

Physics and Physical Oceanography Data Report 99-3

**Observations of Currents,
Temperature and Salinity
in
Placentia Bay, Newfoundland
1998-9**

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Abstract

The data presented here in this report was collected during the dates of April 2, 1998 to June 19, 1998 and April 18, 1999 to June 28, 1999 during an ongoing research project designed to model the circulation in Newfoundland bays. This report is meant to serve as a summary and overview of the data collected during the summers of 1998 and 1999 from Placentia Bay in Newfoundland, Canada. Apart from simple filters used to smooth the raw data, no other processing has been done and little analysis, of the data, has been included in this report.

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Introduction

Placentia Bay is located on the southern coast of the island of Newfoundland, Canada. The bay runs approximately northeast to southwest with the head of the bay, located southwest of Arnold's Cove and the mouth of the bay opening to the Atlantic Ocean. The average width of the bay is approximately 80 kilometers, narrowing to less than 22 kilometers at the head of the bay. The depth is about 125m on average, with a maximum of 200 meters near the mouth.

During the summers of 1998 and 1999, four cruises (Table 1) were initiated to deploy and recover fixed subsurface moorings. At each of the mooring locations instruments were deployed to measure temperature, salinity and current observations at twenty minute intervals.

Two moorings were deployed during the 1998 field study and four were used in 1999. The configuration of each mooring station is listed in Table 4. Information regarding the particular instruments on each mooring is given in Table 2.

Moorings data are represented as time series plot of temperature (Figures 1-2 and 17-20), salinity (Figures 3-4 and 21-24) and residual velocity (Figures 5-6 and 25-28). The velocity is divided into u and v directional vectors representing east-west and north-south velocity respectively with east and north being positive directions. Vector plots (Figures 7-8 and 29-32) of the entire velocity field are also represented with the data sub-sampled at twelve-hour intervals. Summary statistics of mean, standard deviation, minimum and maximum values for each instrument may be found in Tables 7-8 and 13-16.

The major and minor axis along with the Greenwich phase of the main constituents of the tidal currents measured at mooring M1 (10, 180m) and mooring M2 (10, 110m) for the 1998 data set may be found in Tables 5-6. The main tidal constituents for the 1999 data

set may be found in Tables 9-12 where mooring M1 and M2 was measured at 20 and 55m. Mooring M3 was measured at 20m and mooring M4 was measured at 20 and 45m.

Cruise Dates and Station Information

Table 1: Cruise Dates

Cruise	Dates	Ship	Data Type Collected
1	April 2, 1998	C.C.G.S. Mares	Mooring Deployment
2	June 19, 1998	C.C.G.S. Shamook	Mooring Recovery
3	April 18, 1999	C.C.C.S. Shamook	Mooring Deployment
4	June 28, 1999	C.C.G.S. Shamook	Mooring Recovery

Instrumentation

Table 2: Instrument Specifications

Sensor	Range	Accuracy	Resolution
RCM7 Temperature	-2.46° to 21.48°C	±0.05°	0.1% of range
RCM7 Conductivity	0 to 74 mmho/cm	0.025 mmho/cm	0.1% of range
RCM7 Speed	2 to 250 cm/sec	±2% or ±1 cm/sec	2 cm/sec threshold
RCM7 Direction	0° to 359°	±5° for speeds 5 to 100 cm/sec ±7.5° for speeds < 5 and > 100 cm/sec	0.35°
S4 Temperature	-5° to 45°C	±2°C	±0.05°C
S4 Conductivity	0 to 70 mS/cm	±0.2 mS/cm	±0.1 mS/cm
S4 Speed	0 to 350 cm/sec	±2% or ±1 cm/sec	0.2 cm/sec threshold
S4 Direction	0° to 359°	±2°	0.5°
S4 Pressure	0 to 70m	±1%	4mm
Vemco Minilog TR	-4° to 20°C	±0.2°C	0.1°C

Table 3: Mooring Locations

The 1998 Data Set

Station	Latitude	Longitude	Depth (m)	Start Date	Stop Date
M1	47 13.96	54 37.13	242	01-April-98	18-June-98
M2	47 07.19	54 10.36	119	01-April-98	18-June-98

Table 3: Mooring Locations (Cont'd)**The 1999 Data Set**

Station	Latitude	Longitude	Depth (m)	Start Date	Stop Date
M1	47 11.61	54 42.80	106	18-April-99	26-June-99
M2	47 09.07	54 34.98	182	18-April-99	26-June-99
M3	47 02.79	54 18.02	165	18-April-99	26-June-99
M4	47 01.17	54 12.59	55	18-April-99	26-June-99

Note: V – is for Vemco Minilog temperature recorder and S4 represents the InterOcean S4.

