MOORED INSTRUMENT AND CTD OBSERVATIONS FROM BARROW STRAIT, 2008-2009

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Les rapports statistiques servent de véhicule pour la compilation et la diffusion des données sous une forme directement utilisable par les scientifiques et les ingénieurs. En général, les rapports contiennent des données brutes ou analysées mais ne fournissent pas d'interprétations des données. Ces compilations sont préparées le plus souvent à l'appui de travaux reliés aux programmes et intérêts des secteurs des Océans et des Sciences de Pêches et Océans Canada.

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Les établissements de l'ancien secteur des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports en décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du rapport numéro 1 en janvier 1982.

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by

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Abstract

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Instrumented moorings deployed in the eastern end of Barrow Strait from August 2008 to August 2009 provide yearlong records of current, temperature, salinity and ice drift extending a data time series started in August of 1998. The presented current and ice drift data have been collected with acoustic Doppler current profilers (ADCPs) and specialised instrumentation for near-pole direction measurement. Yearlong records of temperature, salinity and density for fixed depths from moored CTDs are also presented, as well as two months of daily upper ocean profiles of temperature, salinity, fluorescence and dissolved oxygen collected with the Icycler moored profiler. The current and CTD data are presented as filtered and unfiltered time series, spectral and tidal analyses products, and in statistical summaries. Also presented are temperature, salinity and density cross-sections of eastern Barrow Strait based on 17 ship-based CTD stations that have been regularly sampled each year since the start of the program.

Résumé

Pettipas, R. et J. Hamilton. 2013. Moored instrument and CTD observations from Barrow Strait, 2008-2009. Rapp. stat. can. hydrogr. sci. océan. 191: viii + 96 p.

Les amarrages équipés installés à l'extrémité est du détroit de Barrows d'août 2008 à août 2009 ont fourni des enregistrements tout au long de l'année du courant, de la température, de la salinité et de la dérive des glaces, prolongeant ainsi une série chronologique de données qui a commencé en août 1998. Les données présentées sur le courant et la dérive des glaces ont été recueillies à l'aide de profileurs de courant à effet Doppler (ADCP) et d'instruments spécialisés pour la mesure de la direction à proximité des pôles. Les enregistrements tout au long de l'année de la température, de la salinité et de la densité pour les profondeurs fixes effectués par les profileurs de STD amarrés, ainsi que les profils quotidiens en couche supérieure des océans de la température, de la salinité, de la fluorescence et de l'oxygène dissous recueillis pendant deux mois par le

profileur amarré Icycler, sont également présentés. Les données sur le courant et les données de STD sont présentées sous la forme de séries chronologiques filtrées et non filtrées, de produits d'analyse spectrale et d'analyse de la marée, et de résumés statistiques. Les profils en travers de température, de salinité et de densité de l'est du détroit de Barrows sont également présentés et sont basés sur 17 stations de profils de STD à bord de navires qui ont été régulièrement échantillonnées tous les ans depuis le début du programme.

Introduction

A field program to quantify and examine the inter-annual variability of the exchange through Barrow Strait (a principal pathway between the Arctic and North Atlantic Oceans), was started by BIO investigators in August of 1998. Data from the first 10 years of this study, along with a description of the methods used, have previously been reported [Pettipas and Hamilton, 2013a, 2013b, Pettipas et al., 2010, 2008, 2006, 2005; Hamilton et al., 2008, 2004, 2003, 2002]. Described here are moored instrument data from the eleventh year of the study.

Yearlong records of temperature, salinity and density information derived from moored Microcat CTD data are presented as unfiltered and low-pass filtered time series, and also as power spectra. Current rate and direction (from ADCPs and custom pole compasses) are presented as progressive vector plots, unfiltered and low-pass filtered contour plots, and as time series plots for depths corresponding to the moored CTDs. Seasonally averaged statistical summaries for both the CTD and current data are provided as graphs and in tabular form. Results of tidal analyses of the current data give tidal amplitudes, phase, and ellipse orientation as a function of depth for each of the 5 main tidal constituents (K1, M2, O1, S2, P1). Separate tidal analyses have been done for periods of immobile, solid ice cover and periods of open water.

Ice drift velocity, obtained from the acoustic Doppler current profilers (ADCPs), are presented as yearlong time series. Two months (August, September) of daily profiles of temperature, salinity, fluorescence and dissolved oxygen over the top 40 m of the water column are also presented. These data were collected with the moored profiler Icycler, described in Fowler et al. [2004]. Two complete yearlong Icycler records have previously been collected on the South side of Barrow Strait, one in 2007-2008 [Pettipas and Hamilton, 2013b] and one in 2003-2004 [Hamilton et al., 2008]. In 2008-2009 the sensor float was lost in early October, so only 2 months of data are reported here.

Mooring Locations and Description

Five instrumented moorings were distributed at 2 sites (South and South-Central) on the southern side of Barrow Strait (Figure 1) to provide the data required for extending the volume, freshwater and heat transport time series started in 1998. ADCPs manufactured by Teledyne RD Instruments and precision heading references (Watson Industries, Inc.) were mounted in streamlined buoyancy packages to provide current rate and direction information. The technique used to obtain reliable direction measurements here, where conventional compass technology is inadequate due to the proximity of the site to the magnetic pole, is described in detail by Hamilton [2004, 2001]. The upward looking ADCPs logged average speeds from 100 pings over a 5 minute on-period every 2 hours, and also provided a simultaneous ice drift speed throughout the yearlong deployments. 307 kHz Workhorse Sentinel ADCPs (WHADCPs) were used at both the South and South-Central sites, providing currents over the 10 to 70 m depth interval. At the South-Central site a 150 kHz Quartermaster ADCP (QMADCP) was also used, to measure currents over almost the entire water column (from 20 m to 235 m depth). Concurrent direction measurements were logged separately with the precision heading reference systems, and have been merged with the ADCP speed data for presentation here. All 3 ADCP/compass systems were successfully recovered with full data sets. SeaBird Microcat CTDs were used to measure temperature, conductivity and pressure every 30 minutes at targeted depths of 40, 80 and 150 m at both sites, as well as one near-bottom at the South-Central site, and one just under the Icycler profiler at the South site. All of these CTDs provided complete data sets.

One of the moorings at the South site supported a *Pro-Oceanus* pCO_2 sensor that failed to work, and an *EnviroTech Microlabs* water sampler which drew and stored a 150 ml sample every 24 days from its deployment depth of 36 m. This was the second consecutive year water samples were collected in this fashion. On recovery, samples were preserved for later analyses that included processing for oxygen isotopes used for water mass identification. These results are not reported here. There was also a plan to moor an Ice Profiling Sonar (IPS) at the South-Central site, but the instrument failed to turn on so the mooring was not deployed.

A sixth mooring was deployed in waters of 270 m depth off the northern side of the Strait for ArcticNet colleagues, replacing a mooring we deployed for them the previous year. It was instrumented with an ice profiling sonar, an *Aural* hydrophone, and a CTD (45 m depth), but did not support a sediment trap in 2008-2009 as it did the previous year. Only the CTD data from this ArcticNet mooring are presented in this report. An illustration of the 6 moorings is shown in Figure 2.

A summary of the 2008-2009 moorings and instrumentation, including mooring positions, instrument depths and acquired data records, is presented in Table 1.

Data Processing

Current Speed and Direction Data

The 307 kHz Workhorse ADCPs (WHADCPs) were mounted in streamlined buoyancy packages (A2 "SUBs" manufactured by Open Seas Inc.) and set up to measure current relative to the instrument axes, ignoring their own compass information. These instruments were set up to average over a depth interval of 4 m. Current data above 12 m were rejected based on RDI's standard echo intensity quality criterion. These acoustic Doppler current profilers also record ice drift velocity when there is 100% or near-100% ice cover. A 307 kHz WHADCP was moored at 74 m depth at both the South and South-Central sites to provide currents over the upper water column. At the South-Central site where the bottom depth is 274 m, the 150 kHz Quartermaster ADCP (QMADCP) moored near bottom (249 m) provided near full water column coverage, overlapping the range of the 307 kHz unit in the top 70 m.

Direction was provided using an independent compass package mounted in the buoyancy package tail to give the orientation of the ADCP relative to magnetic north. Initiation of a compass sample cycle was triggered by the commencement of the bihourly ADCP measurement by making use of Teledyne RDI's "RDS3 interface" to provide a turn-on pulse to the compass. The compass was programmed to take a 10 s sample in the middle of the 5 minute ADCP sampling interval. This conserved compass battery power, and took advantage of previous experience that current direction does not change

significantly over 5 minutes at the study location [Hamilton et al., 2003]. Direction records were then adjusted for the variation in magnetic declination using magnetic observatory data from the NRCAN observatory in Resolute to get direction relative to true north.

Vertical excursions of the WHADCPs caused by current drag forces acting on the mooring were typically small, exceeding 3 m only 0.7% of the time at both sites.

Moored CTD Data

SeaBird Microcat CTDs were set up to measure temperature, conductivity and pressure every 30 minutes for the yearlong deployments. Instrument dips due to current drag forces acting on the moorings were small. Maximum dips of the 40 m CTDs were 3 m for the South site mooring and 8 m for the South-Central and ArcticNet moorings.

Low-Pass Filtering

Some of the data series presented have been filtered to remove the semidiurnal and diurnal tides using the technique described by Godin (1972). The technique uses three simple averaging filters applied in sequence. Godin, working with hourly observations, recommends two consecutive applications of a filter that averages over 24 samples, followed by one that averages over 25 samples. Here for the bi-hourly current data, we sequentially apply 12,12, and 13 sample averaging filters, while for the semi-hourly Microcat CTD data we sequentially apply 48, 48 and 50 sample averaging filters.

Tidal Analysis

Harmonic tidal analyses of current data using Foreman's (1978) method are presented separately for the period of broken or no ice cover, and the period of immobile, consolidated ice. At the South site the open water period was Aug 4 to Oct 1, 2008 (8 weeks) while the consolidated, landfast ice period was Jan 11 to March 29, 2009 (11 weeks, which is less than half the length of what it was in the previous year). At the

South-Central site, the open water period was very similar (Aug 3 to Oct 6), but the period of landfast ice was too short to allow for tidal analysis. Tidal ellipse axes amplitudes, orientations and phases for the main tidal constituents (K1, M2, O1, P1 and S2) are plotted as a function of depth.

The periodic vector function describing a particular constituent, traces an ellipse over a tidal cycle with major and minor amplitudes defined by the length of the semi-major and semi-minor axes. The major axis amplitude is always positive. The sign of the minor axis amplitude defines the rotation sense of the current ellipse. When positive the vector traces the ellipse in a counter-clockwise direction; when negative, the rotation sense is clockwise. Ellipse orientation is the angle measured counter-clockwise from east to the semi-major axis. The phase is a measure of the timing of high water referenced to astronomic positions over the Greenwich meridian. Phase is measured counter-clockwise from this chosen reference.

Data Presentation

Yearlong time series of half-hourly sampled temperature, salinity and density from the moored CTDs are shown in Figures 3- 5. There is only weak late summer freshening at the 40 m level compared to what was typically seen in previous years. The most notable is freshening of about 1 psu over a 2 week period at the end of September at the 37 m level of the South site. Here too the water is about 0.5 psu fresher than the annual mean from mid-October to early January. Power spectra of the moored CTD measurements are shown in Figures 6 - 8. Diurnal and weaker semi-diurnal signals are observed in the South and South-Central records whereas at the ArcticNet site, most of the energy is in the semi-diurnal band.

Yearlong progressive vector diagrams for each ADCP are shown in Figures 9-11. An eastward along-strait flow predominates in the upper water column at both the South (Fig 9) and South-Central (Fig 11) sites, although the flow at the South-Central site is rotated 25° counter clockwise from the direction of the mean flow at the South site which is along strait (105°). The QMADCP indicates a strong northward component in the lower water column (Fig 10) as observed in previous years.

A month of bihourly current data are presented as along-strait and cross-strait components for each ADCP in Figures 12-14, where positive values are defined as flow towards 105° true and 15° true, respectively. These figures reveal the strong tidal nature of the flow. Yearlong records of low-pass filtered data (tides removed) for the 3 instruments are shown in Figures 15-17. Mean flow in the upper water column is predominantly eastward at both sites as in previous years.

The two month long records of salinity, temperature, fluorescence and dissolved oxygen from the moored profiler, Icycler before the sensor float was lost, are shown in Figure 18. The water in the top 20 m at the Southern site in August – September was about 2 psu fresher than at the 40 m level, which is slightly less near-surface freshening than observed in the previous year, and this fresher layer was only half as thick as observed with Icycler in 2003-2004 [Hamilton et al., 2008].

Fluorescence was measured with a pumped WetLabs WS3S fluorometer integrated with the pumped SBE-19plus CTD system on the Icycler sensor float. As in 2007-2008, periods of high fluorescence persist into the early fall, with highest values between 10 and 30m, and only low values near the surface. Values ≥ 14 mg/m^3 are shown as dark red. Also shown in Figure 18 are Icycler data from a pumped Sea-Bird SBE43 dissolved oxygen sensor. Higher dissolved oxygen concentrations in the upper 40 m appear to be concurrent with elevated fluorescence. No in situ oxygen sampling to calibrate and verify these Icycler dissolved oxygen measurements was done.

Smoothed temperature, salinity and current data (where available) are shown for each moored CTD level in Figures 19-27. Tables 2 through 19 provide a summary of the CTD and ADCP data at the CTD depths, with statistics computed over each season, and for the entire year. For the South-Central site, WHADCP data are reported in the tables for the 36m level, while QMADCP data are reported for the deeper levels (74, 154 and 234 m). Density has been included in these statistical summaries.

Annual and seasonal mean flows are summarised in Figures 28-33. Each 4 m binned value for the WHADCPs (8 m for the QMADCP) is shown except for WHADCP data from the bins centered at 36 and 40 m depth at the South site and 40 m depth at the South-Central site, which were not reported because of acoustic contamination at this

level created by the buoyancy package at the top of the mooring. Annual and seasonal along-strait mean currents at both the South and South-Central sites return to more typical values after the very low flows of 2007-2008. Significant cross-strait currents at the South-Central site are evident as usual, but there isn't the strong seasonality in the strength of this northward component as there was in 2007-2008 when the mean currents were weaker. The variance in the bi-hourly, and low-pass filtered current data for the yearlong ADCP records are shown in Figure 34. The results demonstrate that tides account for a larger portion of the variance in the along-strait current speeds at the South-Central site than at the South site.

Tidal analysis results for each of the 3 ADCP data sets are presented as profiles for the 5 largest tidal constituents in figures 35 – 49. Separate analyses have been done for open water and immobile ice-covered periods at the South site but only for the open water period at the South-Central site because there was no significant period of immobile ice there. Ellipse orientations are along-strait as expected. Tidal constants are summarised in Tables 20 – 24.

Ice velocities through the year at both sites were derived from the WHADCPs (Figures 50 and 51). Sections in the record when there are no data indicate periods of open water, or partial ice cover as determined by applying the manufacturer's suggested data quality standards to the ice velocity data. In addition, the ice drift velocity estimate and the adjacent estimates were rejected when the magnitude of the "error velocity" for a particular ensemble was greater than 1 cm/s. Although ice was immobile for close to 3 months at the South site, it never stop moving at the South-Central site.

Finally, a station map for the August 2009 ship-based CTD survey is shown in Figure 52. Contour plots showing the results of a 17 station cross-section across the eastern end of the strait at the longitude of the moorings is shown in Figure 53. The results indicate an eastward geostrophic flow along the southern half of Barrow Strait and a weaker westward flow confined near the coast in the upper 100 m on the North side. A line of 7 CTD stations was also completed off Gascoyne Inlet (G1-G7). A statistical summary of CTD data from all stations from both of these lines is presented in Table 25.

Acknowledgements

We thank Ingrid Peterson and Kumiko Azetsu-Scott for their reviews of this report.

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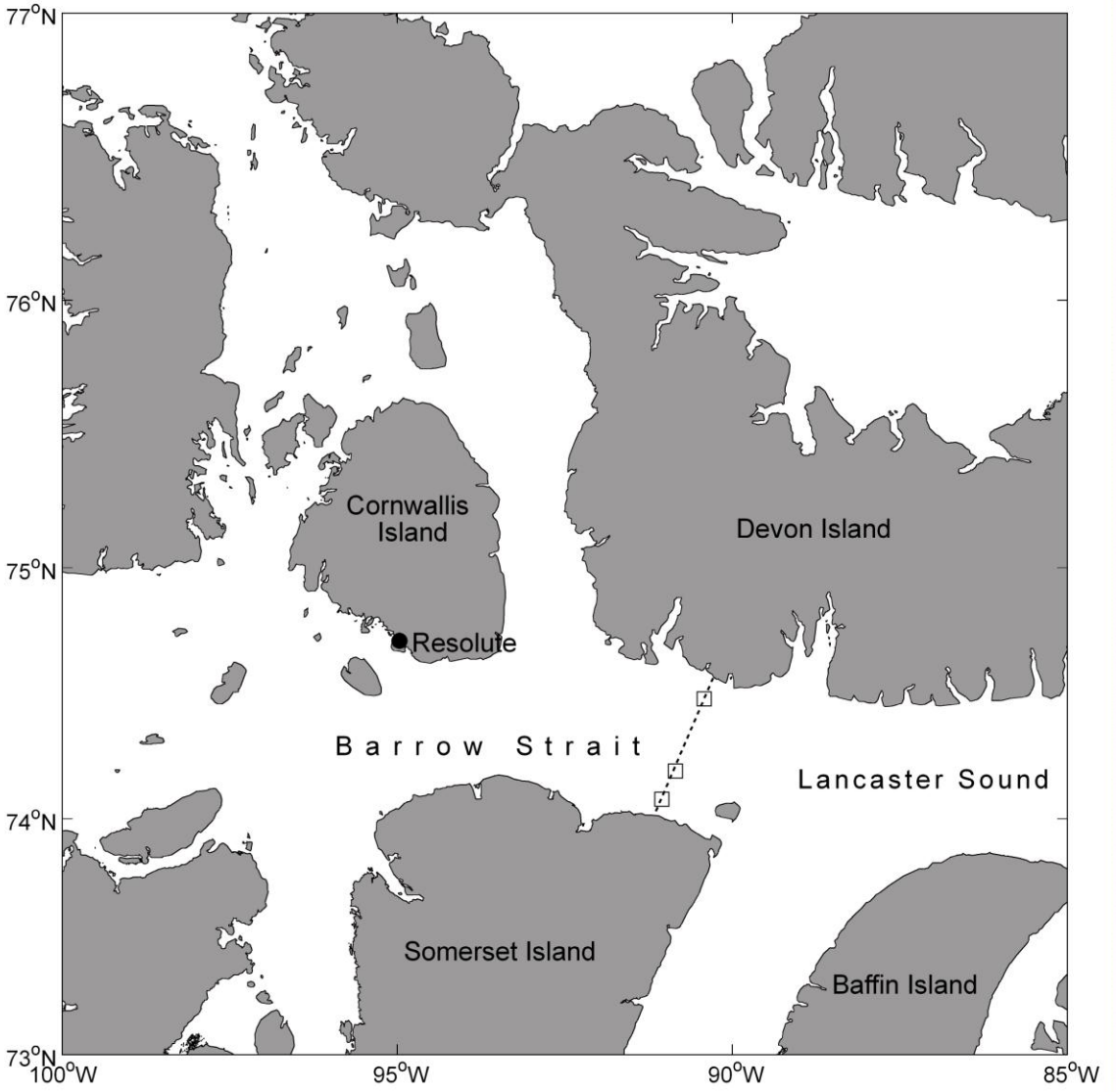
Pettipas, R., J. Hamilton and S. Prinsenberg. 2005. Moored current meter and CTD observations from Barrow Strait, 2001-2002. Can. Data Rep. Hydrogr. Ocean Sci. 166 : v + 118 p.

Figure 1: A map of the work area showing the location of the mooring sites. Moving from South to North, the open boxes represent the South (3 moorings), South-Central (2 moorings) and ArcticNet (1 mooring) sites. The dashed line represents the hydrographic survey line.



<u>Figure 2</u>: Illustration of the instrumented moorings.

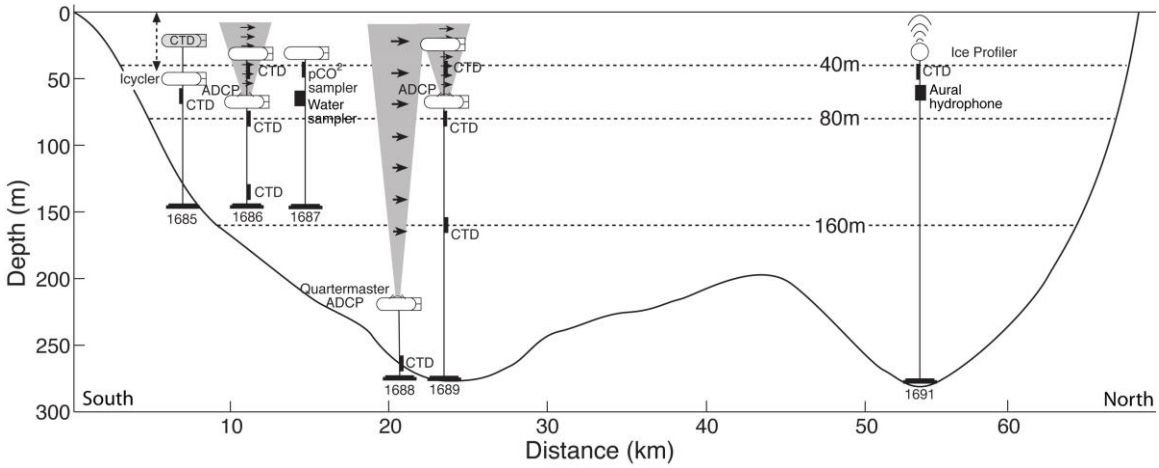


Figure 3: Moored 30 min. CTD data, South Side Barrow Strait. August 2008 – August 2009

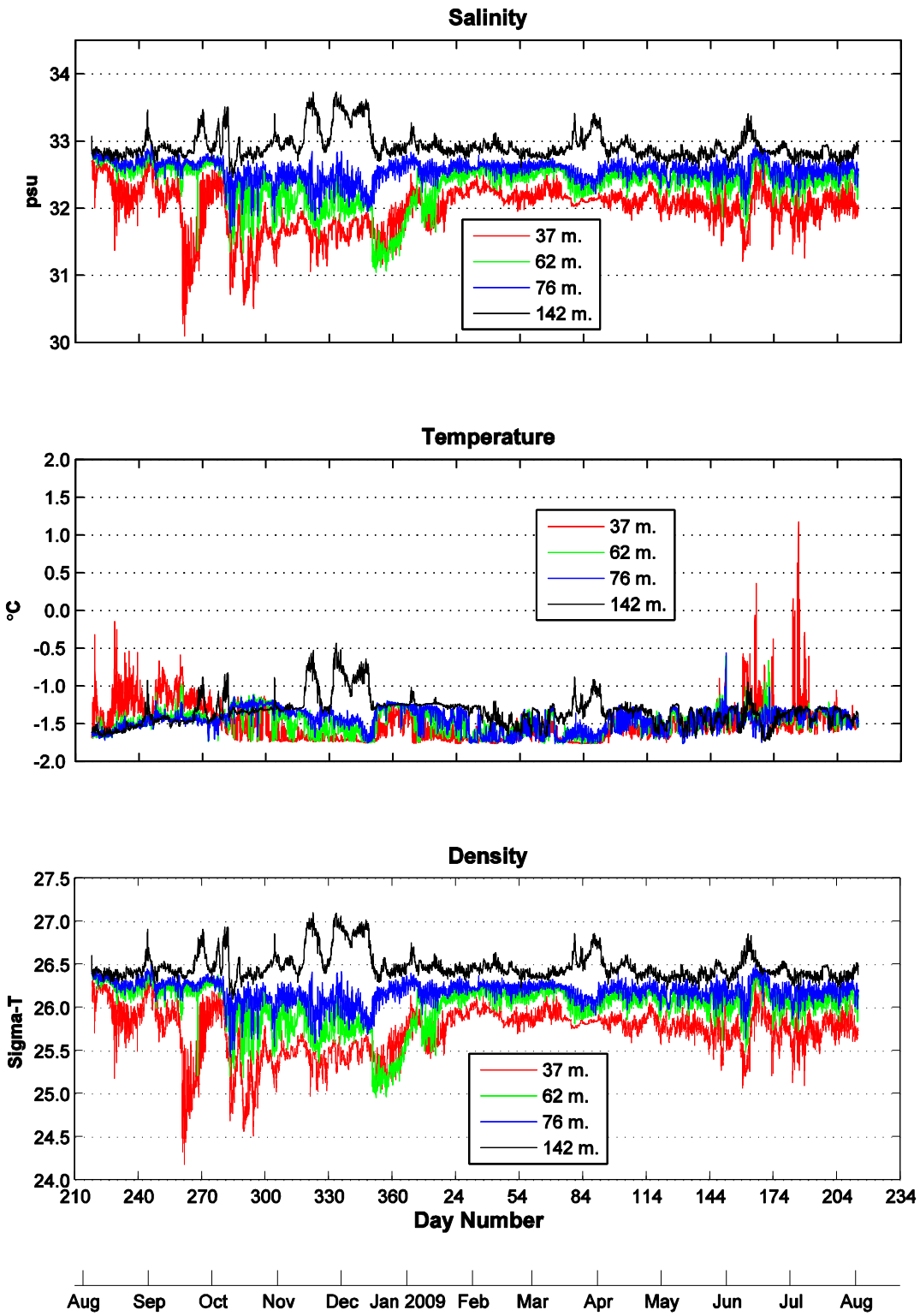


Figure 4: Moored 30 min. CTD data, South-Central Barrow Strait. August 2008 – August 2009

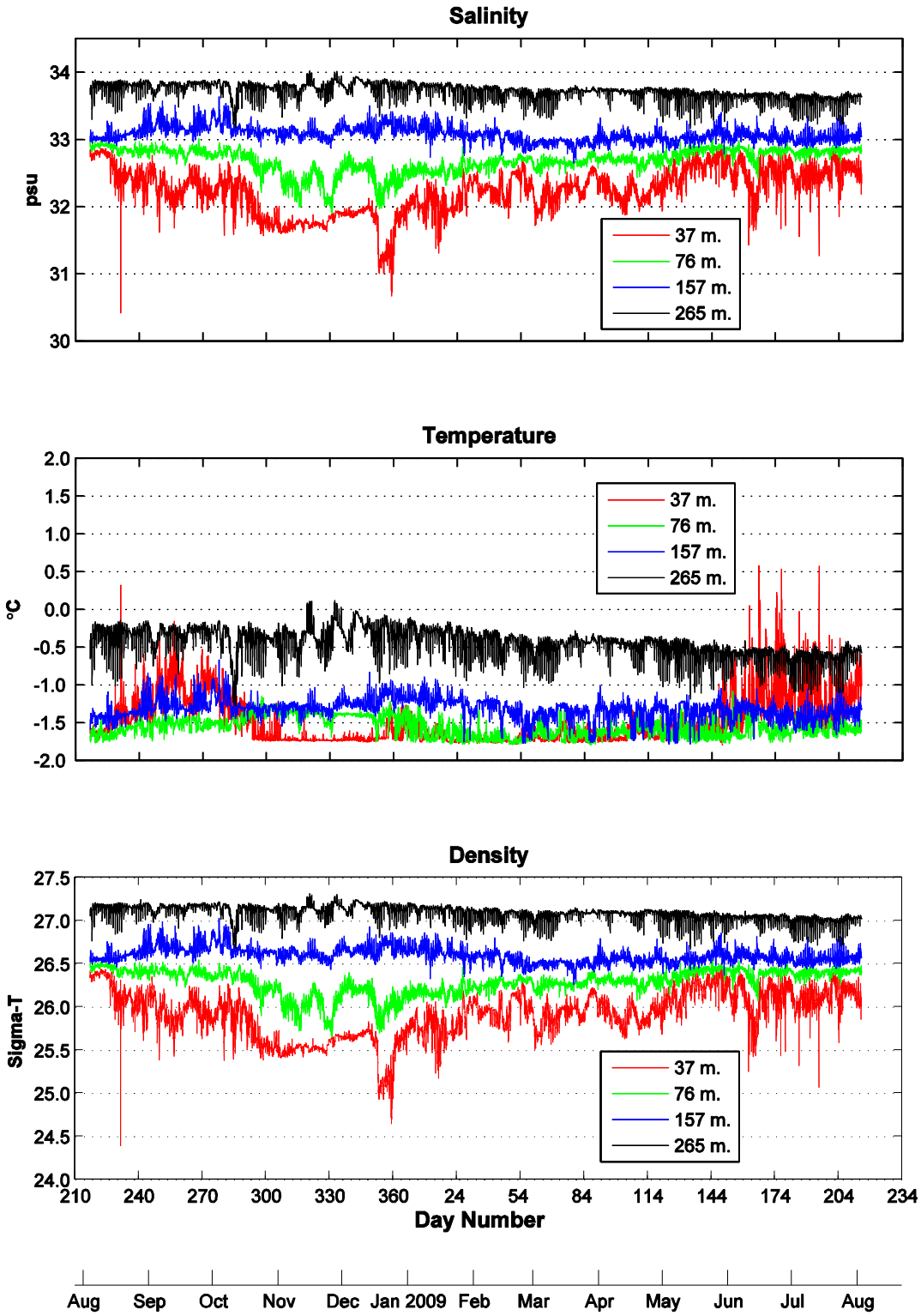


Figure 5: Moored 30 min. CTD data, ArcticNet Mooring. August 2008 – August 2009

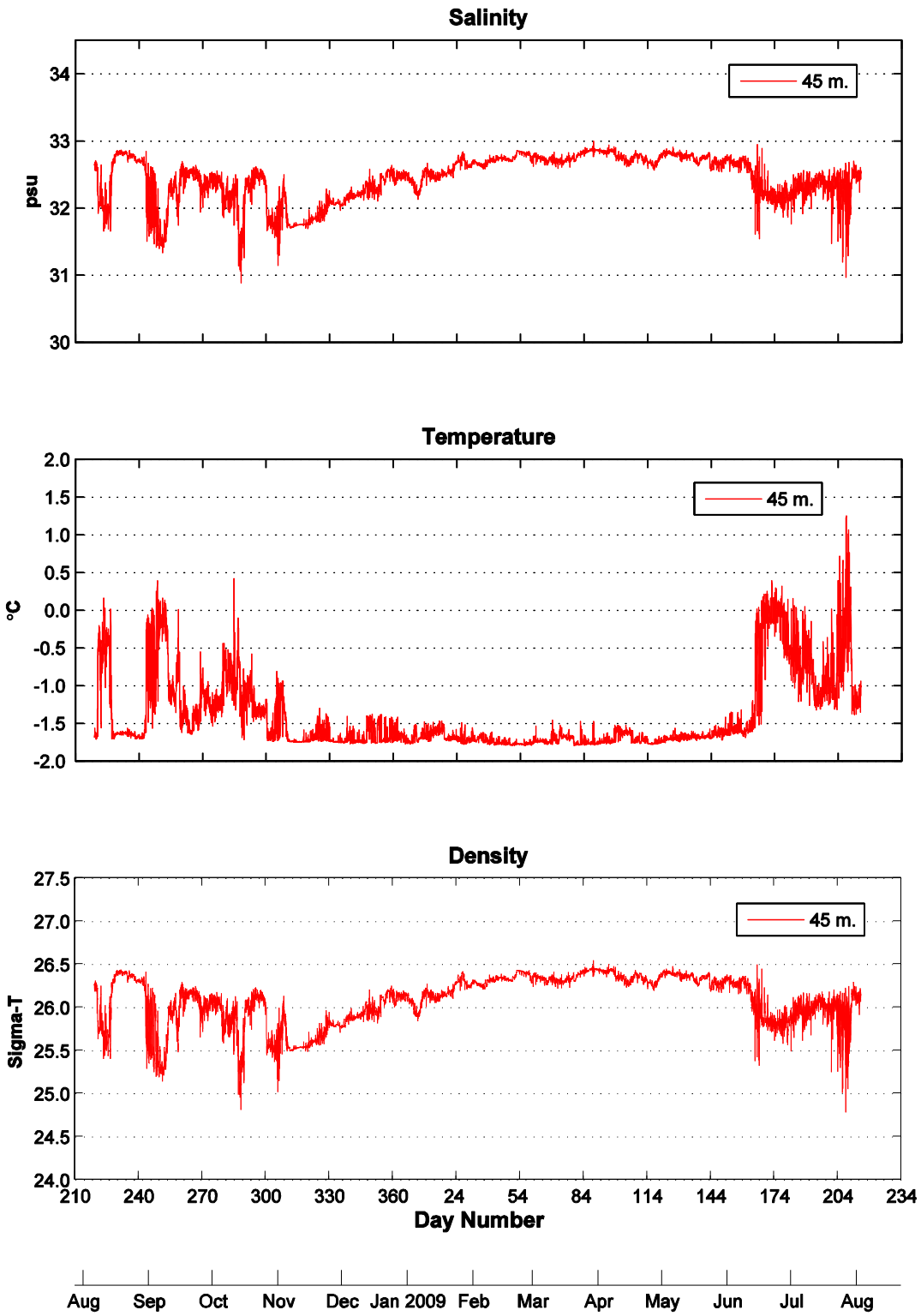


Figure 6: Power Spectra of moored bi-hourly CTD data. South Side Barrow Strait: Aug. 2008 – Aug. 2009.

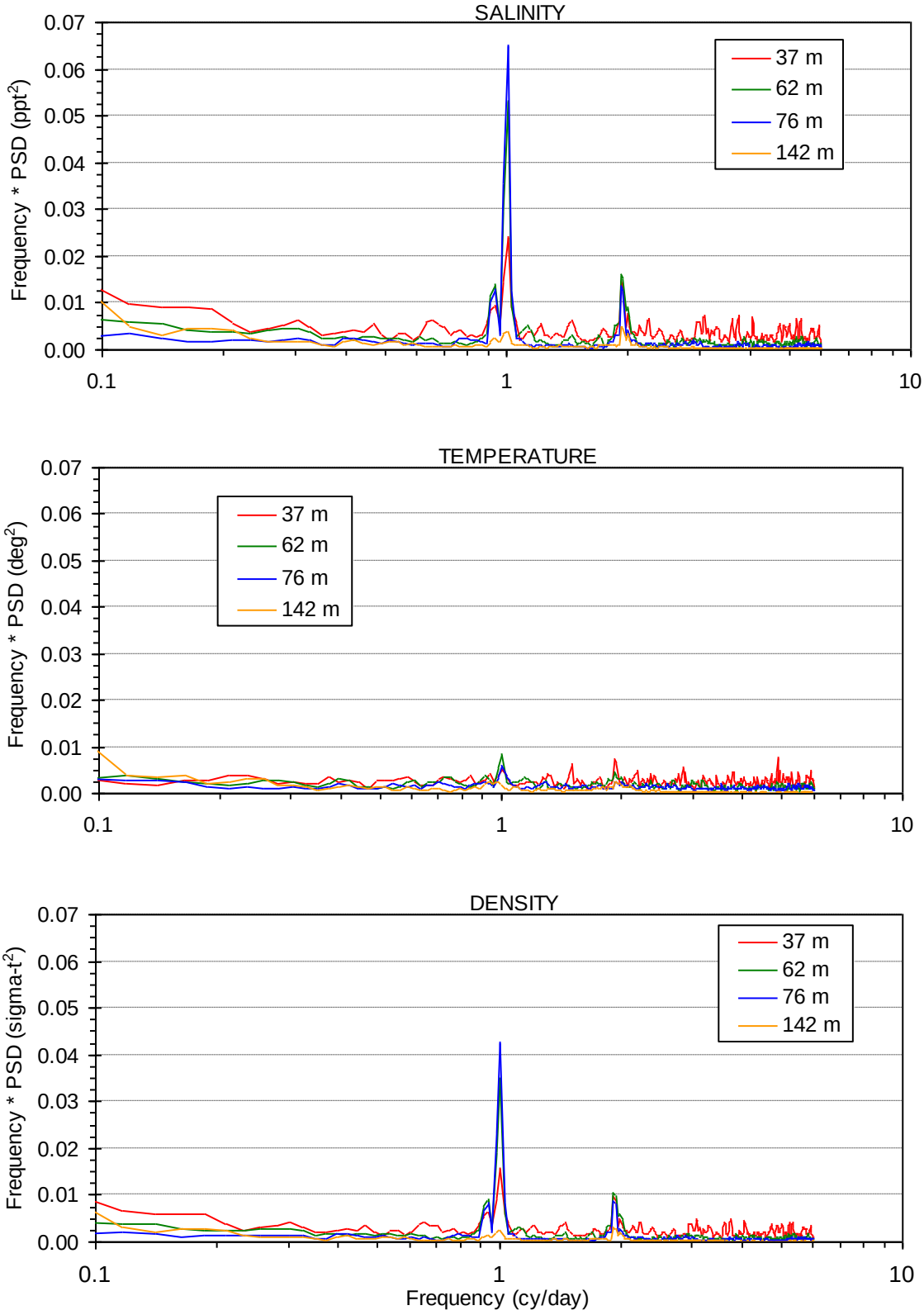


Figure 7: Power Spectra of moored bi-hourly CTD data. South-Central Barrow Strait: Aug. 2008 – Aug. 2009.

