R/V Endeavor 539 Cruise (EN539) Final Report
May 26-June 2, 2014
Reykjavik, Iceland to Reykjavik Iceland

Science Personnel:
Delia Oppo, Chief Scientist (Woods Hole Oceanographic Institution; WHOI)
David Thornalley, Co-Chief Scientist (University College London; UCL)
Lloyd Keigwin (WHOI)
Ian Nicholas McCave (Cambridge University)
Ian Hall (Cardiff University)
Michael McCarthy (Marine Imaging Technologies, Woods Hole)
Marleen Jeglinski (WHOI)
Kathryn Pietro (WHOI)
Ning Zhao (MIT/WHOI student)
William Gray (UCL student)

Lynne Butler (Marine Technician)

Objective:

The main purpose of this cruise was to collect multicores along two depth transects to measure grain size variations during the last millennium, from which variations in Iceland-Scotland Overflow Water (ISOW) will be inferred. The cruise transect is shown in black below. The first of the two transects (Figure 1) was cored transiting from north to south along the eastern flank of the Bjorn Drift and the second was along an unnamed drift between the West Katla Drift and the Bjorn Drift. Most sites cored were previous cored by either gravity or piston corer in 1993 aboard the R/V Ewing (EW9302, D. Oppo and S. Lehman, co-chiefs). In addition, we collected multicores at 3 sites off these two transects – two of these sites had been previously cored with gravity corers and one site had been previously instrumented with a current meter. We also used 3.5 kHz to identify sediment suitable for coring at depths shallower than sites previously cored – these two shallow sites, at 1037 m and 792 m, were cored at the end of the cruise before transiting back to Reykjavik.

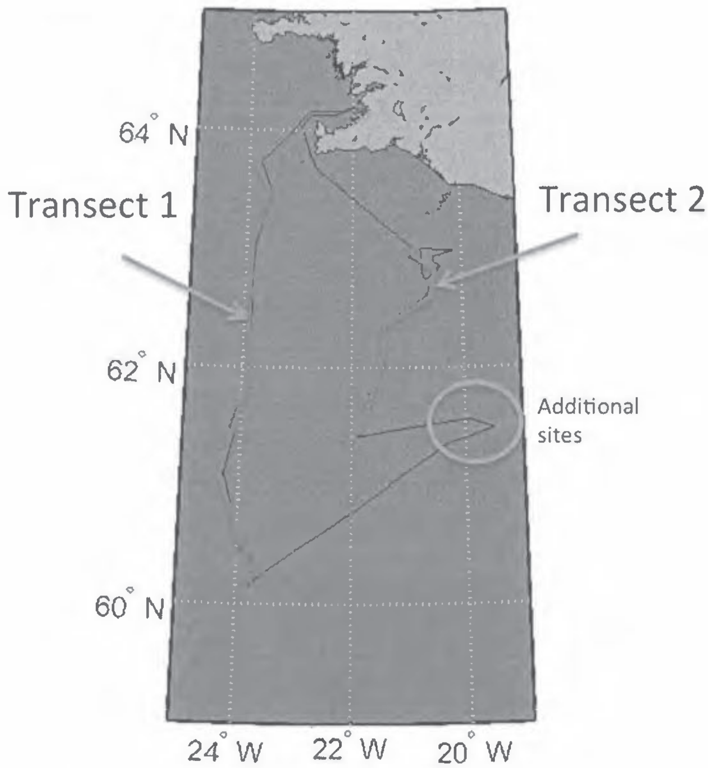

Figure 1. Cruise track with coring transects highlighted in red.

In total (see Table) we deployed the multicorer 21 times at 20 sites. The core sties range in depth from 792 to 2311 m. Although one deployment recovered only 1 of 8 multicores, the remaining deployments collected between 5 and 8 subcores each time. Typically for a full recovery of 8 subcores one subcore was slabbed and sampled into plastic bags, the tops of 3 subcores were saved for calibration work, and the remaining 4 subcores were archived whole. When fewer subcores were recovered, fewer subcores were archived whole. We also deployed the gravity corer 5 times, with good recovery 4 times. The gravity cores, which were recovered from water depths ranging from 1467 to 2275m. varied in length from 2.79 to 4.18 m.