Table 4: Mooring Configuration**The 1998 Data Set**

Configuration: Mooring M1		Configuration: Mooring M2	
Instrument	Depth (m)	Instrument	Depth (m)
Serial No.		Serial No.	
V – 3448	5.0	V – 2366	5.0
S4 – 1560	10.0	S4 – 1561	10.0
V – 3449	20.0	V – 2367	20.0
V – 3450	30.0	V – 2368	30.0
V – 3478	40.0	V – 2700	40.0
V – 3479	50.0	V – 2701	50.0
V – 3480	100.0	V – 3446	100.0
RCM – 10129	180.0	S4 – 1281	110.0
V – 3447	237.0	V – 3481	114.0

The 1999 Data Set

Configuration: Mooring M1		Configuration: Mooring M2	
Instrument	Depth (m)	Instrument	Depth (m)
Serial No.		Serial No.	
V – 2368	10.0	V – 3790	10.0
S4 – 1555	20.0	S4 – 1556	20.0
V – 2700	30.0	V – 3450	30.0
V – 2701	40.0	V – 3478	40.0
RCM – 10132	55.0	RCM - 10133	55.0
V – 5169	80.0	V – 3479	80.0
V – 3446	95.0	V – 3482	100.0
		V – 3749	130.0
		V – 3750	172.0

Table 4: Mooring Configuration (Cont'd)

Configuration: Mooring M3		Configuration: Mooring M4	
Instrument	Depth (m)	Instrument	Depth (m)
Serial No.		Serial No.	
V – 3790	10.0	V – 3803	10.0
S4 – 1557	20.0	S4 – 1558	20.0
V – 3494	30.0	V – 3804	30.0
V – 3496	40.0	V – 3807	40.0
RCM – 10134	55.0	RCM - 10135	45.0
V – 3797	80.0	V – 4406	51.0
V – 3798	100.0		
V – 3799	130.0		
V – 3802	155.0		

Mooring Locations for the 1998 Data Set

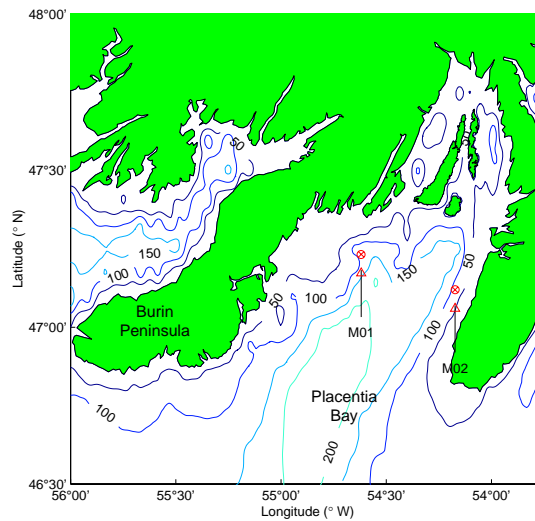


Figure 1: Mooring locations including bathymetry of the main study area revealing contour lines with 50 meter intervals.

Mooring Locations for the 1999 Data Set

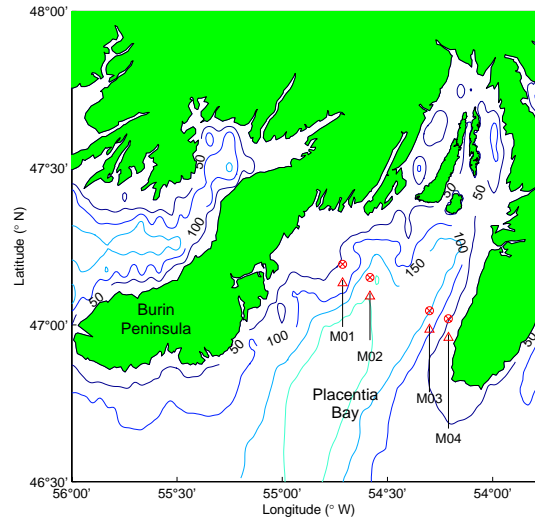


Figure 2: Mooring locations including bathymetry of the main study area revealing contour lines at 50 meter intervals.

Analysis

Data were collected at 20-minute intervals from all the mooring stations. The data were detided using an eighth order low pass Butterworth filter with a pass band corresponding to a period of 30.5 hours and a stop band corresponding to a period of 26.5 hours.

Data for the tidal analysis was first filtered using an eighth order low pass Butterworth filter with a pass band corresponding to a period of 3 hours and a stop band corresponding to a period of 2 hours in order to remove high frequency fluctuations in the data. After filtering the 20-minute data was sub-sampled at 1-hour intervals and then analyzed using M. Foreman's tidal analysis software (Foreman 1977).