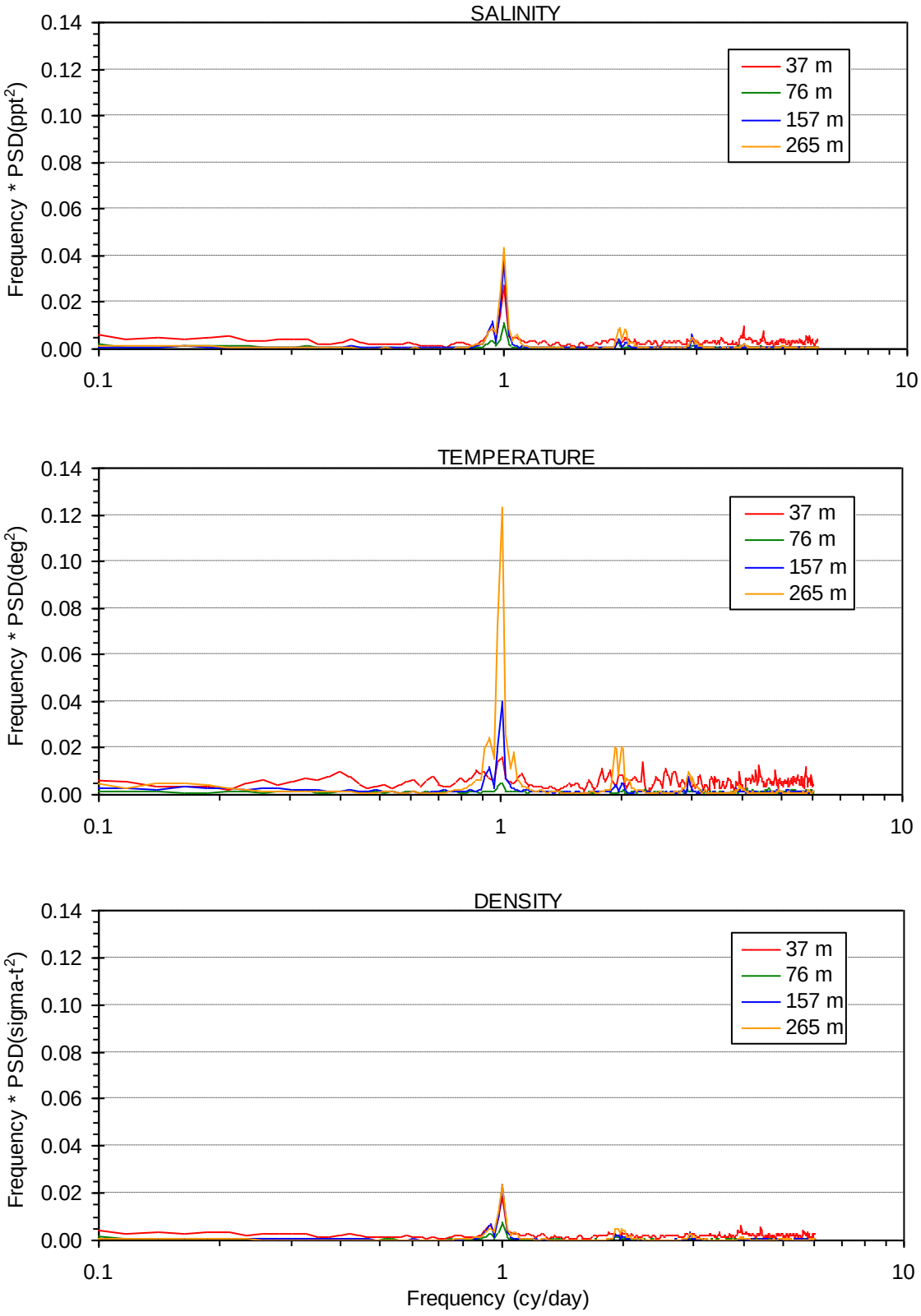


Figure 8: Power Spectra of moored bi-hourly CTD data. ArcticNet Mooring: Aug. 2008 – Aug. 2009.

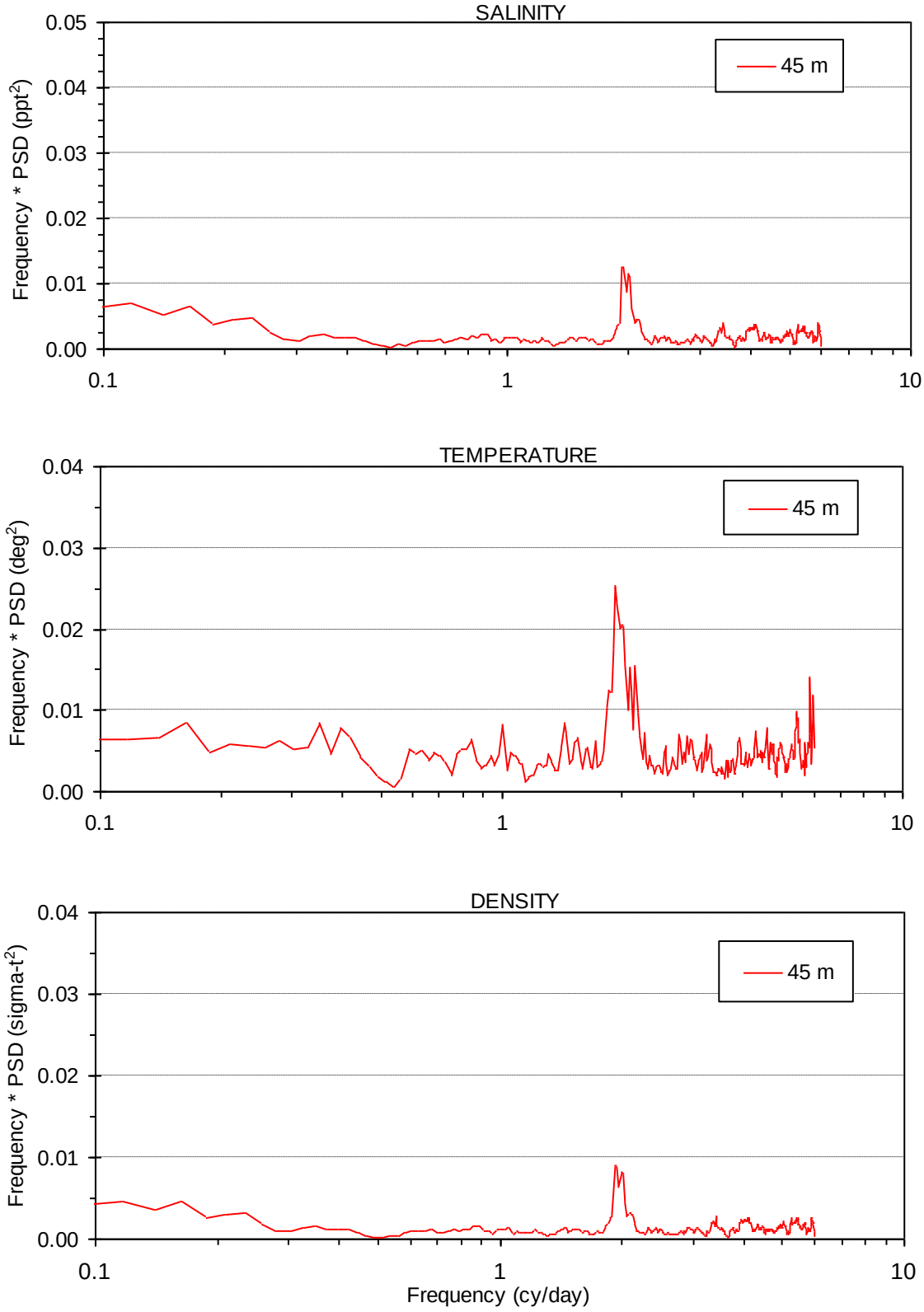


Figure 9: Progressive Vector Diagram, South Side Barrow Strait.
Aug. 4, 2008 – Aug. 1, 2009

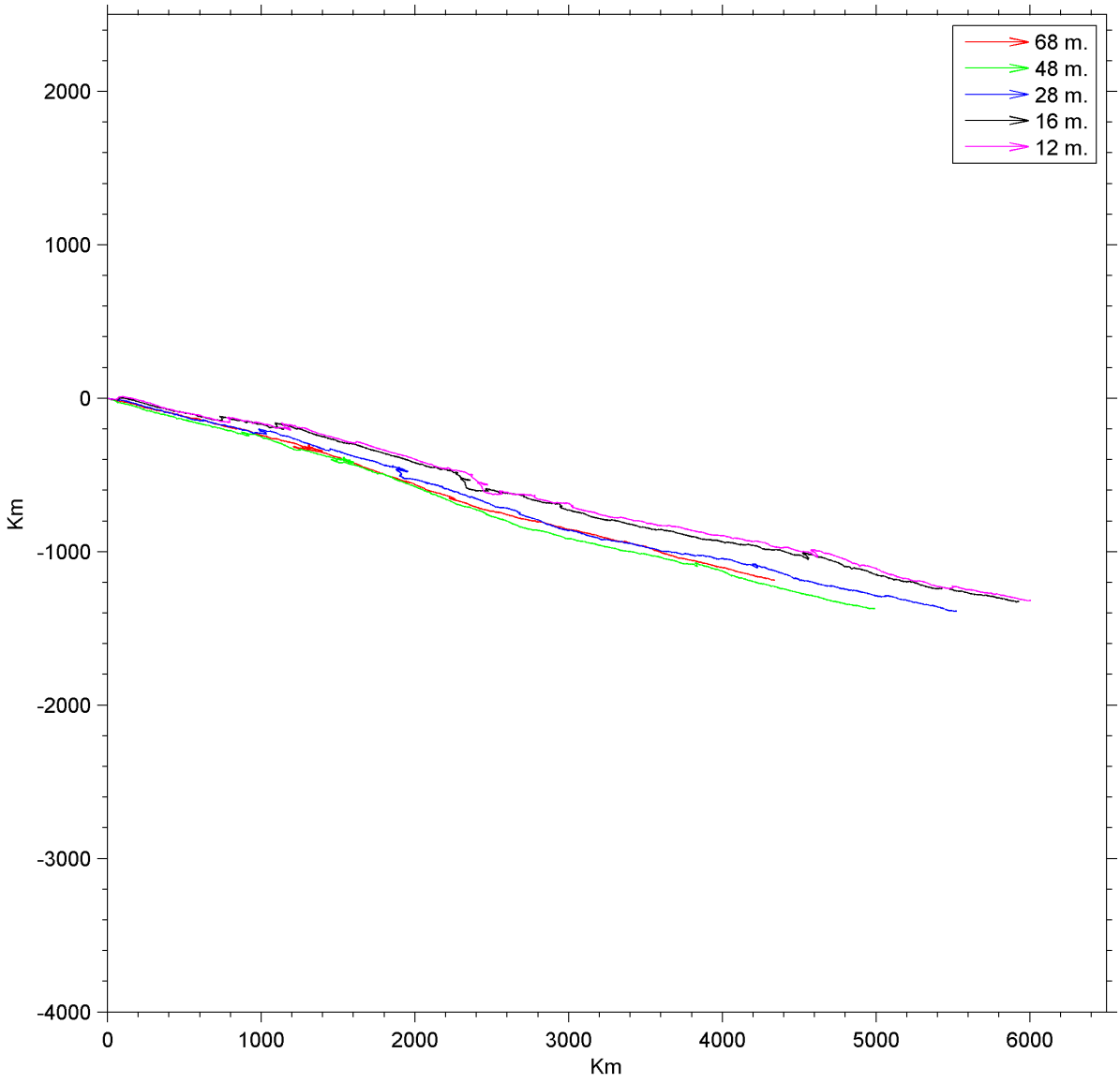


Figure 10: **Progressive Vector Diagram, South-Central Barrow Strait. (Quarter Master ADCP) Aug. 3, 2008 – Aug. 2, 2009**

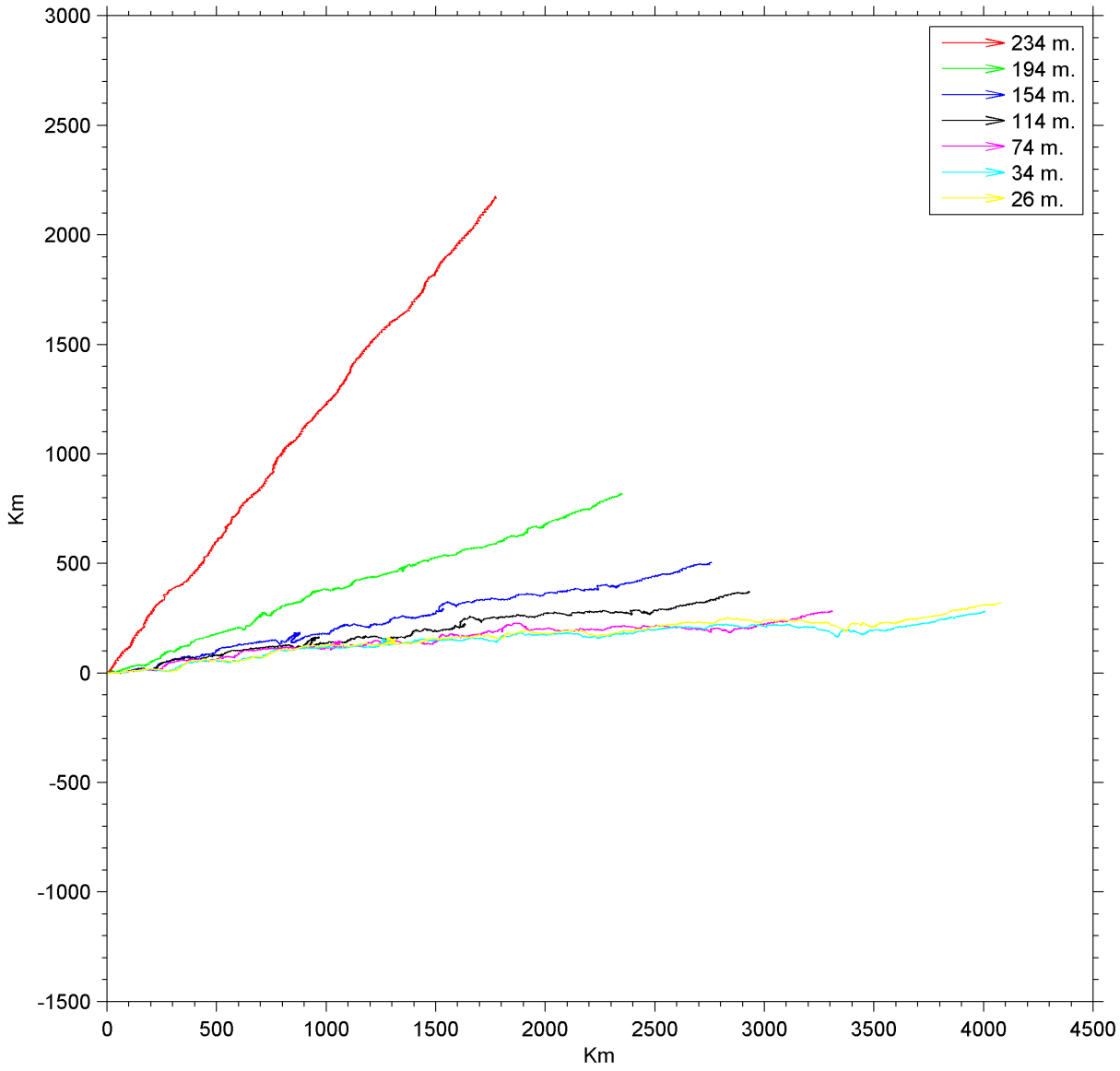


Figure 11: Progressive Vector Diagram, South-Central Barrow Strait. (Workhorse ADCP) Aug. 3, 2008 – Jul. 16, 2009

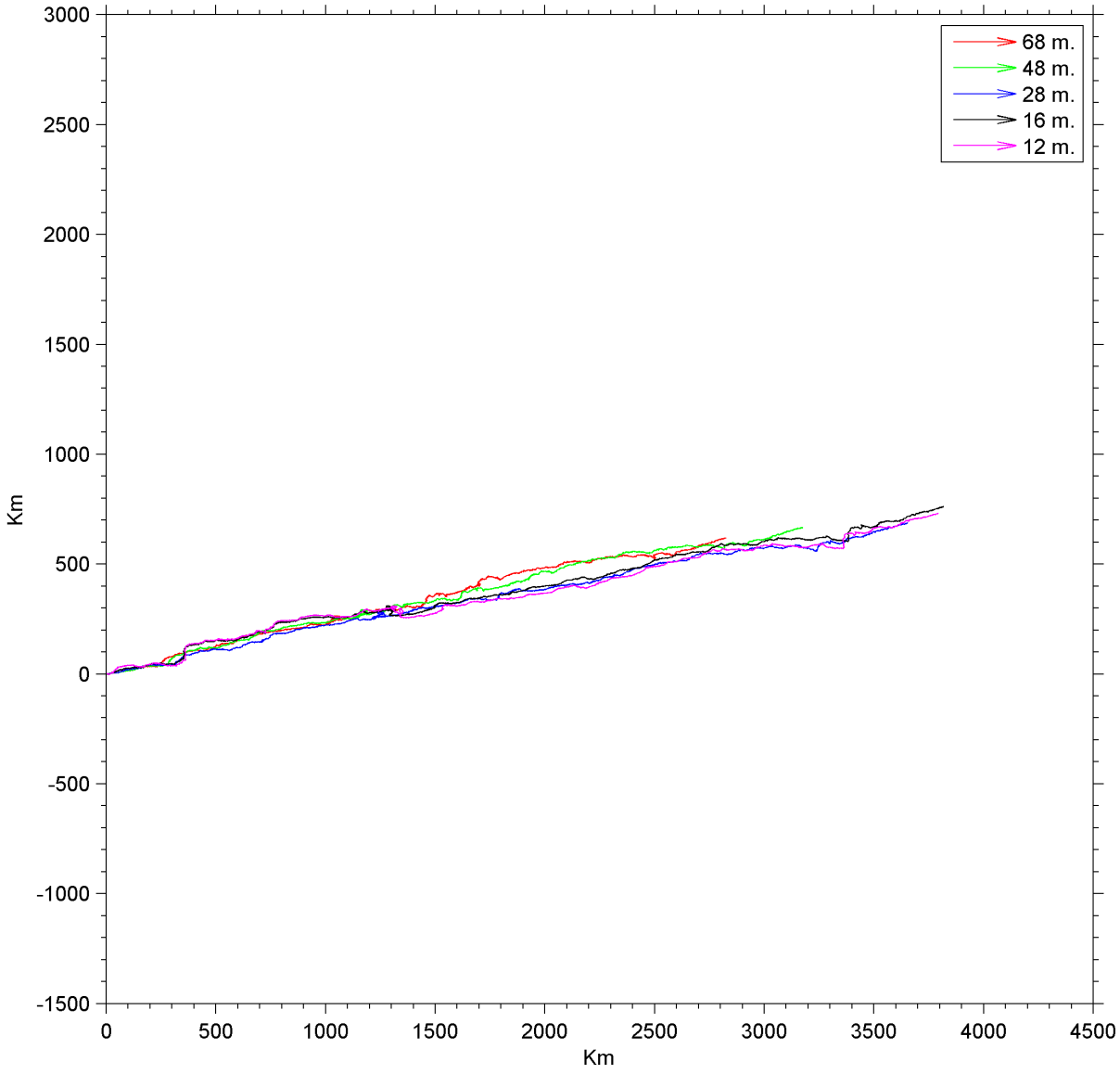


Figure 12: Bi-hourly current data, South Side Barrow Strait. Sep. 1, 2008 – Sep. 30, 2008

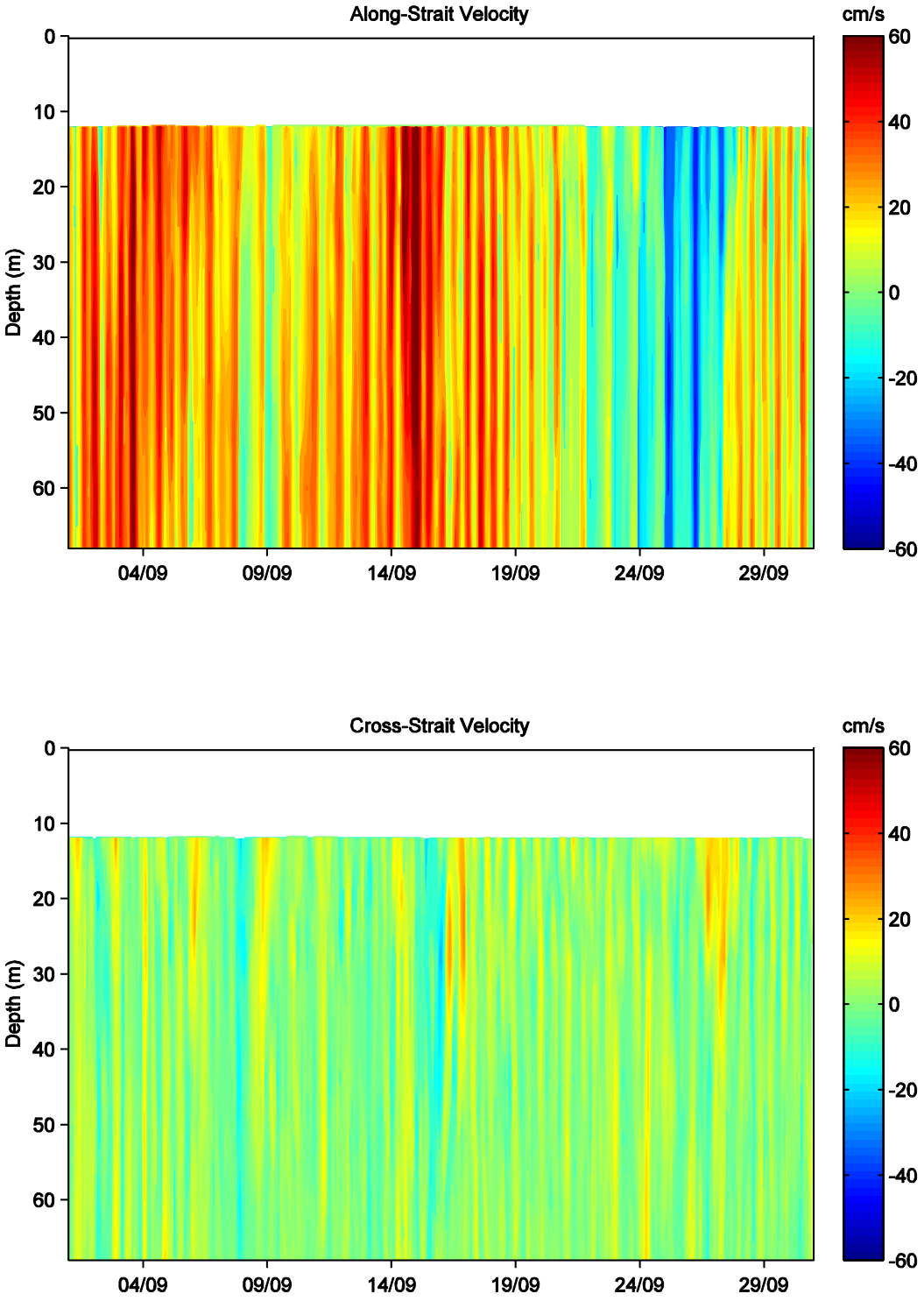


Figure 13: Bi-hourly current data, South-Central Barrow Strait. (Quarter Master ADCP), Sep. 1, 2008 – Sep. 30, 2008

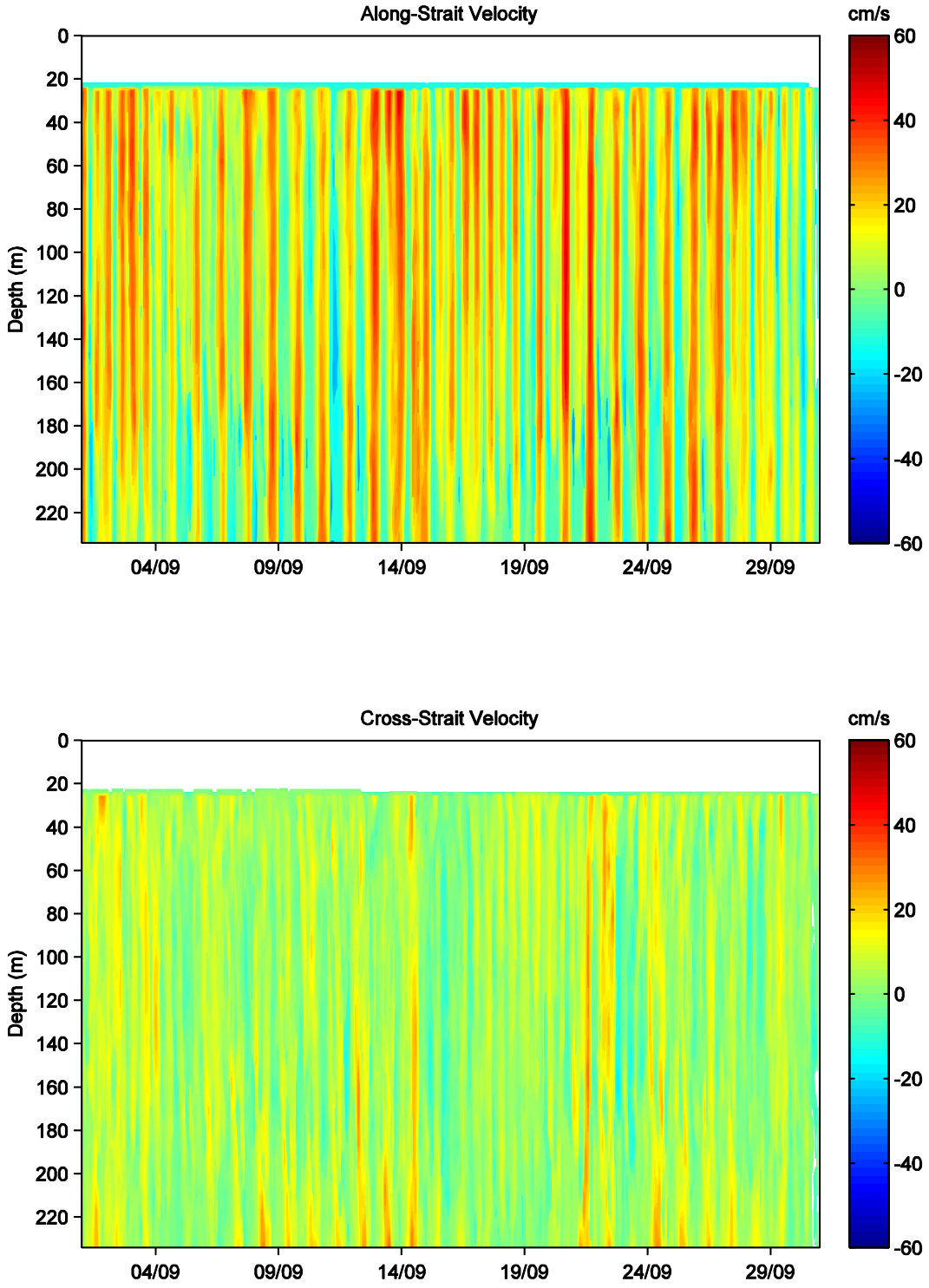


Figure 14: Bi-hourly current data, South-Central Barrow Strait. (Workhorse ADCP) Sep. 1, 2008 – Sep. 30, 2008

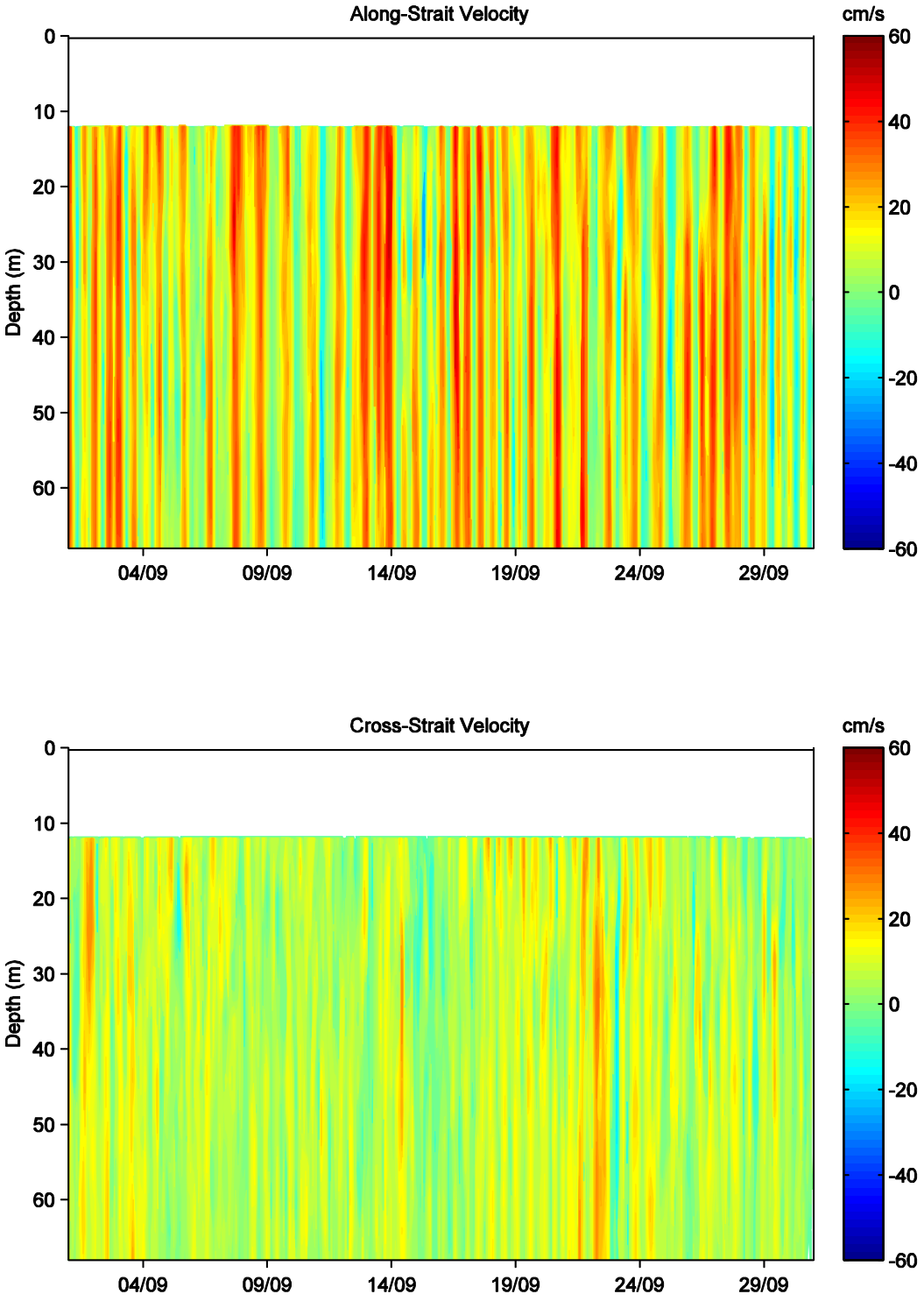


Figure 15: Low-pass filtered currents, South Side Barrow Strait. August 2008 – August 2009

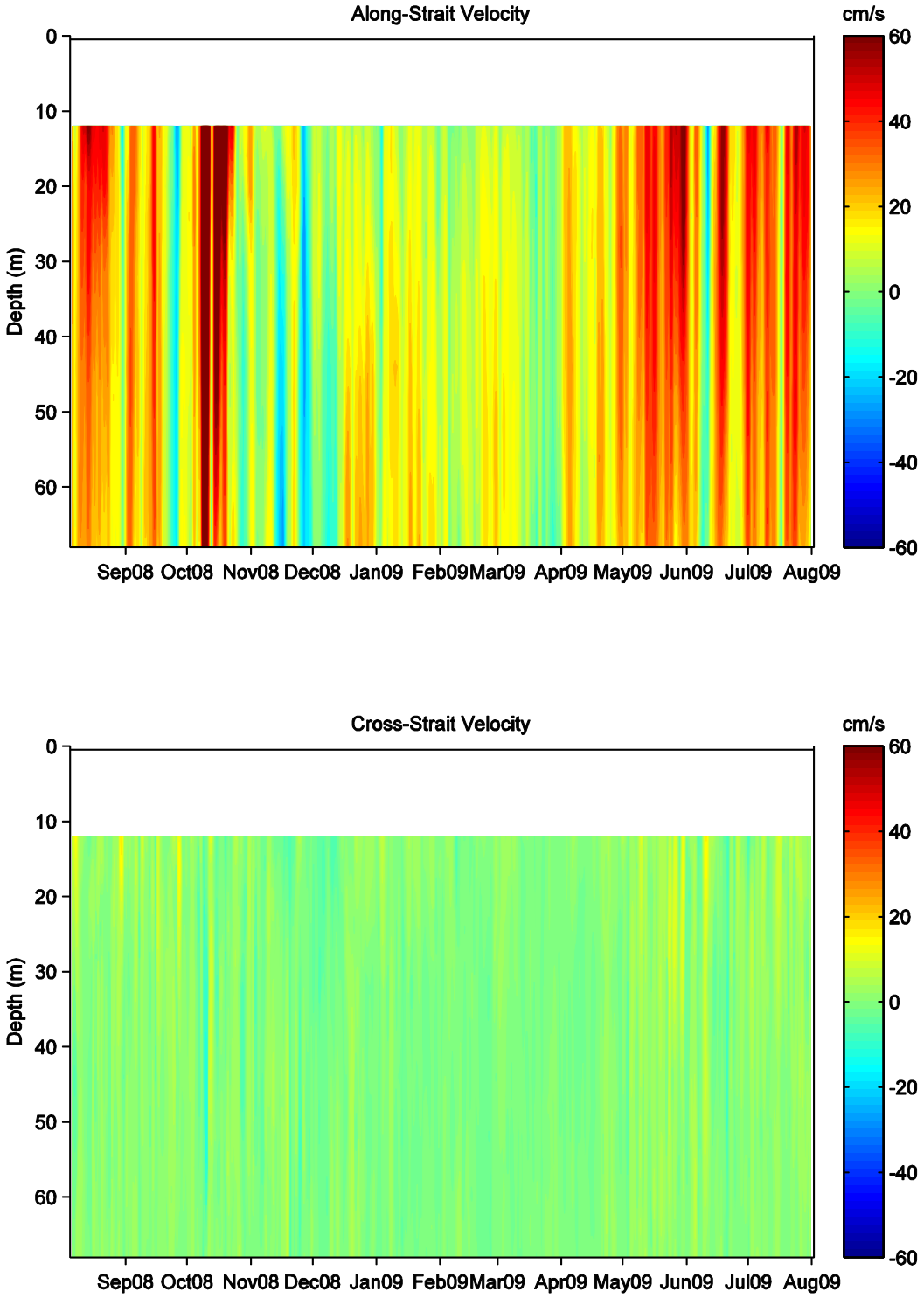
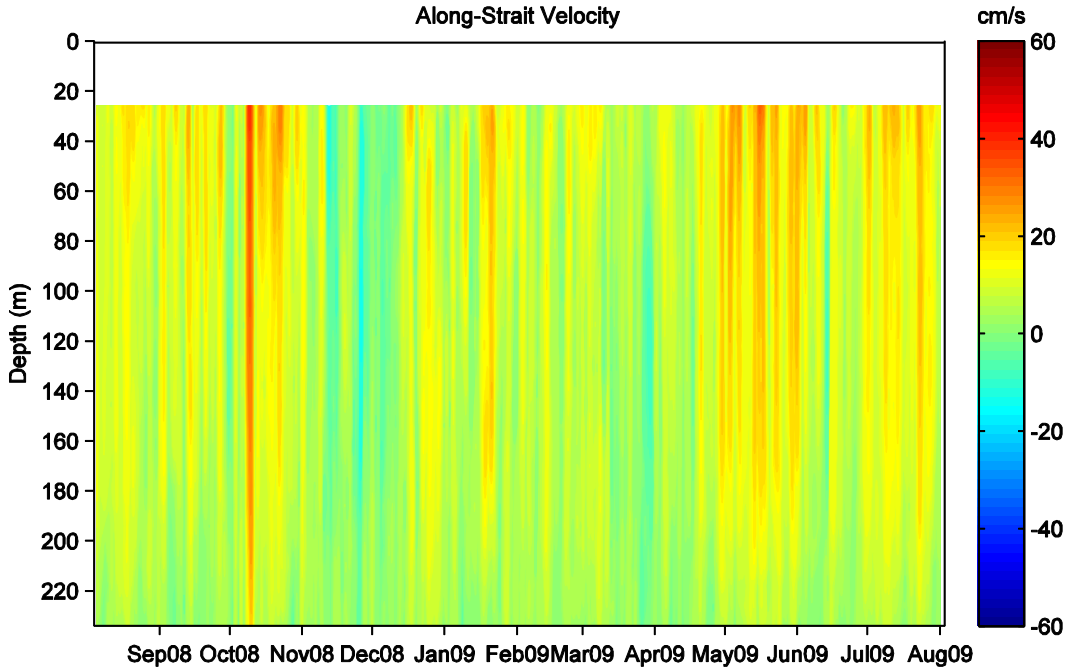


