106	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
150/3	304	pH	3	Difference between replicate measurements was 0.0014 units.
151/2	201	Bottle	2	SLOG: Bottle fired at same depth.
151/2	202	Bottle	2	SLOG: Bottle fired at same depth.
152/1	101	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.
152/1	107	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
152/1	120	Salinity	3	Does not fit cast profile. Edge of high gradient. Code questionable.
153/2	209	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
154/2	203	Salinity	3	Does not fit cast profile. Sample value compares better with niskin 2. Possibly mis-sampled. Code questionable.
154/2	205	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
154/2	206	Salinity	3	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
154/2	214	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.
154/2	214	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
155/1	102	Salinity	4	Does not fit cast profile. Possibly mis-sampled. Sample value compares better with niskin 1. Code bad.
156/2	203	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.
156/2	206	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
156/2	208	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
157/1	102	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
157/1	106	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
157/1	107	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
157/1	118	Salinity	3	Does not fit down cast profile. Edge of high gradient. Code questionable.
157/1	120	Salinity	3	Does not fit cast profile. High gradient. Code questionable.
157/1	124	pH	3	Difference between replicate measurements was 0.0033 units
158/3	305	Bottle	2	SLOG: Niskin fired on the fly.
158/3	305	pH	3	Difference between replicate measurements was 0.0024 units
158/3	307	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
158/3	308	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
158/3	321	Salinity	3	Does not fit cast profile. No analytical problems noted. Edge of high gradient. Code questionable.
158/3	322	Salinity	3	Does not fit cast profile. No analytical problems noted. Edge of high gradient. Code questionable.
159/1	103	Salinity	4	Does not fit cast profile. Possibly mis-sampled. Sample value compares better with niskin 2. Code bad.
159/1	109	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
159/1	115	O2	4	Sample value does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.

Station /Cast	Sample Number	Property	Quality Code	Comment
159/1	122	Refc.Temp.	2	SBE35 value high vs. CTD1 & CTD2. 8 second trip delay likely not observed. Code bad.
159/1	123	O2	4	Sample value does not fit cast profile, adjacent casts or other criteria. Likely fits up cast data. Code questionable.
160/1	105	Salinity	4	Does not fit cast profile. Debris noted in analytical cell.
160/1	106	Salinity	4	Does not fit cast profile. Debris noted in analytical cell.
160/1	107	Salinity	4	Does not fit cast profile. Debris noted in analytical cell.
160/1	114	Salinity	4	Does not fit cast profile. Debris noted in analytical cell.
160/1	120	Refc.Temp.	3	SBE35 value high vs. CTD1 & CTD2. Code questionable
160/1	122	Refc.Temp.	3	SBE35 value high vs. CTD1 & CTD2. Code questionable
161/2	211	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
162/3	301	Salinity	3	Does not fit cast profile. Samples possibly run before reaching lab temperature equilibrium. Code questionable.
162/3	302	Salinity	3	Does not fit cast profile. Samples possibly run before reaching lab temperature equilibrium. Code questionable.
162/3	303	Salinity	3	Does not fit cast profile. Samples possibly run before reaching lab temperature equilibrium. Code questionable.
162/3	305	Salinity	3	Does not fit cast profile. Samples possibly run before reaching lab temperature equilibrium. Code questionable.
162/3	308	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
163/2	202	Salinity	4	Does not fit cast profile. Possibly mis-sampled. Sample value compares better with niskin 2. Code bad.
163/2	206	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
163/2	207	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
164/2	223	pH	3	Difference between duplicates was 0.0017.
164/2	223	Refc.Temp.	4	Unstable temperature read in all three sensors. High gradient. Code bad.
166/3	306	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
166/3	310	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
166/3	320	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
167/1	103	pH	3	Difference between replicate measurements was 0.0015 units
167/1	109	Salinity	4	Does not fit cast profile. Analytical or sampling problems are likely. Code bad.
167/1	120	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
167/1	123	Salinity	4	Does not fit cast profile. Analytical or sampling problems are likely. Code bad.
168/1	103	Salinity	4	Does not fit cast profile. Possibly mis-sampled. Sample value compares better with niskin 2. Code bad.
168/1	103	Talk	3	Seems high. Value confirmed with Duplicate.
168/1	105	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
168/1	106	Salinity	5	Sample missing. Possibly skipped niskin while sampling.
169/2	204	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.
170/2	208	Salinity	3	Does not fit cast profile. No analytical problems are likely. Code questionable.
170/2	220	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
170/2	223	Refc.Temp.	3	SBE35 value reads low vs CTD2 & SBE35. Code questionable.
171/1	102	Salinity	2	Does not fit cast profile, adjacent casts or other criteria. Possibly sampled from the wrong niskin. Value compares well with bottle 101 sample. Left for PI review.

