ICEX-09 XCTD Test

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ABSTRACT:

Test deployments of under-ice submarine-launched eXpendable Conductivity Temperature Depth (U/ISSXCTD) probes were conducted by the US Navy Arctic Submarine Laboratory (ASL) during the 2009 Navy ICe EXercise (ICEX-09) in the Arctic Ocean. These tests were conducted in order to evaluate the accuracy and reliability of XCTD probes when launched from submarines while operating under sea ice, and thus their suitability for further use in the SCICEX program of Science Accommodation Missions (SAMs) in the Arctic Ocean. 16 U/ISSXCTD probes were available for test deployment during ICEX-09. Of these, 2 probes failed pre-launch tests and were not launched, 2 were deployed but failed to return data, and the remaining 12 returned acceptable data, but over depth ranges significantly shorter than stated in the manufacturer's specifications. Funding for the ICEX-09 XCTD testing was provided by Office of Naval Research grant N00014-09-M-0056 to the Scotttish Association for Marine Science (SAMS).

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1. Introduction

The SCience ICe EXercise (SCICEX) program was established in 1994 to make use of the unique capabilities of nuclear-powered submarines as data-collection platforms in the ice-covered waters of the Arctic Ocean. During the latter half of the 1990's, five SCICEX 'dedicated science' cruises were conducted in the Arctic Ocean using US Navy submarines under terms that allowed for onboard participation by civilian scientists. These dedicated-science cruises were very successful in terms of collecting a broad range of multidisciplinary data in regions and times of year previously inaccessible to the scientific community (Edwards and Coakley, 2003). Following the success of the dedicated science cruises, the terms governing the collection of civilian scientific data from Navy submarines in the Arctic were expanded to include 'Science Accommodation Missions', in order to increase sampling flexibility while recognizing that the increasing demands on the submarine fleet would render Navy support for future dedicated science cruises very unlikely.

Data collected during the SCICEX dedicated science cruises contributed to widespread recognition of the 'amplification' of global climate change signals in the Arctic. In particular, SCICEX measurements were combined with declassified, earlier submarine-based measurements to quantify the rate of change of sea ice thickness over the last four decades of the twentieth century (Rothrock et al., 1999). SCICEX submarine-based water column measurements were combined with climatological data to quantify upper ocean warming and water mass variability (Morison et al., 1998; Steele and Boyd, 1998; Gunn and Muench, 2001) at basin scale. The assessment of upper ocean water mass variability was dependent upon measurement of temperature and salinity profiles throughout the upper 1000m, obtained through underway deployment of under-ice submarine-launched expendable CTD (UISSXCTD) probes. Data collected through deployment of these XCTDs on long, across-basin SCICEX transects provided incomparable, synoptic views of the changing temperature and salinity of the upper layers of the Arctic Ocean around the turn of the century.

The submarine-launched XCTDs deployed during the SCICEX dedicated-science and science-accommodation Arctic Ocean missions of the late 1990’s and early 2000’s were analog devices that were produced by Sippican, Inc. Following development of a digital XCTD by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and subsequent transition of production of this probe to the Tsurumi-Seiki Co (TSK), Lockheed-Martin-Sippican (LMS) discontinued production of its own analog probe, and now supplies the TSK digital probes in a configuration for deployment from US submarines. Deployment of the TSK digital XCTDs by the Arctic Submarine Laboratory on a cruise in 2004 yielded significantly higher failure rates than previously experienced with deployment of the analog XCTDs. Investigation by LMS into the high failure rates experienced by surface-vessel users of TSK XCTDs pointed to an engineered safety feature (an ‘instrument time-out’ circuit) as the cause for failure to return data. Since TSK has expressed no interest in removing the safety ‘time out’ feature, LMS has changed their launch procedure to increase the reliable use of the XCTDs.

Since the beginning of the SCICEX program, environmental observations within the Arctic Ocean have substantially increased, in particular during the International Polar Year (IPY) 2007-2009, yet there is presently widespread recognition of the need for further, persistent observation of important aspects of climate variability within the Arctic. A coordinated system of persistent observations has been identified by US and international research programs (SEARCH, ISAC) as a fundamental mechanism to achieve improved understanding of the processes leading to variability. Within this context, the collection of SCICEX SAM data has been explicitly identified as an element of the US Arctic Observing Network (NSF AON). There is thus a mandate for increased Arctic environmental sampling using Navy submarines, however it is now essential to resolve all remaining uncertainties regarding reliability of the TSK/Sippican XCTDs prior to expanding their deployment in SCICEX SAMs.

2. ICEX-2009 XCTD TEST

In recognition of the need to verify the capability of Navy submarines to reliably obtain vertical profiles of temperature and salinity using the TSK/Sippican UISSXCTD probes, the Office of Naval Research (ONR) provided funding for an assessment that was conducted in spring of 2009. The US Navy Arctic Submarine Laboratory (ASL) conducted the test deployment from a US Navy submarine in conjunction with the 2009 ICe EXercise (ICEX-09) at the APLIS (Applied Physics Lab Ice Station) ice camp in the Beaufort Sea near 73° 12'N 146° 27'W in March, 2009.

Following the ICEX-09 test deployments, ASL provided the XCTD data together with data logs and comments on test process and results to the SAMS PI. ASL also provided CTD data from casts conducted at the APLIS ice camp during the test period. The PI then conducted basic quality control and data analysis, and provided a report on the test at a meeting of the SCICEX Science Advisory Committee (SAC) in October 2009. The results of this test were made available to the SAC to inform the discussion on the fitness of XCTD probes for further use from submarines as part of the SCICEX program, and were reflected in the SCICEX Science Plan (SCICEX SAC, 2010). Table 1 shows the project timeline.