Figure 16: Low-pass filtered currents, South-Central Barrow Strait. (Quarter Master ADCP) August 2008 – August 2009



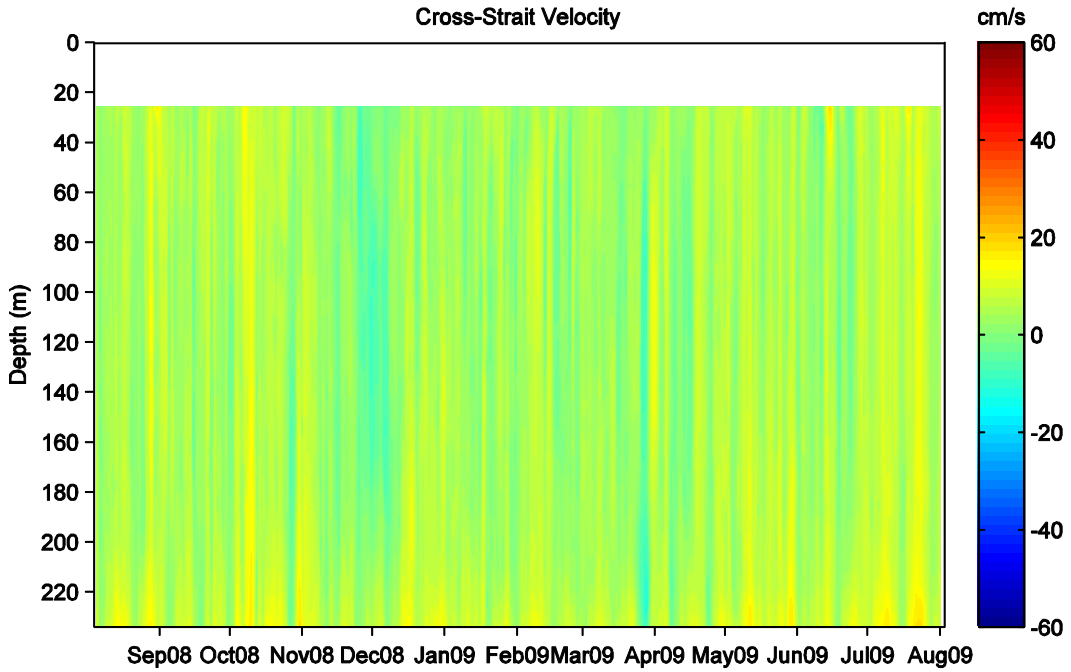


Figure 17: Low-pass filtered currents, South-Central Barrow Strait. (Workhorse ADCP) August 2008 – July 16, 2009

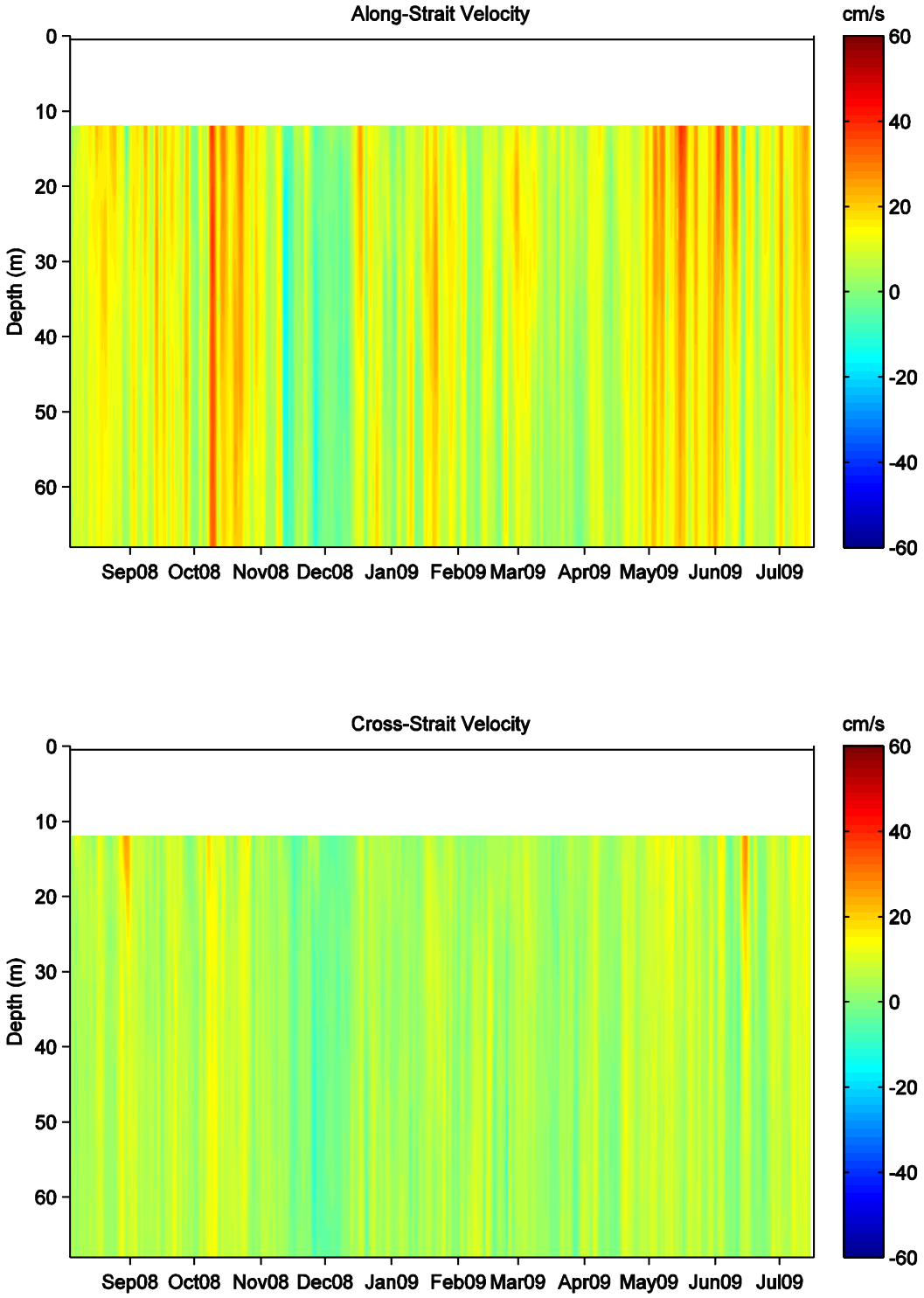
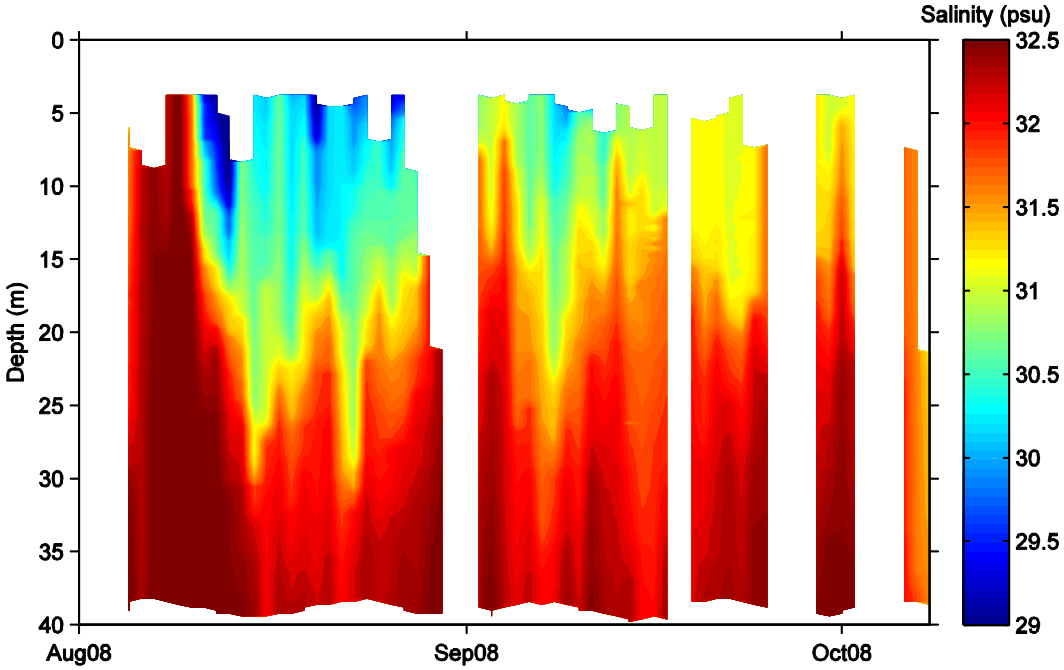
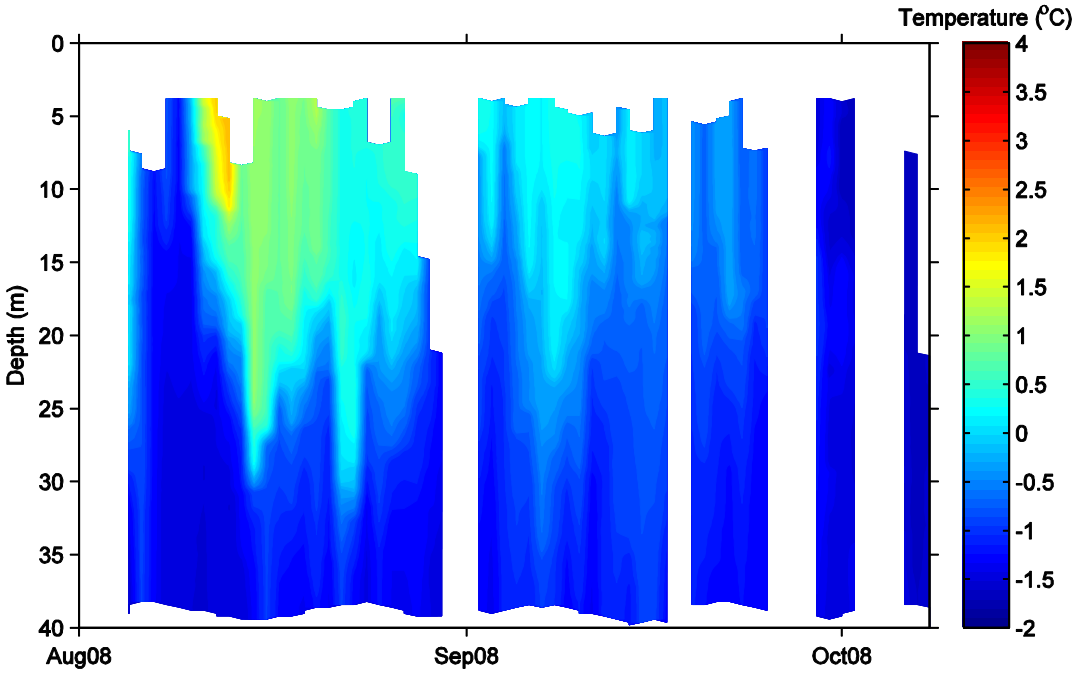
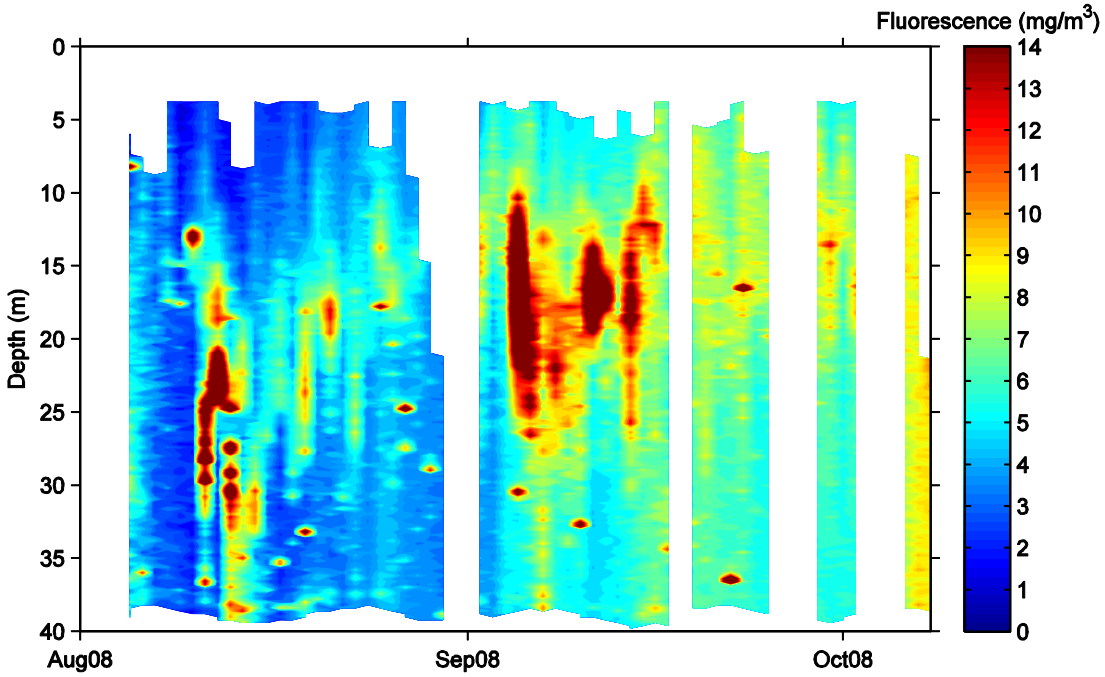


Figure 18: Daily Icycler Measurements
South Side Barrow Strait, August 2008 - October 2008





<u>Figure 18 (continued)</u>: Daily Icycler Measurements
South Side Barrow Strait, August 2008 – October 2008



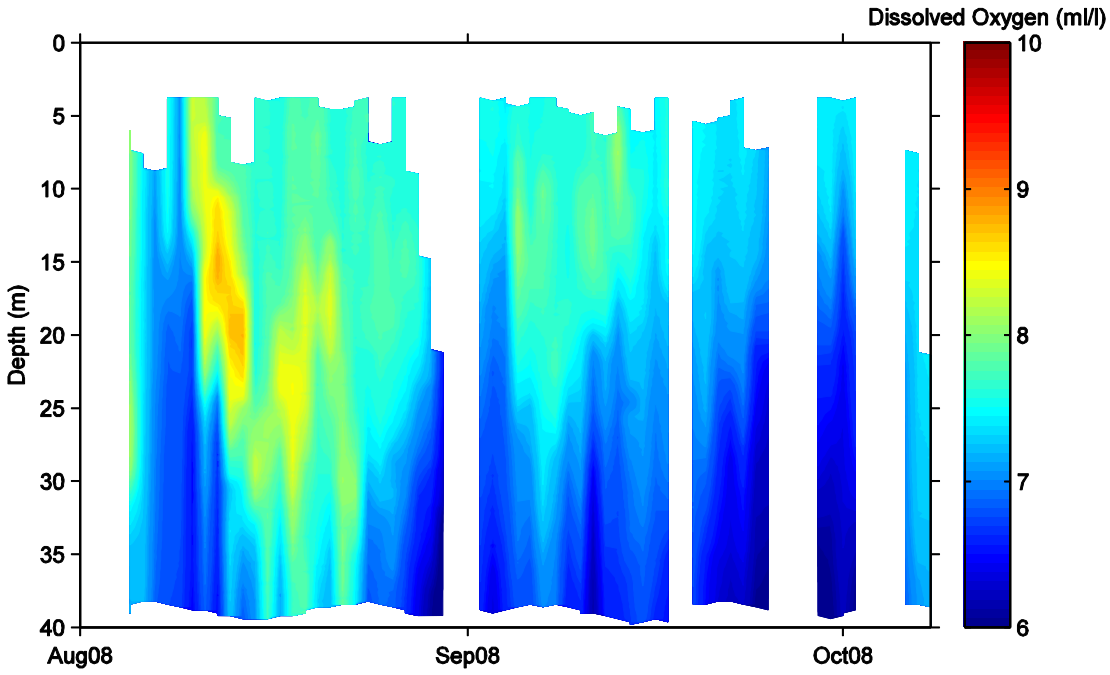


Figure 19: Low-pass filtered T,S (37 m.) and current data (32 m.). South Side Barrow Strait: August 2008 - August 2009.

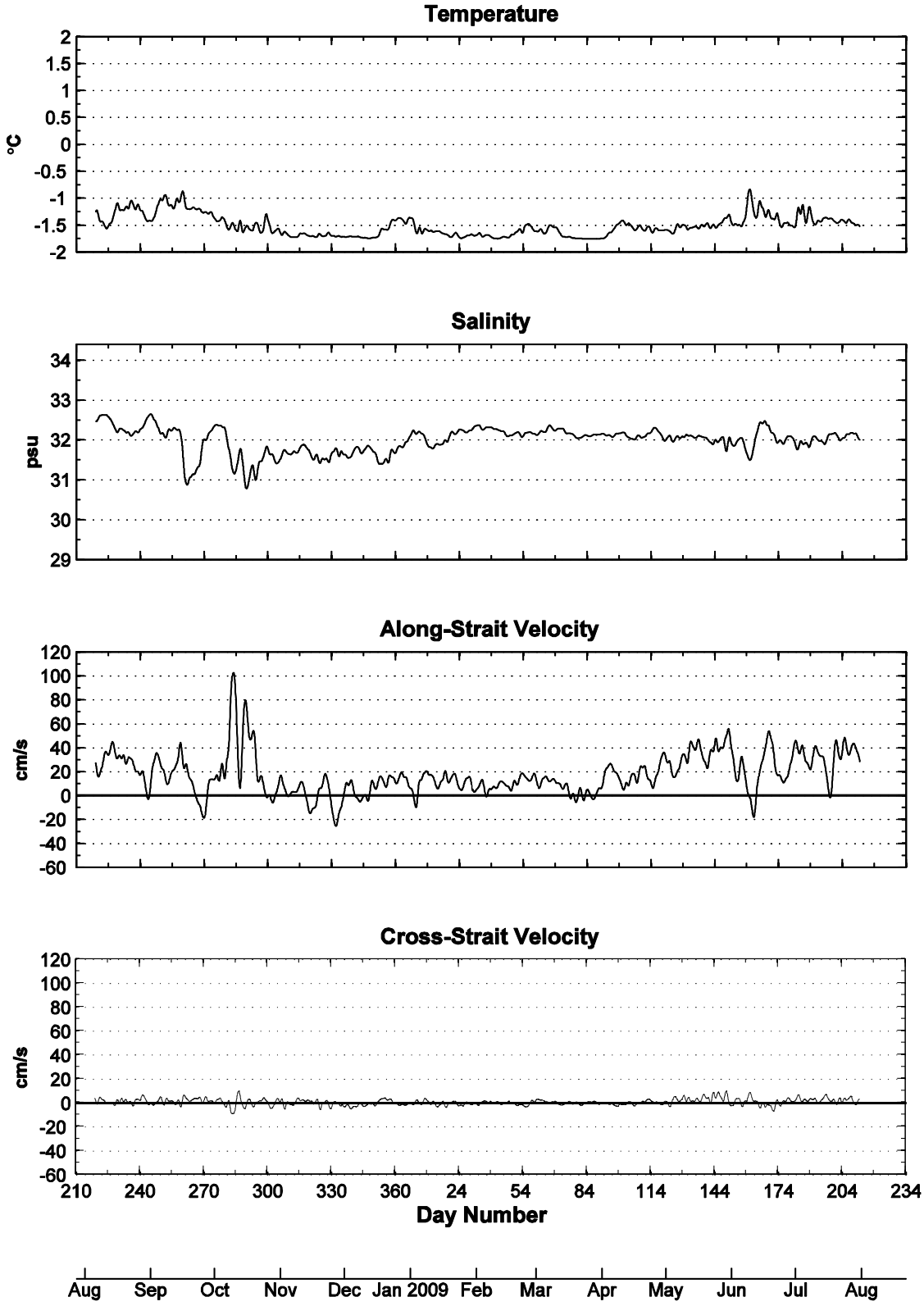


Figure 20: Low-pass filtered T,S (62 m.) and current data (60 m.). South Side Barrow Strait: August 2008 – August 2009.

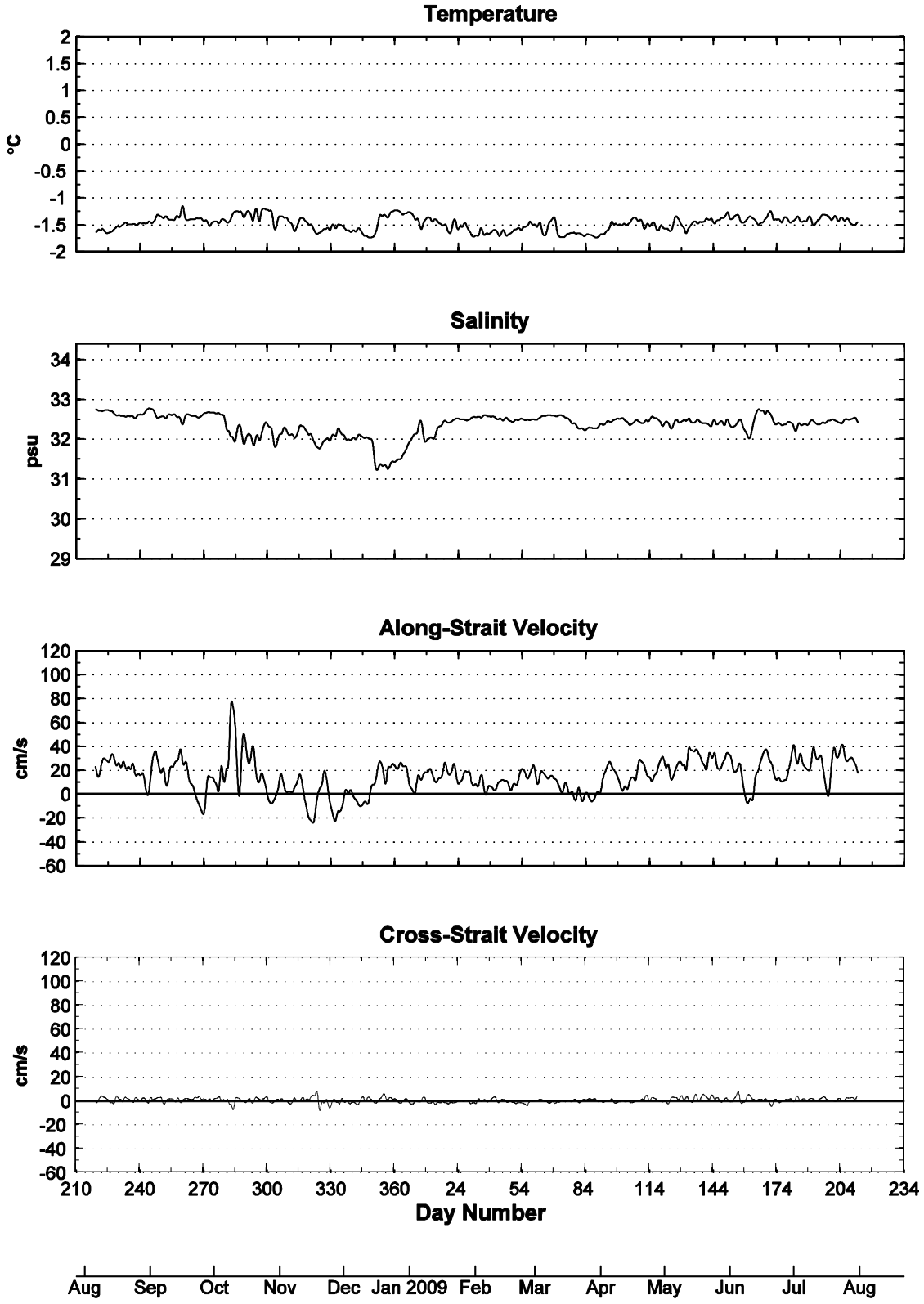


Figure 21: Low-pass filtered T,S (76 m.) and current data (68 m.). South Side Barrow Strait: August 2008 – August 2009.

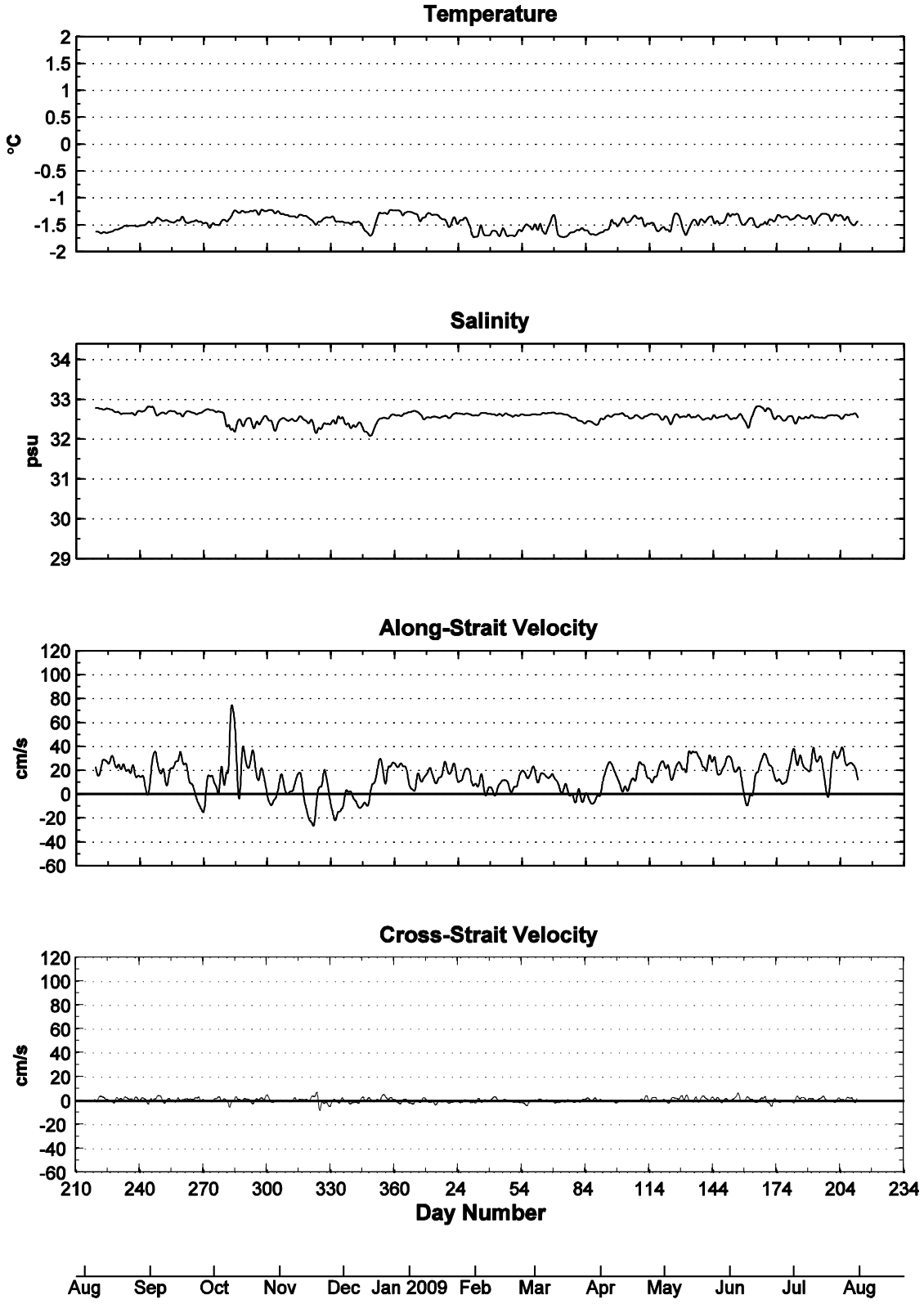


Figure 22: Low-pass filtered T,S data (142 m.)
South Side Barrow Strait: August 2008 – August 2009.

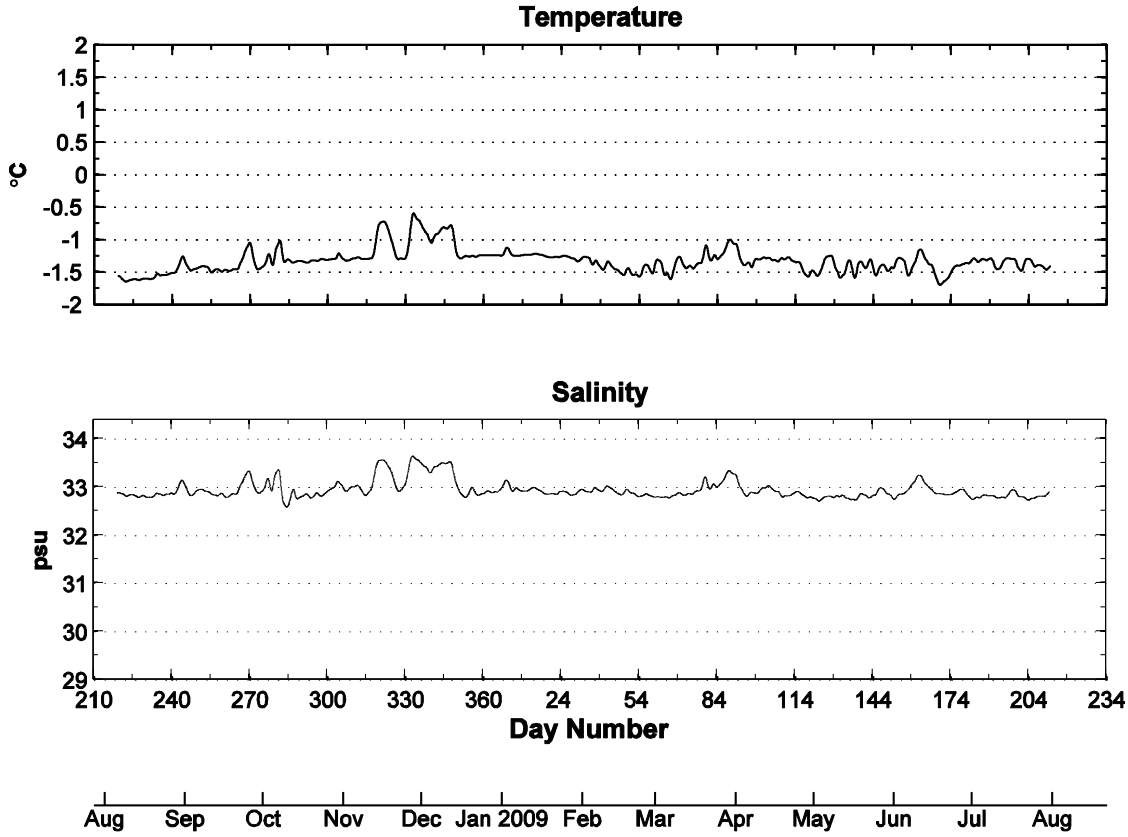


Figure 23: Low-pass filtered T,S (37 m.) and current data (36 m.). South-Central Barrow Strait: August 2008 - August 2009.

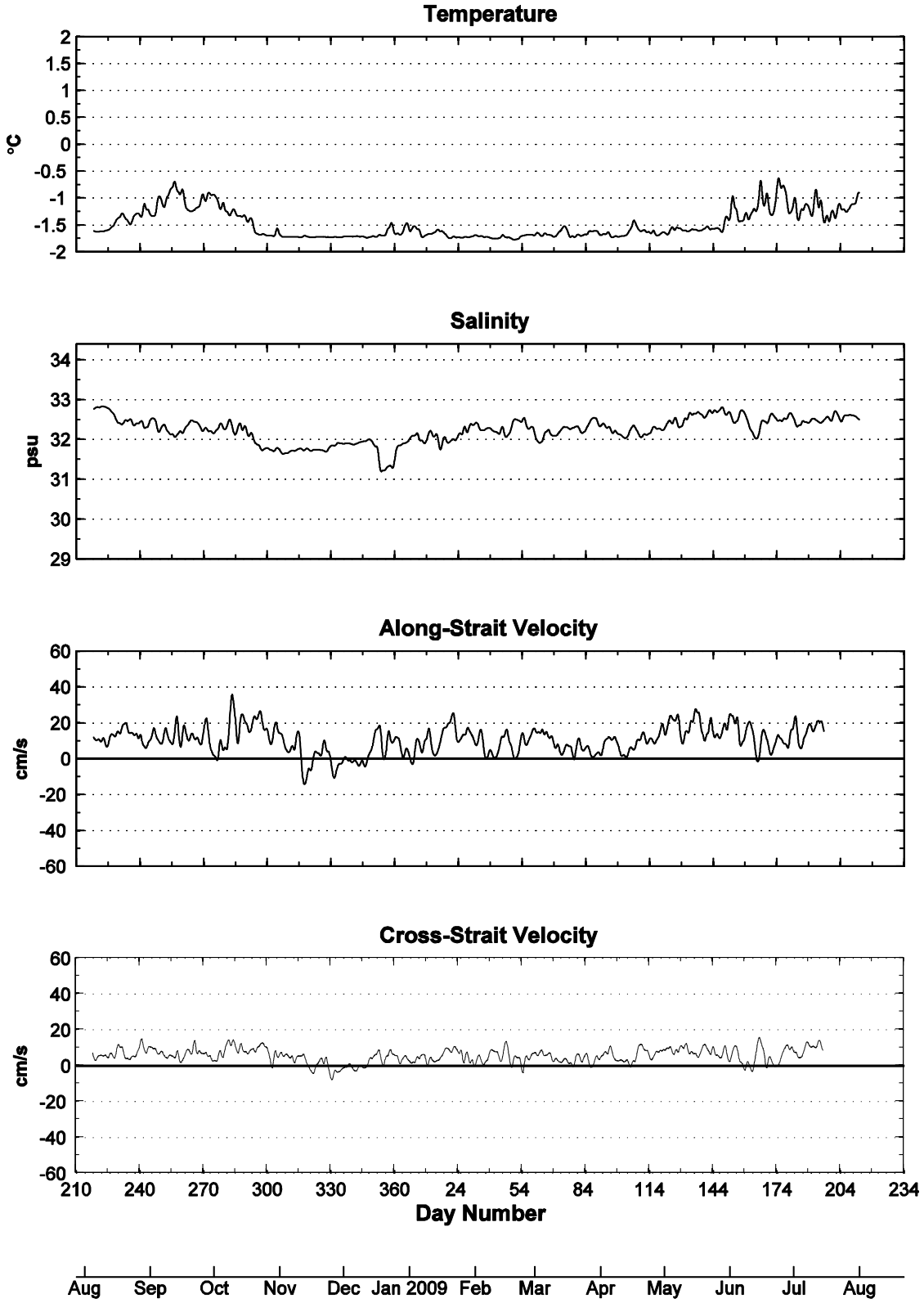


Figure 24: Low-pass filtered T,S (76 m) and current data (74 m.). South-Central Barrow Strait: August 2008 - August 2009.

