

# THE JOINT RUSSIAN-AMERICAN LONG-TERM CENSUS OF THE ARCTIC (RUSALCA)

## Chukchi Sea Expedition 1-15 September 2012 CTD Data Processing Report

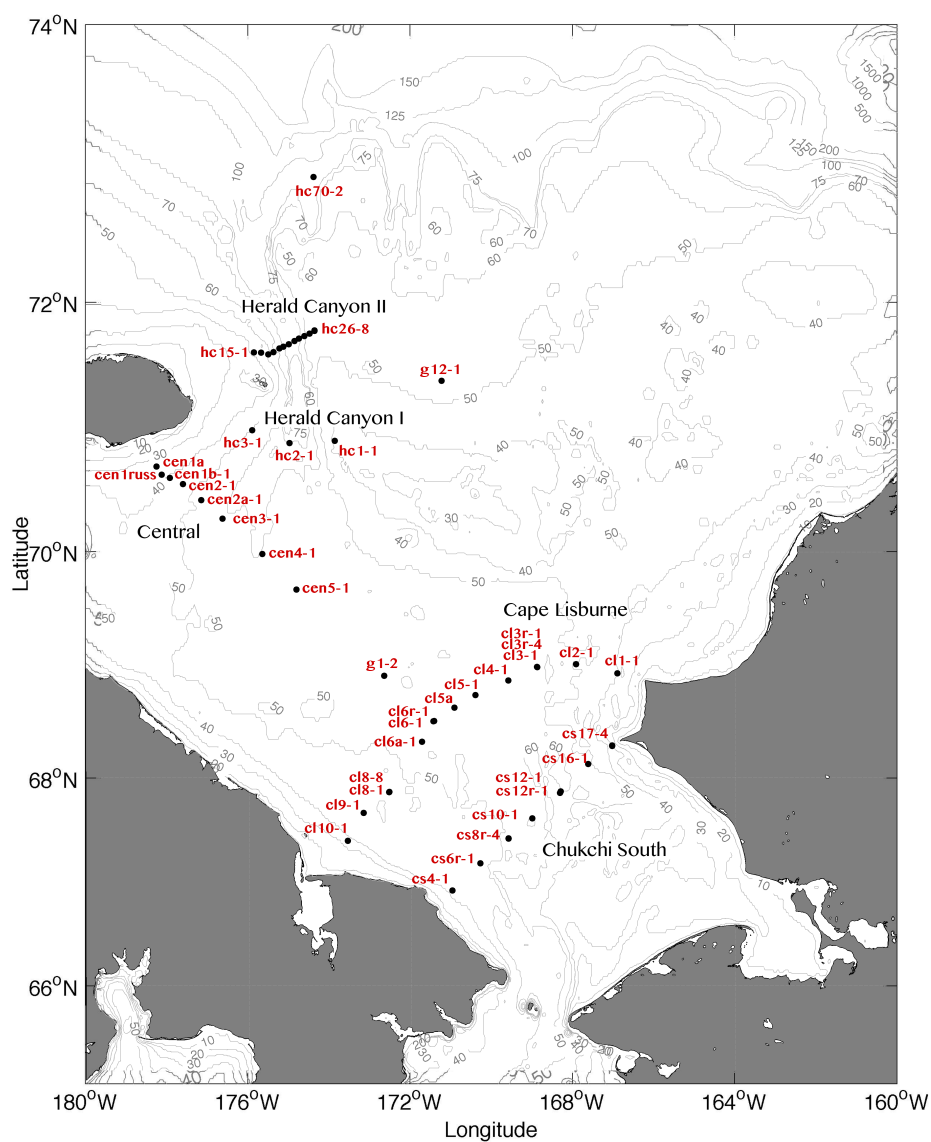


Figure 1. RUSALCA 2012 CTD station positions are shown as black circles. The complete listing of station positions can be found in the last section of this report.

