

## Documentation for G01360 Analog Subset

This addendum to the documentation for data set G01360, Submarine Upward Looking Sonar Ice Draft Profile Data and Statistics, was provided to NSIDC on 13 June 2006 by Mark Wensnahan, Polar Science Center, University of Washington. It describes a subset of the submarine upward looking sonar ice draft data (data set G01360) distributed by NSIDC. This subset is referred to as the analog subset, because (with the exception of one cruise) it was derived from traces on paper rolls.

Please see Citing These Data in the documentation for Submarine Upward Looking Sonar Ice Draft Profile Data and Statistics for how to cite the data set.

*(Begin documentation from M. Wensnahan)*

This data set consists of sea-ice draft data collected by U.S. Navy submarines in the Arctic Ocean using upward looking sonar. The data are broken up into individual cruises by year and secondarily by letter (e.g. 1984c is the third cruise from 1984). Each cruise consists of a series of two types of files: (a) ice draft profiles along the travel route and (b) statistics derived from the profile data.

The data presented here were processed by the Polar Science Center at the University of Washington. The data were derived by digitizing analog paper charts with the exception of the 1999 SCICEX cruise which was derived from digitally recorded data. The digitizing procedures for the analog data can be found in *Wensnahan and Rothrock (2005)* and *Rothrock and Wensnahan (2006)*.

In brief, processing of the paper charts requires the following steps:

- Scanning of the charts
- Transcription of logs of ships position, speed, and depth as a function of time
- Editing, calibration and digitizing of scanned charts
- Segmenting of digitized data based on course, speed, and depth
- Declassification of the data by the US Navy Arctic Submarine Lab (ASL)

Great care has been taken to process the analog data so that they are as equivalent to the digitally recorded data as possible (*Wensnahan and Rothrock, 2005*).

The data from 1999 SCICEX was processed under contract by Bronson Hills Associates, the same company that processed much of the digitally recorded draft data available from NSIDC from the U.S. Army's Cold Regions Research and Engineering Laboratory (CRREL). All of the documentation for the previously released digitally recorded data applies to the 1999 SCICEX data. The rest of this documentation will address only the analog data, for 1999 SCICEX please refer to [http://nsidc.org/data/docs/noaa/g01360\\_upward\\_looking\\_sonar/index.html](http://nsidc.org/data/docs/noaa/g01360_upward_looking_sonar/index.html).

The original data are classified information and contain accurate time and position stamps. The publicly-released data are unclassified. The SCICEX cruises are declassified with exact position and time information. All other data include position information accurate to within only 5 minutes of latitude and longitude and date information to within only 10 days. The U.S. data are also generally restricted to a region outside the Exclusive Economic Zones of other countries. Additionally, the ship name associated with a given cruise is often classified and is not available for many cruises this data set.



## Processing information

### Data file formats

The files are in ASCII text format. Both the profile data files and the statistics files contain header information giving the date, location and other details of each file (see below). The draft profiles consist of sequential pairs of numbers representing the distance along track and the ice draft. Statistics files corresponding to each draft file provide the normalized histogram, mean, mode, and standard deviation of the profile.

The length of the profiles can range widely from a few kilometers to hundreds of kilometers. In the case of profiles longer than 50km the files are also broken up into subsegments of 50km or less (e.g. 1982a-013\_-uwa.series is a profile of 67km and is broken up into 1982a-013a-uwa.series of 50km length and 1982a-013b-uwa.series of 17km length). For a given file the submarine was traveling at relatively constant speed (allowed variations of  $\pm 2$  knots and 34%), depth (to within 50ft), and course (to within a few degrees).

### File name conventions

The analog data use a different file naming convention than the digital data. The basic convention for profile data is

**yyyy-nnnz-uwa.series** or **yyyyx-nnnz-uwa.series**

and for the statistics files

**yyyy-nnnz-uwa.stats** or **yyyyx-nnnz-uwa.stats**

with

yyyy ... year of the cruise  
 x ..... letter designating cruise if more than one occurred in a given year  
 nnn ..... sequential numbering of data segment sorted by time  
 z..... an underscore "\_" designates a full segment when the boat was at a single course,  
           speed and depth or a letter designating a subsegment of a larger segment.  
 uwa ..... University of Washington analog data  
 rCC.....roll number (ex. r01) not all files have this