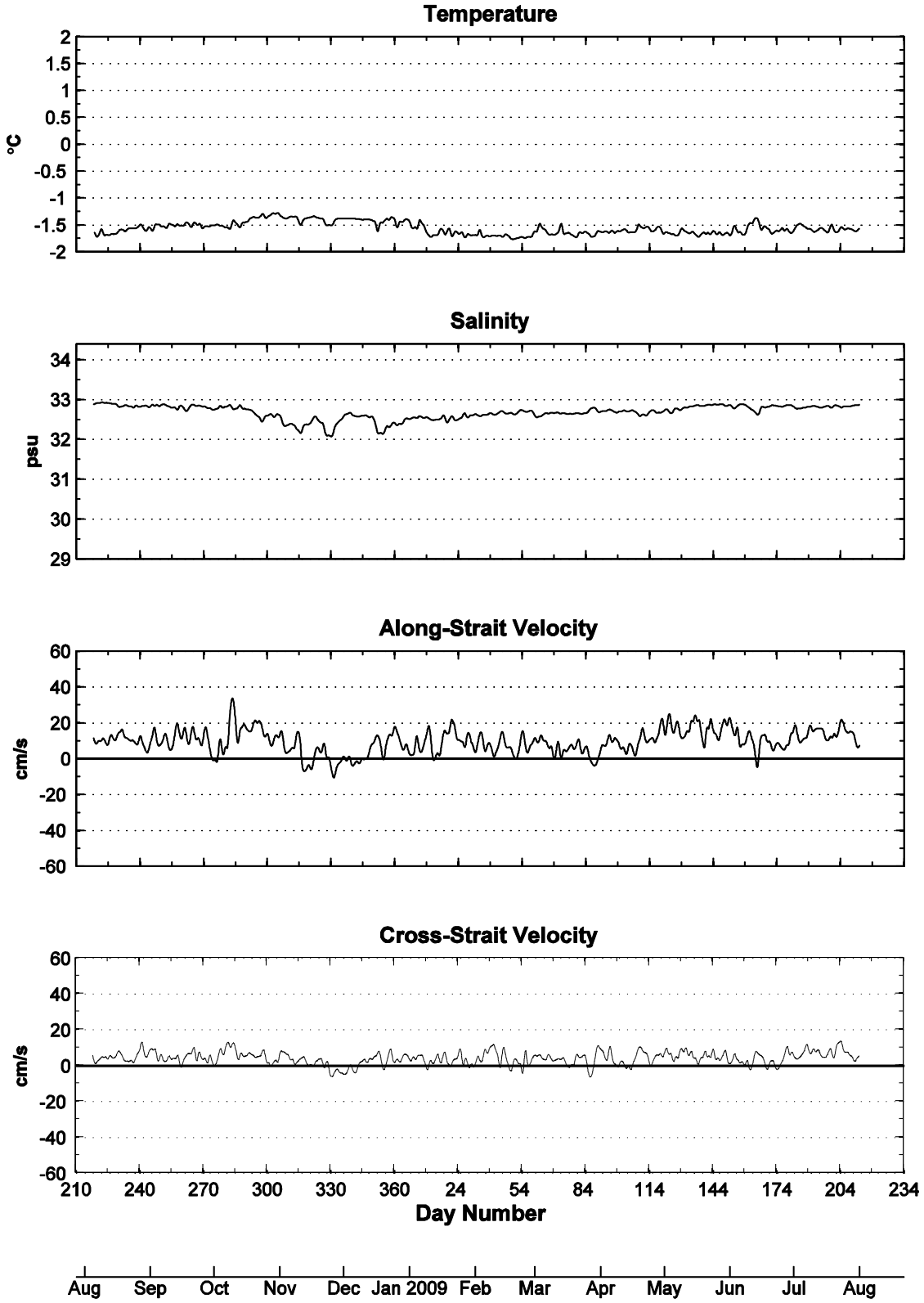


Figure 25: Low-pass filtered T,S (157 m.) and current data (154 m). South-Central Barrow Strait: August 2008 – August 2009.

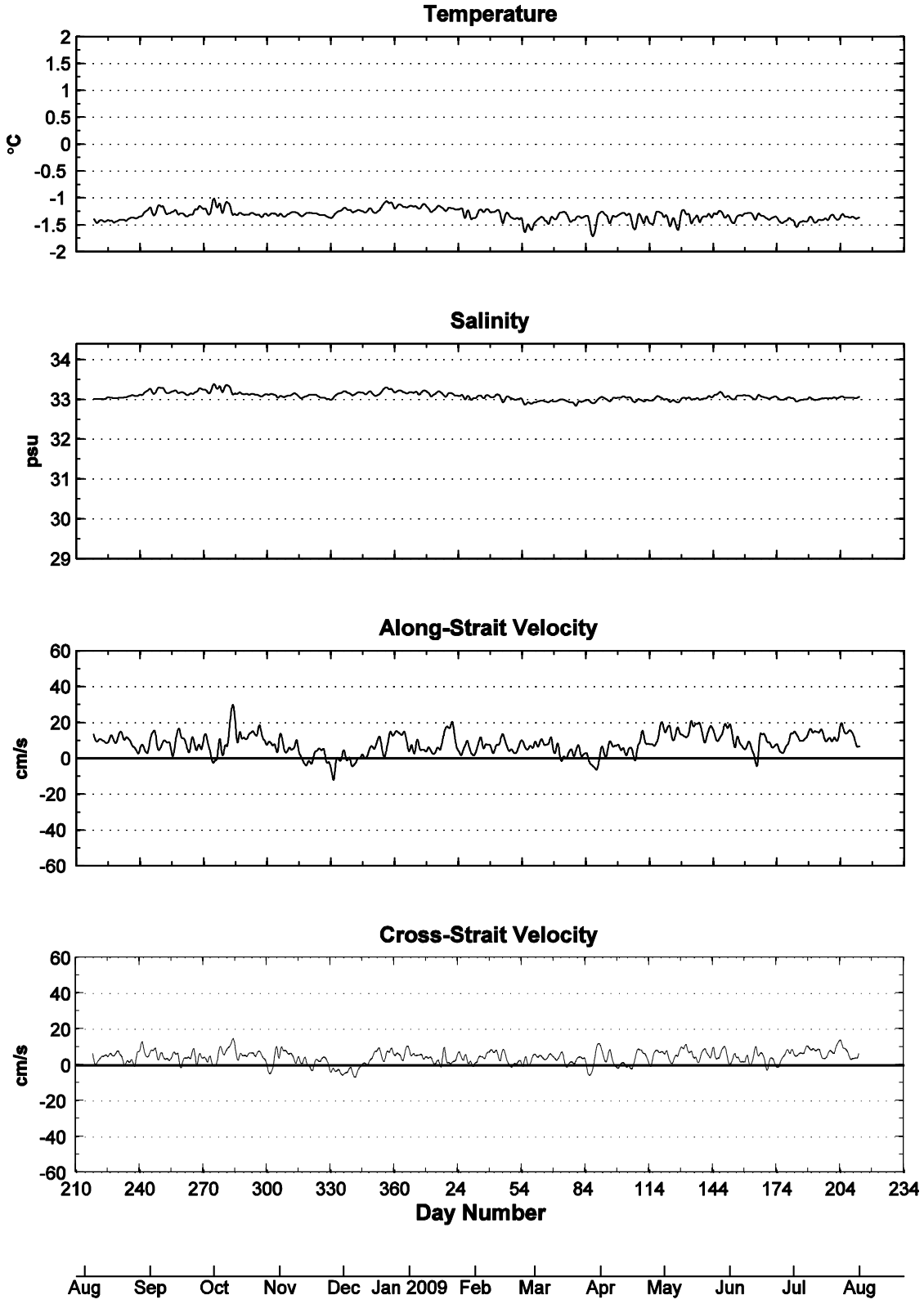


Figure 26: Low-pass filtered T,S (265 m.) and current data (234 m.). South-Central Barrow Strait: August 2008 – August 2009.

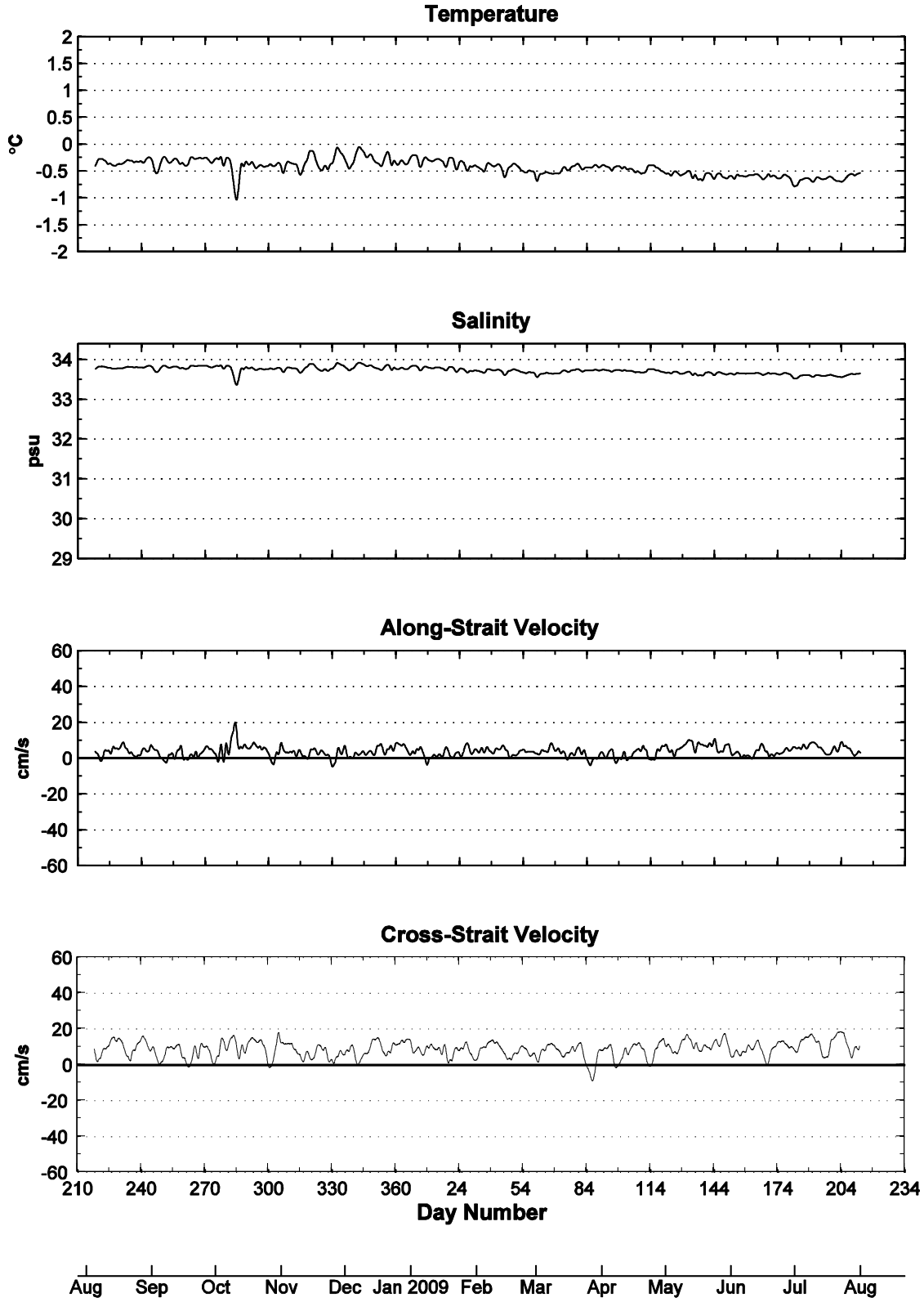


Figure 27: Low-pass filtered T,S data (45 m.)
ArcticNet Mooring: August 2008 – August 2009.

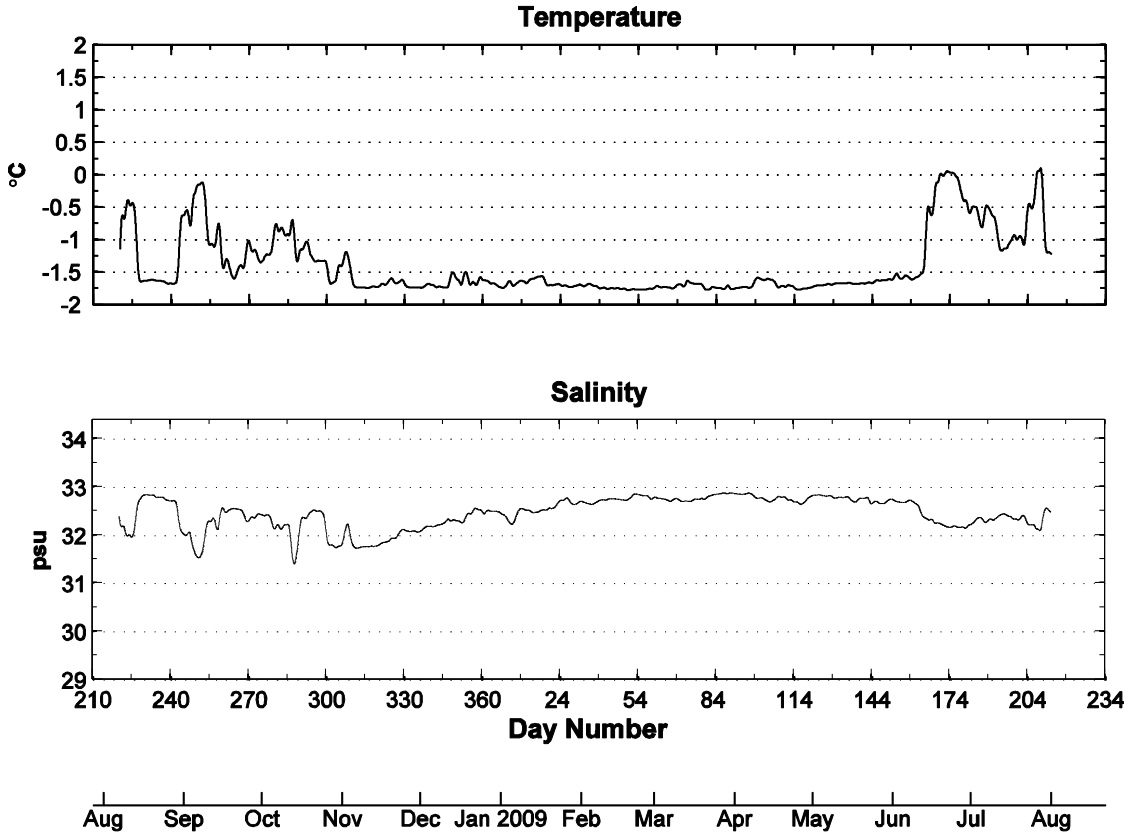


Figure 28: Mean Flows, Aug. 4, 2008 to Aug. 1, 2009.

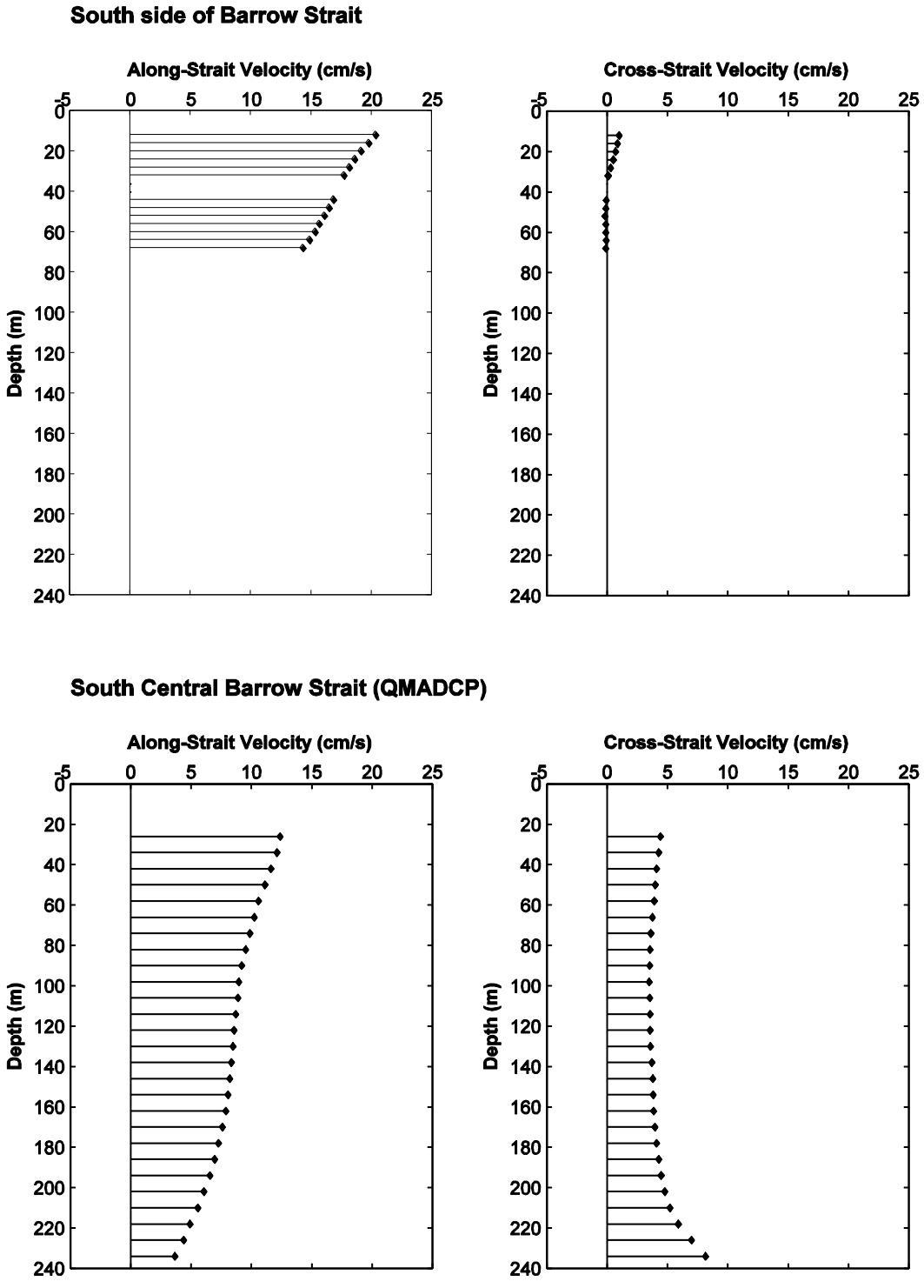


Figure 28: Mean Flows, Aug. 4, 2008 to Aug. 1, 2009. (continued)

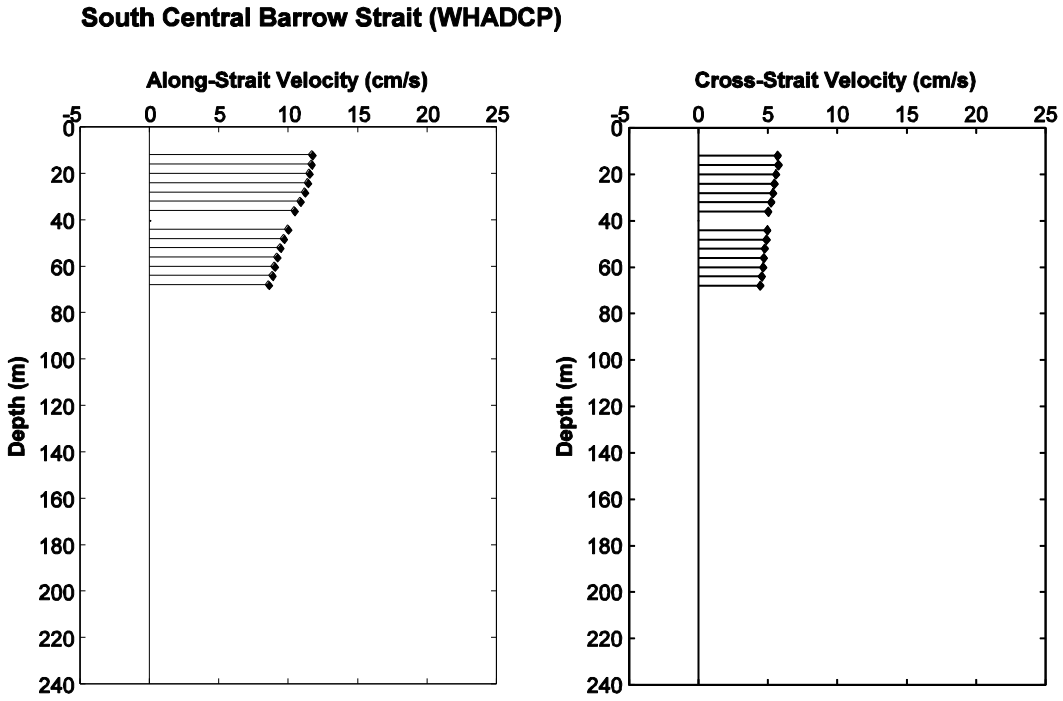


Figure 29: Mean Flows, Late Summer: Aug. 2008 to Sep. 2008.

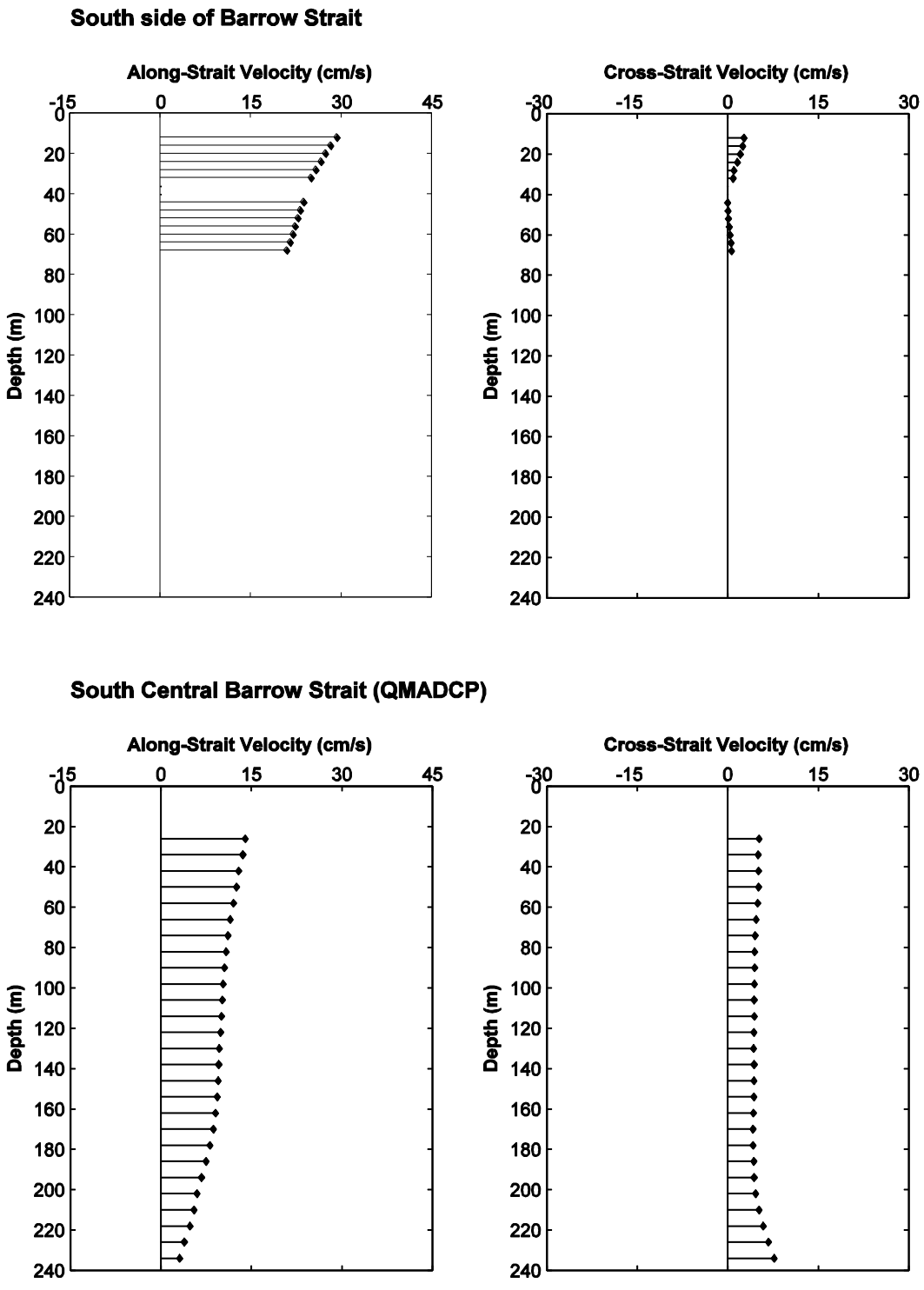


Figure 29: Mean Flows, Late Summer: Aug. 2008 to Sep. 2008 (continued)

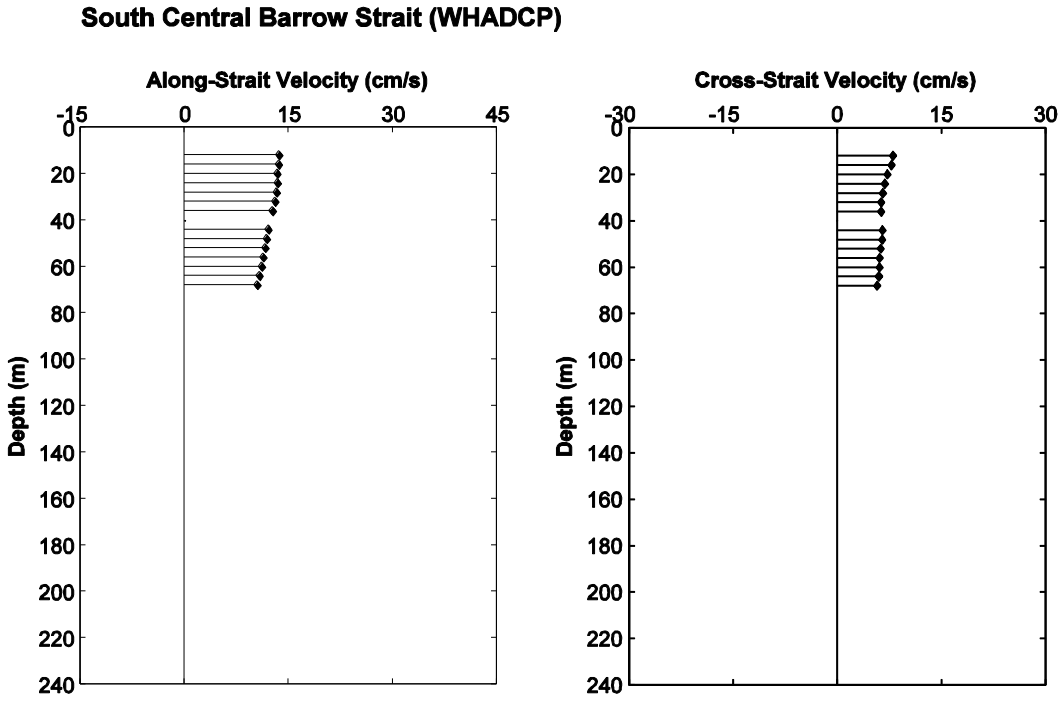


Figure 30: Mean Flows, Fall: Sep. 2008 to Dec. 2008.

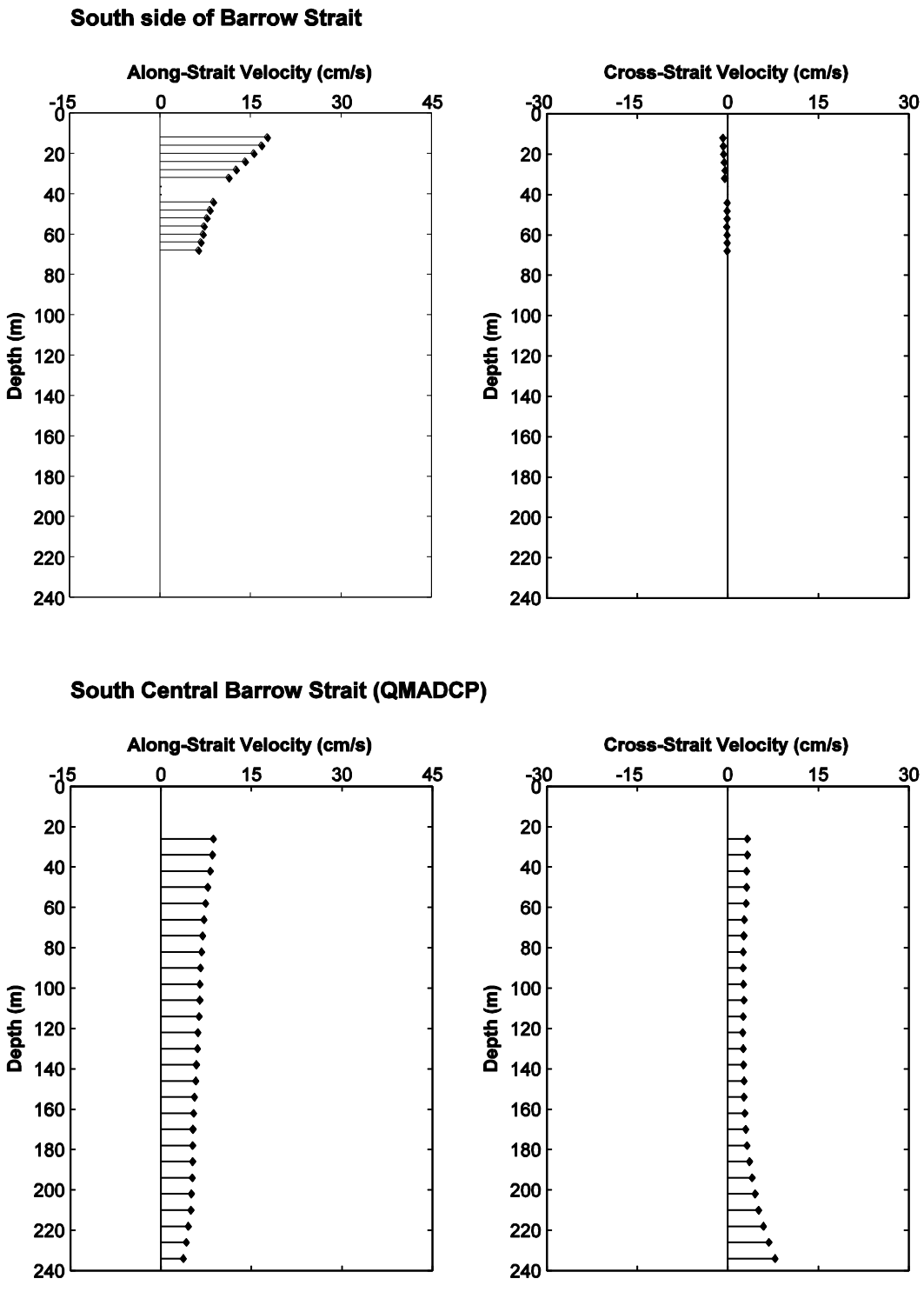


Figure 30: Mean Flows, Fall: Sep. 2008 to Dec. 2008 (continued).

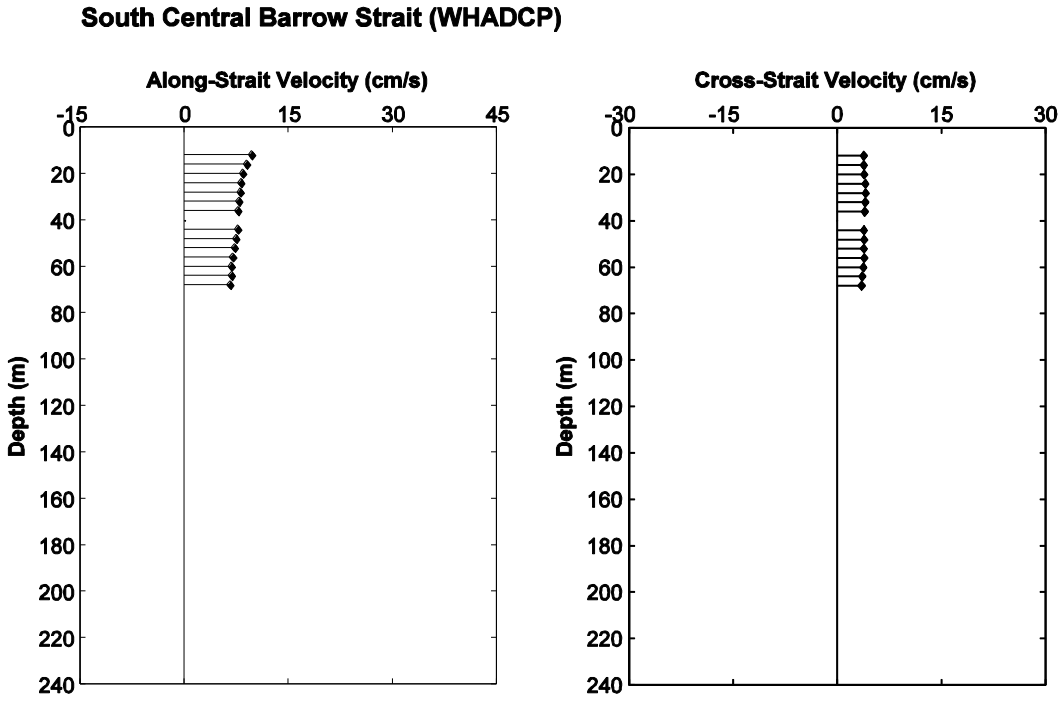


Figure 31: Mean Flows, Winter: Dec. 2008 to Mar. 2009.