Tidal Data

The tidal analysis summarized below, was obtained using the tidal current analysis software of M. Foreman (Foreman 1977). Although the length of the record allows for determination of several additional constituents, only the main diurnal and semi-diurnal constituents have been included. The calculation was performed using a Rayleigh

observation factor of 1.0. The main constituents of the tidal currents are described by: the semi-major and semi-minor axes of the representative tidal ellipses along with the corresponding Greenwich phase. The inclination of the ellipse indicates the angle the semi-major axis makes with the positive x-axis (east). A positive value for the length of the semi-minor axis indicates that the current rotates counter clockwise around the tidal ellipse while a negative value indicates a clockwise rotation.

The main tidal constituents for the 1998 data set

Table 5: Main Constituents of the Tidal Currents at Mooring: M1 Depth: 10m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	13.046	0.000	56.2	180.0
MSF	0.00282193	1.961	1.105	51.0	346.3
O1	0.03873065	0.725	-0.364	140.0	156.7
K1	0.04178075	1.571	-1.242	177.0	351.0
M2	0.08051140	5.977	-2.069	104.6	110.9
S2	0.08333334	1.456	-0.697	121.2	124.6

Table 5: Main Constituents of Tidal Currents at Mooring: M1 Depth: 180m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	1.961	0.000	43.9	180.0
MSF	0.00282193	0.646	-0.248	76.3	349.1
O1	0.03873065	0.679	-0.065	11.7	135.2
K1	0.04178075	0.513	-0.194	148.2	257.9
M2	0.08051140	2.427	0.270	163.8	199.0
S2	0.08333334	0.660	0.229	171.0	253.5

Table 6: Main Constituents of the Tidal Currents at Mooring: M2 Depth: 10m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	12.037	0.000	79.4	360.0
MSF	0.00282193	5.528	-0.189	71.4	308.5
O1	0.03873065	1.144	0.216	115.2	127.8
K1	0.04178075	1.037	-0.387	40.6	101.2
M2	0.08051140	3.797	-0.387	67.1	29.2
S2	0.08333334	1.486	-0.778	68.3	44.7

Table 6: Main Constituents of Tidal Currents at Mooring: M2 Depth: 110m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	1.285	0.000	178.8	180.0
MSF	0.00282193	0.773	0.200	118.2	263.3
O1	0.03873065	1.288	0.000	1.6	168.9
K1	0.04178075	0.396	-0.250	132.8	182.9
M2	0.08051140	1.694	0.882	168.7	107.5
S2	0.08333334	0.450	0.007	143.1	83.2

The summary statistics for the 1998 data set

The statistics presented below were calculated over the 78 days from Julian day 91 to Julian day 169. The statistics (indicated with an asterick) for those data sets with gaps in the data were calculated for all valid data points between the above mentioned dates.

Table 7a: Summary Statistics for Temperature and Salinity from Mooring M1, 1998

Mooring: M1		Temperature				Salinity				
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-3448	5	Raw	3.74	2.37	0.10	9.50				
		Filtered	3.75	2.36	0.16	9.21				
S4-1560	10	Raw	3.35	2.21	0.16	9.06	32.05	0.22	30.98	32.51
		Filtered	3.35	2.19	0.19	7.29	32.07	0.19	31.36	32.50
V-3449	20	Raw	2.63	1.90	0.00	6.50				
		Filtered	2.63	1.88	0.17	5.84				
V-3450	30	Raw	2.06	1.62	0.00	5.60				
		Filtered	2.06	1.60	0.07	5.24				
V-3478	40	Raw	1.36	1.17	0.00	4.40				
		Filtered	1.36	1.14	-0.01	3.83				
V-3479	50	Raw	0.93	0.77	-0.10	3.50				
		Filtered	0.93	0.75	-0.10	2.74				
V-3480	100	Raw	0.10	0.23	-0.40	0.80				
		Filtered	0.11	0.21	-0.24	0.63				
RCM-10129	180	Raw	-0.30	0.07	-0.52	-0.11	32.79	0.05	32.64	32.93
		Filtered	-0.30	0.07	-0.48	-0.14	32.81	0.05	32.68	32.93
V-3447	237	Raw	-0.28	0.06	-0.40	-0.10				
		Filtered	-0.28	0.06	-0.40	-0.18				

Table 7b: Summary Statistics for Current from Mooring M1, 1998

Mooring: M1			East-West Velocity				North-South Velocity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-3448	5	Raw								
		Filtered								
S4-1560	10	Raw	-7.32	10.15	-54.29	27.55	-10.67	10.05	-53.12	22.15
		Filtered	-7.36	3.42	-34.33	15.51	-10.51	2.74	-41.59	5.04
V-3449	20	Raw								
		Filtered								
V-3450	30	Raw								
		Filtered								
V-3478	40	Raw								
		Filtered								
V-3479	50	Raw								
		Filtered								
V-3480	100	Raw								
		Filtered								
RCM-10129	180	Raw	-1.38*	7.88*	-1.83*	8.63*	-1.30*	7.58*	-11.07*	8.49*
		Filtered	-1.43*	1.91*	-12.94*	2.84*	-1.38*	1.62*	-6.14*	1.98*
V-3447	237	Raw								
		Filtered								