### File header information

The analog profile and statistics files contain the same file header information. As an example, the file "1975-000\_-uwa.series" has the following header

```

-----PROCESSING INFORMATION-----
  Organization: APL/UW
    Processor: Mark Wensnahan
  Processing Date: 06/16/05
    Cruise ID: 1975
    Roll Number: 36
      Segment: 1
    Subsegment:
    Ave Cutoff: 120
  Ave PxlCnt(6-9m): 114
    File Type: For release (contains approximate date and locations)
-----

-----DATE-----
      Year: 1975
      Month: May
  Third of Month: 1
-----

-----SEGMENT DESCRIPTION-----
  Beginning Latitude: 84.6
  Beginning Longitude: 6.2
    Ending Latitude: 84.5
    Ending Longitude: 6.7
    Number of Drafts: 6562
  Length of Track(km): 6.447
  Sample Length(km): 6.447
    Sonar Depth(m): 106
  Ave Boat Speed(kts): 17.0
-----
  
```

The header is broken up into three blocks of information

**Processing information:** This is information primarily of interest to us as the processors of the data but which may be relevant to others.

Organization: Applied Physics Lab at the University of Washington.  
 Processor: Person responsible for digitizing the data.  
 Processing Date: Date data was digitized  
 Cruise ID: Year of cruise  
 Roll Number: The analog data are recorded on sequentially numbered rolls  
 Segment: Sequential number indicating portion of analog roll  
 Subsegment: Letter designating subsegment of segment longer than 50km  
 Ave Cutoff: Threshold used to define data trace  
 Ave PxlCnt(6-9m): Ave number of pixels in the 6-9m range on the scanned image

File Type: Either classified or unclassified ("For release")

**Date:** The date the data were acquired. The data is reported only to within a third of a month (1=Days 1 to 10, 2=Days 11 to 20, 3=Days 21 to 31)

**Segment description:** This is information location and length of the data segment plus the submarine speed and depth. All locations are reported to within 0.1°.

Beginning Latitude: Latitude at the beginning of the segment  
Beginning Longitude: Longitude at the beginning of the segment  
Ending Latitude: Latitude at the end of the segment  
Ending Longitude: Longitude at the beginning of the segment  
Number of Drafts: Number draft records in the file  
Length of Track(km): Total distance from the beginning to end of the segment  
Sample Length(km): Distance over which data is available (due to data gaps)  
Sonar Depth(m): Average Depth of the sonar transducer  
Ave Boat Speed(kts): Average boat speed

### Ice Draft Files

After the header the data from "1975-000\_-uwa.series" looks like this:

```
Format: Distance Along Track(m), First Return(m)
!!! Begin !!!
0.000, 1.370
0.869, 1.370
1.738, 1.370
2.605, 1.400
3.475, 1.370
4.342, 1.340
5.209, 1.340
6.080, 1.340
6.947, 1.560
7.814, 1.590
8.684, 1.400
...
6444.924, 4.300
6445.789, 4.480
6446.660, 4.620
!!! End !!!
```

In general the analog data is spaced more widely than the digital data do to the inherent resolution of the paper record. Unlike the previously released digital data, the analog profiles are not interpolated. Instead the data contains the distance along track corresponding to each draft measurement.

Gaps of up to 10 minutes are allowed within the segment. The gaps are not recorded separately but simply show up as a larger than normal change in the along-track distance between two drafts.

### Ice Statistics Files

Basic statistics are provided for each profile regardless of sample length. As an example, the statistics data for the profile from "1975-000\_-uwa.series" is contained in "1975-000\_-uwa.stats". After the header the file looks like this:

```
----Normalized histogram of ice draft----
```

```

Bin Width (m): 0.10
Number of Bins: 300

Bin, Lower Bound, Fraction
!!! Begin !!!
0, 0.0, 0.0035
1, 0.1, 0.0035
2, 0.2, 0.0078
3, 0.3, 0.0143
4, 0.4, 0.0117
5, 0.5, 0.0069
6, 0.6, 0.0041
7, 0.7, 0.0020
8, 0.8, 0.0017
9, 0.9, 0.0050
10, 1.0, 0.0075
.....
294, 29.4, 0.0000
295, 29.5, 0.0000
296, 29.6, 0.0000
297, 29.7, 0.0000
298, 29.8, 0.0000
299, 29.9, 0.0000
!!! End !!!

-----
---GENERAL DRAFT STATISTICS---
Mean (m): 2.560
StdDev (m): 1.653
Mode (m): 1.550
-----