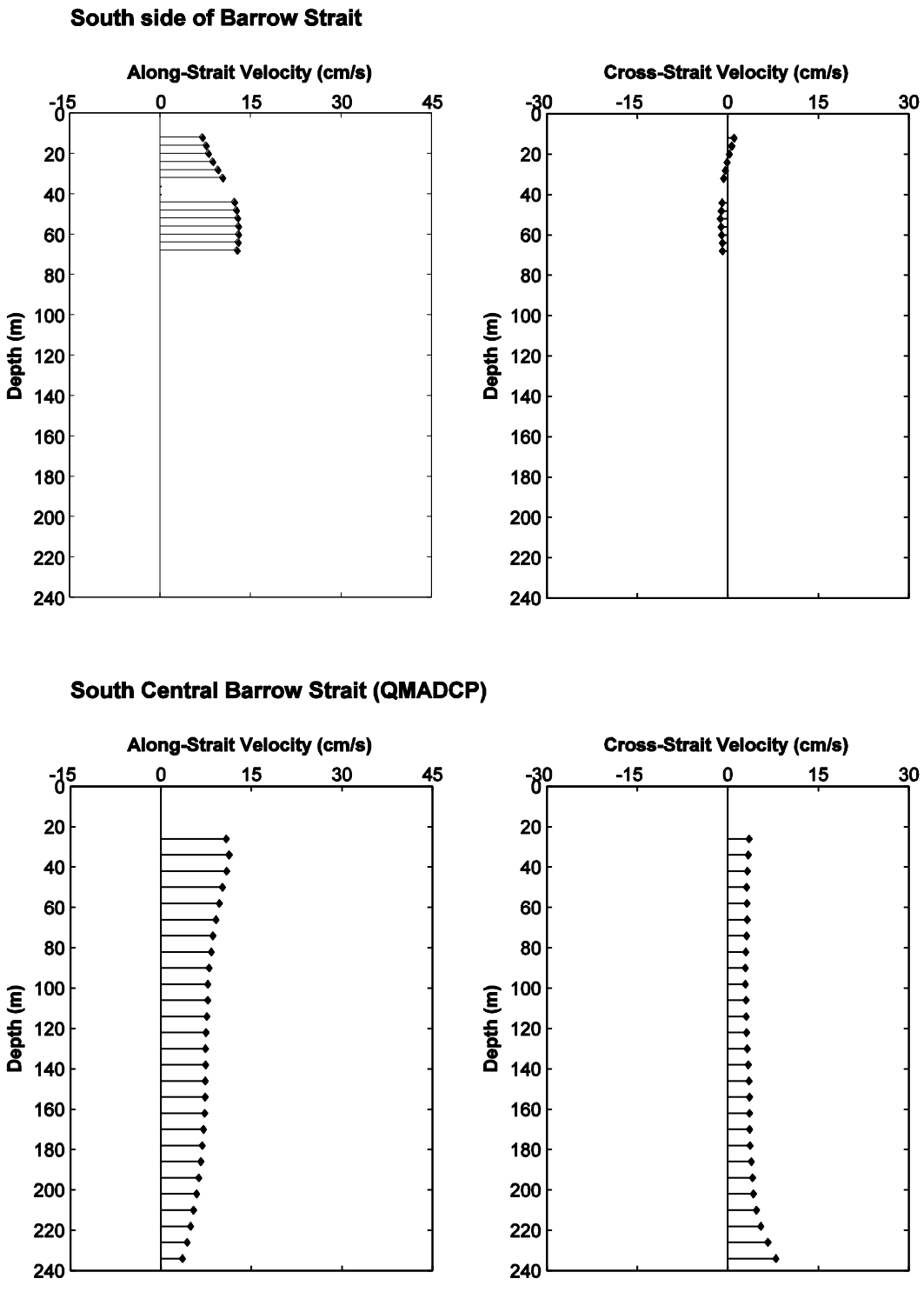


Figure 31: Mean Flows, Winter: Dec. 2008 to Mar. 2009 (continued).

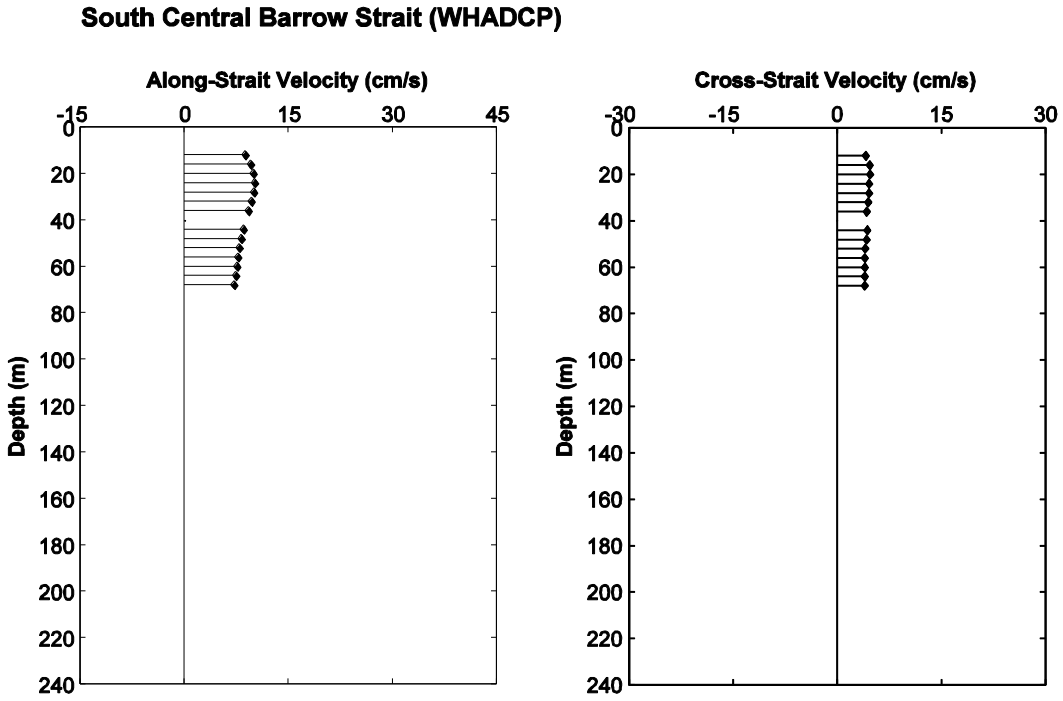


Figure 32: Mean Flows, Spring: Mar. 2009 to Jun. 2009.

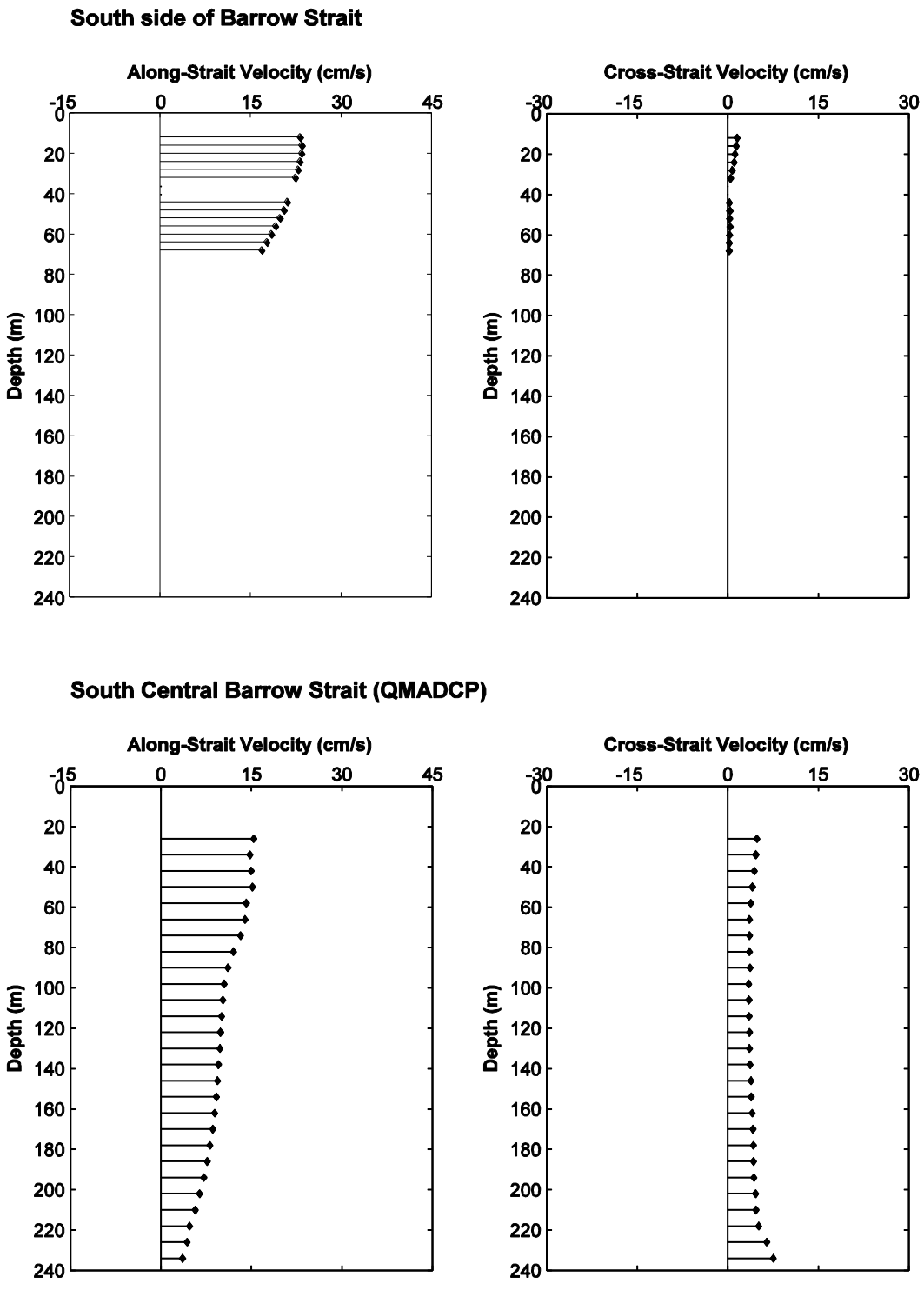


Figure 32: Mean Flows, Spring: Mar. 2009 to Jun. 2009 (continued).

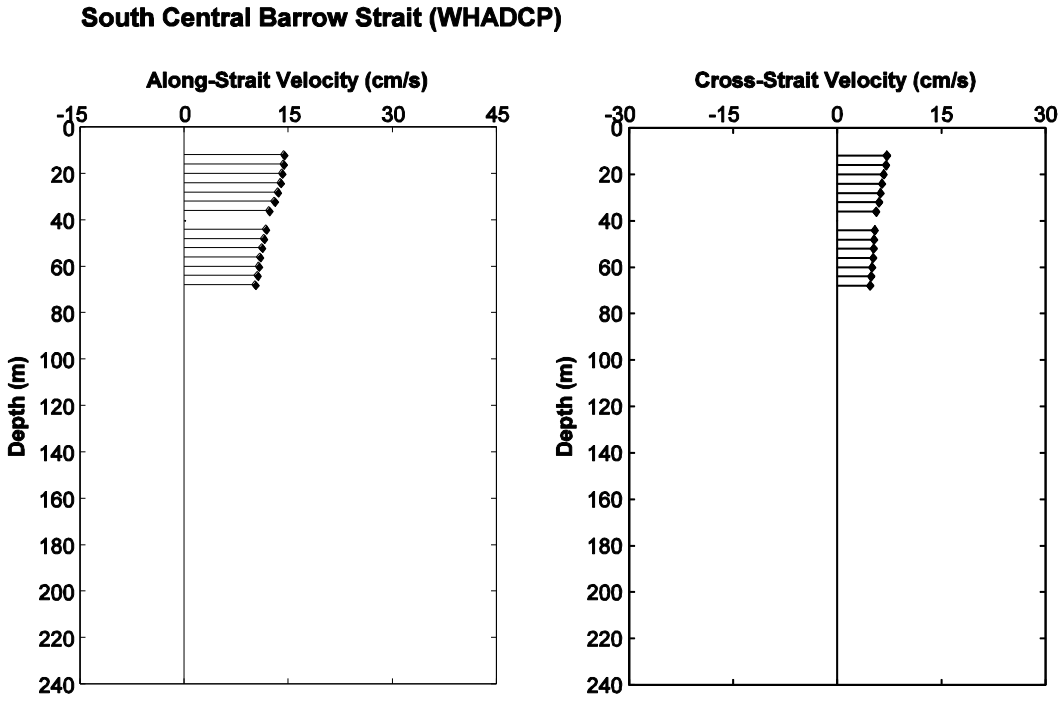


Figure 33: Mean Flows, Early Summer: Jun. 2009 to Aug. 2009.

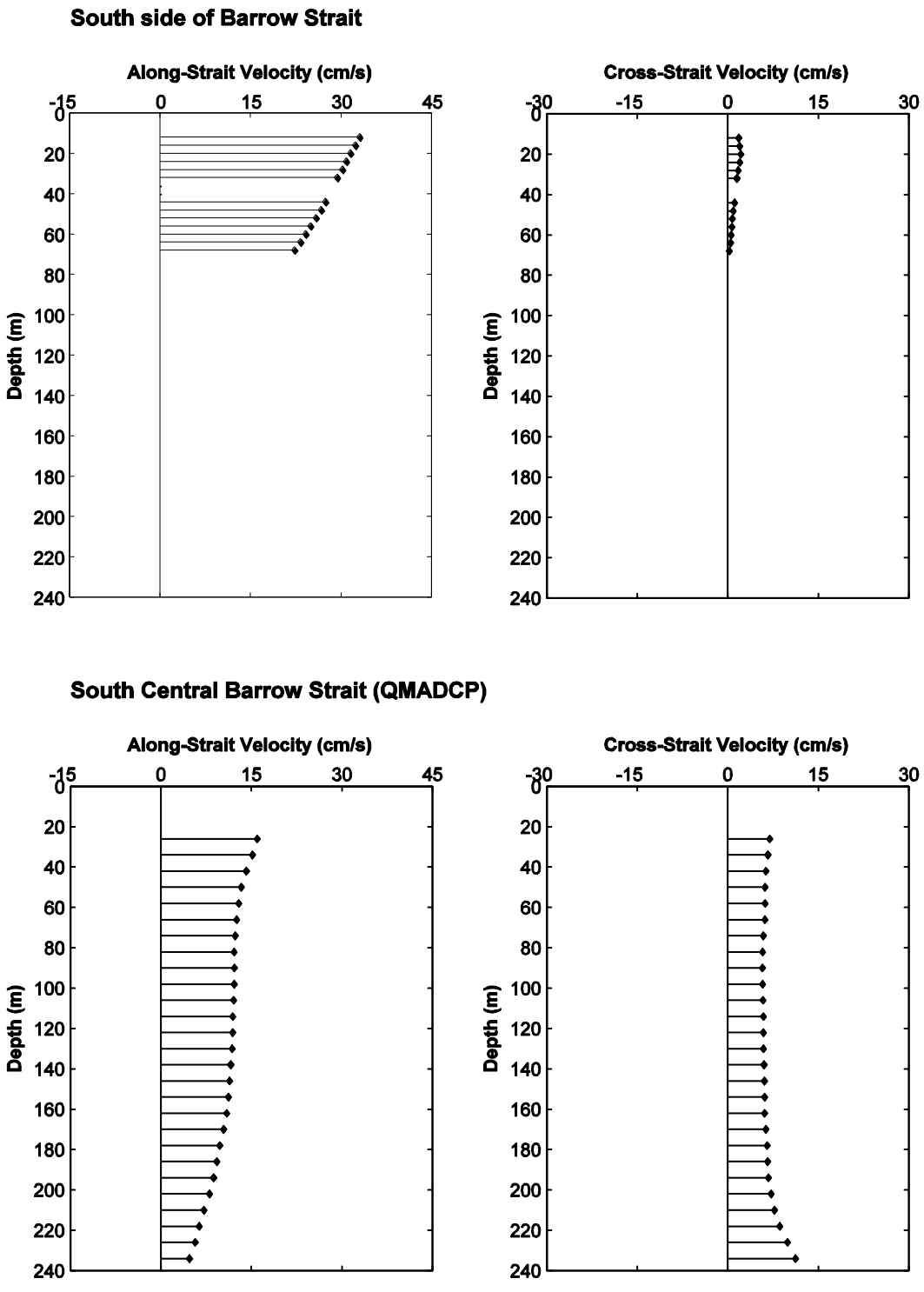


Figure 33: Mean Flows, Early Summer: Jun. 2009 to Aug. 2009 (continued).

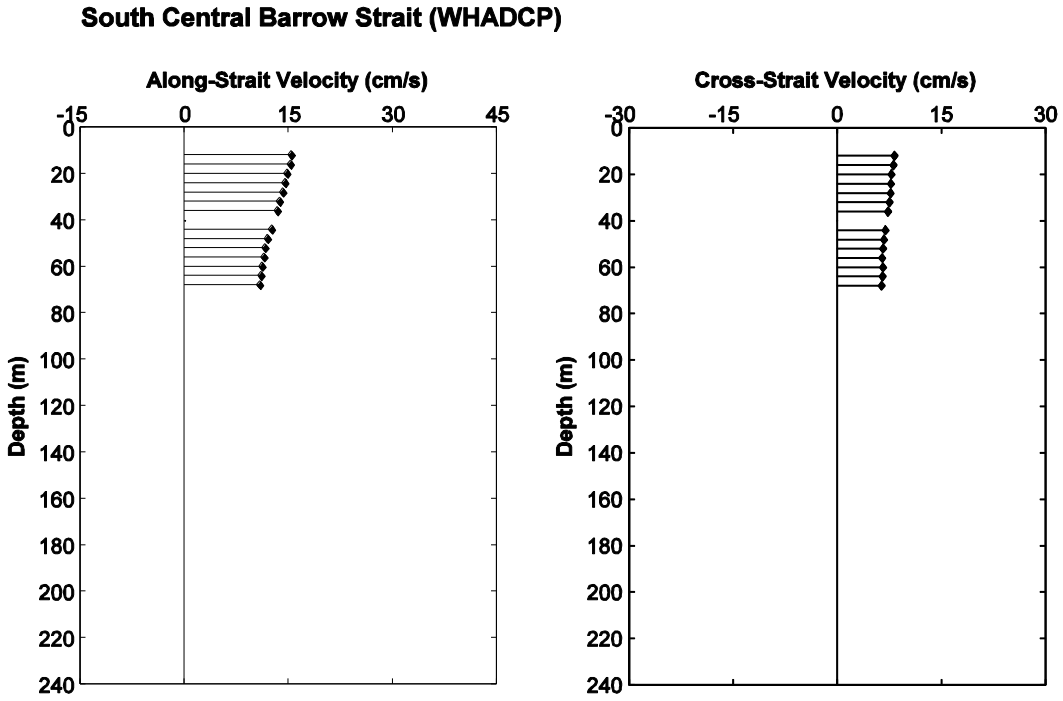


Figure 34: Variance in bi-hourly and low-pass filtered currents. Aug. 2008 to Aug. 2009.

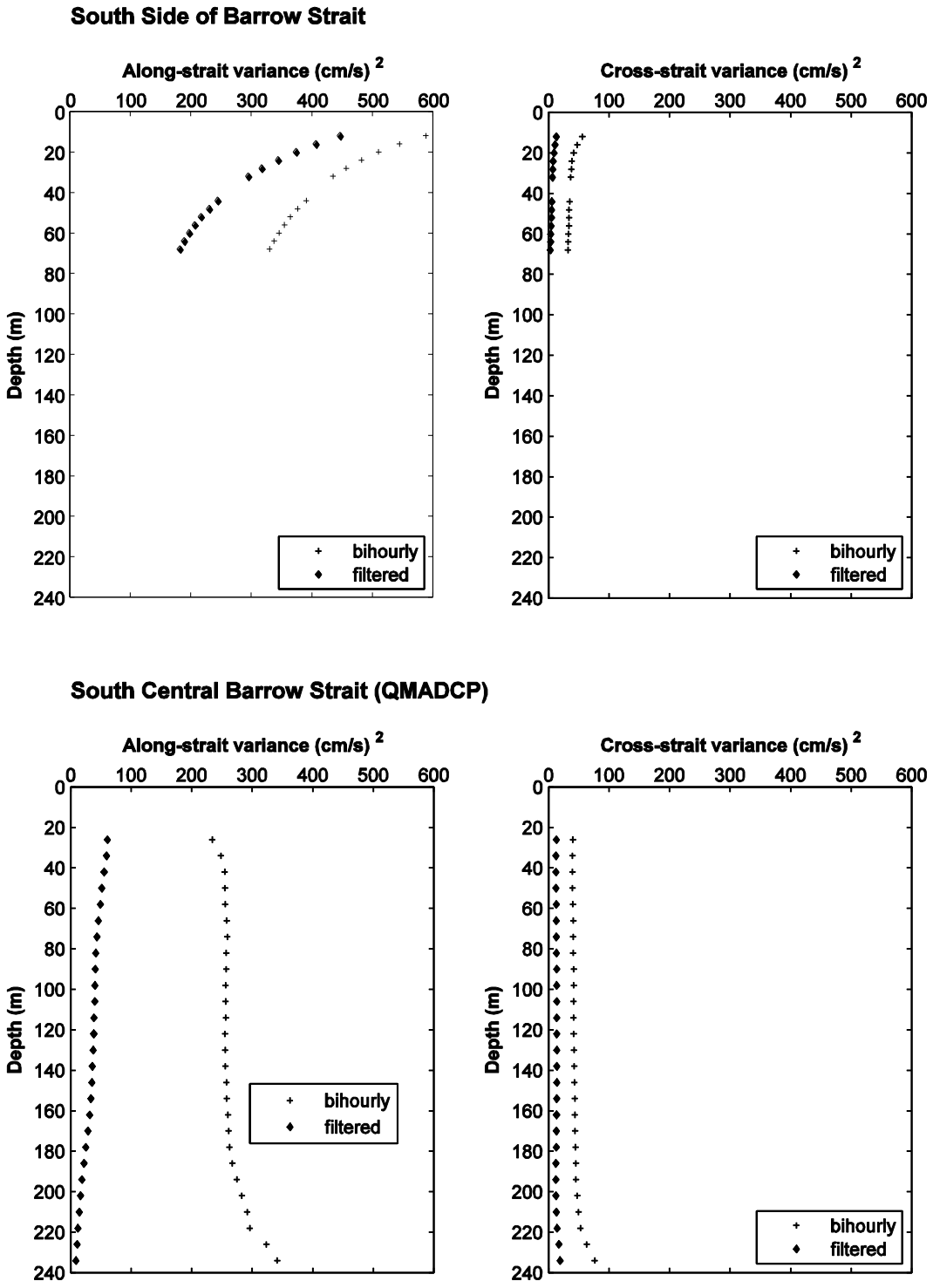


Figure 34: Variance in bi-hourly and low-pass filtered currents Aug. 2008 to Aug. 2009 (continued).

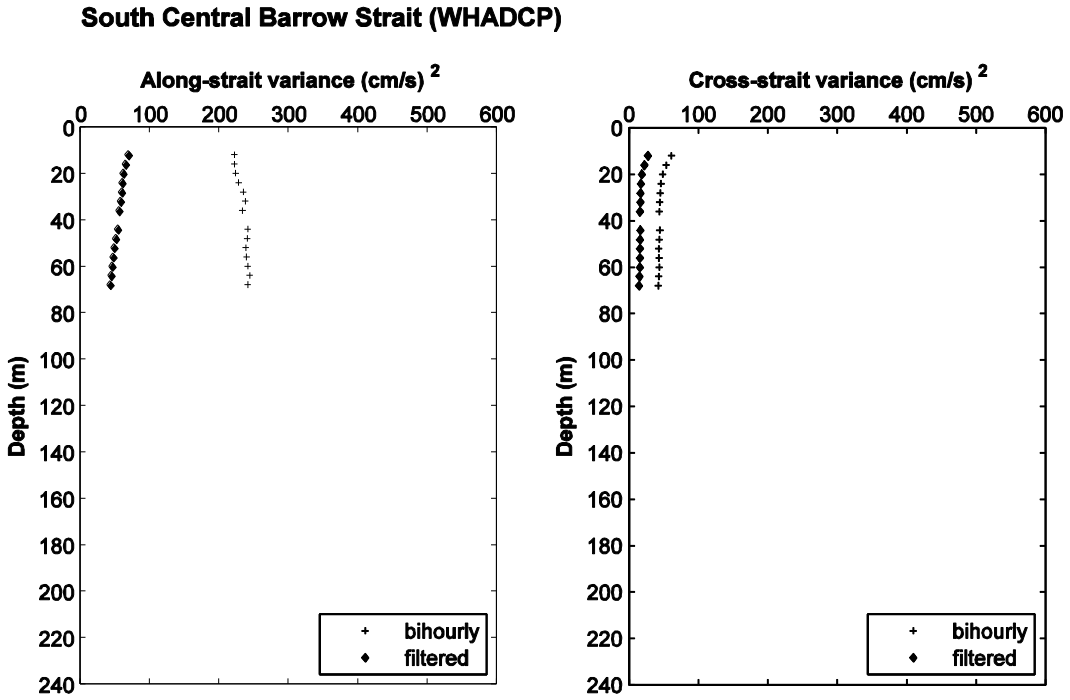
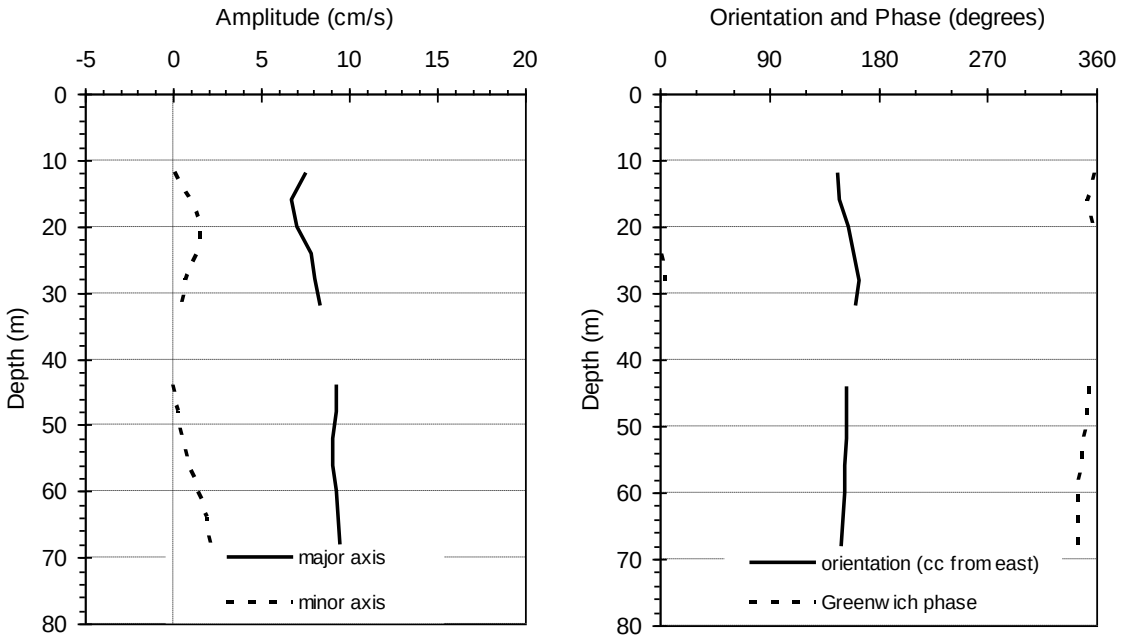


Figure 35: K1 Tidal Constituent, South Side of Barrow Strait

For Ice Free Period (Aug. 4, 2008 to Oct. 1, 2008):



For Solid Ice Period (Jan. 11, 2009 to Mar. 29, 2009):

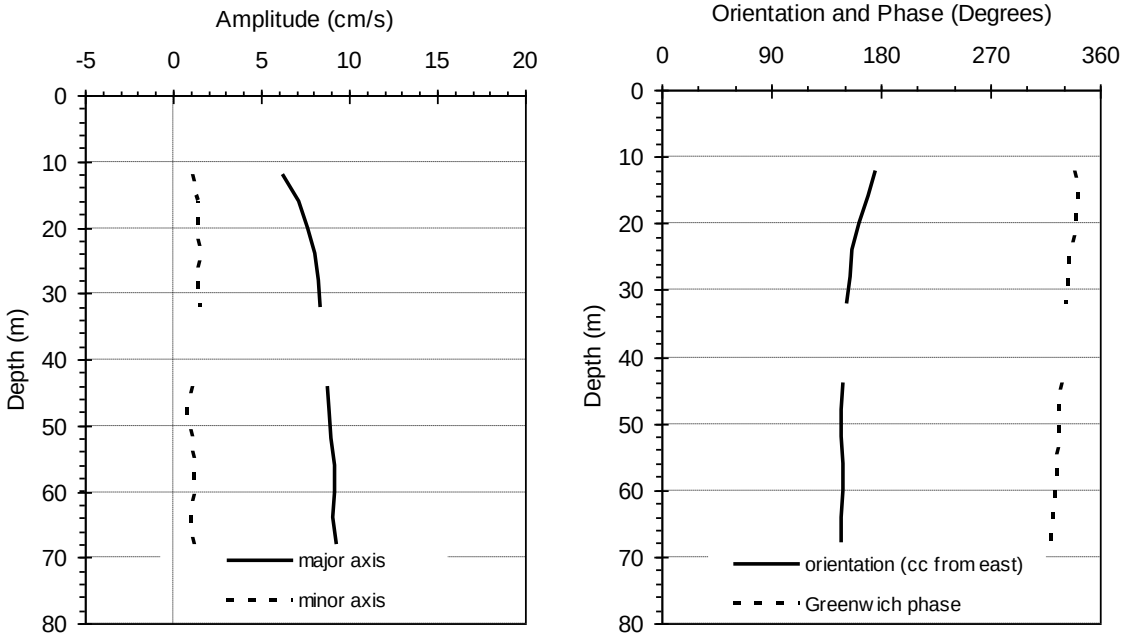
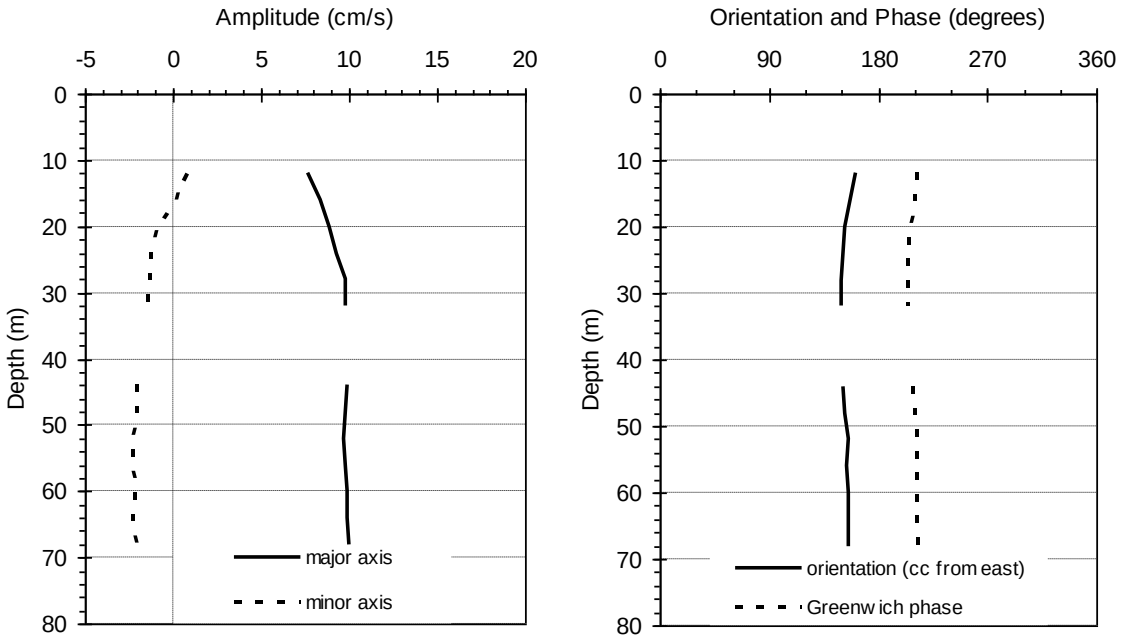


Figure 36: M2 Tidal Constituent, South Side of Barrow Strait

For Ice Free Period (Aug. 4, 2008 to Oct. 1, 2008):



For Solid Ice Period (Jan. 11, 2009 to Mar. 29, 2009):

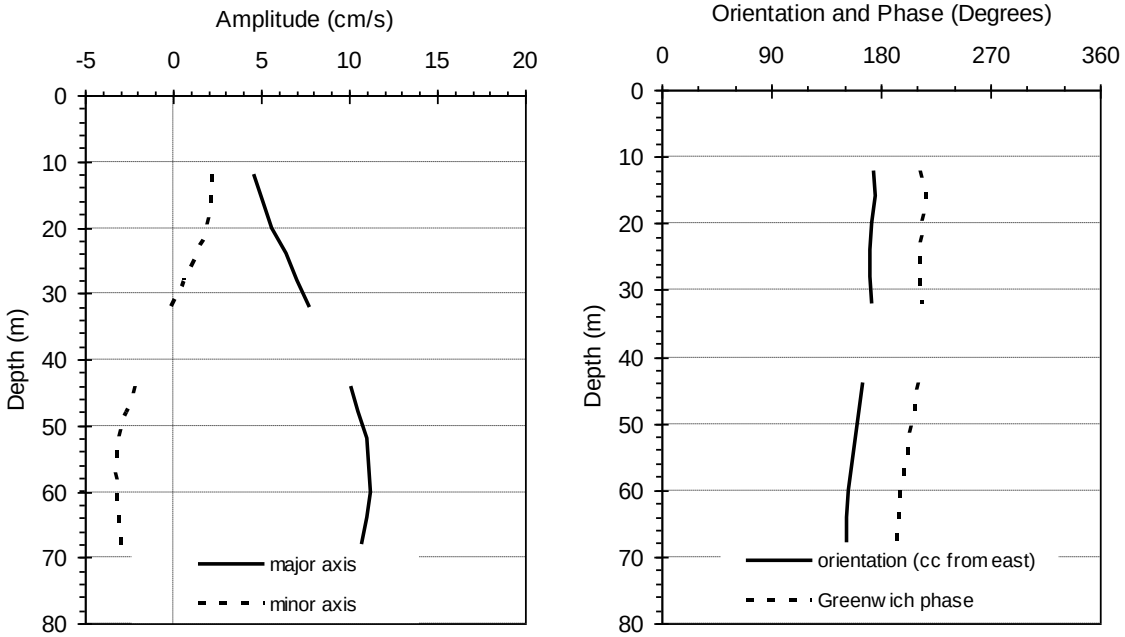
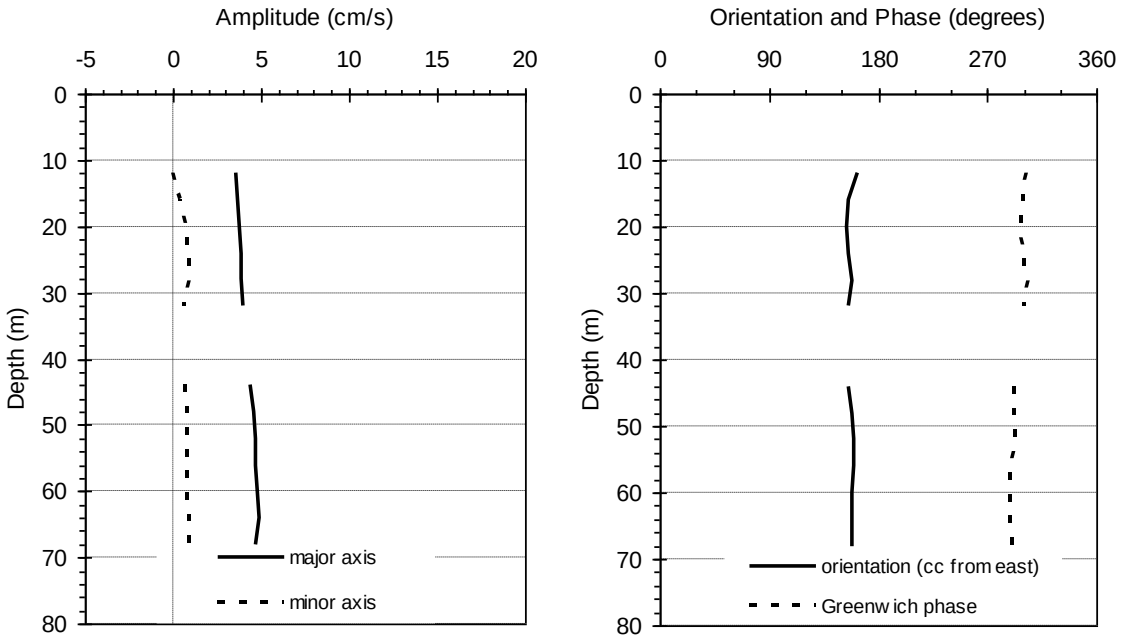


Figure 37: O1 Tidal Constituent, South Side of Barrow Strait

For Ice Free Period (Aug. 4, 2008 to Oct. 1, 2008):



For Solid Ice Period (Jan. 11, 2009 to Mar. 29, 2009):