Table 8a: Summary Statistics for Temperature and Salinity from Mooring M2, 1998

Mooring: M2			Temperature				Salinity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-2366	5	Raw	3.21	2.39	0.10	10.20				
		Filtered	3.20	2.17	0.12	9.62				
S4-1561	10	Raw	3.02	2.18	0.12	9.29	32.49	0.35	31.60	33.12
		Filtered	3.02	2.17	0.16	8.13	32.52	0.34	31.85	33.06
V-2367	20	Raw	2.68	1.99	0.10	7.00				
		Filtered	2.68	1.99	0.09	6.71				
V-2368	30	Raw	2.38	1.78	0.10	6.50				
		Filtered	2.38	1.77	0.11	5.99				
V-2700	40	Raw	1.91	1.47	0.00	5.40				
		Filtered	1.91	1.45	0.07	5.10				
V-2701	50	Raw	1.29	1.09	-0.40	4.70				
		Filtered	1.29	1.07	-0.15	4.55				
V-3446	100	Raw	0.24	0.37	-0.50	1.50				
		Filtered	0.25	0.36	-0.43	1.19				
S4-1281	110	Raw	0.16	0.34	-0.49	1.04	32.61	0.08	32.36	32.83
		Filtered	0.16	0.33	-0.44	0.87	32.64	0.07	32.51	32.82
V-3481	114	Raw	0.23	0.34	-0.40	1.10				
		Filtered	0.23	0.33	-0.35	0.94				

Table 8b: Summary Statistics for Current from Mooring M2, 1998

Mooring: M2			East-West Velocity				North-South Velocity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-2366	5	Raw								
		Filtered								
S4-1561	10	Raw	1.96	8.38	-30.69	46.88	10.76	14.04	-34.49	53.13
		Filtered	1.95	6.10	-20.51	17.41	10.74	-24.97	44.56	44.56
V-2367	20	Raw								
		Filtered								
V-2368	30	Raw								
		Filtered								
V-2700	40	Raw								
		Filtered								
V-2701	50	Raw								
		Filtered								
V-3446	100	Raw								
		Filtered								
S4-1281	110	Raw	1.40	5.19	-19.71	26.73	-0.13	4.29	-20.10	29.51
		Filtered	1.39	3.50	-12.19	12.95	-0.14	2.95	-9.67	9.91
V-3481	114	Raw								
		Filtered								

Observations:

The time series plots of the detided temperature and salinity reveal a seasonal trend of increasing temperature and decreasing salinity at all moorings and at all depths. It should be noted that instrument RCM-10129 was set to record data at a 30 minute time interval whereas the other instruments recorded at a 20 minute time interval. The information recorded by this instrument was then interpolated to a time line corresponding to one containing a 20 minute time interval.

Near surface currents (10 m depth) at mooring M1 are dominantly south-westerly and are dominantly north-easterly at mooring M2. This suggests that the general near surface circulation for this region is of a cyclonic nature. Generally, the near surface currents in this study area appear to flow inwards along the eastern shore and exit along the western shore. There is some evidence of counter currents flowing at depths of 110m, this is evident at mooring M2.

The main tidal constituents for the 1999 data set

Table 9: Main Constituents of the Tidal Currents at Mooring: M1 Depth: 20m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	7.437	0.000	40.0	180.0
MSF	0.00282193	1.326	0.509	45.4	130.8
O1	0.03873065	0.670	-0.600	148.5	301.2
K1	0.04178075	0.450	0.272	101.6	256.0
M2	0.08051140	5.807	-1.357	64.4	216.6
S2	0.08333334	1.491	-0.080	71.7	256.7

Main Constituents of Tidal Currents at Mooring: M1 Depth: 55m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	4.965	0.000	46.6	180.0
MSF	0.00282193	0.779	-0.025	31.3	222.7
O1	0.03873065	1.081	-0.112	34.9	185.7
K1	0.04178075	0.346	0.088	20.3	133.4
M2	0.08051140	5.395	-0.968	41.1	220.9
S2	0.08333334	1.339	-0.391	38.1	278.2

Table 10: Main Constituents of the Tidal Currents at Mooring: M2 Depth: 20m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	11.183	0.000	48.7	180.0
MSF	0.00282193	1.543	-0.496	75.0	267.2
O1	0.03873065	0.823	-0.442	119.0	309.8
K1	0.04178075	1.182	-0.565	165.4	27.2
M2	0.08051140	3.370	0.507	68.9	211.1
S2	0.08333334	0.468	-0.081	92.5	279.7