Task	Responsibility	Date
Procurement of XCTDs	SAMS	November, 2008
Deployment of XCTDs	ASL	21-22 March, 2009
Delivery of XCTD data to SAMS	ASL	May, 2009
Report to SCICEX SAC	SAMS	5 October, 2009
Final Report	SAMS	December 2010

A. DESCRIPTION OF THE TEST

Sixteen XCTD probes were provided to ASL and scheduled for deployment from USS HELENA near the APLIS ice camp on 21-22 March 2009. Two of the probes failed pre-launch continuity checks and consequently were not launched. Data was returned successfully for 12 of the remaining 14 XCTDs, all of which were launched per the revised procedure described in the Sippican operations manual. Details of the deployment sequence and results are shown in Appendix 1 (provided by ASL). Appendix 1 also shows that, with the exception of one probe that was launched much later in the following morning, the XCTDs were launched in rapid succession over a period of 2.5 hours during the evening of

21 March. A listing of the Sippican Export Data Files resulting from the test is shown in Table 1.

ASL personnel made several pertinent observations regarding the outcome of the XCTD test, and drew two main conclusions (all of which are shown in Appendix, which was provided by ASL personnel):

(1) Implementation of the currently recommended launch procedure, recently revised by Sippican to accommodate the TSK time-out circuitry, reduced the probe data return failure rate from 45% to 25%, but this is still significantly higher than the levels typical of the analog probe usage during the dedicated-science phase of the SCICEX program (12-15%).

(2) The accuracy and early termination of the probe data both require further examination.

B. XCTD CASTS

As noted in the ASL report (Appendix 2), plots of raw XCTD profiles reveal variability in the recorded temperature and salinity as well as depth, though the analysis shown in Section 3 reveals that much of the apparent variability in temperature and salinity at any given depth is the result of the variability in the probe depths. Although this variability could be the result of a combination of oceanic variability associated with internal wave displacement of the temperature and salinity structure and probed depth errors, the resulting depth errors are within the stated accuracy of the probes (see Appendix 5).

Cast Number	Export Data File (.EDF) name	UISSXCTD probe serial number	Profile maximum depth (m)
2	C3_002	08079824	434
4	C3_004	08079833	317
5	C3_005	08079828	578
6	C3_006	08079837	583
7	C3_007	08079838	533
8	C3_008	08079827	577
9	C3_009	08079834	379
10	C3_010	08079825	382
11	C3_011	08079839	386
12	C3_012	08079826	394
13	C3_013	08079829	390
14	C3_014	08079840	377

Table 1. XCTD Export Data File (.EDF) names, probe serial numbers and profile maximum depths (in meters). Note that there is no file C3_003.

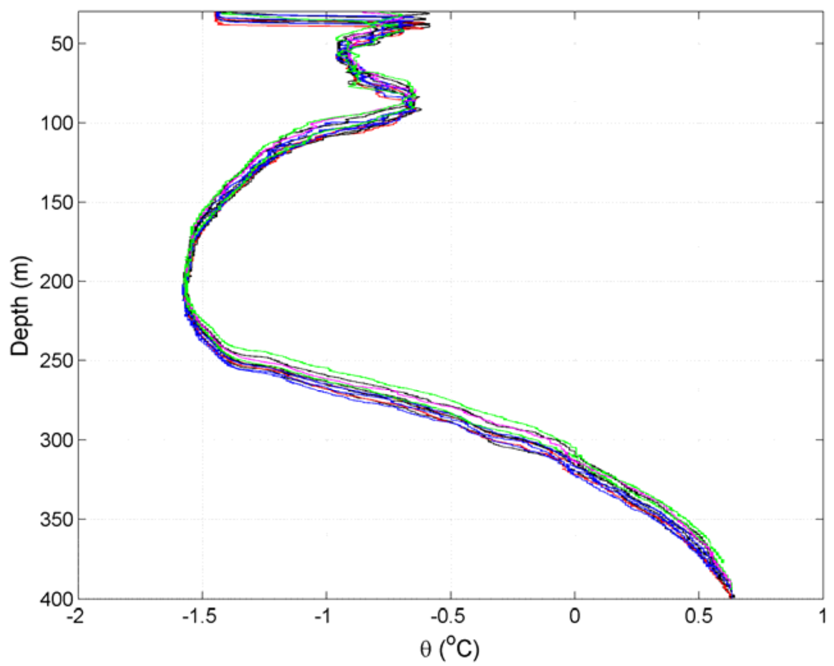

FIGURE 1. Temperature as a function of recorded depth for XCTD casts 2-14 (no cast 13).

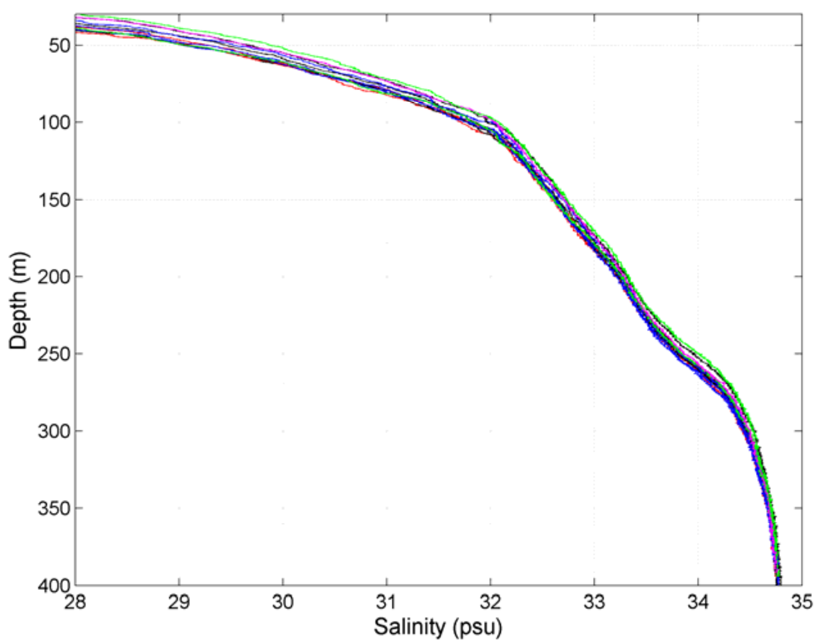

FIGURE 2. Salinity as a function of recorded depth for XCTD casts 2-14 (no cast 13)