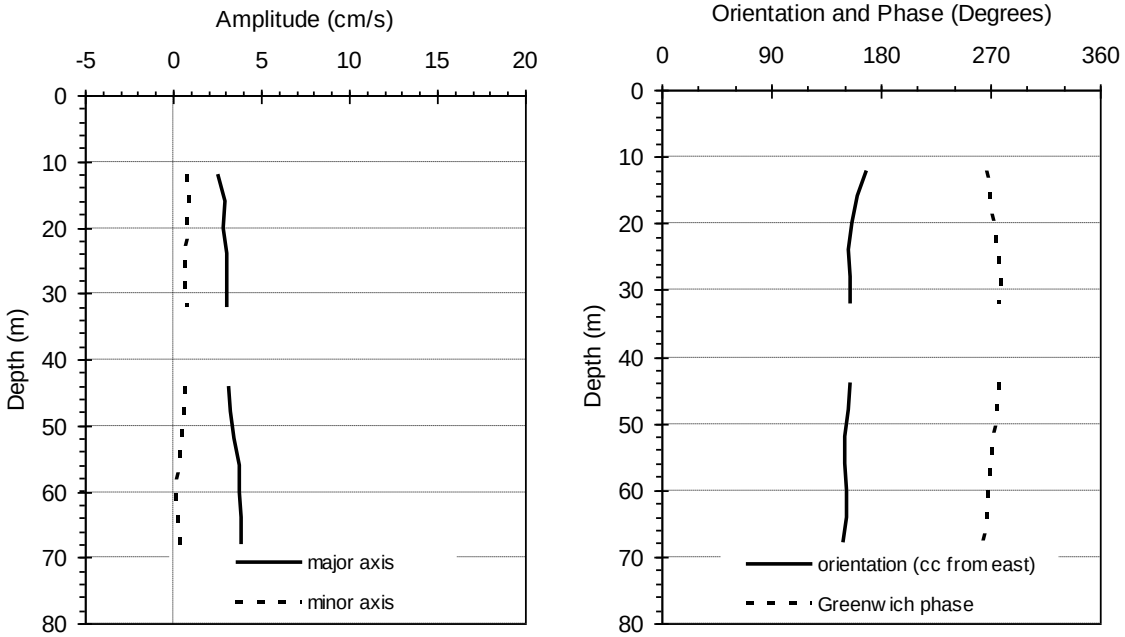
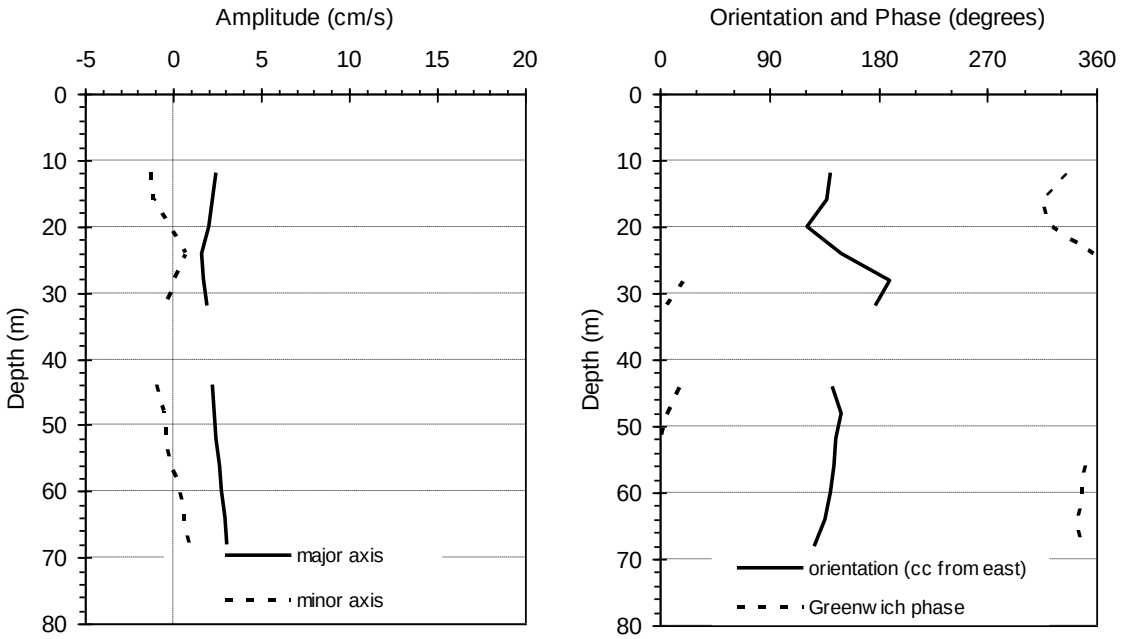


Figure 38: P1 Tidal Constituent, South Side of Barrow Strait

For Ice Free Period (Aug. 4, 2008 to Oct. 1, 2008):



For Solid Ice Period (Jan. 11, 2009 to Mar. 29, 2009):

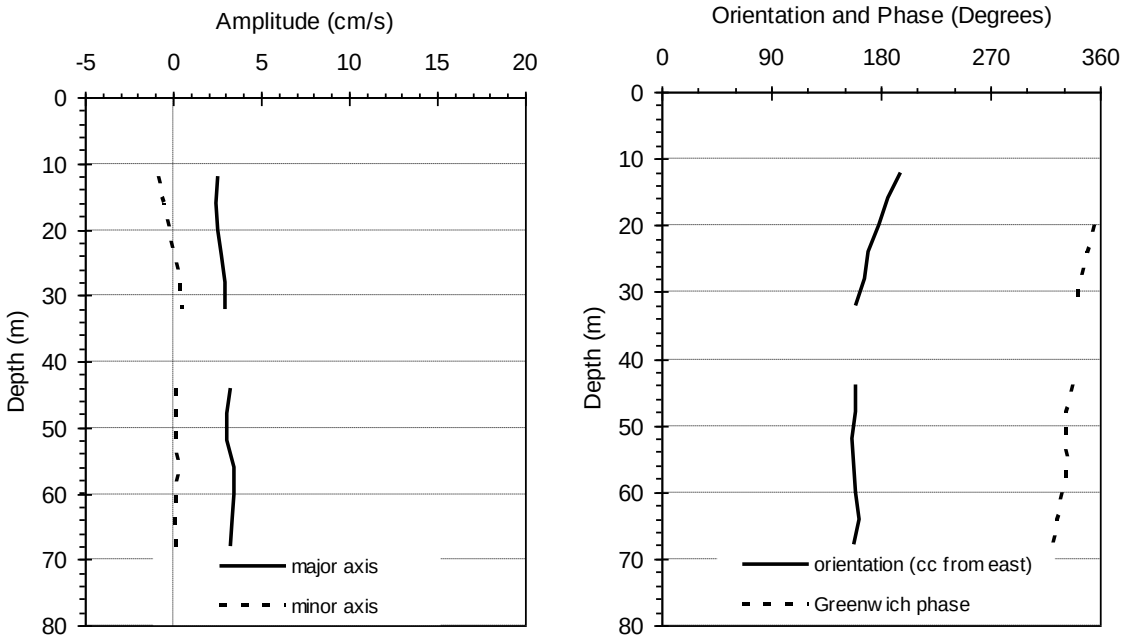
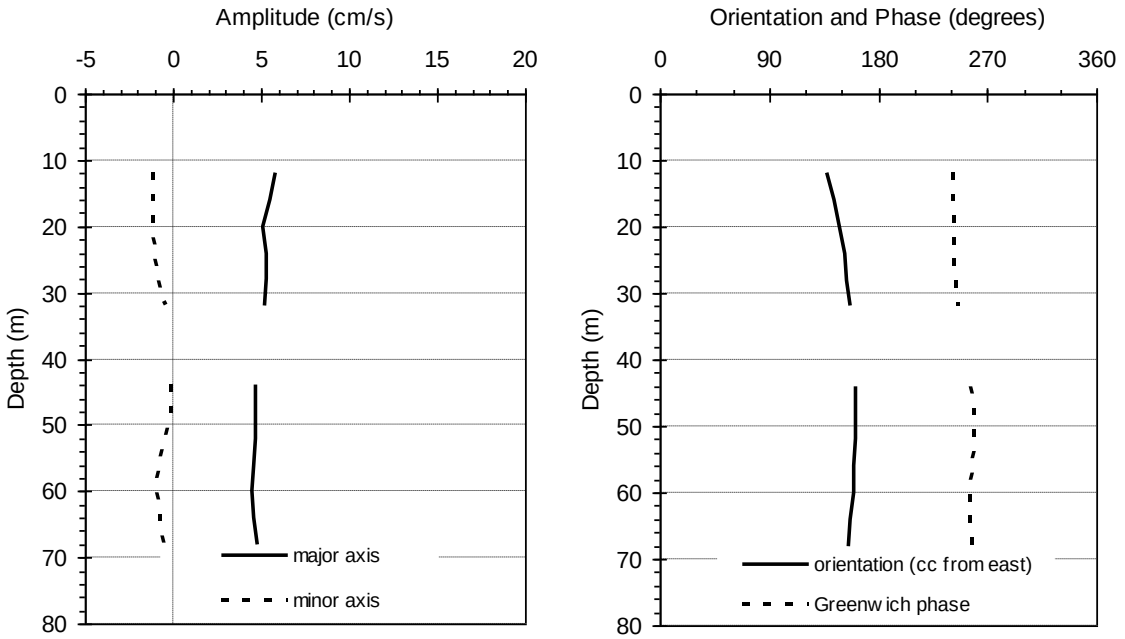


Figure 39: S2 Tidal Constituent, South Side of Barrow Strait

For Ice Free Period (Aug. 4, 2008 to Oct. 1, 2008):



For Solid Ice Period (Jan. 11, 2009 to Mar. 29, 2009):

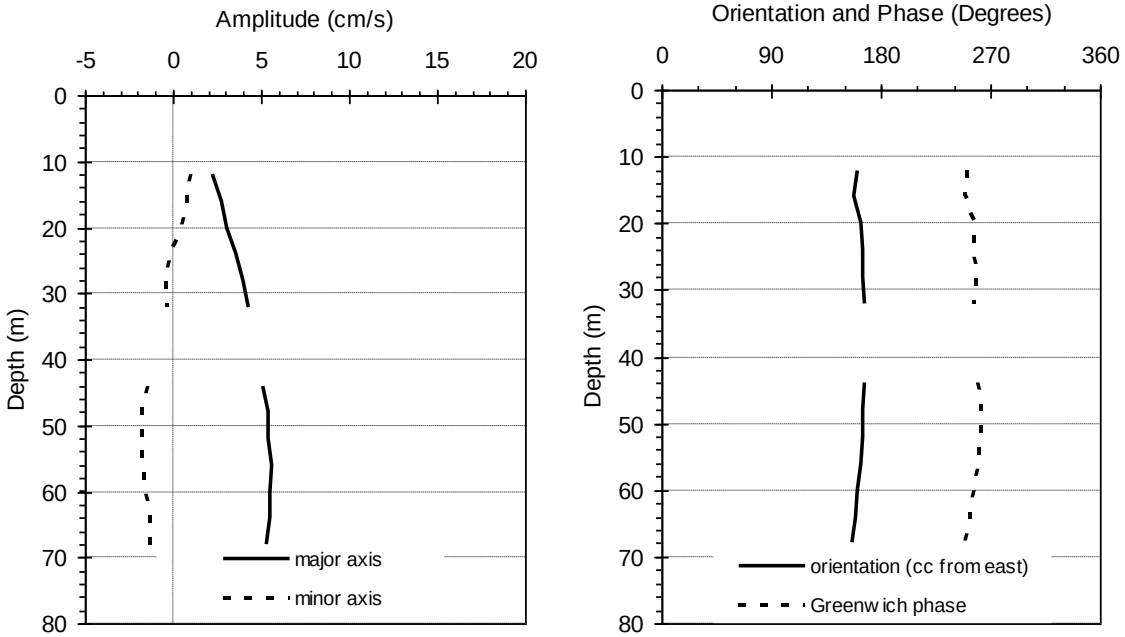
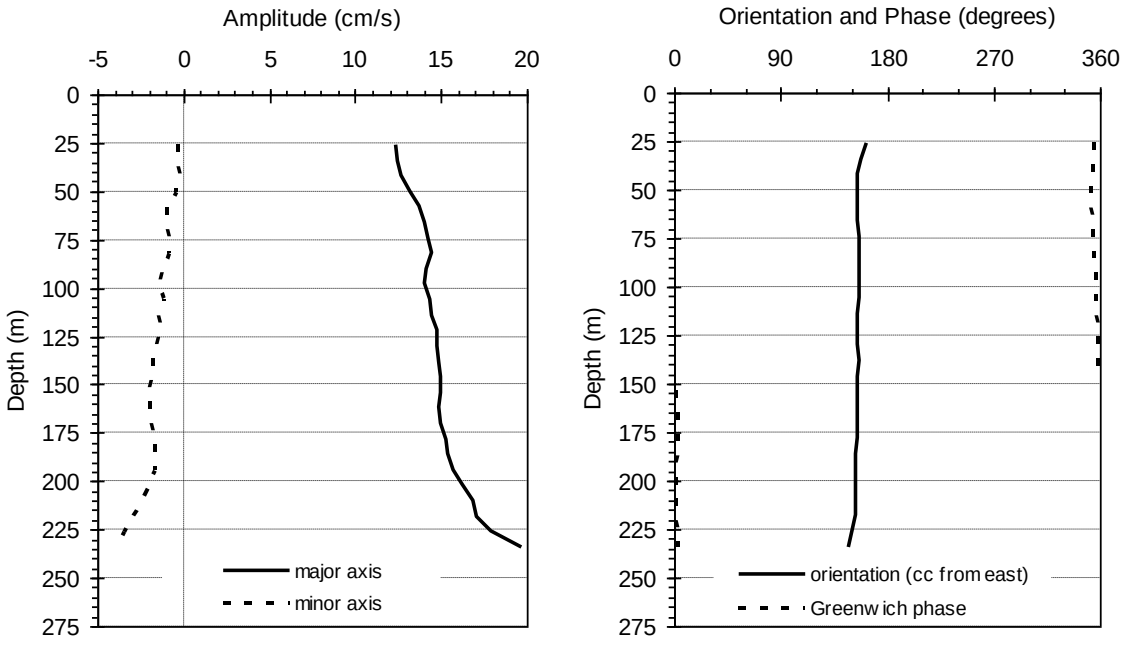


Figure 40: K1 Tidal Constituent, South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period

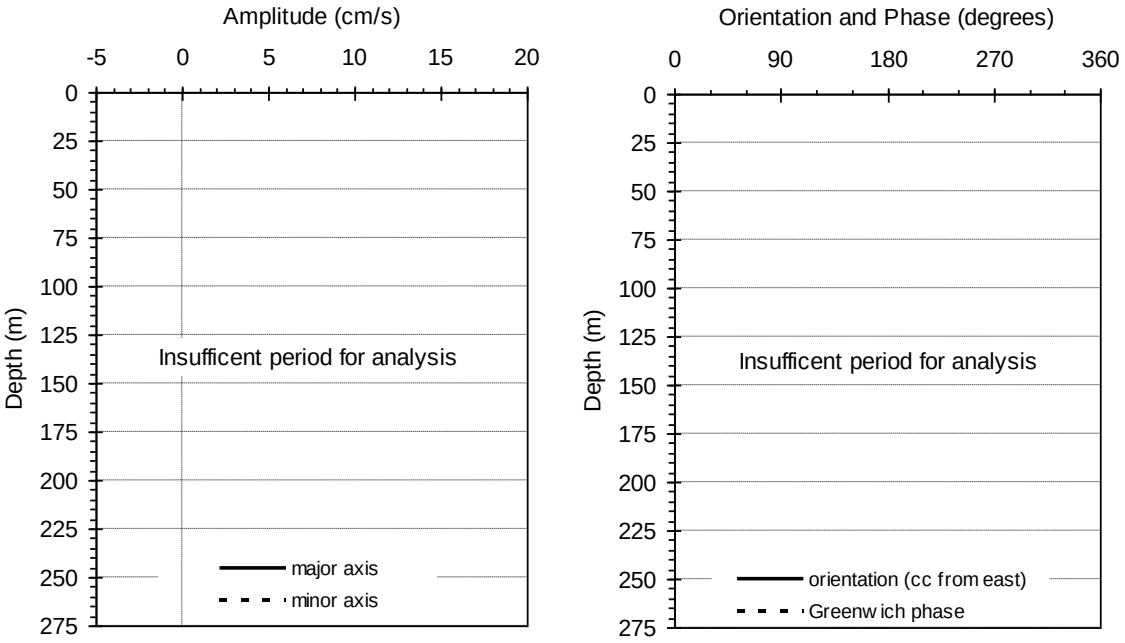
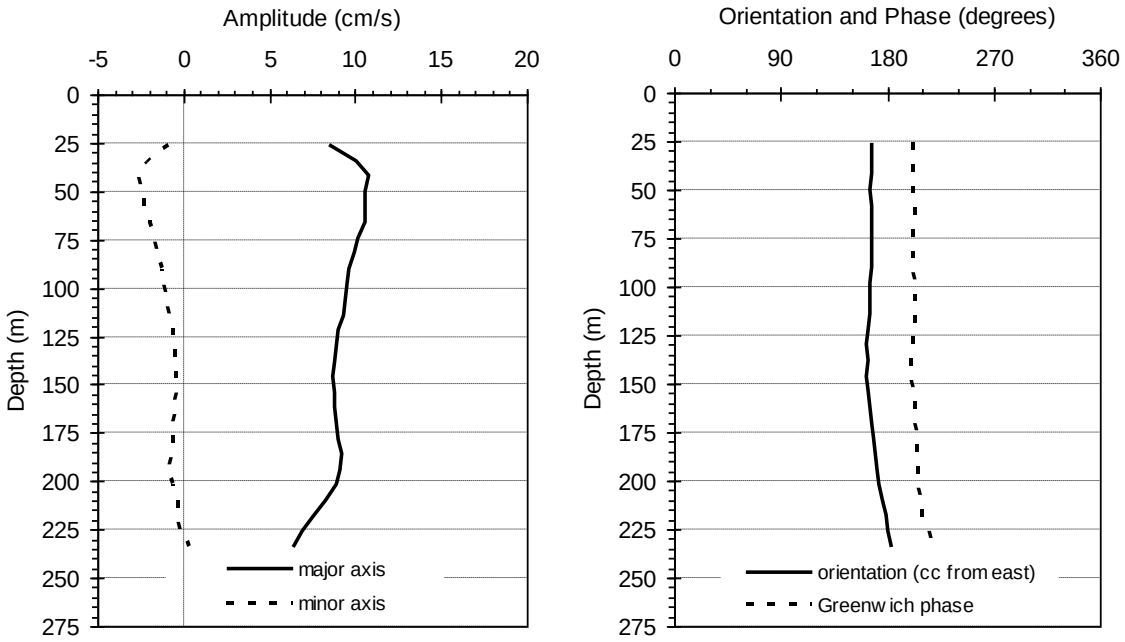


Figure 41: M2 Tidal Constituent, South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period

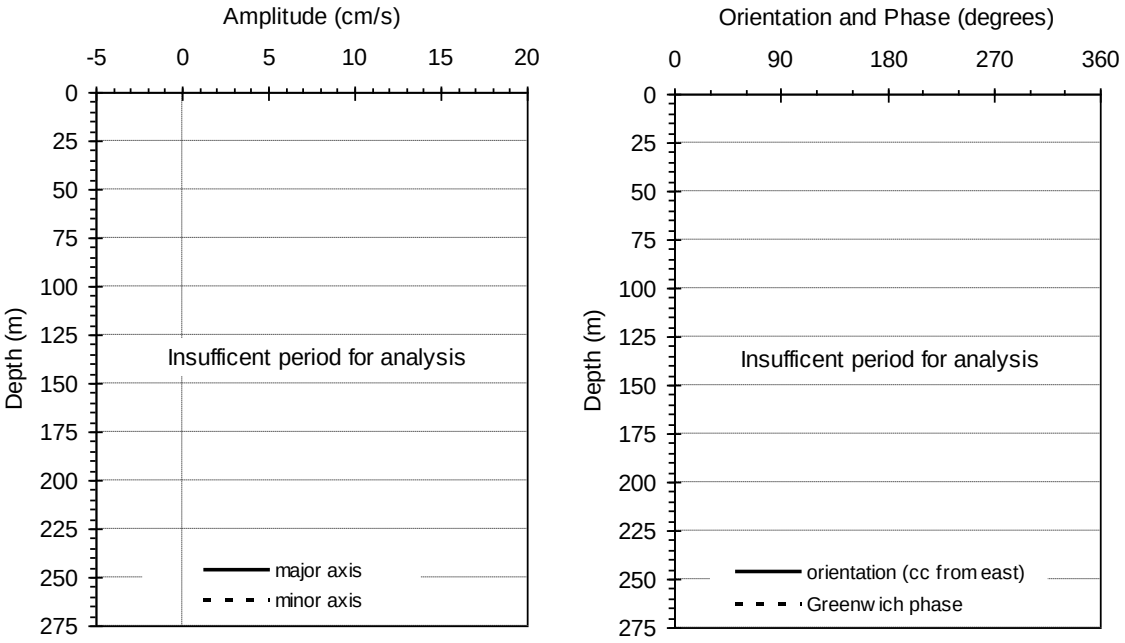
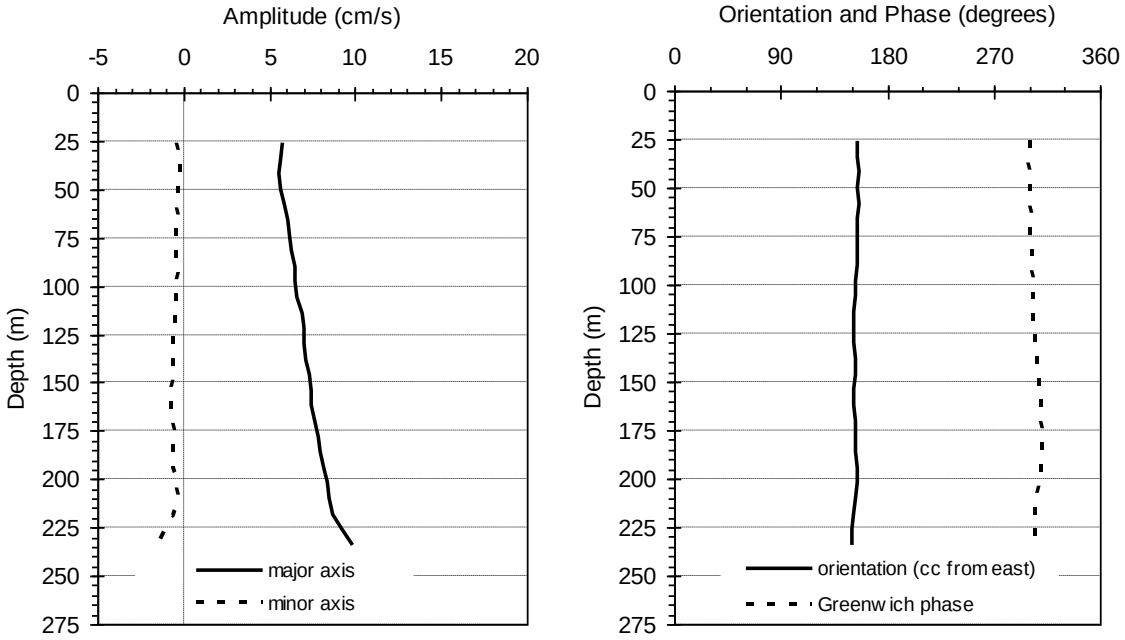


Figure 42: O1 Tidal Constituent, South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period

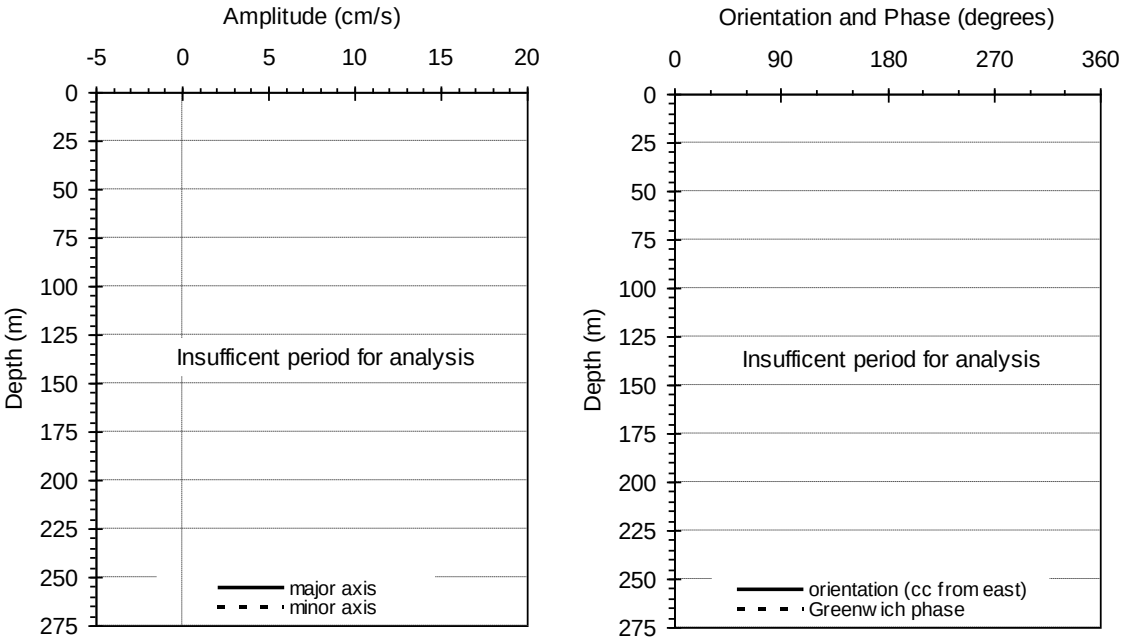
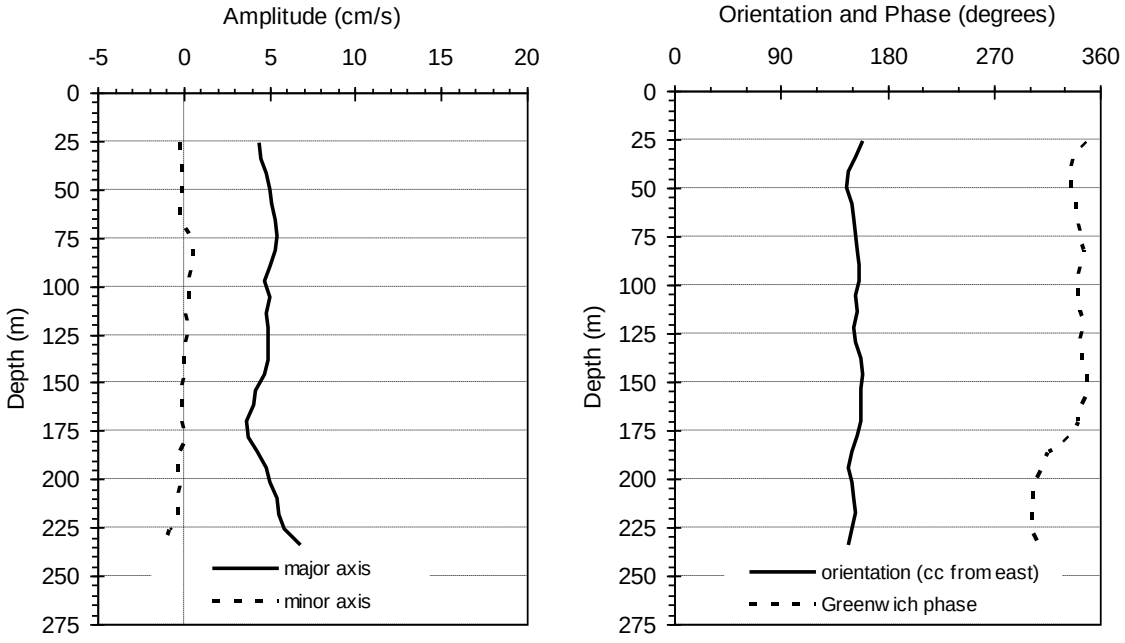


Figure 43: P1 Tidal Constituent, South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period

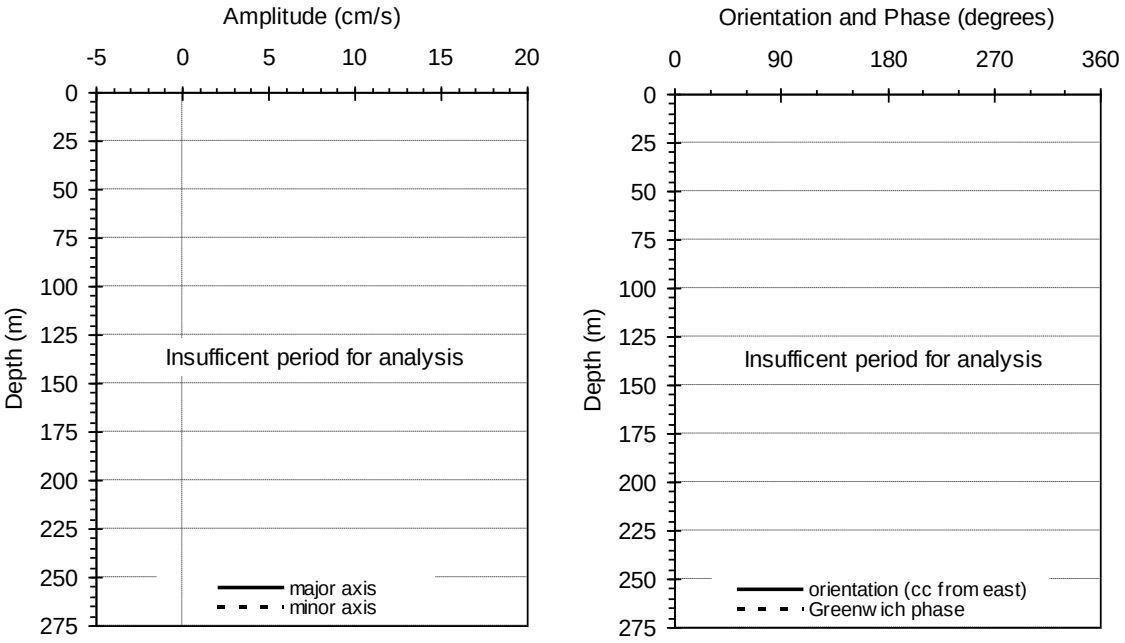
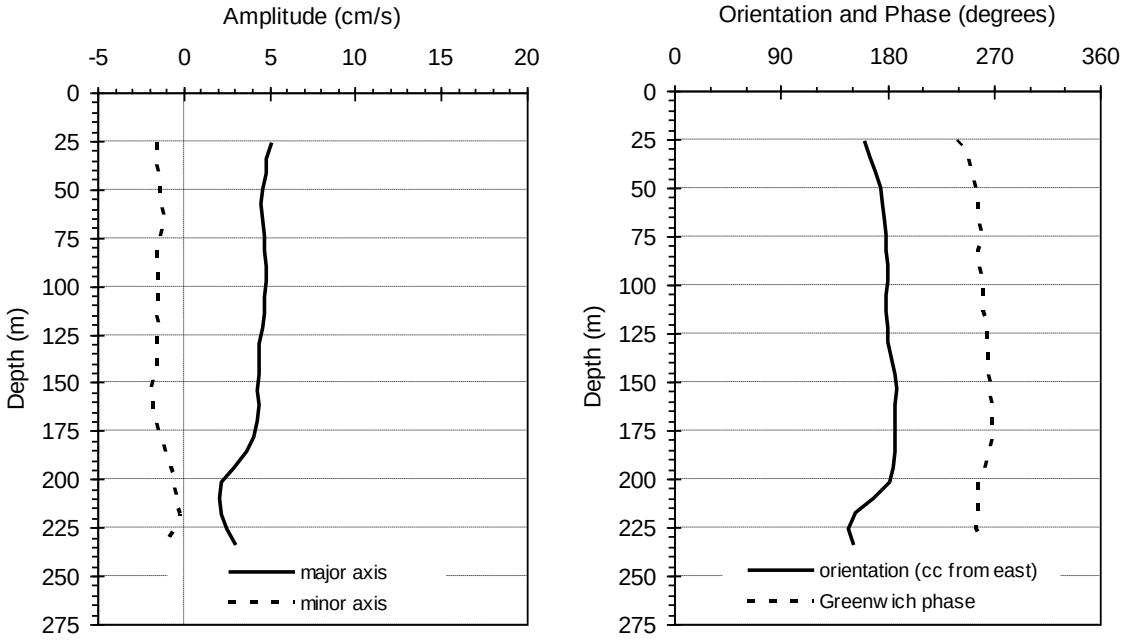


Figure 44: S2 Tidal Constituent, South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period

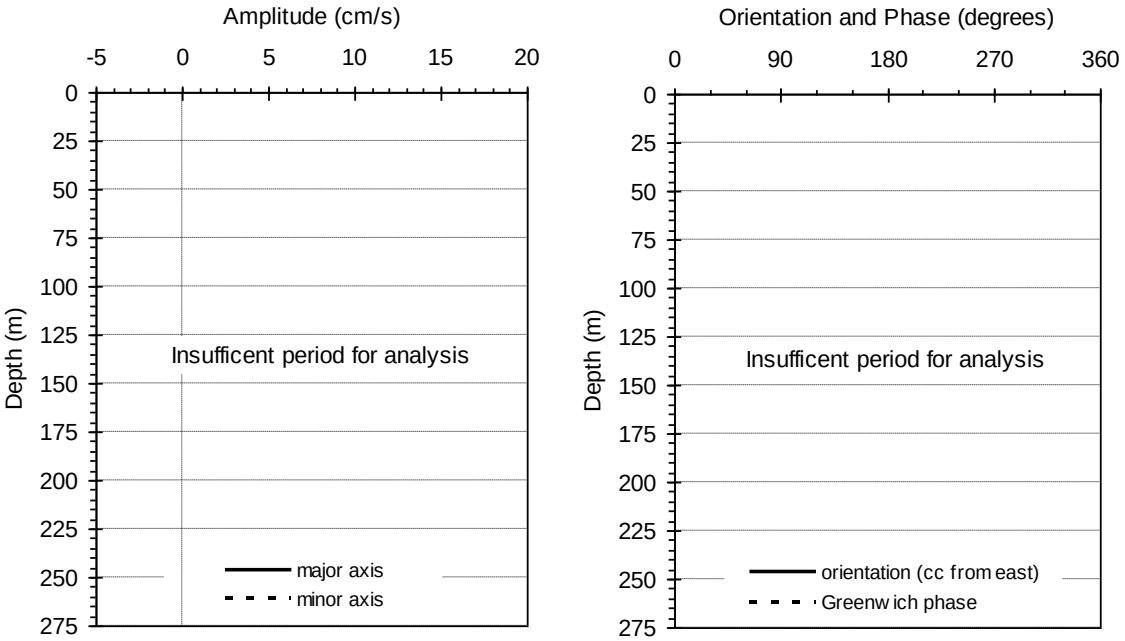
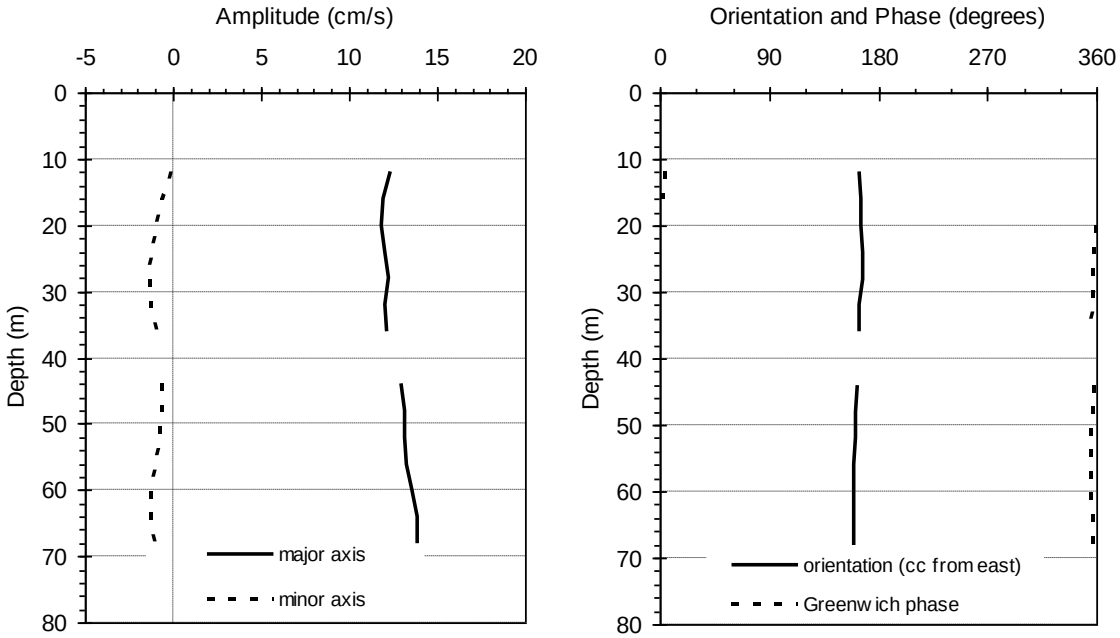