Main Constituents of the Tidal Currents at Mooring: M2 Depth: 55m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	7.158	0.000	58.8	180.0
MSF	0.00282193	1.948	-0.612	77.6	269.8
O1	0.03873065	0.462	0.010	149.1	139.5
K1	0.04178075	0.640	-0.108	116.9	89.5
M2	0.08051140	4.319	-0.854	59.0	210.7
S2	0.08333334	1.365	-0.096	61.2	261.3

Table 11: Main Constituents of the Tidal Currents at Mooring: M3 Depth: 20m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	18.230	0.000	80.4	0.0
MSF	0.00282193	3.384	0.135	90.7	2.0
O1	0.03873065	1.133	-0.118	164.6	288.9
K1	0.04178075	0.678	-0.377	121.3	40.6
M2	0.08051140	4.308	0.156	59.5	165.0
S2	0.08333334	2.005	-0.711	66.0	212.2

Table 12: Main Constituents of the Tidal Currents at Mooring: M4 Depth: 20m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	11.827	0.000	68.1	360.0
MSF	0.00282193	0.425	-0.125	58.1	324.5
O1	0.03873065	3.056	-0.928	67.9	49.4
K1	0.04178075	0.964	0.083	172.2	353.4
M2	0.08051140	4.411	0.258	50.7	155.7
S2	0.08333334	1.677	0.607	46.0	202.7

Main Constituents of Tidal Currents at Mooring: M4 Depth: 45m

Name	Frequency	Major Axis (cm/s)	Minor Axis (cm/s)	Inclination	G. Phase
ZO	0.00000000	3.894	0.000	65.9	360.0
MSF	0.00282193	0.531	0.030	53.6	101.5
O1	0.03873065	1.106	-0.510	178.4	327.0
K1	0.04178075	0.686	-0.084	77.4	172.9
M2	0.08051140	3.718	0.653	52.2	156.3
S2	0.08333334	0.936	0.230	56.6	184.1

The summary statistics for the 1999 data set

The statistics presented below were calculated over the 69 days from Julian day 108 to Julian day 177. The statistics (indicated with an asterick) for those data sets with gaps in the data were calculated for all valid data points between the above mentioned dates.

Table 13a: Summary Statistics for Temperature and Salinity from Mooring M1, 1999

Mooring: M1			Temperature				Salinity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-2368	10	Raw	4.90	2.57	1.40	11.10				
		Filtered	4.90	2.55	1.45	9.86				
S4-1555	20	Raw	4.37	2.27	1.33	9.81	32.40	0.24	31.76	32.85
		Filtered	4.37	2.24	1.46	8.66	32.32	0.05	32.14	32.48
V-2700	30	Raw	3.02	1.40	0.90	7.60				
		Filtered	3.02	1.33	1.30	7.30				
V-2701	40	Raw	1.96	0.66	0.80	7.00				
		Filtered	1.96	0.57	0.94	3.21				
RCM-10132	55	Raw	1.23	0.30	0.47	2.55	31.42	0.28	30.21	31.77
		Filtered	1.24	0.25	0.72	1.93	32.25	0.04	32.12	32.25
V-5169	80	Raw	0.70	0.27	-0.10	1.60				
		Filtered	0.70	0.22	0.19	1.46				
V-3446	95	Raw	0.56	0.27	-0.10	1.40				
		Filtered	0.56	0.23	-0.01	1.14				

Table 13b: Summary Statistics for Current from Mooring M1, 1999

Mooring: M1			East-West Velocity				North-South Velocity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-2368	10	Raw								
		Filtered								
S4-1555	20	Raw	-5.82	6.78	-35.16	15.77	-4.86	7.34	-44.28	15.76
		Filtered	-5.81	5.13	-26.84	4.36	-3.29	2.93	-12.28	4.16
V-2700	30	Raw								
		Filtered								
V-2701	40	Raw								
		Filtered								
RCM-10132	55	Raw	-3.30	5.10	-22.02	10.37	-3.50	4.76	-20.29	11.61
		Filtered	-3.29	2.93	-12.28	4.16	-3.52	2.78	-11.42	2.67
V-5169	80	Raw								
		Filtered								
V-3446	95	Raw								
		Filtered								

Table 14a: Summary Statistics for Temperature and Salinity from Mooring M2, 1999

Mooring: M2			Temperature				Salinity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-3447	10	Raw	5.34	2.90	1.50	11.70				
		Filtered	5.35	2.88	1.42	11.61				
S4-1556	20	Raw					31.42*	0.28*	30.21*	31.77*
		Filtered			No Data		31.44	0.27	30.31	31.74
V-3450	30	Raw	3.03	1.43	0.90	7.50				
		Filtered	3.03	1.35	1.09	5.89				
V-3478	40	Raw	2.01	0.69	0.70	4.80				
		Filtered	2.01	0.62	0.89	4.00				
RCM-10133	55	Raw	1.28	0.35	0.38	2.70	32.25	0.04	32.12	32.41
		Filtered	1.29	0.30	0.65	2.30	32.27	0.03	32.22	32.36
V-3479	80	Raw	0.72	0.26	0.00	1.70				
		Filtered	0.72	0.25	0.11	1.39				
V-3482	100	Raw	0.49	0.23	0.00	1.10				
		Filtered	0.49	0.22	0.07	1.01				
V-3749	130	Raw	0.03	0.18	-0.40	0.50				
		Filtered	0.03	0.18	-0.30	0.48				
V-3750	172	Raw	-0.12	0.19	-0.50	0.40				
		Filtered	-0.12	0.18	-0.47	0.39				