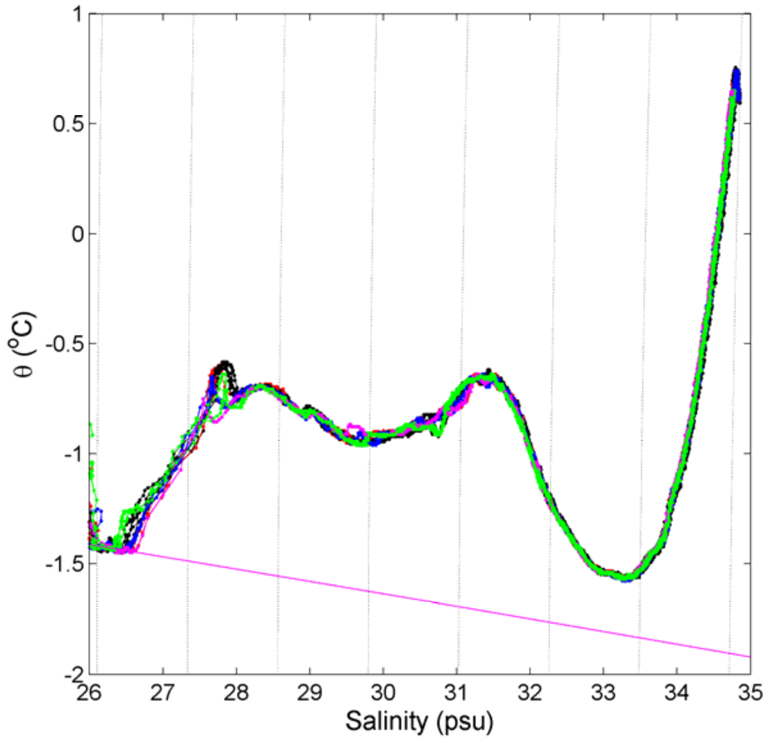

FIGURE 3. Temperature/salinity relationships for XCTD casts 2-14 (no cast 13). Also shown are isopycnal lines (dashed) and the freezing line (magneta) for surface pressure.

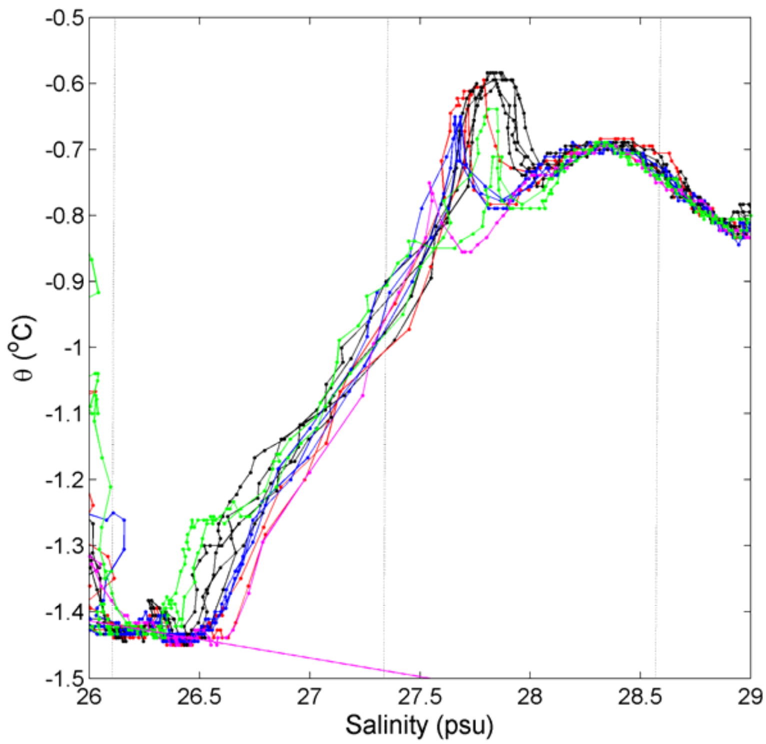

FIGURE 4. Close up of the near-surface temperature/salinity relationships for XCTD casts 2-14 (no cast 13). Also shown are isopycnal lines (dashed) and the freezing line (magneta) for surface pressure.