Figure 45: K1 Tidal Constituent, South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period

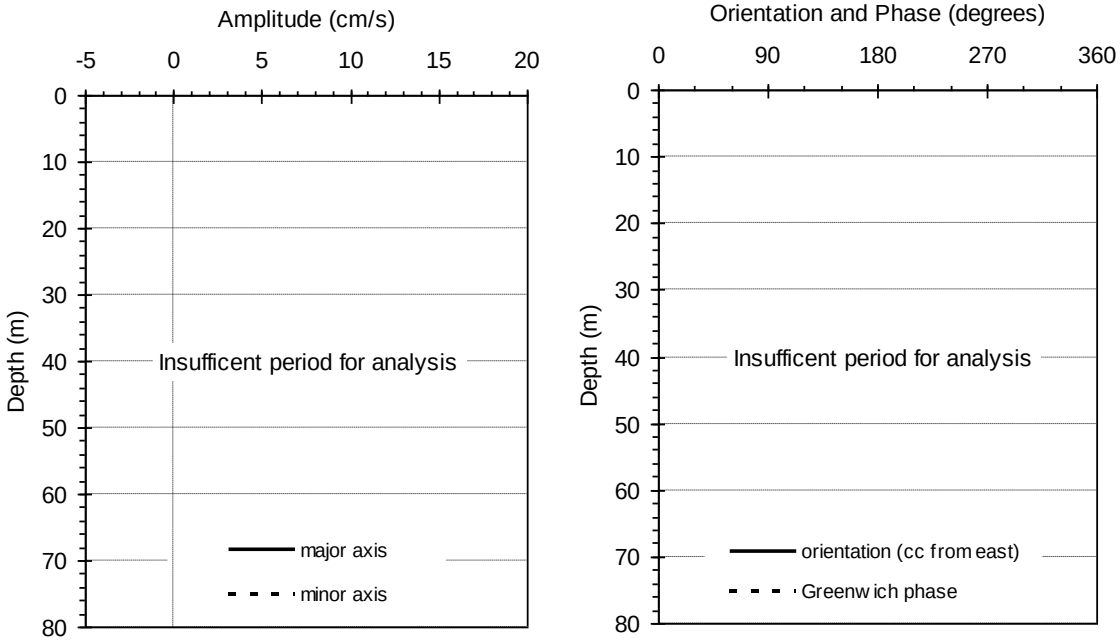
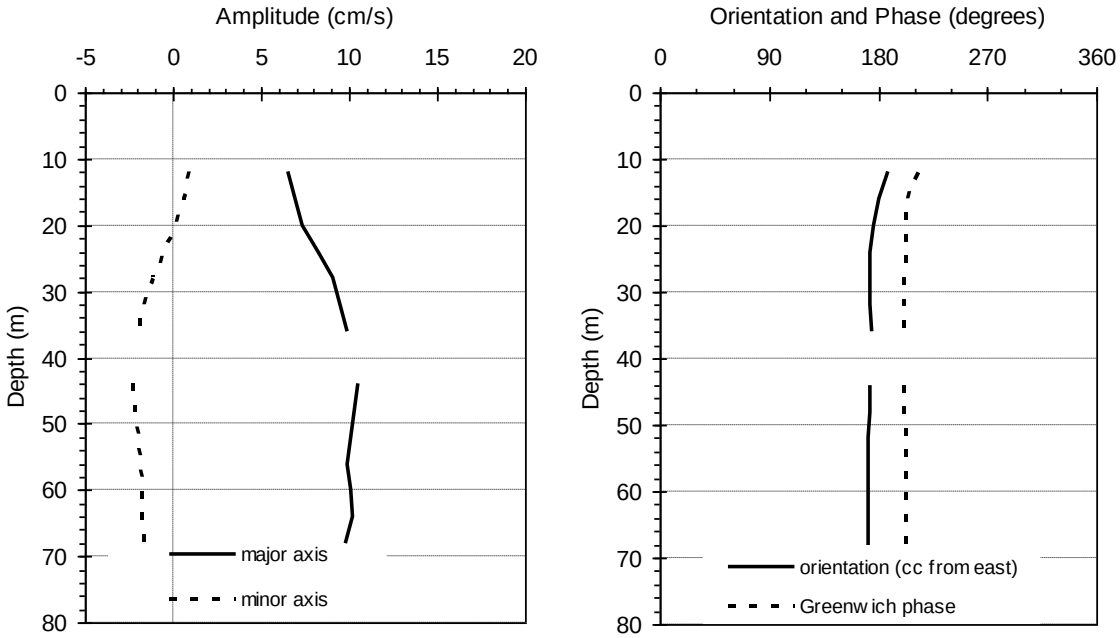


Figure 46: M2 Tidal Constituent, South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period

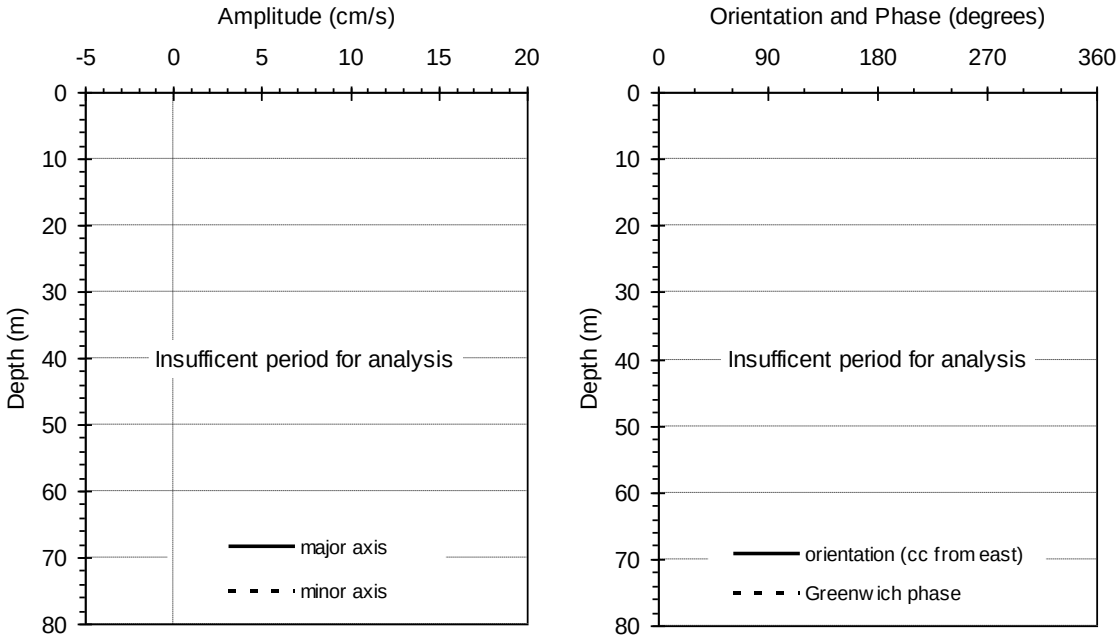
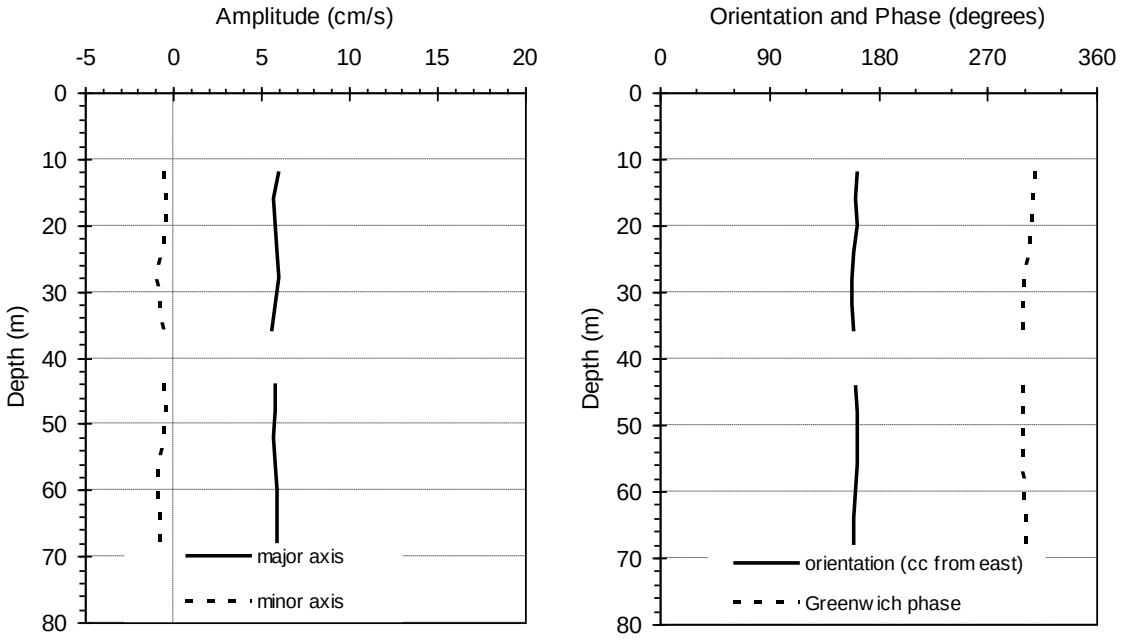


Figure 47: O1 Tidal Constituent, South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period

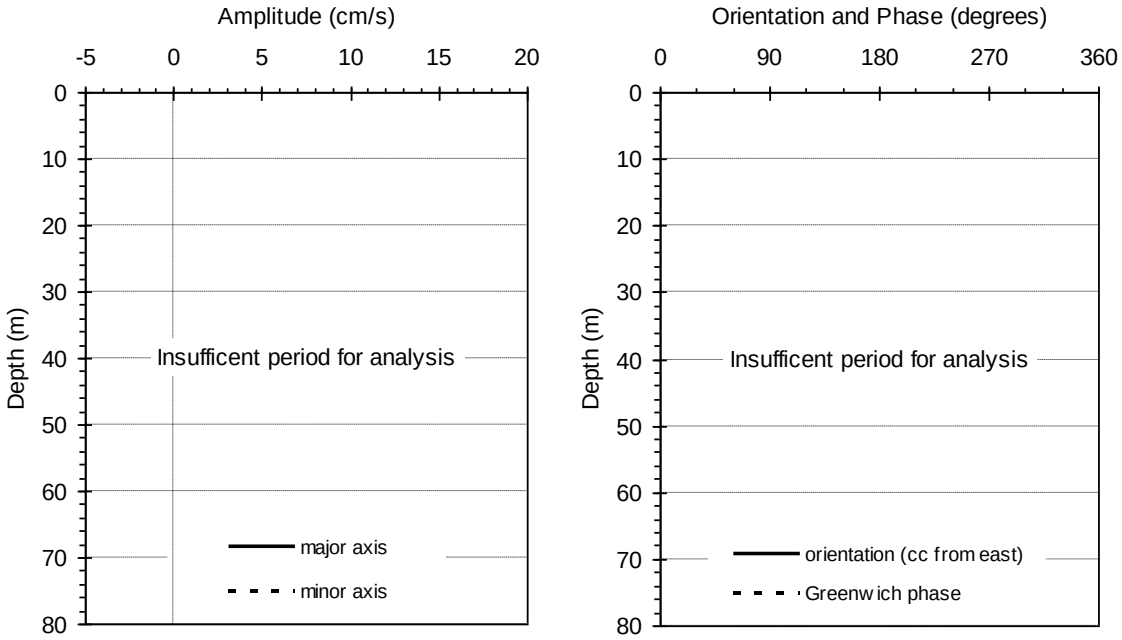
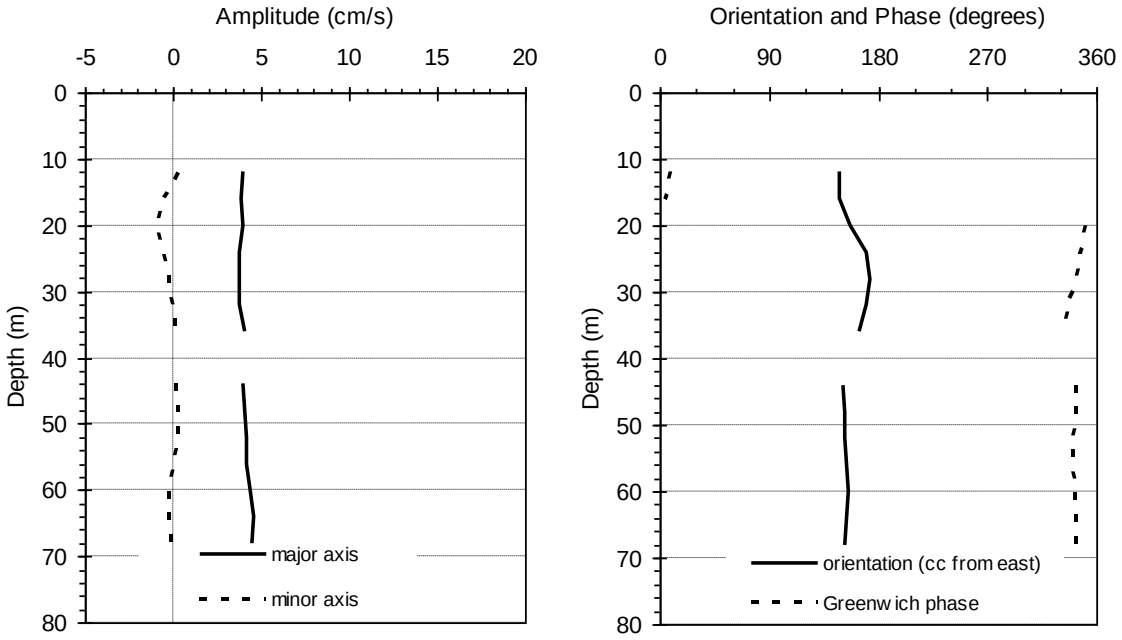


Figure 48: P1 Tidal Constituent, South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period

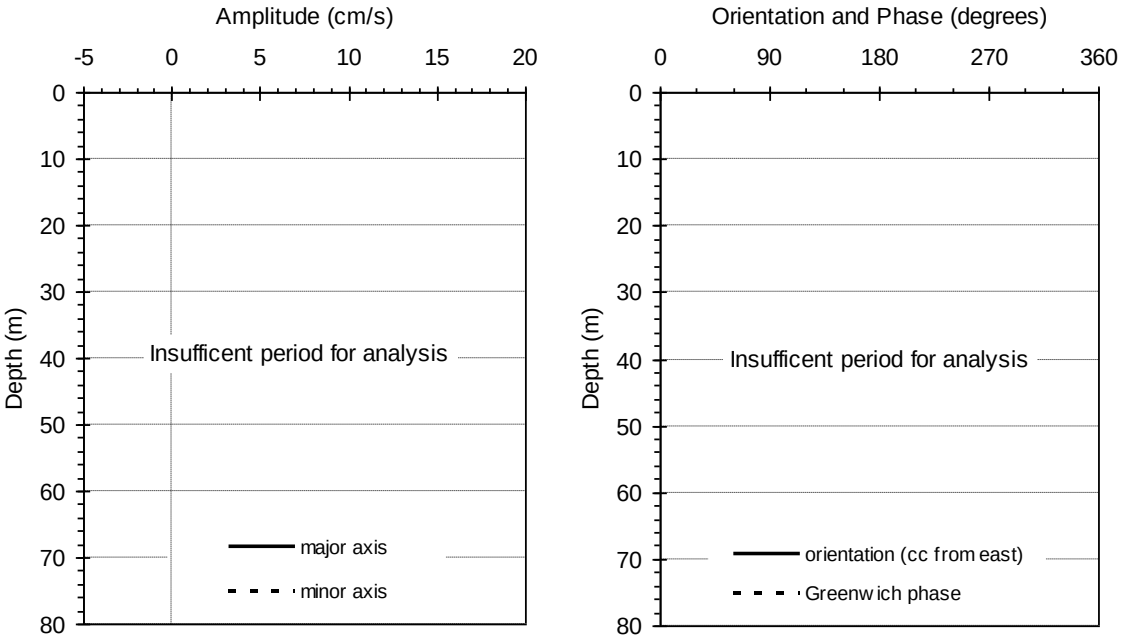
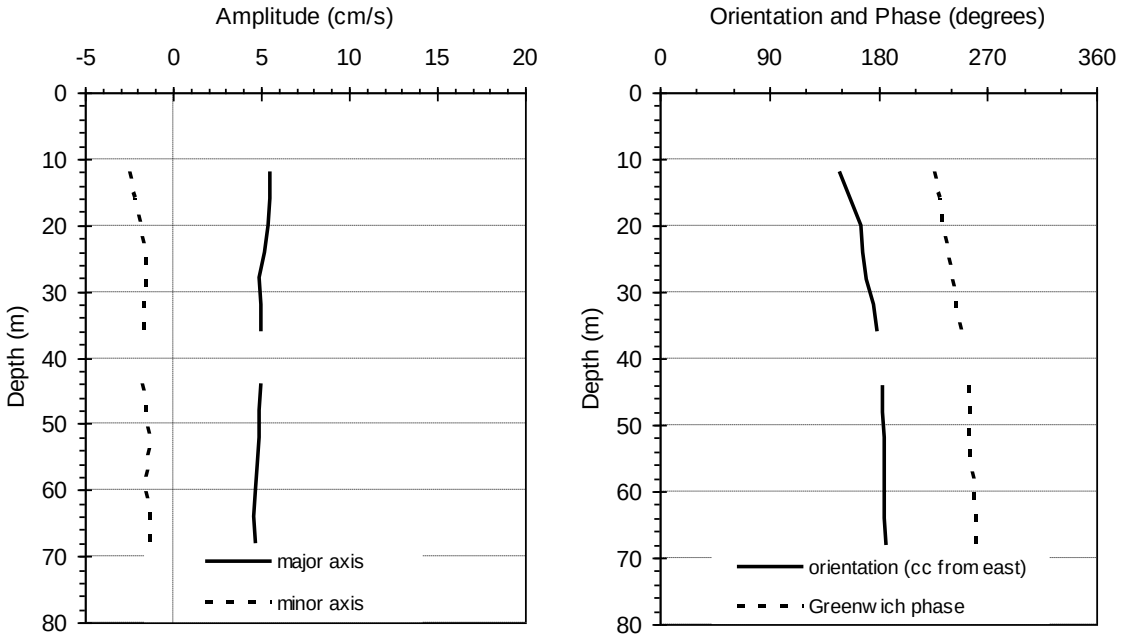
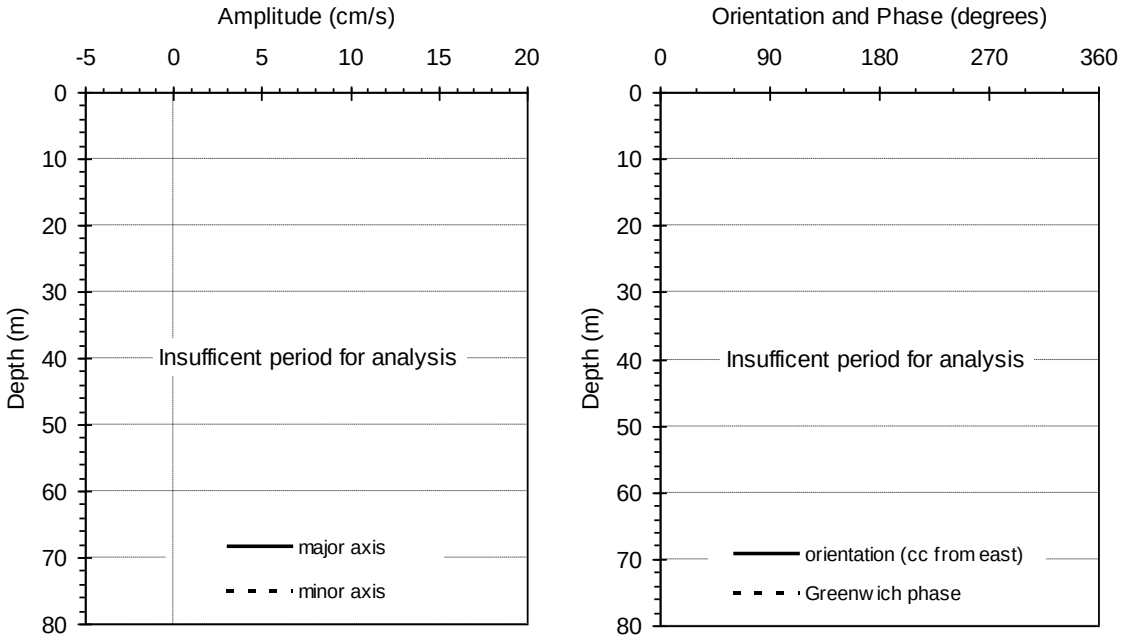


Figure 49: S2 Tidal Constituent, South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 to Oct. 6, 2008)



For Solid Ice Period



<u>Figure 50</u>: Ice velocity data, South side of Barrow Strait
August 2008 – August 2009

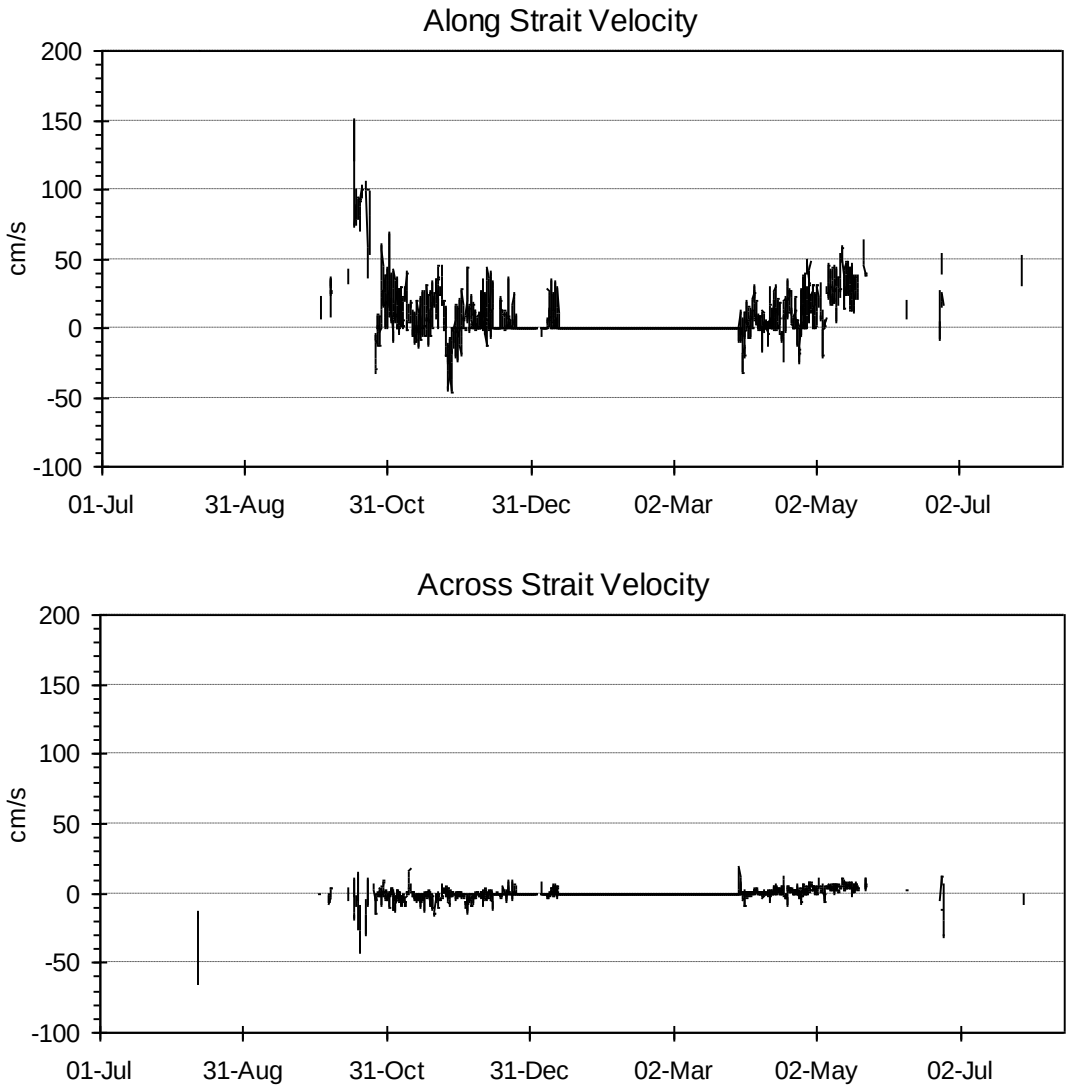


Figure 51: Ice velocity data, South-Central Barrow Strait (Workhorse ADCP) August 2008 – July 2009

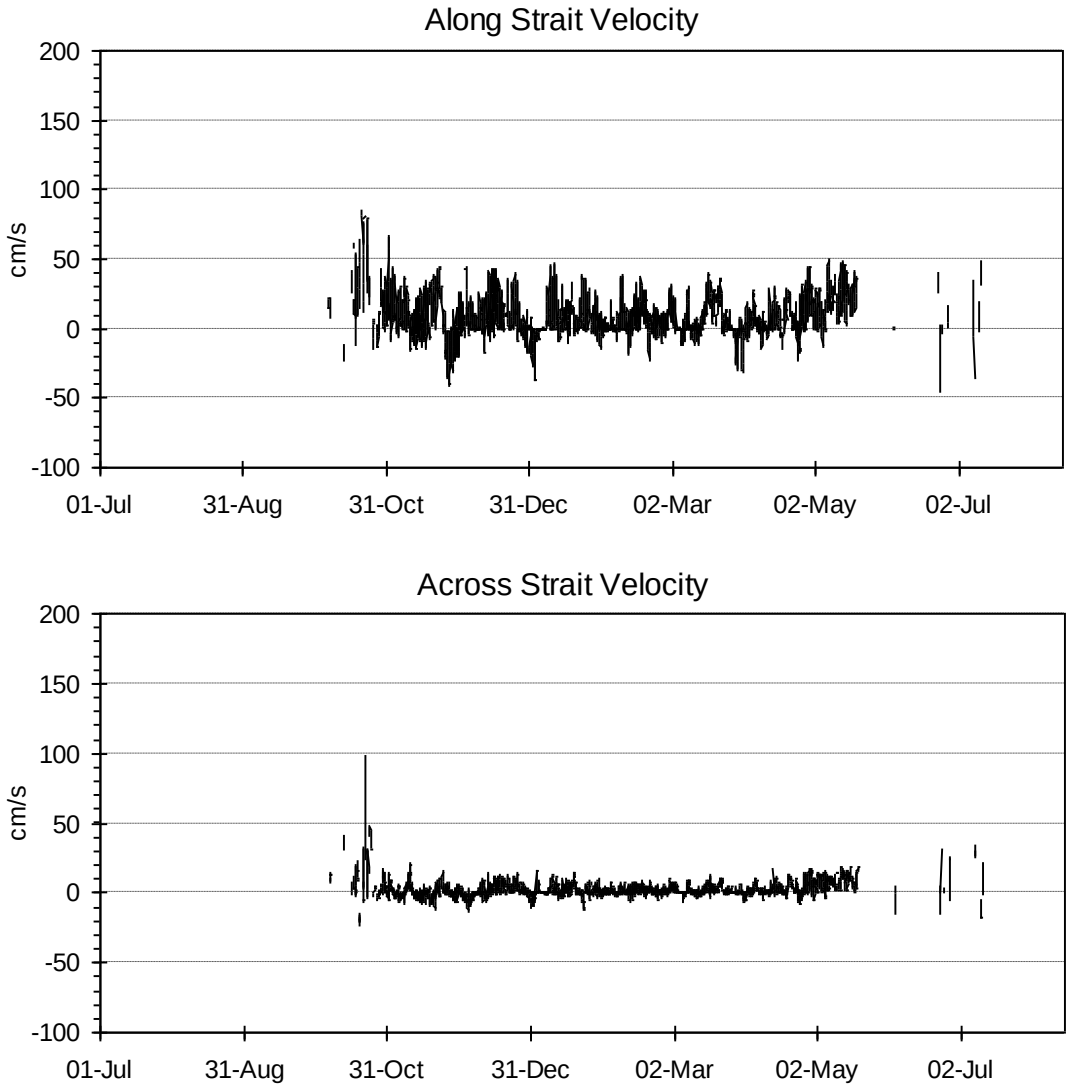


Figure 52: CTD Station Positions, August 2009

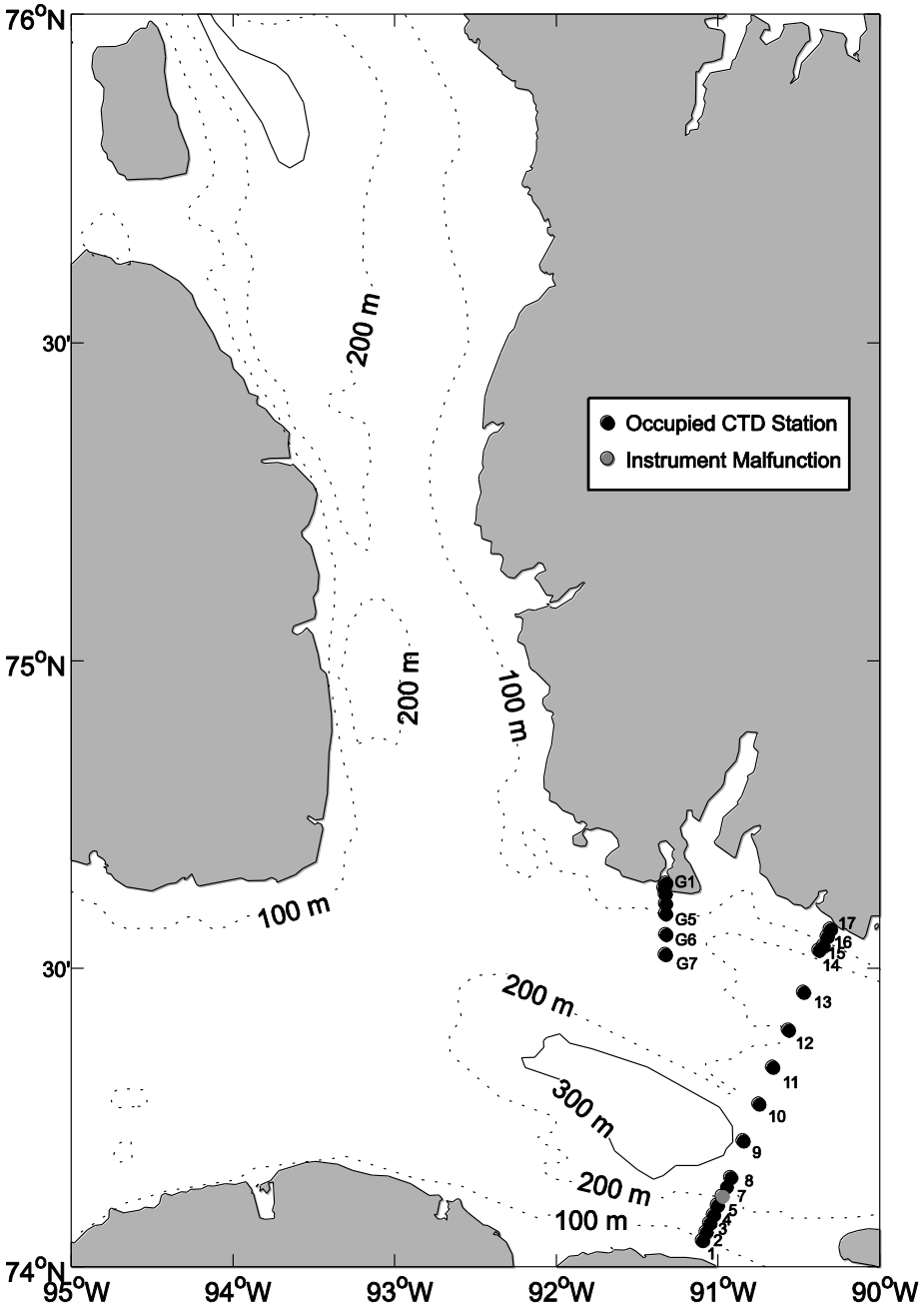


Figure 53: Eastern Barrow Strait CTD Line, Aug. 6-8, 2009

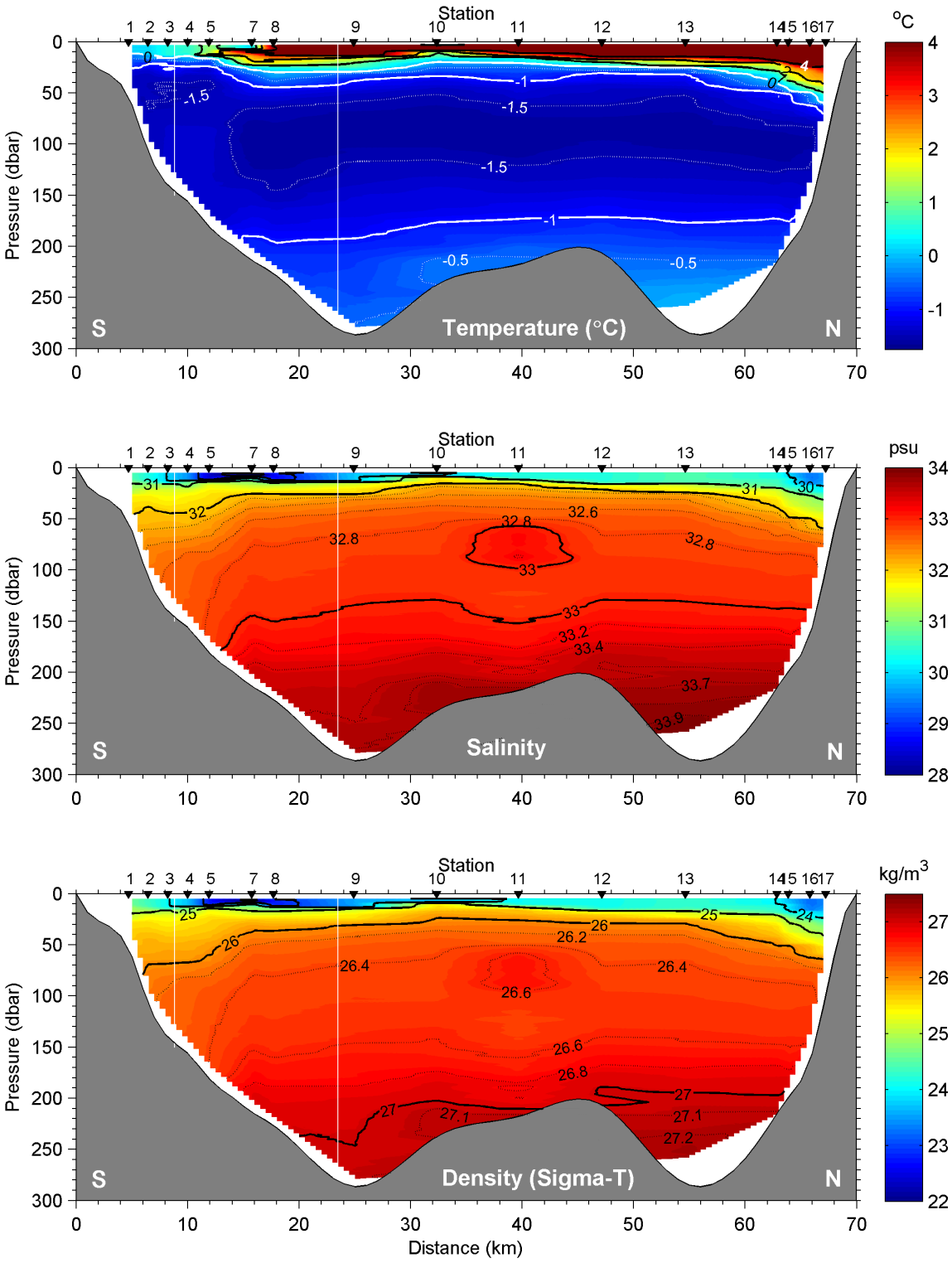


Table 1: Mooring Summary, 2008-2009

South Barrow Strait

BIO Consecutive Mooring #	Instrument Type	Moored Depth(m)	Sounding (m)	Latitude (N)	Longitude (W)	Start Date-Time (GMT)	End Date-Time (GMT)	Sampling Interval (Seconds)
†1685	ICYCLER	51	152	74.0832	-91.0137	05-Aug-2008 16:00	08-Oct-2008 16:00	86400
1685	MCTD	62	152	74.0832	-91.0137	04-Aug-2008 21:00	01-Aug-2009 18:30	1800
1686	MCTD	37	145	74.0817	-91.0481	04-Aug-2008 18:00	01-Aug-2009 17:00	1800
1686	WHADCP	74	145	74.0817	-91.0481	04-Aug-2008 18:00	01-Aug-2009 16:00	7200
1686	MCTD	76	145	74.0817	-91.0481	04-Aug-2008 18:00	01-Aug-2009 17:00	1800
1686	MCTD	142	145	74.0817	-91.0481	04-Aug-2008 18:00	01-Aug-2009 17:00	1800
1687	PCO2 Sampler	35	147	74.0794	-91.0267			
1687	Water sampler	36	147	74.0794	-91.0267	Aug-2008	Aug-2009	24 days