## 1. Cruise Overview

The third broad-scale survey of the Joint Russian-American Long-Term Census of the Arctic (RUSALCA) program took place from 1-15 September, 2012 aboard the research vessel *Khromov*. A total of 55 conductivity-temperature-depth (CTD) casts, comprising several sections, were occupied between Bering Strait and the vicinity of Herald Canyon. The original plan called for more sections, but a combination of inclement weather, significant pack-ice, and logistical challenges limited the number of stations. Figure 1 shows the station locations, and the table at the end of this document (Section 7) lists the pertinent information for each cast. The CTD package was provided by the Woods Hole Oceanographic Institution (WHOI) and consisted of a 21-place rosette with 10-liter bottles. The sensor suite contained a Sea-Bird model SBE911plus CTD with dual temperature and conductivity sensors, a dissolved oxygen sensor, 660-nm transmissometer, chlorophyll- $\alpha$  and two CDOM fluorometers, underwater and surface PAR sensors, and an altimeter. The package also included an upward- and downward-facing RDI Workhorse 300kHz lowered ADCP system, and a SeaScan Video Plankton Recorder. See [http://www.whoi.edu/science/PO/pickart/rusalca/docs/rusalca12\\_cruise\\_report\\_Hydrography.pdf](http://www.whoi.edu/science/PO/pickart/rusalca/docs/rusalca12_cruise_report_Hydrography.pdf) for a complete report of the instrumentation used during the cruise. Here we describe the processing and editing of the CTD data, and explain the structure of the final pressure-averaged downcast files. The data can be downloaded from <http://www.whoi.edu/science/PO/pickart/rusalca/php/rusalca.php>, which also contains vertical profiles of the individual stations and vertical section plots.

## 2. Data Quality Control

The CTD data were processed using the recommended post-acquisition sequence of SeaBird routines for an SBE 9. This included removing out-of-water records, editing parameters to exclude outliers, filtering pressure, temperature, and conductivity, and deriving salinity and oxygen from the edited values. The result is a one-decibar averaged profile in Seabird ascii format with a lengthy header that contains the processing history for that file. Files were then converted to a different ascii format with a simple three-line header for continued processing using WHOI Matlab scripts. The objective of the final processing was to assess conductivity and temperature sensor performance and to remove bad conductivity and/or temperature values as indicated by density inversions in the downcast portion of the profile. To accomplish this, plots of salinity, potential temperature, and potential density versus pressure were created for each CTD station and inspected for bad data points, which were identified and dealt with according to the following criteria:

1. Erroneous surface or bottom points that could not be interpolated were removed.
2. Faulty data due to sensor problems were removed and replaced with data from the alternate sensor (for temperature and conductivity).
3. In cases where the value in a particular bin was -9 (SeaBird flag for bad data), that entry was removed entirely from the final calibrated file.

All the modifications made based on criteria 1 and 2 listed above are reported in Table 1.

Station	Pressure (db)	Modified
cen1russ	1-3	removed (spike in salinity)
cl5a	1-2	removed (spike in salinity)
cl8-8	4	removed (spike in salinity)
hc2-1	27 - 43	used value from secondary salinity sensor
hc1-1	25 - 36	used value from secondary salinity sensor
hc3-1	20 - 30	used value from secondary salinity sensor
hc19-1	50	removed (spike in o2)

Table 1 – Data that were modified or removed due to bad quality.

As noted above, in select CTD stations throughout the cruise, SeaBird processing routines flagged some of the bins as -9, indicating bad data. This was a result of increased ship heave at certain locations, which meant that specific data bins did not have enough points to constitute an accurate value. Table 2 lists all the pressure bins flagged as bad, in which cases the entire row was removed.

Station	Pressure (db)	Modified
hc18-1	47-50	removed (bad data flag)
hc19-1	17-22, 24-28, 30	removed (bad data flag)
hc20-1	34,38,39,50,55-66	removed (bad data flag)
hc21-1	5-10,12,14,16-17,20,27,48-49,52,54,58,62-65	removed (bad data flag)
hc26-1	14	removed (bad data flag)
hc70-2	87-91	removed (bad data flag)

Table 2 – Data that were removed due to bad data flags from SeaBird processing.

### 3. WOCE Quality Flags

The quality flag in the last column of each record indicates modifications made to the original data. Each bit of the quality word corresponds to a column in the data file. Quality codes are interpreted as such:

0 replaced

1 measured but not quality controlled

2 good data.

3 questionable data.

4 bad data. (*Note: for this cruise, all bad data were removed so no quality flag of 4 was assigned*)

7 interpolated data. (*Note: for this cruise, no data were interpolated*)

QC 1 was used for all measurements other than Temperature and Salinity.