Station /Cast	Sample Number	Property	Quality Code	Comment
171/1	121	Salinity	4	Does not fit cast profile, adjacent casts or other criteria. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Code bad.
172/1	101	Salinity	4	Does not fit cast profile, adjacent casts or other criteria. Possibly sampled from the wrong niskin. Code bad.
172/1	105	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
172/1	106	pH	3	Difference between replicate measurements was 0.002 units
172/1	106	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
172/1	120	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
173/1	101	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
173/1	106	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
173/1	120	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
174/3	306	Salinity	4	Does not fit cast profile. Possibly mis-sampled. Sample compares better with sample drawn from btl 5. Code bad.
174/3	307	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
174/3	324	pH	3	Difference between duplicates was 0.0025.
175/1	102	Salinity	4	Does not fit cast profile. Possibly sampled from the wrong niskin. Value compares well with bottle 101 sample. Code bad.
175/1	121	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
175/1	122	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
175/1	123	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
176/2	202	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	203	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	204	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	205	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	206	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	207	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	208	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	209	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	210	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	211	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	211	O2	4	Does not fit cast profile, adjacent casts or other criteria. Analytical or sampling problems are likely.
176/2	212	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.

Station /Cast	Sample Number	Property	Quality Code	Comment
176/2	213	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	214	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	215	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	216	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	217	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	218	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	219	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	220	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	221	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	222	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	223	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
176/2	224	ctdc1	4	CTDC1 had a notable scaling offset during upcast. Biofouling observed on primary conductivity sensor.
177/1	101	Salinity	4	Does not fit cast profile. Analytical or sampling problems are likely. Code bad.
177/1	105	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
177/1	110	Salinity	4	Sample accidentally tripped on the fly. Sample does not match CTDC1 or the other salinity sample at same depth. Code bad.
177/1	121	pH	3	Difference between replicate measurements was 0.0028 units
177/1	121	Refc.Temp.	3	Unstable temperature read in all three sensors. High gradient. Code questionable.
177/1	123	Refc.Temp.	3	Unstable temperature read in all three sensors. High gradient. Code questionable.
178/3	319	Bottle	2	SLOG: Leak on bottle seal of niskin 19.
178/3	321	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
179/1	107	Salinity	3	Does not fit cast profile. Analytical or sampling problems are likely. Code bad.
179/1	120	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
179/1	121	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
180/2	201	Salinity	3	Does not fit cast profile. No problems were noted by the analyst. Code questionable.
180/2	210	Salinity	3	Does not fit cast profile. No problems were noted by the analyst. Code questionable.
180/2	222	pH	3	Difference between duplicates was 0.0011 units.
180/2	223	Refc.Temp.	3	Unstable temperature read in all three sensors. High gradient. Code questionable.
181/1	103	Salinity	3	Does not fit cast profile. No problems were noted by the analyst. Code questionable.
181/1	108	pH	3	Difference between replicate measurements was 0.0033 units.