We deployed the CTD three times, and collected water for oxygen and carbon isotope measurements, and salinity measurements at 11-12 depths in each cast. The CTD data show that Labrador Sea Water (LSW) overlies Iceland Scotland Overflow Water (ISOW) in our study area (e.g. Figure 2)

We also collected near-bottom water with a Niskin bottle attached to the multi-corer frame for these same analysis. The Niskin broke at Station 17, possibly because the wire caught the bracket and removed it from the Niskin bottle during pullout. Following this event, bottom water was collected and filtered from the top of a multicore tube.

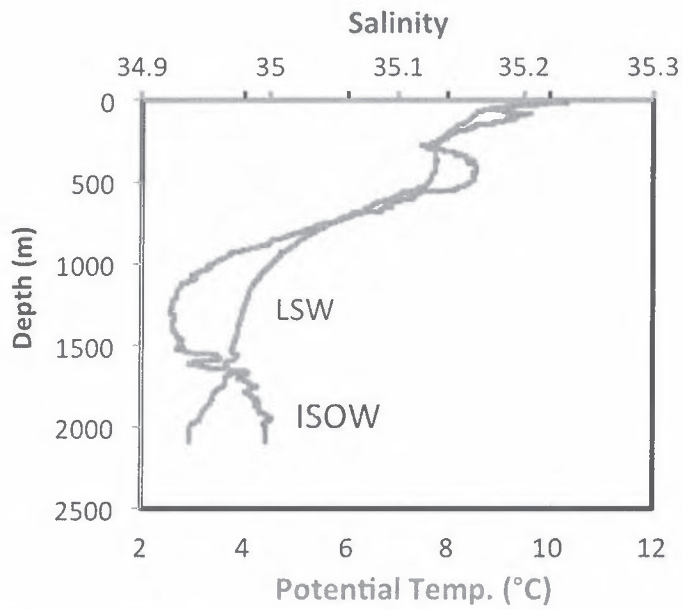

Figure 2. CTD data from EN539 station 8

Post cruise analysis:

CONTEXT: Our published results showed a decrease in the strength of ISOW since the mid-Holocene climatic optimum. We attributed this trend to an insolation-forced increase in drift ice, and sea ice export from the Arctic to Nordic Seas. Model results we presented suggested that these caused a decrease in the depth of convection in the Greenland seas, potentially weakening ISOW. Our published records ended at ~ 500y BP. New records from multicores will allow us to determine if ISOW increased at the end of the Little Ice Age, with the decreased export of sea ice from the Arctic and decrease in drift ice.

Of the 13 multicores cores we have worked on so far, 9 have Fm>1, implying "modern" core tops. Two tops were not dated because of the certainty that they would also be modern. We have developed 13 Late Holocene grain size records from these multicores. We have collected radiocarbon dates, some 210Pb and 137Cs profiles, counted Spheroidal Carbonaceous Particles, and are in the process of sending out tephra samples for geochemical analysis. These and other activities are geared towards developing accurate age models, without which the records of the last century are difficult to interpret. Based on our current age models, some of out key findings are still tentative.

Key Findings:

- Detailed grain size records from all depths (and two transects) studied so far (1500-2300 m) suggest a decline in strength of ISOW during the last 700 yrs
- Stacking the records in many different ways suggests that the greatest decline occurred at ~1750.
- Splicing this stack with our published Holocene stack suggests that ISOW since 1750 was exceptionally weak compared with the previous ~ 7000 yrs.
- Results therefore imply that ISOW strength did not recover at the end of the Little Ice Age. We hypothesize that freshwater from melting Little Ice Age glaciers inhibited ISOW recovery
- Comparison to one published record from DSOW (from the Eirik Ridge) suggests that this post-LIA weak ISOW was not compensated fro by DSOW, but this result is preliminary.

We have presented the results at several meetings. Several of the results are being summarized for submission to peer-reviewed journals. Progress is a little slow due to the challenge of developing reliable age models for young sediment. For this, we are turning to Cs-137, geochemical fingerprinting of ash layers, and anthropogenic signatures.

Presentations:

Fall AGU 2015

D. Thornalley, D. Oppo, P. Moffa-Sanchez, I. Hall, L. Keigwin: Pronounced Weakening of Deep Components of the AMOC During the Late Holocene Caused by Export of Arctic Sea-Ice and Freshwater, PP42B-07.