### 4. Sensor Accuracy

Since the cruise took place on the shallow Chukchi shelf, where spatial variation in water properties is strong, in-situ salinity calibration is ineffective. As such, no water sample salinity measurements were taken. In lieu of an in-situ calibration, the following procedure was performed to assess the accuracy of the CTD salinity measurements. The values measured by the dual sensors were regressed against each other, excluding depths shallower than 30 m. An initial regression line was determined, all values outside the three standard deviation envelope were discarded, and the regression was calculated again. The standard deviation of the resulting scatter, which is taken as a rough measure of the salinity accuracy, was .062. This analysis revealed a slight drift in one of the sensors as a function of increasing salinity. Consequently, the data from the secondary conductivity sensor have been removed from the final calibrated files. (We note, however, that for the few data bins where the primary conductivity sensor exhibited pronounced spikes, the secondary data were substituted, see Table 1).

Both temperature sensors have been sent to SeaBird for calibration. This report will be updated to reflect the calibration information once the sensors are returned from SeaBird.

## 5. DCC File Format

A sample of the format of the final “downcast conductivity calibrated” file (.dcc) is shown below. The file contains three header lines, where the first two lines contain the information for cruise ID, station number, latitude, longitude, date, and time. The third header line contains the column labels for the data. The last column of data contains the WOCE quality flags. A more detailed description of these quality flags can be found at the WOCE website - [http://woce.nodc.noaa.gov/woce\\_v3/wocedata\\_1/woce-uoat/document/qcflags.htm](http://woce.nodc.noaa.gov/woce_v3/wocedata_1/woce-uoat/document/qcflags.htm)

```

RU12 Calibrated Conductivity and Temperature Station:cs6r-1
Latitude: 67.1940 Longitude: -176.3017 Date: 091412 Time: 17:13
Pres T90(1) T90(2) Sal(1) OxCur OXVG Trans Flur Turbidity Altimeter wocecode
3.0 1.62990 1.63000 21.48490 2.515600 8.202 78.2145 -0.0048 9.7909 68.89 22222111111
4.0 1.62860 1.62860 21.48680 2.544100 8.320 78.2983 -0.0054 9.7911 42.46 22222111111
5.0 1.62880 1.62910 21.48920 2.553000 8.357 78.2250 -0.0043 9.7910 45.31 22222111111
6.0 1.62880 1.62900 21.48730 2.554500 8.365 78.1868 -0.0064 9.7914 75.71 22222111111
7.0 1.62720 1.62810 21.49190 2.557100 8.376 78.2377 -0.0066 9.7910 45.08 22222111111
8.0 1.62610 1.62450 21.49490 2.556300 8.375 78.2778 -0.0057 9.7915 42.53 22222111111
9.0 1.57760 1.59180 21.64780 2.556500 8.379 78.5390 -0.0057 9.7911 42.32 22222111111
10.0 1.54400 1.54390 21.74170 2.553500 8.369 78.8954 -0.0060 9.7911 41.05 22222111111
11.0 1.42940 1.41910 22.49860 2.541400 8.304 82.2414 -0.0054 9.7916 54.15 22222111111
12.0 1.38430 1.37450 22.71320 2.535400 8.278 84.0057 -0.0051 9.7911 49.25 22222111111
13.0 1.13240 1.16420 23.46740 2.526600 8.256 82.7085 -0.0055 9.7914 37.60 22222111111