C. CTD CASTS:

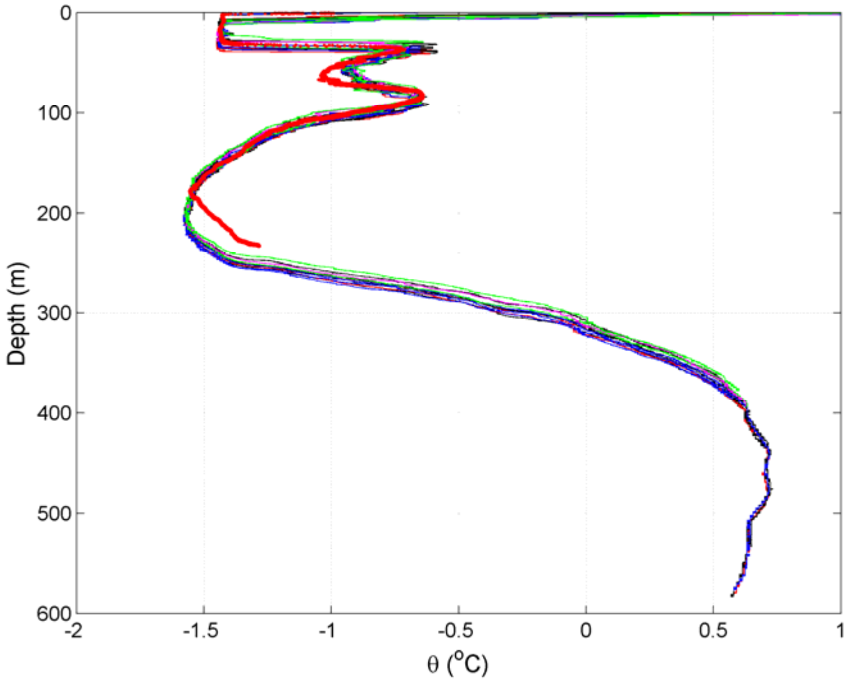

Figure 5. XCTD Temperature profiles with CTD cast overlaid in red.

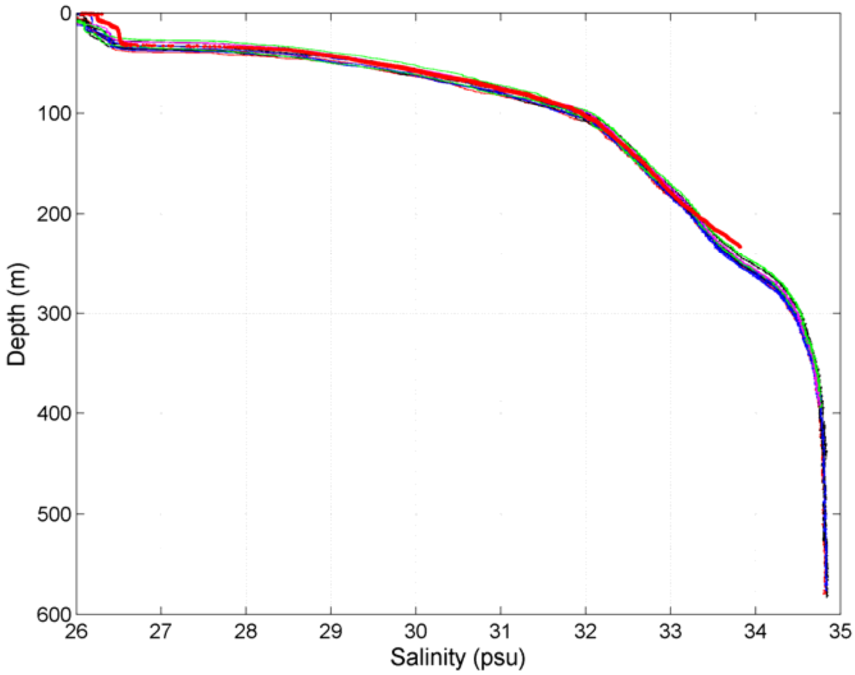

Figure 6. XCTD Salinity profiles with CTD cast overlaid in red

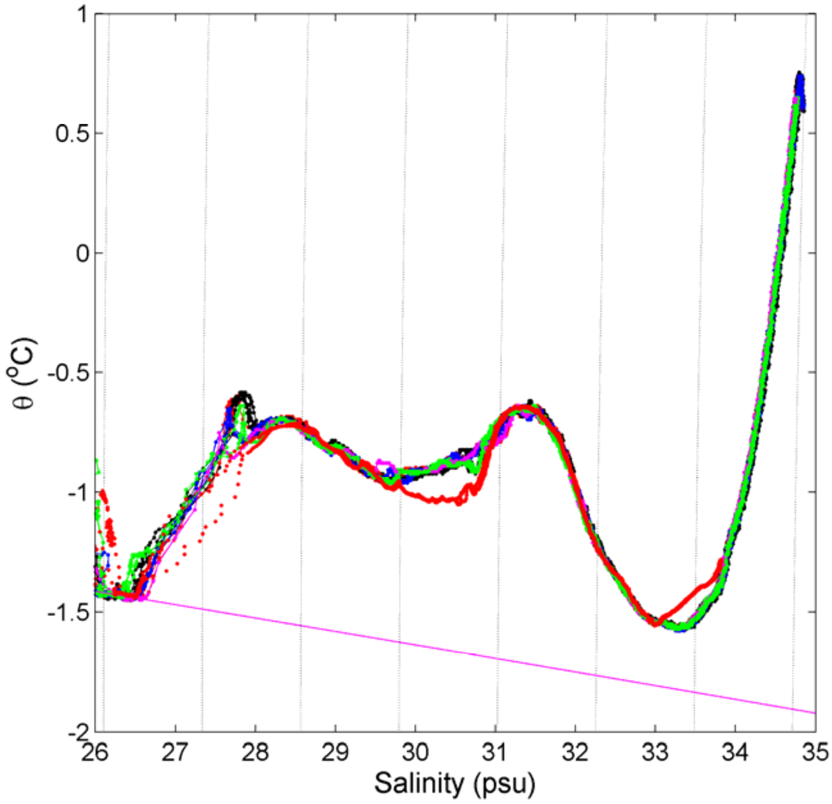

Figure 7. XCTD Potential Temperature – Salinity curves with CTD relationship overlaid in red