Table 14b: Summary Statistics for Currents from Mooring M2, 1999

Mooring: M2			East-West Velocity				North-South Velocity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-3447	10	Raw								
		Filtered								
S4-1556	20	Raw	-7.41	6.58	-37.85	14.76	-8.48	6.97	-42.04	14.73
		Filtered	-7.43	4.79	-25.94	3.48	-3.83	3.35	-28.27	3.56
V-3450	30	Raw								
		Filtered								
V-3478	40	Raw								
		Filtered								
RCM-10133	55	Raw	-3.81	5.15	-31.47	14.75	-6.52	8.00	-39.03	13.56
		Filtered	-3.83	3.35	-16.29	5.80	-6.51	6.48	-27.51	7.31
V-3479	80	Raw								
		Filtered								
V-3482	100	Raw								
		Filtered								
V-3749	130	Raw								
		Filtered								
V-3750	172	Raw								
		Filtered								

Table 15a: Summary Statistics for Temperature and Salinity from Mooring M3, 1999

Mooring: M3			Temperature				Salinity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-3790	10	Raw	5.54	3.03	1.20	11.20				
		Filtered	5.54	3.02	1.41	10.93				
S4-1557	20	Raw	4.97	2.88	0.94	10.82	32.16	0.34	31.39	33.14
		Filtered	4.98	2.86	1.25	10.70	32.18	0.33	31.64	33.10
V-3794	30	Raw	2.67	1.43	0.70	9.00				
		Filtered	2.67	1.32	0.94	6.68				
V-3796	40	Raw	1.59	0.50	0.40	4.30				
		Filtered	1.59	0.44	0.94	3.05				
RCM-10134	55	Raw	1.02	0.40	-0.14	2.65	32.38	0.07	32.18	32.61
		Filtered	1.02	0.35	0.64	1.94	32.41	0.06	32.27	32.55
V-3797	80	Raw	0.32	0.38	-0.50	1.60				
		Filtered	0.32	0.35	-0.35	1.47				
V-3798	100	Raw	0.06	0.35	-0.60	1.60				
		Filtered	0.06	0.34	-0.50	1.44				
V-3799	130	Raw	-0.14	0.32	-0.70	1.50				
		Filtered	-0.14	0.31	-0.64	1.31				
V-3802	155	Raw	-0.13	0.30	-0.80	1.60				
		Filtered	-0.13	0.30	-0.61	1.33				

Table 15b: Summary Statistics for Current from Mooring M3, 1999

Mooring: M3			East-West Velocity				North-South Velocity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-3790	10	Raw								
		Filtered								
S4-1557	20	Raw	2.75	7.27	-25.50	33.00	17.61	11.70	-11.78	73.62
		Filtered	2.74	4.49	-9.56	16.93	17.66	9.86	3.61	63.01
V-3794	30	Raw								
		Filtered								
V-3796	40	Raw								
		Filtered								
RCM-10134	55	Raw								
		Filtered			No Data				No Data	
V-3797	80	Raw								
		Filtered								
V-3798	100	Raw								
		Filtered								
V-3799	130	Raw								
		Filtered								
V-3802	155	Raw								
		Filtered								

Table 16a: Summary Statistics for Temperature and Salinity from Mooring M4, 1999

Mooring: M4			Temperature				Salinity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-3803	10	Raw	5.09	2.63	1.10	11.00				
		Filtered	5.09	2.59	1.19	10.96				
S4-1558	20	Raw	4.44	2.19	1.13	10.88	33.77	0.27	32.89	34.23
		Filtered	4.45	2.07	1.19	7.16	33.79	0.26	33.14	34.26
V-3804	30	Raw	3.07	1.44	0.40	8.70				
		Filtered	3.09	1.31	0.98	7.16				
V-3807	40	Raw	2.20	0.99	0.40	7.70				
		Filtered	2.23	0.85	0.75	5.34				
RCM-10135	45	Raw	1.93	0.86	0.32	7.60	32.29	0.10	31.80	32.62
		Filtered	1.94	0.71	0.39	5.13	32.31	0.08	32.00	32.57
V-4406	51	Raw	1.55	0.70	0.00	6.70				
		Filtered	1.56	0.57	0.11	4.40				