14.0 1.03770 0.99410 23.77020 2.520600 8.237 82.0606 -0.0050 9.7910 36.15 22222111111
15.0 0.89530 0.89080 24.25070 2.517000 8.230 81.3143 -0.0055 9.7908 34.86 22222111111
16.0 0.84470 0.84500 24.77650 2.519600 8.221 80.9962 -0.0053 9.7910 33.69 22222111111
17.0 1.08730 1.03530 25.26300 2.545300 8.246 81.5776 -0.0061 9.7911 32.43 22222111111
18.0 2.14820 2.11370 26.22740 2.561500 8.033 86.7027 -0.0063 9.7909 31.48 22222111111
19.0 1.13510 1.17650 26.85400 2.503700 7.983 85.9689 -0.0047 9.7910 30.31 22222111111
20.0 0.98560 0.99770 27.00340 2.510700 8.036 85.8973 -0.0053 9.7910 29.41 22222111111
21.0 0.95800 0.95530 27.14760 2.518300 8.065 86.7204 -0.0055 9.7909 28.46 22222111111
22.0 0.86230 0.86140 27.27850 2.522400 8.096 85.6525 -0.0057 9.7911 27.21 22222111111
23.0 0.79780 0.80920 27.50510 2.522400 8.099 83.3707 -0.0050 9.7912 26.61 22222111111
24.0 0.92640 0.91630 27.78290 2.529800 8.087 77.6847 -0.0045 9.7914 25.60 22222111111
25.0 1.40010 1.45800 28.00130 2.538800 8.012 81.8959 -0.0051 9.7911 24.37 22222111111
26.0 2.09640 2.09010 28.96690 2.559300 7.896 89.9900 -0.0043 9.7910 23.22 22222111111
27.0 2.42260 2.41560 29.45000 2.579500 7.884 90.1935 -0.0058 9.7911 22.12 22222111111
28.0 2.21650 2.22590 30.24820 2.539100 7.730 90.9300 -0.0055 9.7909 21.12 22222111111
29.0 1.85390 1.85490 30.84260 2.497700 7.613 91.2803 -0.0060 9.7910 20.11 22222111111
30.0 0.92060 1.16570 31.65420 2.491700 7.737 90.5771 -0.0058 9.7908 19.11 22222111111
31.0 0.86930 0.18910 32.04850 2.444600 7.704 76.3562 -0.0057 9.7909 18.28 22222111111
32.0 0.01950 0.02180 32.36000 2.368100 7.362 77.2796 -0.0058 9.7909 17.09 22222111111
33.0 -0.53580 -0.49380 32.50540 2.320600 7.306 85.3007 -0.0056 9.7910 16.19 22222111111
34.0 -1.09900 -1.08350 32.60940 2.289500 7.287 88.1475 -0.0052 9.7911 14.78 22222111111
35.0 -1.02530 -1.03250 32.74180 2.234300 7.041 88.6361 -0.0056 9.7910 13.96 22222111111
36.0 -0.86960 -0.87960 32.80120 2.138700 6.621 81.7315 -0.0050 9.7909 13.13 22222111111
37.0 -0.71680 -0.72120 32.85190 1.997700 6.021 73.5597 -0.0059 9.7909 11.84 22222111111
38.0 -0.61290 -0.61260 32.80480 1.936400 5.755 71.9327 -0.0053 9.7912 10.83 22222111111
39.0 -0.68230 -0.68330 32.90130 1.849500 5.414 67.6182 -0.0052 9.7907 9.53 22222111111
40.0 -0.68700 -0.68810 32.90950 1.822800 5.308 66.8898 -0.0045 9.7908 8.82 22222111111
41.0 -0.65260 -0.65430 32.93130 1.780400 5.131 66.1631 -0.0059 9.7909 7.79 22222111111
42.0 -0.66170 -0.65710 32.99980 1.779800 5.128 64.9731 -0.0052 9.7908 6.94 22222111111
43.0 -0.77260 -0.76370 33.16770 1.771300 5.104 54.8837 -0.0061 9.7908 12.28 22222111111
44.0 -0.80900 -0.80790 33.19480 1.715900 4.883 33.0800 -0.0058 9.7909 41.10 22222111111
45.0 -0.81800 -0.81940 33.19650 1.689200 4.777 27.7285 -0.0053 9.7910 40.28 22222111111

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## 6. Bottom Depth

The bottom depth values in the last column of the station positions table were calculated by using the data from the altimeter and pressure sensor on the package. For each cast, the maximum depth attained by the CTD was added to the altimeter value recorded at that time.