3. <u>ANALYSIS: XCTD ACCURACY</u>

1. Data was returned successfully for 12 of the 16 XCTDs that were obtained from Sippican for Arctic testing from submarines. Two of the failures never properly passed pre-launch tests and were thus not launched. The remaining two failures were launched, but did not return data. I have inquired about the two probes that failed pre-launch tests. ASL is checking with the vessel (USS Helena, SSN 725) regarding the location/status of the probes, for possible return to the Sippican for a post-mortem. **Note: Sippican was interested in analyzing the two probes that failed pre-launch tests to determine the source of failure, but these were never made available. In the future, failed probes should be retained for further analysis.**

2. None of the successful probes provided profiles as deep as 600m. 7 of the 12 successful probes returned data to maximum depths that were shallower than 400m. This is significantly less than the advertised profile depth of 1000m. **Note: determining the cause of and resolving the failure of probes to successfully**

return data to the probe designed maximum profile depth is clearly the most important outstanding issue that must be resolved by Sippican.

3. The depth-time equation is of the form depth = depcoef1 + depcoef2*time + depcoef3*time^2, where depcoef1 is 0. With earlier versions of the SSXCTD, the probe was designed to invert at a depth > 0 m, and then begin profiling downwards. Clearly, with ice overhead it is not sensible for the probe to rise to a depth of 0 m, because of the strong possibility of contacting sea-ice. **Note: 40 ft is the depth at which the probe is designed to invert prior to profiling. Should this be reflected in the value of depcoef1 stored in memory for the probes?**

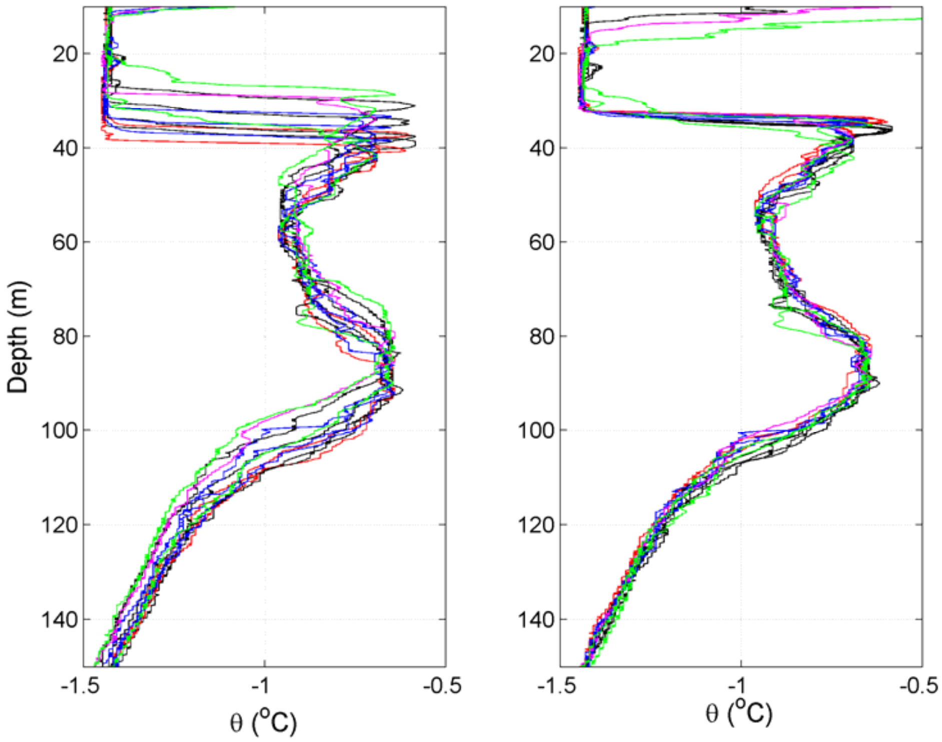

FIGURE 8. XCTD potential temperature profiles with depth as reported (left), and the same profile data plotted with depths offset such that the base of mixed layer base is aligned in each (right).

4. Data fields for temperature, conductivity, salinity, sound speed, and density are represented to two significant digits in the .EDF files. The .EDF files I received from ASL were in mixed English/metric units (depth in feet, temperature in degrees F, conductivity in mS/cm, sound velocity in ft/s, density in lb/ft^3). Truncation of the depth values at tenths of feet corresponds to reported depth increments that alternate from 0.4 to 0.5 feet, although the probe's fall-rate coefficients and sampling rate (40 msec) correspond to actual depth increments of about 0.45 feet. Ordinarily, this is probably not of much significance, however it came to my attention in trying to evaluate the probe data quality through comparison to each other and to CTD cast(s), where I hoped to use the data at the highest possible resolution. For this report, I have inferred time from the sample rate and coefficient values, and initial depth value, and have reprocessed the data using pressure (inferred from recomputed depth) in the computation of salinity. Through this reprocessing, the small vertical-scale (< 10 m) structure of the recomputed salinity (and hence density) differs from the truncated values in the .EDF files. A more significant consequence follows from representation of the temperature field to two decimal places: with temperature output in degrees F, the temperature least count corresponds to a minimum temperature increment of 0.018°C, which is significantly larger than the specified resolution of 0.01 °C. **Note: there is clearly a need for Sippican to provide depth at higher resolution and temperature at the sensor resolution, regardless of what units are selected for data output**.