Table 16b: Summary Statistics for Current from Mooring M4, 1999

Mooring: M4			East-West Velocity				North-South Velocity			
Instrument	Depth(m)		Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
V-3802	10	Raw								
		Filtered								
S4-1558	20	Raw	4.24	7.63	-24.90	36.74	10.40	10.49	-23.48	52.67
		Filtered	4.31	5.78	-12.39	23.53	10.56	8.70	-15.60	32.28
V-3804	30	Raw								
		Filtered								
V-3807	40	Raw								
		Filtered								
RCM-10135	45	Raw	1.58	4.53	-17.08	25.06	3.53	7.24	-16.19	40.60
		Filtered	1.60	2.66	-9.30	8.81	3.60	5.62	-10.80	24.34
V-4406	51	Raw								
		Filtered								

Observations:

The time series for the detided temperature and salinity reveal a seasonal trend of increasing temperature and decreasing salinity at all moorings and at depths above 55m. Whereas the temperature decreases and salinity increases at moorings M1, M2, and M3 and at depths below 55m. This is due to vertical mixing with cold saline water. It should be noted that the temperature values at 20m of depth on mooring M2 (instrument S4-1556) were erroneous. Upon examining the instrument, it was found that the temperature sensor had malfunctioned.

Near surface currents (20m depth) for the regions of interest are dominantly south-westerly at mooring M1 and M2 and north-easterly at mooring M3 and M4. This suggests

that the general near surface circulation for this region is of a cyclonic nature. It should be noted that the speed and direction values at 55m of depth on mooring M3 (instrument RCM-10134) were erroneous. Upon examining the data it was found that the instrument was not able to deviate from a particular direction as well there was signs of chafing on the instrument peddle wheel.