## 7. Station Positions Table

Filename	Latitude (Deg N)	Longitude (Deg W)	Date	Time	Cast Depth(m)	Bottom Depth(m)
cen1a	70.7085	178.2988	06-Sep-2012	19:58:00	35.63	37.72
cen1b-1	70.6155	177.9713	06-Sep-2012	13:05:00	39.59	41.71
cen1russ	70.6437	178.1718	06-Sep-2012	22:22:00	22.76	43.42
cen2-1	70.5652	177.6443	06-Sep-2012	11:08:00	42.56	44.97
cen2a-1	70.4330	177.1943	06-Sep-2012	08:57:00	51.47	54.69
cen3-1	70.2797	176.6693	06-Sep-2012	04:02:00	53.45	57.13
cen4-1	69.9828	175.6857	06-Sep-2012	00:01:00	56.42	63.21
cen5-1	69.6790	174.8460	05-Sep-2012	18:33:00	51.47	57.41
cl1-1	68.9480	166.9178	02-Sep-2012	03:57:00	44.54	46.80
cl10-1	67.4093	173.5757	14-Sep-2012	03:25:00	30.69	33.51
cl2-1	69.0298	167.9342	02-Sep-2012	09:04:00	45.53	50.70
cl3-1	69.0032	168.8938	02-Sep-2012	12:45:00	50.48	53.57
cl3r-1	69.0048	168.9000	12-Sep-2012	23:34:00	50.48	57.34
cl3r-4	69.0045	168.9010	13-Sep-2012	01:27:00	48.50	55.94
cl4-1	68.8840	169.6088	02-Sep-2012	15:52:00	52.46	57.50
cl5-1	68.7535	170.4240	02-Sep-2012	18:32:00	53.45	61.36
cl5a	68.6407	170.9423	02-Sep-2012	20:38:00	51.47	59.04
cl6-1	68.5188	171.4615	02-Sep-2012	22:52:00	52.46	60.09
cl6a-1	68.3308	171.7430	03-Sep-2012	14:00:00	50.48	58.27
cl6r-1	68.5205	171.4412	13-Sep-2012	10:18:00	50.48	57.63
cl8-1	67.8692	172.5482	13-Sep-2012	17:58:00	45.54	52.64
cl8-8	67.8667	172.5510	13-Sep-2012	20:19:00	44.55	46.25
cl9-1	67.6733	173.1800	14-Sep-2012	01:04:00	44.55	48.71
cs10-1	67.6220	169.0145	15-Sep-2012	03:11:00	46.53	51.23
cs12-1	67.8737	168.3142	01-Sep-2012	00:14:00	52.46	57.56
cs12r-1	67.8602	168.3347	15-Sep-2012	05:58:00	53.45	60.21
cs16-1	68.1287	167.6362	01-Sep-2012	15:26:00	48.50	51.32
cs17-1	68.2983	167.0418	01-Sep-2012	18:16:00	23.76	39.58
cs17-4	68.2933	167.0430	01-Sep-2012	21:05:00	35.64	38.65
cs4r	66.9320	170.9892	14-Sep-2012	13:51:00	40.59	42.56
cs6r-1	67.1940	170.3017	14-Sep-2012	17:13:00	44.55	51.49
cs8r-1	67.4312	169.6030	14-Sep-2012	20:26:00	48.51	51.11
cs8r-4	67.4317	169.6042	14-Sep-2012	22:35:00	47.52	52.10
g1-2	68.9255	172.6725	03-Sep-2012	08:31:00	50.48	57.55
g12-1	71.3980	171.2597	11-Sep-2012	21:47:00	48.49	54.75
hc1-1	70.9192	173.8988	07-Sep-2012	12:12:00	35.63	39.97
hc15-1	71.6205	175.8960	09-Sep-2012	16:52:00	37.61	40.28
hc16-1	71.6177	175.7173	09-Sep-2012	15:48:00	41.57	44.89

hc17-1	71.6040	175.5417	09-Sep-2012 14:25:00	38.60	49.99
hc18-1	71.6213	175.4085	09-Sep-2012 06:51:00	50.47	54.52
hc19-1	71.6520	175.2660	09-Sep-2012 05:48:00	51.46	61.66
hc2-1	70.9000	175.0127	07-Sep-2012 19:45:00	66.31	74.40
hc20-1	71.6640	175.1650	09-Sep-2012 04:54:00	66.30	69.93
hc21-1	71.6838	175.0352	09-Sep-2012 03:17:00	65.31	71.57
hc22-1	71.7077	174.8898	08-Sep-2012 22:16:00	67.29	71.37
hc23-1	71.7275	174.7848	08-Sep-2012 21:27:00	66.30	69.92
hc24-1	71.7472	174.6465	08-Sep-2012 20:25:00	63.34	69.33
hc25-1	71.7670	174.5208	08-Sep-2012 19:30:00	55.42	61.26
hc26-1	71.7878	174.3945	08-Sep-2012 13:31:00	50.47	54.80
hc26-8	71.7902	174.3962	08-Sep-2012 18:14:00	50.47	52.13
hc3-1	71.0033	175.9335	08-Sep-2012 02:58:00	46.52	48.40
hc70-2	72.9398	174.4222	11-Sep-2012 04:31:00	91.03	100.17