```

The basic statistics are a histogram of the profile drafts plus the mean, standard deviation, and the mode of the drafts. The histogram uses 10cm bins ranging from 0 to 30m. The values are normalized by the total number of counts in the histogram such that the sum of the fractions in the individual bins equals one. The mode is the mode of the histogram as given in the file. All bins are listed including bins with fractions equal to zero. All statistics use the entire draft profile including open water. The statistics file does not contain many of the ancillary statistics given in the digital data such as autocorrelation, keel spacing, etc.

**Summary of individual cruises**

Each cruise presents its own unique set of issues which will impact how the data were processed. Below we give a brief summary of issues encountered in the processing of each cruise. In general, the issues most often encountered are (1) the quality of the analog charts recording, (2) the ease of selection of open water (OW) used to calibrate the data, and (3) the presence of noise in the recording (often due to interference from other instruments on the ship). Wave action can impact the selection of OW but this is typically limited to portions of some cruises near the ice edge. It should be noted that the issues sighted below are not unique to the analog data. The released digital draft data have similar issues. For a thorough discussion of many these issues see *Rothrock and Wensnahan (2006)*.

**1975**

The analog data were good with a trace that was dark and generally clean. Much of the data was taken at a high paper feed rate resulting high resolution data. Data gaps are somewhat more

prevalent than in other cruises due to an odd occasional lack of data on the charts. Selection of OW was straightforward.

### **1976**

This was a cruise by ship USN Gurnard in support of AIDJEX. A small amount of this data of this data has previously been released by Scott Polar Research Institute. The previously released portions were derived from digital recorded data while the data released here were derived from analog charts.

Overall the analog data were a good clean set of charts that were easy to work with. Most of charts had dark to very dark traces with very little noise. There were long sections of data with the boat at the same speed and depth throughout. The data should be of high quality. Selection of OW was obvious on most of the charts.

### **1979**

Data consist of a good, clean set of charts with dark traces of uniform intensity. Occasional noise required some additional editing but should not affect the final data. Selection of OW was very difficult in first part of the cruise (segments 000 to 008) due to lack of easily identifiable OW. Thereafter, OW selection was relatively straightforward.

### **1981**

Data consist of a very clean set of charts with generally dark traces of uniform intensity. Selection of OW was fairly straightforward. Navigation data contained limited information on changes in speed or depth and no information on changes in course other than that inferred from the position data. Data were excluded where obvious speed or depth occurred as determined from the data trace. Data conservatively edited to exclude sections with potential, unmarked boat maneuvers.

### **1982a**

This was a good set of charts overall. First group of charts (segments 000 to 017) had the sonar gain turned up high resulting in charts with moderate amounts of noise that required additional editing. The second group of charts (segments 018 to 093) were generally clean with little noise. Selection of OW was fairly straightforward throughout the cruise. Some wave action (approximately  $\pm 25$ cm peak to peak) evident in the Beaufort Sea. Navigation data was somewhat sparse and data were edited conservatively to exclude sections with potential, unmarked boat maneuvers.

### **1983a**

The charts for this cruise were generally good with fairly dark traces and little to no noise. Selection of OW was generally clear and straightforward. Segments 027 to 033 have some wave action (approximately  $\pm 15$ cm peak to peak)

### **1984b**

The data consist of a very clean charts overall. Selection of OW was fairly straightforward though hampered by a lack of information on changes in boat speed or depth. Exclusions for changes in

speed and depth based conservatively on characteristics of the trace and operating characteristics of cruise. Additionally, some segments had large discrepancies in the along-track distance estimated from boat speed and from latitude and longitude. These segments, about 10% of the digitized profiles, have been excluded from the released data.

### **1984c**

The charts are clean overall with a trace that is sometimes dark, but more often on the lighter side. A number of segments of charts were rejected as too faint to be digitized. Selection of OW was fairly straightforward though most OW sections were short and not always obvious.