South-Central Barrow Strait

BIO Consecutive Mooring #	Instrument Type	Moored Depth (m)	Sounding (m)	Latitude (N)	Longitude (W)	Start Date-Time (GMT)	End Date-Time (GMT)	Sampling Interval (Seconds)
1688	QMADCP	249	274	74.1997	-90.8491	03-Aug-2008 20:00	02-Aug-2009 12:00	7200
1688	MCTD	269	274	74.1997	-90.8491	03-Aug-2008 20:00	02-Aug-2009 13:30	1800
1689	MCTD	37	267	74.1959	-90.8413	03-Aug-2008 19:30	02-Aug-2009 12:30	1800
‡1689	WHADCP	74	267	74.1959	-90.8413	03-Aug-2008 20:00	16-Jul-2009 14:00	7200
1689	MCTD	76	267	74.1959	-90.8413	03-Aug-2008 19:30	02-Aug-2009 12:30	1800
1689	MCTD	157	267	74.1959	-90.8413	03-Aug-2008 19:30	02-Aug-2009 12:30	1800
1690	IPS	55	270	Not Deployed				

ArcticNet

BIO Consecutive Mooring #	Instrument Type	Moored Depth (m)	Sounding (m)	Latitude (N)	Longitude (W)	Start Date-Time (GMT)	End Date-Time (GMT)	Sampling Interval (Seconds)
1691	ULS	44	274	74.4697	-90.3850			
1691	MCTD	45	274	74.4697	-90.3850	05-Aug-2008 21:00	02-Aug-2009 17:00	1800
1691	hydrophone	58	274	74.4697	-90.3850			

† Data terminated early due to instrument failure

‡ Battery was dead on recovery, resulting in less data return

Table 2: South Barrow Strait, Microcat/ADCP statistical summary
Late summer: August 4, 2008 - September 20, 2008

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	32	-1.22	0.21	-1.70	-0.14	32.21	0.46	30.09	32.76	25.90	0.37	24.18	26.36	24.96	15.67	-27.36	72.09	0.85	6.82	-19.05	20.80
62	60	-1.47	0.12	-1.70	-0.97	32.62	0.10	32.17	32.89	26.24	0.09	25.86	26.45	21.99	14.36	-29.17	63.32	0.37	5.52	-17.59	16.04
76	68	-1.51	0.09	-1.72	-1.20	32.69	0.08	32.43	32.96	26.30	0.06	26.07	26.51	20.93	14.04	-28.57	62.04	0.60	5.28	-15.45	17.88
142		-1.51	0.09	-1.67	-0.92	32.85	0.09	32.68	33.47	26.43	0.07	26.28	26.91								

Table 3: South-Central Barrow Strait, Microcat/ADCP statistical summary
Late summer: August 3, 2008 - September 20, 2008

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	36	-1.28	0.29	-1.71	0.32	32.44	0.24	30.41	32.87	26.09	0.20	24.39	26.44	12.68	14.37	-36.59	48.73	6.31	6.45	-9.64	30.78
76	74	-1.58	0.09	-1.77	-1.38	32.84	0.06	32.61	32.98	26.42	0.05	26.23	26.54	11.07	14.10	-24.45	47.63	4.49	5.35	-9.15	22.24
157	154	-1.34	0.12	-1.59	-0.84	33.12	0.11	32.91	33.57	26.64	0.08	26.47	26.99	9.33	14.47	-25.48	47.46	4.30	6.03	-11.60	25.94
265	234	-0.34	0.13	-1.01	-0.15	33.79	0.07	33.29	33.90	27.15	0.05	26.77	27.25	3.07	18.83	-42.83	43.70	7.66	9.34	-17.24	41.81

Table 4: South Barrow Strait, Microcat/ADCP statistical summary
Fall: September 21, 2008 – December 20, 2008

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	32	-1.59	0.18	-1.75	-1.02	31.64	0.35	30.50	32.57	25.45	0.28	24.51	26.19	11.34	27.24	-49.20	133.31	-0.52	6.64	-32.85	23.15
62	60	-1.46	0.16	-1.75	-1.11	32.13	0.35	31.04	32.79	25.84	0.28	24.96	26.38	7.06	23.19	-56.83	121.53	-0.13	6.55	-33.07	23.52
76	68	-1.39	0.12	-1.75	-1.12	32.44	0.20	31.63	32.85	26.09	0.16	25.43	26.42	6.31	22.63	-59.70	110.84	-0.12	6.26	-31.99	21.69
142		-1.17	0.23	-1.50	-0.43	33.08	0.28	32.46	33.73	26.61	0.22	26.10	27.11								

Table 5: South-Central Barrow Strait, Microcat/ADCP statistical summary
Fall: September 21, 2008 – December 20, 2008

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	36	-1.55	0.27	-1.75	-0.53	31.93	0.29	31.00	32.67	25.68	0.23	24.93	26.28	7.77	16.58	-37.44	59.00	3.92	7.04	-17.25	30.61
76	74	-1.42	0.09	-1.76	-1.15	32.55	0.23	31.90	33.01	26.18	0.19	25.65	26.55	6.87	16.85	-35.07	54.75	2.62	6.44	-15.35	26.80
157	154	-1.26	0.10	-1.54	-0.67	33.14	0.11	32.87	33.63	26.66	0.08	26.44	27.03	5.54	16.71	-34.83	57.17	2.64	7.11	-19.45	32.64
265	234	-0.35	0.20	-1.28	0.12	33.78	0.11	33.17	34.02	27.14	0.08	26.68	27.32	3.69	17.01	-45.94	45.86	7.82	8.38	-13.04	38.47

Table 6: South Barrow Strait, Microcat/ADCP statistical summary
Winter: December 21, 2008 – March 20, 2009

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	32	-1.62	0.12	-1.77	-1.25	32.12	0.20	31.11	32.51	25.83	0.17	25.02	26.15	10.34	12.06	-36.90	48.82	-0.73	4.59	-14.14	13.57
62	60	-1.53	0.16	-1.77	-1.19	32.33	0.36	31.06	32.72	26.00	0.29	24.97	26.32	12.95	14.22	-27.08	53.05	-1.04	5.34	-16.90	15.15
76	68	-1.50	0.18	-1.78	-1.20	32.61	0.07	32.23	32.83	26.23	0.06	25.92	26.40	12.71	14.29	-30.43	50.29	-0.91	5.36	-18.09	16.70
142		-1.34	0.12	-1.67	-0.88	32.89	0.09	32.61	33.42	26.45	0.07	26.23	26.87								

Table 7: South-Central Barrow Strait, Microcat/ADCP statistical summary
Winter: December 21, 2008 – March 20, 2009

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	36	-1.68	0.09	-1.78	-1.26	32.11	0.27	30.66	32.68	25.83	0.22	24.65	26.29	9.24	13.97	-37.74	56.86	4.21	5.90	-15.91	23.84
76	74	-1.63	0.13	-1.79	-1.22	32.58	0.11	32.11	32.89	26.21	0.09	25.83	26.47	8.57	15.24	-35.46	52.56	3.11	6.59	-17.04	28.86
157	154	-1.29	0.15	-1.77	-0.90	33.06	0.13	32.64	33.42	26.59	0.10	26.26	26.87	7.28	15.50	-29.39	48.51	3.58	6.19	-14.44	26.68
265	234	-0.41	0.16	-1.04	-0.08	33.73	0.10	33.29	33.90	27.10	0.07	26.77	27.22	3.52	18.31	-43.16	45.84	7.94	7.89	-11.81	33.55

Table 8: South Barrow Strait, Microcat/ADCP statistical summary
Spring: March 21, 2009 – June 20, 2009

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	32	-1.51	0.20	-1.76	0.36	32.07	0.18	31.20	32.89	25.79	0.15	25.06	26.45	22.37	19.33	-58.89	78.01	0.43	5.93	-24.36	24.72
62	60	-1.49	0.15	-1.76	-0.60	32.42	0.15	31.70	32.88	26.08	0.13	25.49	26.45	18.43	16.36	-34.12	59.56	0.30	5.21	-19.43	23.13
76	68	-1.48	0.14	-1.76	-0.56	32.56	0.13	31.90	32.94	26.19	0.10	25.65	26.50	16.82	15.98	-35.00	59.45	0.20	5.37	-19.72	23.63
142		-1.37	0.15	-1.74	-0.92	32.90	0.15	32.59	33.41	26.46	0.12	26.21	26.86								

Table 9: South-Central Barrow Strait, Microcat/ADCP statistical summary
Spring: March 21, 2009 – June 20, 2009

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	36	-1.53	0.25	-1.80	0.58	32.40	0.23	31.42	32.95	26.06	0.19	25.25	26.51	12.21	14.63	-31.98	52.21	5.60	6.39	-18.13	27.97
76	74	-1.62	0.10	-1.79	-1.08	32.76	0.09	32.42	33.02	26.35	0.08	26.07	26.57	13.19	15.74	-26.37	53.03	3.55	6.50	-17.65	26.65
157	154	-1.37	0.13	-1.79	-1.01	33.02	0.08	32.78	33.40	26.56	0.06	26.37	26.86	9.19	15.93	-29.11	56.26	3.88	6.54	-15.59	23.81
265	234	-0.53	0.13	-1.19	-0.32	33.68	0.08	33.16	33.79	27.06	0.06	26.67	27.14	3.55	18.04	-44.19	41.78	7.53	9.05	-20.96	39.78

Table 10: South Barrow Strait, Microcat/ADCP statistical summary
Early Summer: June 21, 2009 – August 1, 2009

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	32	-1.42	0.22	-1.65	1.18	32.02	0.16	31.25	32.50	25.75	0.13	25.10	26.14	29.37	17.26	-21.69	70.43	1.47	6.52	-16.49	31.18
62	60	-1.41	0.08	-1.62	-1.21	32.41	0.11	31.98	32.67	26.07	0.09	25.72	26.28	24.12	16.23	-20.47	67.59	0.55	5.61	-16.70	17.23
76	68	-1.38	0.08	-1.62	-1.26	32.55	0.10	32.17	32.77	26.18	0.08	25.87	26.36	22.26	15.96	-21.48	66.53	0.26	5.91	-20.94	19.75
142		-1.38	0.08	-1.69	-1.26	32.82	0.08	32.59	33.01	26.40	0.06	26.21	26.55								

Table 11: South-Central Barrow Strait, Microcat/ADCP statistical summary
Early Summer: June 21, 2009 – August 2, 2009†

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	36	-1.14	0.33	-1.63	0.57	32.51	0.14	31.27	32.93	26.14	0.12	25.07	26.48	13.42	17.07	-30.40	58.67	7.26	6.94	-10.70	29.56
76	74	-1.59	0.08	-1.76	-1.29	32.83	0.04	32.64	32.98	26.41	0.03	26.25	26.53	12.28	17.38	-26.39	59.86	5.83	6.14	-13.35	24.44
157	154	-1.40	0.10	-1.66	-1.04	33.02	0.08	32.87	33.37	26.56	0.06	26.44	26.83	11.17	16.96	-35.20	55.15	6.10	6.28	-17.23	25.73
265	234	-0.64	0.13	-1.13	-0.42	33.60	0.09	33.22	33.71	27.01	0.06	26.71	27.09	4.71	22.03	-49.38	54.95	11.21	9.28	-9.14	41.69

† Data for the ADCP at 36 m ended July 16, 2009

Table 12: South Barrow Strait, Microcat/ADCP statistical summary
Complete Record: August 4, 2008 – August 1, 2009

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	32	-1.51	0.22	-1.77	1.18	31.99	0.35	30.09	32.89	25.73	0.28	24.18	26.45	17.72	20.86	-58.89	133.31	0.08	6.06	-32.85	31.18
62	60	-1.48	0.15	-1.77	-0.60	32.35	0.31	31.04	32.89	26.02	0.25	24.96	26.45	15.31	18.60	-56.83	121.53	-0.11	5.72	-33.07	23.52
76	68	-1.45	0.15	-1.78	-0.56	32.56	0.15	31.63	32.96	26.19	0.13	25.43	26.51	14.31	18.18	-59.70	110.84	-0.10	5.68	-31.99	23.63
142		-1.33	0.19	-1.74	-0.43	32.93	0.20	32.46	33.73	26.48	0.15	26.10	27.11								

Table 13: South-Central Barrow Strait, Microcat/ADCP statistical summary
Complete Record: August 3, 2008 – August 2, 2009†

Depth (m)		Temperature (°C)				Salinity (ppt)				Density (Sigma-T)				Along-Strait Velocity (cm/s)				Cross-Strait Velocity (cm/s)			
Microcat	ADCP	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
37	36	-1.49	0.30	-1.80	0.58	32.23	0.33	30.41	32.95	25.92	0.27	24.39	26.51	10.43	15.30	-37.74	59.00	5.02	6.58	-18.13	30.78
76	74	-1.56	0.13	-1.79	-1.08	32.68	0.18	31.90	33.02	26.29	0.15	25.65	26.57	9.86	16.09	-35.46	59.86	3.61	6.39	-17.65	28.86
157	154	-1.32	0.13	-1.79	-0.67	33.07	0.11	32.64	33.63	26.60	0.09	26.26	27.03	8.05	16.06	-35.20	57.17	3.81	6.58	-19.45	32.64
265	234	-0.44	0.19	-1.28	0.12	33.72	0.11	33.16	34.02	27.09	0.08	26.67	27.32	3.65	18.47	-49.38	54.95	8.15	8.75	-20.96	41.81

† Data for the ADCP at 36 m ended July 16, 2009

Table 14: ArcticNet Mooring, Microcat statistical summary
Late Summer: August 5, 2008 – September 20, 2008

Depth (m)	Temperature (°C)				Salinity (ppt)				Density (Sigma-T)			
Microcat	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
45	-1.11	0.59	-1.71	0.39	32.35	0.42	31.33	32.86	26.01	0.36	25.14	26.44

Table 15: ArcticNet Mooring, Microcat statistical summary
Fall: September 21, 2008 – December 20, 2008

Depth (m)	Temperature (°C)				Salinity (ppt)				Density (Sigma-T)			
Microcat	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
45	-1.46	0.31	-1.77	0.42	32.12	0.28	30.88	32.63	25.83	0.23	24.82	26.25

Table 16: ArcticNet Mooring, Microcat statistical summary
Winter: December 21, 2008 – March 20, 2009

Depth (m)	Temperature (°C)				Salinity (ppt)				Density (Sigma-T)			
Microcat	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
45	-1.70	0.07	-1.79	-1.41	32.63	0.14	32.13	32.86	26.25	0.12	25.84	26.44

Table 17: ArcticNet Mooring, Microcat statistical summary Spring: March 21, 2009 – June 20, 2009

Depth (m)	Temperature (°C)				Salinity (ppt)				Density (Sigma-T)			
Microcat	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
45	-1.57	0.40	-1.79	0.25	32.71	0.16	31.54	33.00	26.31	0.14	25.32	26.55

Table 18: ArcticNet Mooring, Microcat statistical summary Early Summer: June 21, 2009 – August 2, 2009

Depth (m)	Temperature (°C)				Salinity (ppt)				Density (Sigma-T)			
Microcat	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
45	-0.62	0.49	-1.39	1.25	32.29	0.17	30.96	32.70	25.94	0.15	24.79	26.30

Table 19: ArcticNet Mooring, Microcat statistical summary Complete Record: August 5, 2008 – August 2, 2009

Depth (m)	Temperature (°C)				Salinity (ppt)				Density (Sigma-T)			
Microcat	Avg	SD	Min	Max	Avg	SD	Min	Max	Avg	SD	Min	Max
45	-1.40	0.50	-1.79	1.25	32.44	0.34	30.88	33.00	26.09	0.28	24.79	26.55

Table 20: Tidal Constants for K1 Constituent

South Side Barrow Strait

For Ice Free Period (Aug. 4, 2008 – Oct. 1, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	7.52	0.07	146	358
16	6.69	0.98	148	353
20	7.03	1.66	155	358
24	7.81	1.32	161	2
28	8.05	0.72	164	4
32	8.40	0.51	162	359
36	Data affected by presence of buoyancy package.			
40				
44	9.30	0.03	154	355
48	9.24	0.33	155	353
52	9.13	0.54	154	350
56	9.07	0.95	153	347
60	9.26	1.47	152	345
64	9.34	1.94	151	345
68	9.44	2.16	150	346

For Solid Ice Period (Jan. 11, 2009 – Mar. 29, 2009):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	6.18	1.15	176	340
16	7.13	1.39	169	342
20	7.66	1.42	162	341
24	8.05	1.50	157	337
28	8.24	1.48	155	333
32	8.39	1.49	153	332
36	Data affected by presence of buoyancy package.			
40				
44	8.75	1.11	148	328
48	8.83	0.87	148	327
52	9.02	1.12	148	326
56	9.13	1.26	149	325
60	9.15	1.20	149	323
64	9.12	1.06	148	321
68	9.28	1.25	148	321

Table 20: Tidal Constants for K1 Constituent (continued)

South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	12.38	-0.15	165	5
16	11.96	-0.60	165	3
20	11.82	-0.90	166	0
24	12.06	-1.20	167	358
28	12.26	-1.34	167	357
32	11.99	-1.23	165	356
36	12.11	-0.96	164	356
40	Data affected by presence of buoyancy package.			
44	12.94	-0.57	163	358
48	13.17	-0.64	162	358
52	13.19	-0.70	161	356
56	13.27	-1.06	161	356
60	13.54	-1.21	160	356
64	13.84	-1.19	160	357
68	13.89	-1.06	160	357

For Solid Ice Period: (Insufficient Data for Analysis)

Table 20: Tidal Constants for K1 Constituent (continued)

South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
26	12.35	-0.26	162	356
34	12.46	-0.26	158	353
42	12.70	-0.20	155	353
50	13.16	-0.43	154	352
58	13.68	-0.94	155	352
66	14.05	-0.95	155	353
74	14.25	-0.81	157	354
82	14.43	-0.80	157	356
90	14.16	-1.14	156	357
98	14.05	-1.33	156	357
106	14.33	-1.17	156	357
114	14.44	-1.45	155	357
122	14.75	-1.31	155	358
130	14.73	-1.54	155	358
138	14.84	-1.80	156	358
146	14.98	-1.86	156	0
154	14.99	-1.93	154	2
162	14.90	-1.94	155	3
170	14.95	-1.82	155	4
178	15.34	-1.65	155	4
186	15.35	-1.62	154	3
194	15.75	-1.65	154	2
202	16.27	-1.95	154	1
210	16.90	-2.43	153	1
218	17.08	-2.92	153	1
226	17.87	-3.46	150	2
234	19.72	-4.04	148	3

For Solid Ice Period: Insufficient Data For Analysis

Table 21: Tidal Constants for M2 Constituent

South Side Barrow Strait

For Ice Free Period (Aug. 4, 2008 – Oct. 1, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	7.63	0.79	162	212
16	8.39	0.18	157	210
20	8.85	-0.88	153	207
24	9.30	-1.20	152	205
28	9.76	-1.30	150	205
32	9.81	-1.43	150	204
36	Data affected by presence of buoyancy package			
40				
44	9.88	-2.03	152	209
48	9.79	-2.07	153	211
52	9.73	-2.26	155	212
56	9.81	-2.28	155	212
60	9.91	-2.19	155	212
64	9.94	-2.21	155	212
68	10.01	-2.06	156	213

For Solid Ice Period (Jan 11, 2009 – Mar. 29, 2009):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	4.64	2.20	175	213
16	5.15	2.13	175	217
20	5.65	1.91	173	214
24	6.39	1.36	172	213
28	7.09	0.60	171	213
32	7.80	-0.11	172	214
36	Data affected by presence of buoyancy package			
40				
44	10.08	-2.15	165	210
48	10.50	-2.64	162	208
52	10.98	-3.01	160	204
56	11.12	-3.23	156	201
60	11.20	-3.19	154	197
64	10.99	-3.08	153	194
68	10.72	-2.98	151	193

Table 21: Tidal Constants for M2 Constituent (continued)

South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	6.50	0.95	188	213
16	6.99	0.62	181	205
20	7.35	0.12	176	203
24	8.24	-0.47	174	203
28	9.08	-1.12	174	201
32	9.48	-1.59	174	202
36	9.95	-1.92	174	202
40	Data affected by presence of buoyancy package			
44	10.55	-2.24	174	201
48	10.32	-2.14	173	202
52	10.08	-1.99	172	202
56	9.93	-1.84	172	203
60	10.06	-1.75	172	204
64	10.18	-1.71	172	203
68	9.76	-1.67	173	203

For Solid Ice Period: Insufficient Data For Analysis

Table 21: Tidal Constants for M2 Constituent (continued)

South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
26	8.53	-0.93	168	203
34	10.09	-2.16	167	202
42	10.79	-2.62	167	201
50	10.60	-2.40	166	203
58	10.64	-2.25	167	203
66	10.62	-1.99	167	203
74	10.14	-1.79	168	202
82	9.95	-1.57	167	202
90	9.68	-1.27	167	202
98	9.53	-1.17	166	204
106	9.47	-0.97	165	203
114	9.32	-0.85	165	203
122	9.02	-0.64	164	203
130	8.94	-0.55	163	202
138	8.80	-0.47	164	201
146	8.73	-0.40	163	201
154	8.80	-0.41	164	202
162	8.81	-0.53	165	203
170	8.96	-0.56	167	204
178	9.06	-0.59	169	204
186	9.18	-0.74	170	206
194	9.09	-0.81	171	206
202	8.92	-0.59	173	206
210	8.31	-0.33	177	207
218	7.51	-0.38	179	210
226	6.92	-0.21	180	215
234	6.42	0.28	184	221

For Solid Ice Period: Insufficient Data For Analysis

Table 22: Tidal Constants for O1 Constituent

South Side Barrow Strait

For Ice Free Period (Aug. 4, 2008 to Oct. 1, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	3.58	0.04	162	302
16	3.71	0.36	155	299
20	3.75	0.69	154	298
24	3.83	0.97	155	299
28	3.89	0.89	158	303
32	3.97	0.60	156	301
36	Data affected by presence of buoyancy package			
40				
44	4.39	0.68	156	292
48	4.55	0.81	159	292
52	4.69	0.81	160	293
56	4.67	0.82	160	290
60	4.81	0.84	158	288
64	4.87	0.96	158	289
68	4.70	0.88	159	290

For Solid Ice Period (Jan. 11, 2009 – Mar. 29, 2009):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	2.59	0.82	168	266
16	2.99	0.88	162	271
20	2.86	0.83	157	273
24	3.03	0.72	154	276
28	3.09	0.71	156	278
32	3.11	0.78	155	277
36	Data affected by presence of buoyancy package			
40				
44	3.19	0.71	155	277
48	3.26	0.65	153	276
52	3.48	0.49	150	273
56	3.73	0.30	151	270
60	3.82	0.16	152	269
64	3.91	0.26	151	267
68	3.88	0.45	150	264

Table 22: Tidal Constants for O1 Constituent (continued)

South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	5.99	-0.51	162	310
16	5.70	-0.44	161	308
20	5.77	-0.37	162	307
24	5.96	-0.65	160	303
28	6.05	-0.88	159	301
32	5.83	-0.72	158	299
36	5.60	-0.55	160	299
40	Data affected by presence of buoyancy package			
44	5.78	-0.53	162	299
48	5.82	-0.41	162	300
52	5.74	-0.55	162	299
56	5.80	-0.77	162	300
60	5.89	-0.78	161	300
64	5.91	-0.67	160	302
68	5.91	-0.74	160	302

For Solid Ice Period: Insufficient Data For Analysis

Table 22: Tidal Constants for O1 Constituent (continued)

South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
26	5.74	-0.38	155	300
34	5.64	-0.21	155	300
42	5.56	-0.16	156	300
50	5.67	-0.24	155	301
58	5.92	-0.36	156	300
66	6.04	-0.30	155	302
74	6.16	-0.38	155	301
82	6.31	-0.40	155	302
90	6.46	-0.33	156	302
98	6.47	-0.36	154	303
106	6.64	-0.44	154	304
114	6.91	-0.49	152	304
122	7.01	-0.53	152	304
130	7.06	-0.61	153	305
138	7.13	-0.64	153	306
146	7.31	-0.64	153	308
154	7.47	-0.66	153	308
162	7.47	-0.71	152	309
170	7.63	-0.56	153	310
178	7.84	-0.46	153	312
186	8.00	-0.59	153	311
194	8.19	-0.58	155	310
202	8.42	-0.35	155	308
210	8.54	-0.29	153	307
218	8.68	-0.63	153	305
226	9.22	-1.03	151	306
234	9.87	-1.51	150	306

For Solid Ice Period: Insufficient Data For Analysis

Table 23: Tidal Constants for P1 Constituent

South Side Barrow Strait

For Ice Free Period (Aug. 4, 2008 – Oct. 1, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	2.42	-1.20	140	335
16	2.27	-1.07	137	314
20	2.05	-0.06	121	323
24	1.63	0.76	150	357
28	1.74	0.08	189	20
32	1.97	-0.38	178	4
36	Data affected by presence of buoyancy package			
40				
44	2.27	-0.87	142	17
48	2.30	-0.48	150	6
52	2.43	-0.41	146	0
56	2.68	-0.13	143	352
60	2.78	0.36	140	348
64	2.97	0.65	136	345
68	3.03	0.93	127	346

For Solid Ice Period (Jan. 11, 2009 – Mar. 29, 2009):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	2.57	-0.79	196	353
16	2.43	-0.54	186	1
20	2.53	-0.20	179	356
24	2.74	0.06	169	349
28	2.93	0.43	167	343
32	3.00	0.49	160	341
36	Data affected by presence of buoyancy package			
40				
44	3.24	0.24	159	338
48	3.07	0.17	159	332
52	3.06	0.23	156	332
56	3.45	0.34	158	333
60	3.51	0.21	160	329
64	3.42	0.14	162	324
68	3.23	0.17	157	322

Table 23: Tidal Constants for P1 Constituent (continued)

South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	3.93	0.34	148	8
16	3.85	-0.47	149	5
20	3.95	-0.96	156	351
24	3.80	-0.55	170	347
28	3.74	-0.18	174	344
32	3.79	-0.03	171	336
36	4.08	0.12	165	335
40	Data affected by presence of buoyancy package			
44	3.95	0.23	151	343
48	4.07	0.30	152	344
52	4.20	0.31	152	340
56	4.13	0.02	155	340
60	4.40	-0.16	155	342
64	4.61	-0.18	155	344
68	4.53	-0.06	153	344

For Solid Ice Period: Insufficient Data For Analysis

Table 23: Tidal Constants for P1 Constituent (continued)

South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
26	4.37	-0.20	159	348
34	4.51	-0.09	154	337
42	4.83	-0.06	147	335
50	5.04	-0.05	146	335
58	5.14	-0.23	150	340
66	5.39	-0.14	152	342
74	5.47	0.30	154	343
82	5.32	0.56	155	346
90	5.00	0.41	156	344
98	4.73	0.29	156	342
106	5.05	0.38	153	342
114	4.88	0.07	154	343
122	4.91	0.23	152	347
130	4.95	0.09	154	344
138	4.94	0.04	158	345
146	4.70	0.01	160	349
154	4.25	-0.15	158	349
162	4.07	-0.13	158	345
170	3.73	-0.10	158	341
178	3.76	0.10	155	332
186	4.31	-0.18	150	316
194	4.79	-0.26	148	310
202	5.00	-0.18	150	306
210	5.45	-0.26	152	304
218	5.57	-0.28	153	302
226	5.89	-0.86	151	302
234	6.80	-1.04	147	309

For Solid Ice Period: Insufficient Data For Analysis

Table 24: Tidal Constants for S2 Constituent

South Side Barrow Strait

For Ice Free Period (Aug. 4, 2008 – Oct. 1, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	5.77	-1.10	138	241
16	5.48	-1.08	143	241
20	5.09	-1.08	148	242
24	5.29	-1.02	153	243
28	5.29	-0.79	154	244
32	5.17	-0.42	157	247
36	Data affected by presence of buoyancy package			
40				
44	4.74	-0.12	162	257
48	4.72	-0.08	162	259
52	4.67	-0.46	162	259
56	4.57	-0.79	161	258
60	4.51	-0.89	160	257
64	4.61	-0.76	157	256
68	4.84	-0.54	156	257

For Solid Ice Period (Jan. 11, 2009 – Mar. 29, 2009):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	2.22	1.05	160	251
16	2.76	0.79	157	249
20	3.08	0.37	164	257
24	3.55	-0.09	166	257
28	3.99	-0.37	165	258
32	4.28	-0.29	167	257
36	Data affected by presence of buoyancy package			
40				
44	5.13	-1.43	166	259
48	5.41	-1.71	166	262
52	5.46	-1.71	166	262
56	5.61	-1.72	163	260
60	5.51	-1.50	161	257
64	5.51	-1.30	159	253
68	5.34	-1.37	157	250

Table 24: Tidal Constants for S2 Constituent (continued)

South-Central Barrow Strait (Workhorse ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
12	5.47	-2.47	149	227
16	5.52	-2.14	157	231
20	5.45	-1.84	166	233
24	5.23	-1.57	167	238
28	4.94	-1.50	171	242
32	4.96	-1.64	176	245
36	5.03	-1.65	179	248
40	Data affected by presence of buoyancy package			
44	4.95	-1.71	183	254
48	4.91	-1.55	183	257
52	4.89	-1.36	185	255
56	4.76	-1.41	186	257
60	4.71	-1.54	185	260
64	4.63	-1.29	185	261
68	4.71	-1.33	187	261

For Solid Ice Period: Insufficient Data For Analysis

Table 24: Tidal Constants for S2 Constituent (continued)

South-Central Barrow Strait (Quarter Master ADCP)

For Ice Free Period (Aug. 3, 2008 – Oct. 6, 2008):

Depth (m)	Major Amplitude (cm/s)	Minor Amplitude (cm/s)	Orientation (degrees cc from East)	Greenwich Phase (degrees)
26	5.11	-1.56	161	239
34	4.88	-1.54	166	249
42	4.83	-1.44	170	252
50	4.67	-1.33	175	254
58	4.47	-1.19	175	257
66	4.61	-1.13	178	258
74	4.70	-1.35	179	260
82	4.71	-1.50	179	256
90	4.85	-1.49	181	259
98	4.83	-1.49	181	260
106	4.71	-1.49	179	261
114	4.71	-1.51	179	261
122	4.62	-1.40	180	264
130	4.45	-1.52	181	265
138	4.37	-1.53	183	266
146	4.41	-1.67	187	266
154	4.34	-1.82	188	267
162	4.37	-1.73	187	268
170	4.30	-1.55	187	269
178	4.11	-1.33	187	268
186	3.68	-1.03	186	267
194	2.90	-0.69	185	263
202	2.26	-0.52	182	256
210	2.07	-0.36	168	256
218	2.18	-0.21	153	256
226	2.53	-0.50	148	256
234	3.07	-1.21	152	259

For Solid Ice Period: Insufficient Data For Analysis

Table 25: CTD Data Statistics, August 2009

Station Name	Date/Time (GMT)	Latitude ^{o}N	Longitude ^{o}W	Pressure Maximum (dbar)	Station Sounding (m)	Minimum Temperature (Deg.C)	Maximum Temperature (Deg.C)	Minimum Salinity (psu)	Maximum Salinity (psu)	Minimum Sigma-T (kg/m^3)	Maximum Sigma-T (kg/m^3)
1	07-Aug-2009 12:20	74.0453	-91.0996	45.5	49	-1.4622	0.1664	30.7103	31.9599	24.6387	25.7021
2	07-Aug-2009 12:40	74.0597	-91.0784	98.0	101	-1.5078	0.1797	30.3393	32.5366	24.3381	26.1702
3	07-Aug-2009 12:59	74.0746	-91.0549	127.5	131	-1.5401	0.5787	29.9587	32.6429	24.0146	26.2537
4	07-Aug-2009 13:20	74.0894	-91.0318	144.0	148	-1.5741	0.6851	29.5592	32.7149	23.6902	26.3125
5	07-Aug-2009 13:45	74.1050	-91.0087	171.0	174	-1.5697	2.2653	28.3774	32.8225	22.7138	26.4004
7	06-Aug-2009 19:48	74.1363	-90.9538	206.5	207	-1.6663	4.4392	27.0954	33.5133	21.7251	26.9424
8	06-Aug-2009 19:18	74.1520	-90.9260	208.0	215	-1.6514	4.8701	28.6527	33.5120	22.7438	26.9411
9	06-Aug-2009 18:29	74.2137	-90.8490	279.5	283	-1.6244	5.7939	29.8298	33.7151	23.4935	27.0919
10	07-Aug-2009 17:15	74.2754	-90.7520	232.0	236	-1.6275	4.3556	29.8825	33.7761	23.6847	27.1393
11	07-Aug-2009 18:00	74.3369	-90.6661	207.0	211	-1.6303	5.0928	30.3736	33.5255	24.0539	26.9398
12	07-Aug-2009 18:40	74.3988	-90.5690	196.5	200	-1.6123	4.8219	30.3968	33.6095	24.0877	27.0151
13	07-Aug-2009 19:20	74.4615	-90.4750	258.5	277	-1.6361	4.6739	30.5319	33.9422	24.1813	27.2559
14	08-Aug-2009 12:17	74.5309	-90.3808	216.5	222	-1.6171	5.4885	30.3702	33.7655	24.0104	27.1300
15	08-Aug-2009 12:45	74.5380	-90.3530	181.5	191	-1.6191	5.6954	29.9098	33.5183	23.6350	26.9470
16	08-Aug-2009 13:15	74.5540	-90.3285	138.0	152	-1.6027	5.4973	29.3580	32.9925	23.1810	26.5393
17	08-Aug-2009 13:40	74.5656	-90.3091	78.0	85	-1.3085	5.5367	29.5908	32.6676	23.4001	26.2725
G1	08-Aug-2009 18:30	74.6411	-91.3263	34.5	40	2.0716	6.1596	29.4161	31.3451	23.1689	25.0395
G2	08-Aug-2009 18:09	74.6334	-91.3386	62.0	67	-1.2752	5.8099	29.3096	32.7170	23.0829	26.3116
G3	08-Aug-2009 17:49	74.6236	-91.3312	125.0	130	-1.4311	5.8188	29.2199	32.9382	23.0118	26.4948
G4	08-Aug-2009 17:25	74.6076	-91.3285	158.5	168	-1.5795	5.3284	29.6292	33.0657	23.3879	26.5956
G5	08-Aug-2009 17:04	74.5911	-91.3286	160.5	171	-1.6234	5.5639	29.6113	33.1973	23.3756	26.6986
G6	08-Aug-2009 15:46	74.5571	-91.3264	143.0	150	-1.6166	5.1089	30.4575	33.1038	24.0659	26.6257
G7	08-Aug-2009 15:20	74.5240	-91.3293	139.0	145	-1.6087	4.9738	30.5372	33.1394	24.1488	26.6538