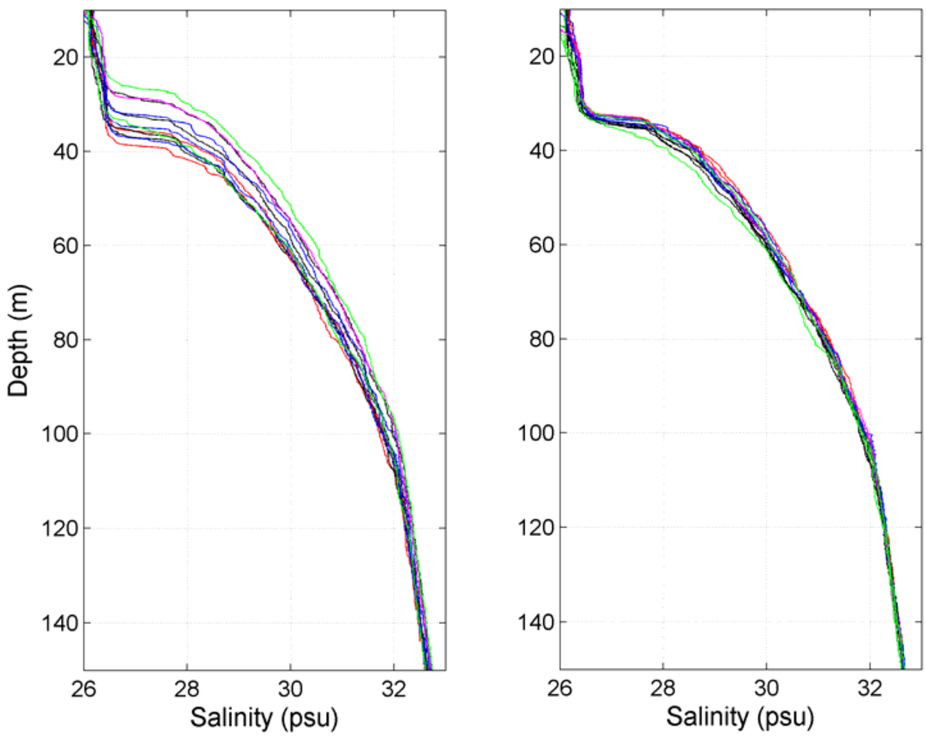

FIGURE 9. XCTD salinity profiles with depth as reported (left), and the same profile data plotted with depths offset such that the base of mixed layer base is aligned in each (right).

Statistic	Z	T	C	S	Z ml
Average	205	-1.57	2.66	33.31	32.04
RMS		0.0040	0.0011	0.0134	3.66
Spread	5	0.0143	0.0041	0.0494	12.71

TABLE 2. Ensemble average of probe-averaged properties around the depth of the temperature minimum at 205 m. In this case the individual probe values have been averaged over a depth range of +/-2.5 m around 205m, including 37-38 points each, and statistics have been formed over the ensemble of 12 probes. Conductivity is in S/m: 10 * C(S/m) = C(mS/cm).

When the ML depths are aligned, as shown in figures 8 and 9, the resulting variability in deeper temperature and salinity values give an estimate of the accuracy of these measurements. To that end, ensemble rms values for 5 m (Table 2) and 10 m (Table 3) averaged values of temperature and salinity data around the depth of the temperature minimum at 205m were computed and are shown in Tables 2 and 3 as estimates of the probe error. Note that the ensemble rms variations in temperature and conductivity, as derived for both 5m and 10m averaged values, are well within the specifications for probe accuracy. The total ensemble spread for average temperature is also well within that specification, and the value for conductivity is close.

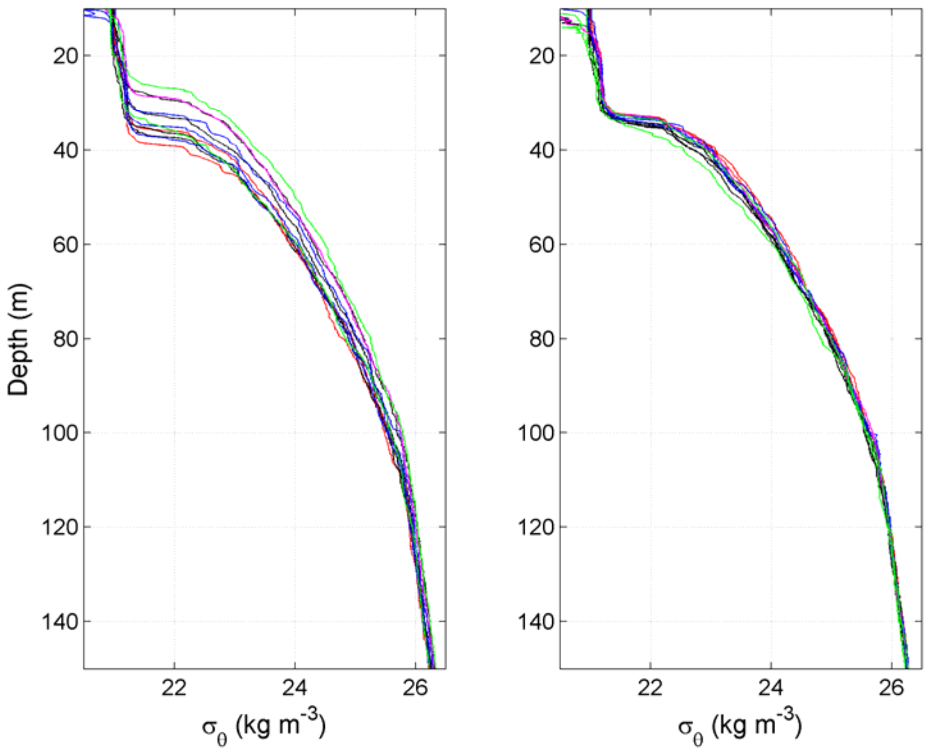

FIGURE 10. XCTD potential density profiles with depth as reported (left), and the same profile data plotted with depths offset such that the base of mixed layer base is aligned in each (right).