The vertical scale of the charts varied during the cruise. Rather than the standard scale from 0-100ft, the early charts were 0-100 fathoms. These data were deemed unusable. Segments 000-023 of the released data primarily used a scale of 0-200ft with occasional sections of 0-100ft. Comparisons indicate that the 0-200ft data has means equivalent to the 0-100ft data and so were kept.

### **1984d**

The charts for this cruise were generally free of noise. However they have generally lighter traces which are inconsistent, with many charts having constantly changing intensities. Thresholds were set to attempt to compensate for this. The OW calibration was straightforward for most charts though some charts show small variations not related to changes in ship speed or depth.

The major issue for this cruise is that no position data was available for segments 033 to 077. The position were interpolated across this section using known ships speeds. This was deemed acceptable based on a number of confirming pieces of evidence. First, a hand drawn map made shortly after the cruise indicates that the ship took essentially a straight line route from the Beaufort Sea to the Pole during this time. Second, this cruise was done in conjunction with 1984c which made a similar traverse to the Pole at the same time. Third, the distance traveled over this leg was calculated from known ships speeds and found to agree well the distance between known positions. We expect that the position are accurate to within approximately 50km for this leg.

### **1987c**

The data consisted of a set of good and very clean set of charts with dark and fairly uniform traces. Selection of OW was generally straightforward. Data should be of high quality.

### **1988c**

This was a clean set of charts, with dark to very dark traces. A few charts have fainter trace. The OW calibration is consistent across some charts, and varies fairly widely across others.

There was a major problem with changes on depth scale for one portion of the cruise with the scale changing between 0-100ft and 0-200ft but no notations to indicate when the scale changes. As a result, large segments of data were rejected as unusable and not released. The released segments all used a consistent 0-100ft scale throughout.

### 1990c

The charts for this cruise are somewhat problematic. The trace intensity varies widely. Many otherwise good data sections had very faint traces and were rejected. Some of the charts are very noisy and needed heavy editing. Some segments were rejected since it was difficult to determine what was noise and what was data.

Most of charts are at 0-200 ft scale with some sections at 0-100 ft scale. The changes in scale were well marked and the final data is a mix of the two scales. Selection of OW was somewhat more difficult in the 0-200ft sections.

### 1993c

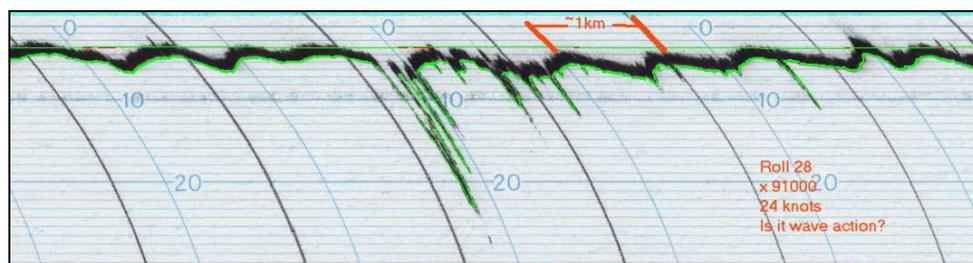
The charts for this cruise are of generally good quality. There is some background noise but the trace is generally dark and easy to pick out. Apparent swells occurs in the OW features in the beginning (segments 000 to 005) and end (segments 030 to 039) portions of the cruise. The problem is not pronounced for 000-005 but is approximately  $\pm 20\text{cm}$  peak to peak for segments 030-039. It seems especially prevalent when the ship is at 575ft and 20kts.

### 1994b

The charts are mostly clean with occasional sections of faint trace. The OW calibration varied without changes in speed and depth. There are indications of wave action for segments 006 to 011.

### 2000a

The charts were clean with a generally dark trace. The OW calibration mostly consistent and straightforward across charts. However, there are indication of swell even far into the ice pack apparently due to the remnants Hurricane Michael in the North Atlantic (see figure below). There is some evidence of dampening in thicker ice areas. The swell is largest in the area just after the pass through the pole over on the Kara/Laptev sides. As usual the OW offset was set to the middle of the swell. However, it was decided that the draft time series for this cruise would include negative drafts to show the swell. The result is that the mean draft should be unbiased but the standard deviation, histogram, and mode will be affected.



*(End documentation from M. Wensnahan)*