Ocean Sciences 2016 **Undergraduate Student*

Y. Zhou*, D. Oppo, J. Gebbie, D. Thornalley.Magnitude of the Suess Effect in the North Atlantic - a Study of Foraminifera and Transient Tracer Simulations. Abstract AH34A-0062

International Conference in Paleoceanography, Utrecht Netherlands, Aug 28-Sep 2, 2016. Thornalley, DJR, DW Oppo, P. Moffa-Sanchez, IR Hall, and LD Keigwin, A Holocene and last 1000 yr perspective on variability in the deep currents of the AMOC: An exceptional twentieth century slowdown of the AMOC?

Fall AGU 2016:

Thornalley, DJR, DW Oppo, P. Moffa Sanchez, I. R Hall, L. D Keigwin, N. Rose, K. Green, F. Pallottino, P.Ortega and J. Robson 'Exceptional Shift to a Weaker Atlantic Meridional Overturning Circulation at the end of the Little Ice Age

Rose, N., DJR Thornalley, DW Oppo. Spheroidal Carbonaceous Particles (SCPs) as Chronological Markers in Marine Sediments

Training and education:

In addition to the 2 graduate students who participated on the cruise, two undergraduate STEM students processed many hundred samples for grain size analysis. One also learned to operate and trouble shoot the mass spectrometer, and became an integral members of our lab team through this project, even working during winter breaks.

One undergraduate student worked on a summer project using the new multicores collected on the cruise. The goal of his project was to determine whether the $d^{13}C$ trends we measured in the most recent sediment were consistent with uptake of anthropogenic carbon from the atmosphere. With significant guidance from a WHOI physical oceanographer, Geoffrey Gebbie, the student used a tracer simulation, with Transit Time Distribution and Equilibrium Time Distribution generated from previous tracer modeling studies, and found a trend that is similar in timing and amplitude to the observations at the core sites.

R/V Endeavor Station Log - Cruise 539

(Bottom locations)

Date 2014	Time-GMT (hit)	Station	*Core/CTD #*	*Event*	*Depth (m)*	*Latitude (°N)*	*Longitude (°W)*	*GGC Length (m)*	*# of multicores*
27-May	534	1	1	GGC	1468	61° 56.643	23°52.520	0	
27-May	802	1	2	MC	1465	61° 56.687	23°52.662		8
27-May	955	1	3	GGC	1467	61° 56.667	23°52.612	2.79	
27-May	1505	2	4	MC	1540	61° 43.230	23°58.561		8
27-May	1901	3	5	MC	1632	61° 29.900	24°10.366		7
28-May	2205	4	6	MC	1671	61° 25.167	24°06.330		8
28-May	707	5	7	MC	1807	61° 5.585	24° 15.978		8
28-May	911	5	8	GGC	1806	61° 5.603	24° 16.074	2.81	
28-May	1505	6	9	MC	2103	61° 29.331	23° 56.533		7
28-May	1828	7	10	MC	1999	60° 24.205	23° 38.434		8
28-May	2254	8	11	GGC	2129	60° 10.192	23° 46.813	4.18	
29-May	33	8	12	CTD	2131	60° 10.067	23° 47.034		
29-May	333	8	13	MC	2129	60° 10.239	23° 46.735		8
29-May	1603	9	14	MC	2274	60° 10.788	20° 20.905		8
29-May	1804	9	15	GGC	2275	60° 10.738	20° 20.961	3.21	
29-May	2225	10	16	MC	2311	61° 28.986	19°32.163		8
29-May	2353	10	17	CTD	2313	61° 28.76	19°32.20		
30-May	430	11	18	MC	2143	61° 34.049	19°57.834		8
30-May	1124	12	19	MC	1810	61° 25.284	21°53.670		8
30-May	1511	13	20	MC	1711	61° 40.289	21°43.955		8
31-May	716	14	21	MC	1647	61° 45.772	21°40.046		5
31-May	1145	15	22	MC	1535	62° 03.785	21°28.341		8
31-May	1508	16	23	MC	1460	62° 19.342	21°27.458		1
31-May	1638	16	24	MC	1462	62° 19.314	21°27.455		7
31-May	2224	17	25	MC	1310	62° 36.749	20°38.147		7
1-Jun	758	18	26	MC	1190	62°45.045	20°40.652		8
1-Jun	852	18	27	CTD	1194	62°45.106	20°40.384		
1-Jun	1325	19	28	MC	1031	62°45.564	20°40.129		5
1-Jun	1724	20	29	MC	792	63°00.324	20°53.037		5