Statistic	Z	T	C	S	Z ml
Average	205	-1.57	2.66	33.31	32.04
RMS		0.0038	0.0011	0.0136	3.66
Spread	10	0.0132	0.0039	0.0480	12.71

TABLE 3. Ensemble average of probe-averaged properties around the depth of the temperature minimum at 205 m. In this case the individual probe values have been averaged over a depth range of +/-5 m around 205m, including 74-75 points each, and statistics have been formed over the ensemble of 12 probes. Conductivity is in S/m: 10 * C(S/m) = C(mS/cm).

4. CONCLUSIONS:

The US Navy Arctic Submarine Laboratory conducted testing of Sippican digital XCTD probes during ICEX-09 on behalf of the SCICEX Science Advisory Committee. This test was conducted in recognition of the need to verify, prior to further expansion of their use in the SCICEX program, the capability of these probes to reliably return high quality Temperature and Salinity profiles when launched by US Navy submarines,. From the data collected during this test, we conclude that:

- Data quality from the probes is acceptable,
- Maximum depth profiled falls well short of the manufacturer’s specification as well as the required depth coverage in the upper layers of the Arctic Ocean, and
- Success rate for probes needs further attention.

We therefore cannot recommend expanded use of Sippican U/ISSXCTDs within the SCICEX SAM framework until the probes can be shown to reliably sample to the full design depth of 1000 m.

5. References

Edwards, M. H., and B. J. Coakley (2003), SCICEX Investigations of the Arctic Ocean System, *Chemie der Erde*, 63, 281-328.

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Rothrock, D. A., Y. Yu and G. A. Maykut (1999), Thinning of the Arctic sea-ice cover, *Geophys. Res. Lett*., 26, 3469-3472.

SCICEX Science Advisory Committee (2010), SCICEX Phase II Science Plan, Part 1: Technical Guidance for Planning Science Accommodation Missions, US Arctic Research Commission, Arlington, VA, 76 pp.

Steele, M., and T. Boyd (1998), Retreat of the cold halocline layer in the Arctic Ocean, *J. Geophys. Res.*, 103, 419-435.

Appendix 1: XCTD log from USS HELENA

XCTD LOG   USS HELENA

Probe No	Type	Launch			Results	Max Depth (ft)
		Date	Time	Delay (s)		
8079824	XCTD	21-Mar	2126	90		1454
8079836	XCTD	21-Mar	2146	60	no data	
8079833	XCTD	21-Mar	2207	60		1040
8079831	XCTD	21-Mar			failed pre-test/not launched	
8079828	XCTD	21-Mar	2228	55		1902
8079837	XCTD	21-Mar	2242	60		1913
8079838	XCTD	21-Mar	2256	45		1750
8079827	XCTD	21-Mar	2305	45		1893
8079834	XCTD	21-Mar	2315	45		1243
8079825	XCTD	21-Mar	2323	45		1252
8079832	XCTD	21-Mar			failed pre-test/not launched	
8079839	XCTD	21-Mar	2337	35		1268
8079826	XCTD	21-Mar	2346	35		1292
8079835	XCTD	21-Mar	2352	40	no data	
8079829	XCTD	21-Mar	2358	40		1278
8079840	XCTD	22-Mar	530	40		1237

Delay = time from start of probe test to time of launch

Appendix 2: Notes from ICEX-09 deployment of XCTDs by USS HELENA

XCTD Test
USS HELENA
ICEX 1-09

1. Sixteen Mk 21 XCTD probes, procured by ONR, were launched by USS HELENA at ice camp APLIS on 21-22 Mar 2009. All tests were made using a Mk 21 test kit provided by Sippican rather than the ship's sonar system. The following data is provided for analysis:

    a. Export data files for all probes launched.

    b. A table listing probe numbers, date/time of launch, delay between probe activation and launch, and maximum depth at which data was recorded.

    c. The data from a CTD cast made from the ice camp at the same time as the probe launches.

2. Of the sixteen probes, two failed pre-launch continuity checks and were not launched. All of the remaining probes were launched, well within the new 3.5 minute window specified by Sippican. Of those, two failed to provide any data and the other twelve provided data to depths below 1000 ft.

3. Observations.

    a. The probes were launched in a random order relative to their serial numbers.

    b. The four failures were distributed throughout the launch sequence. However, the two that failed pre-checks were consecutive serial numbers (8079831 & 8079832) as were the two that launched but provided no data (8079835 & 8079836).

    c. Comparison with the CTD data indicates a slight offset in temperature and an obvious offset in CTD values. There also appears that there may be a slight error in the fall rate (depth) algorithm, though not nearly as severe in earlier generations of probes.

    d. Although designed to provided data to a depth of 3609 ft, all of the probes stopped providing data at depths between 1040 – 1913 ft.

    e. None of the probes experienced the data scatter frequently seen in earlier batches of probes.

4. ASL Conclusions.

    a. The use of the quickened launch procedures reduced the overall failure rate from about 45% (seen on the 2005 test) to 25%, still short of the 12-15% regularly achieved on previous SCICEX cruises.

    b. The accuracy and early termination of the probe data should be examined more closely.

Appendix 3: Excerpts from the APLIS internet 'postcards' posted by Jeff Gossett

The submarines which participated in ICEX-09 were:

USS Helena (SSN 725), a Los Angeles ("first flight") class submarine, based in San Diego, CA and commanded by Cmdr. Daniel J. Brunk,

USS Annapolis (SSN 760), an improved Los Angeles class (688I) submarine, based in Groton, CT and commanded by Cmdr. Michael O. Brunner.