Station /Cast	Sample Number	Property	Quality Code	Comment
181/1	121	Salinity	4	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
181/1	122	Salinity	4	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
183/1	103	Salinity	3	Does not fit cast profile. No problems were noted by the analyst. Code questionable.
183/1	110	TAlk	3	Might be ~4 units high.
183/1	114	TAlk	3	Might be ~5 units high.
183/1	119	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
183/1	120	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
184/1	101	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
184/1	102	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
184/1	120	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
185/1	117	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
186/1	113	pH	2	Large plankton in sample.
186/1	114	pH	6	Large plankton in sample.
186/1	121	pH	2	Plankton and glassy shards observed in sample.
187/3	316	Salinity	4	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Code bad.
187/3	318	Salinity	4	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Code bad.
189/1	110	Salinity	4	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Code bad.
190/1	115	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
191/4	402	Salinity	4	Does not fit cast profile. Sample compares better with niskin 1. Possible mis-sample. Code bad.
191/4	405	Salinity	3	Does not fit down cast profile. No problems were noted by the analyst.
191/4	406	Salinity	3	Does not fit down cast profile. No problems were noted by the analyst.
191/4	413	pH	3	Difference between replicate measurements was 0.0013
192/1	103	Salinity	3	Does not fit cast profile, adjacent casts or other criteria. No problems were noted by the analyst.
192/1	122	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
193/1	103	pH	3	Difference between duplicates was 0.0019 units
193/1	117	pH	5	Bottle broke in lab.
193/1	122	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
193/1	123	Refc.Temp.	4	SBE35 value reads high vs CTDT1 & CTDT2. Code bad.
194/1	101	Salinity	4	Does not fit cast profile. Possible contamination from fresh water surface in cell from analysis run prior to 194. Code bad.
194/1	121	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
194/1	122	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
195/2	201	Salinity	3	Does not fit cast profile. No problems were noted by the analyst.
195/2	202	Bottle	2	SLOG: Brown goop on niskin 2. DIC cleaned it off.

Station /Cast	Sample Number	Property	Quality Code	Comment
195/2	208	Bottle	2	SLOG: Grey paint on niskin 8 spigot.
195/2	220	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
195/2	221	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
196/2	202	Salinity	4	Does not fit down cast profile. Possible cross-contamination. Code bad.
196/2	210	Salinity	3	Does not fit down cast profile. No problems noted by analyst. Code questionable.
196/2	220	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
196/2	221	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
197/1	120	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
197/1	121	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
197/1	124	Refc.Temp.	4	Unstable temperature read in all three sensors. High gradient. Code bad.
198/2	220	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
199/2	219	O2	4	Value matches bottle 218. Possibly missampled.
200/1	118	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
200/1	119	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
200/1	120	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
201/2	202	Salinity	3	Does not fit cast profile. No analytical problems noted. Code questionable.
201/2	219	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
201/2	220	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
201/2	221	Salinity	2	Does not fit down cast profile. Presumably fresher water at surface is causing analytical problems in the high gradient region of profile. Left for PI review.
203/2	201	TAlk	3	Niskin mis-trip or leak suspected. Seems high. Value confirmed with Duplicate.
203/2	219	pH	5	Bottle cracked in the water bath.
204/1	101	TAlk	3	Niskin mis-trip or leak suspected. Seems high. Value confirmed with Rerun.
204/1	104	pH	3	Difference between duplicates was 0.0014 units
206/1	117	Refc.Temp.	4	SBE35 value reads high vs CTDT1 & CTDT2. Wait time probably not observed. Code bad.
206/1	118	Refc.Temp.	4	SBE35 value reads high vs CTDT1 & CTDT2. Wait time probably not observed. Code bad.
206/1	122	Salinity	4	Does not fit cast profile. Sampling or analytical problems likely. Code bad.
206/1	124	pH	3	Difference between duplicates was 0.0022 units
207/1	114	Refc.Temp.	3	Unstable temperature read in all three sensors. Code questionable.
207/1	115	Refc.Temp.	3	Unstable temperature read in all three sensors. Code questionable.

References

Joyc94.

Joyce, T., ed. and Corry, C., ed., "Requirements for WOCE Hydrographic Programme Data Reporting," Report WHPO 90-1, WOCE Report No. 67/91 ., pp. 52-55, WOCE Hydrographic Programme Office, Woods Hole, MA, USA (May 1994, Rev. 2).

CCHDO Data Processing Notes

Date 2015-07-22
Data Type Flag updates
Action Data available
Summary salinity and oxygen flag updates
Name Courtney Schatzman
Note file p16n_hy1.csv submitted by Courtney Schatzman on 2015-07-21 available online as received notes:
salinity 126-1-1 vlo vs ctdsal bad bottle mark 4
salinity 127-1-1 vlo vs ctdsal bad bottle mark 4
oxygen 173-1-21 vvvlo vs ctdoxy,P mark 4 likely sample collection error

Date 2015-08-26
Data Type Cruise Report
Action Data available
Summary Ready to go online
Name Jerry Kappa
Note The preliminary PDF cruise report for P16N_2015 Leg 2 is ready to go online. It includes all of the PI-provided data reports, a linked table of contents, linked figures and tables and these CCHDO Data Processing Notes.