All XCTDs were deployed from USS Helena

March 19, 2009: Greetings from APLIS. USS Helena (SSN 725) arrived during the pre-dawn hours this morning. In order to get here from San Diego, Helena came through the Bering Strait. This involved a 900 nm transit through shallow water, all of it covered with ice, sometimes requiring almost constant maneuvers to avoid threatening ice. With really shallow water, even small ice keels can pose a hazard to the submarine. This is where the ice avoidance sonar I talked about yesterday is essential.

[On ICEX testing:] our highest priority test is evaluating the effectiveness of our torpedoes in an under-ice environment. In order to accomplish this, both submarines have been loaded out with several exercise torpedoes and they will take turns launching these at each other. The results will enable us to determine whether our torpedoes work in the Arctic sonar conditions and what we might do to improve them.

March 20, 2009: The pace of testing slowed down enough today for Helena to surface. Since Helena cannot break through as much ice as Annapolis, we needed to find thinner ice. This is where the variability of the Arctic tricked us. Because the ice in this area hasn't been moving for 4 days, all of the thin ice features have had a chance to thicken up. That's good for future Annapolis surfacings but bad for Helena surfacings. But we found a new lead that had opened up about 11 nm east of camp.

March 28, 2009: This is the last day of testing for Helena. She surfaced again to debark the people riding to support camp testing and embarked two additional ASL riders to assist with the southbound transit of the Bering Strait. They have been tremendous to work with - always right where they needed to be and anxious to get on with the next test. The fantastic crew of Helena are now headed home to San Diego with an Arctic experience of a lifetime.

March 29, 2009: This was the first time a First Flight 688 Class submarine operated at an ice camp. This venerable class, formerly limited to the fringes of the Arctic, has now, thanks to Helena, proven itself as a full-fledged Arctic warrior.

We had nine submarine surfacings – six by Annapolis, three by USS Helena (SSN 725).

Appendix 4. Excerpts from relevant emails from Tim Boyd to Jeff Gossett

1 June 2009

Hi Jeff,

Thanks for the XCTD data. I've attached a few figures that might be of interest

1. Two figures with XCTD temperature and salinity profiles, respectively, showing as you noted some variation in the depths of similar water mass properties. (I'm not sure at this point how much of this is oceanic and how much is instrumental.)
2. One figure that is a T-S diagram, showing the good correspondence of the T-S characteristics of the water mass features, including the shallow mixed layer segment at the freezing point (the magenta line is the freezing point curve).
3. One figure that is the CTD temperature profile over the full range of the profile, from the surface to about 230m depth, and another figure that focuses in on the region of 70 to 75 meters depth. In the full-range profile it appears that the file contains both an upcast and a downcast, however, in the close-up it appears that there is a lot of noise in the profile, possibly due to processing which binned both upcast and downcast together. Would it be possible for me to obtain the raw CTD data, together with the '.con' files to try to figure out where the CTD noise is coming from?

With respect to the two XCTDs that failed the pre-launch checks, I am wondering whether these were retained by ASL, and whether we can send them back to Sippican for analysis. In particular, I am wondering whether (in addition to the faults that prevented launching) these probes will have an indication of why all of the successfully launched probes terminated the data return so much earlier than their design depths.

In reading over reviewer's comments on the SCICEX science plan this past weekend, I noticed that Jamie Morison commented on his program's poor results using the Sippican interface for the TSK AXCTD (the air-launched version). I wonder whether some of the problems being experienced might be in the Sippican deck units.

2 June 2009

Hi Jeff,

Thanks again. Judging by the clustering of the XCTD data in the T-S plot I sent yesterday, I think the precision (i.e. repeatability) of the sensors is pretty good. It appears from the figures I have attached with this email, that the CTD cast was not taken through the same hunk of upper ocean as the XCTD casts. Note the excusion of the red dots (i.e. the CTD cast) in the profile of Temperature (at around 80m and >200m) and also the T-S figure. Presumably the USS Helena pulled some distance away from the APLIS camp prior to doing the profiles. Are there other CTD casts from the same general period that might (a) compare better, and (b) extend deeper, and which I might use to compare to the XCTDs for an estimate of their accuracy. It would be best to find a profile that extends as deep as the deepest XCTD (max depth 600m). If passing the data to me is feasible, I can do all the processing and searching, etc.

I notice that all of the XCTD profiles have depth coefficients of the form: depth = depcoef1 + depcoef2*time + depcoef3*time^2, where depcoef1 (the constant offset) = 0, and all profiles correspondingly begin with depth = 0 ft. The old, analog probes were designed to turn over at some prescribed depth > 0 m, and then begin profiling downward. Do you have any feel for whether these probes have really been designed to rise right up to the surface, or whether the coefficients used are just an accident? The coefficients are, incidentally, the same as I came across in a 1998 Journal of Oceanography (Japanese journal) paper on a CTD/XCTD comparison. Do you think this might have some bearing on (a) the failure rate, or (b) the reduced max depth of the profiles?

I will pursue this and a couple of other issues with Sippican. One other issue is that the program which generates the .EDF files truncates data (depth and conductivity) at a level that introduces errors into the salinity, if one tries to recompute properly by using pressure rather than depth. Would it be possible to obtain the original .RDF files so as to illustrate some of these problems directly to Sippican? Are there any other issues that you think need to be brought to Sippican's attention at this time? Perhaps with respect to ease of use of their interface, or their new launch proceedure?

Appendix 5: XCTD Specifications

Specifications for digital XCTD probe developed by Tsurimi Seiki (TSK) Co Ltd and marketed in the US by Lockheed Martin Sippican

Sensors	Conductivity	Temperature	Depth
Range	0 to 70 mS/cm	-2 to 35 °C	1000 m
Resolution	0.017 mS/cm	0.01 °C	17 cm
Accuracy	± 0.03 mS/cm	0.02 °C	2% (20 m at 1000 m)
Response Time	40 mSec	100 mSec	-