The 1998 Mooring Data – Temperature

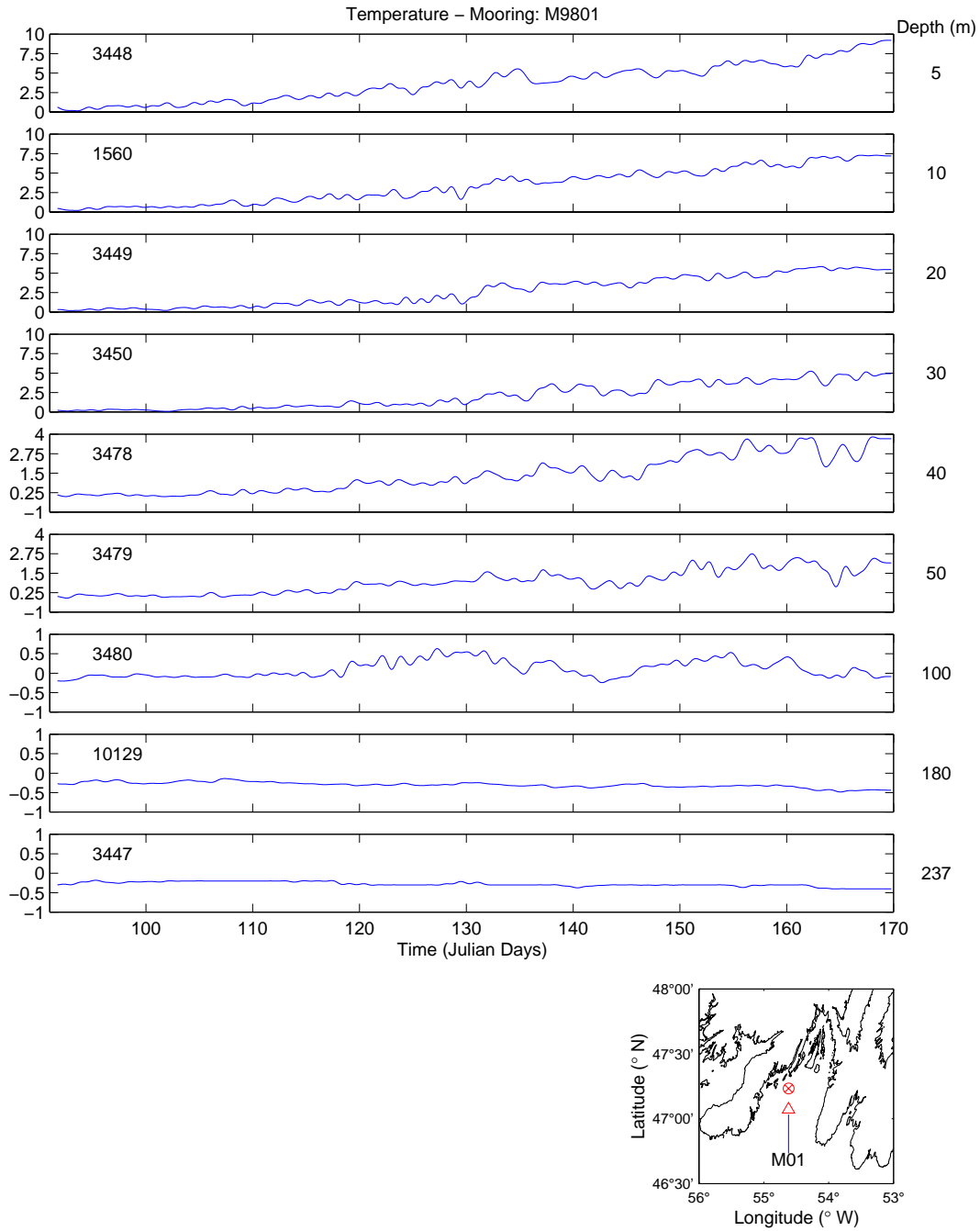


Figure 3: Time series of detided temperature at Mooring M1. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

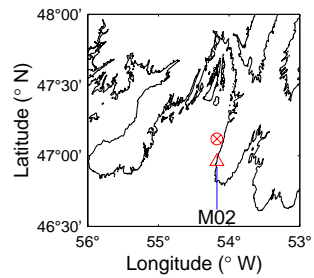
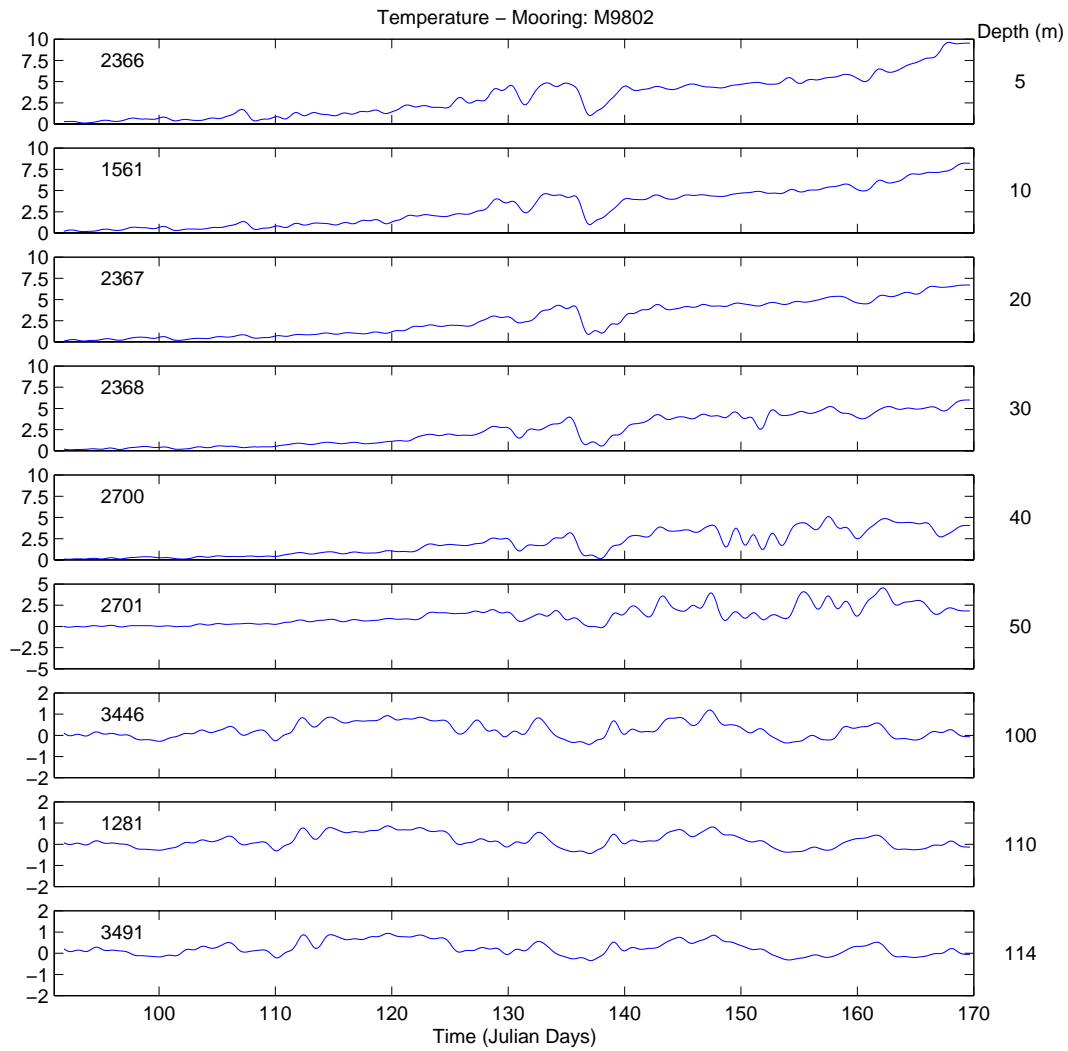


Figure 4: Time series of detided temperature at Mooring M2. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

Salinity

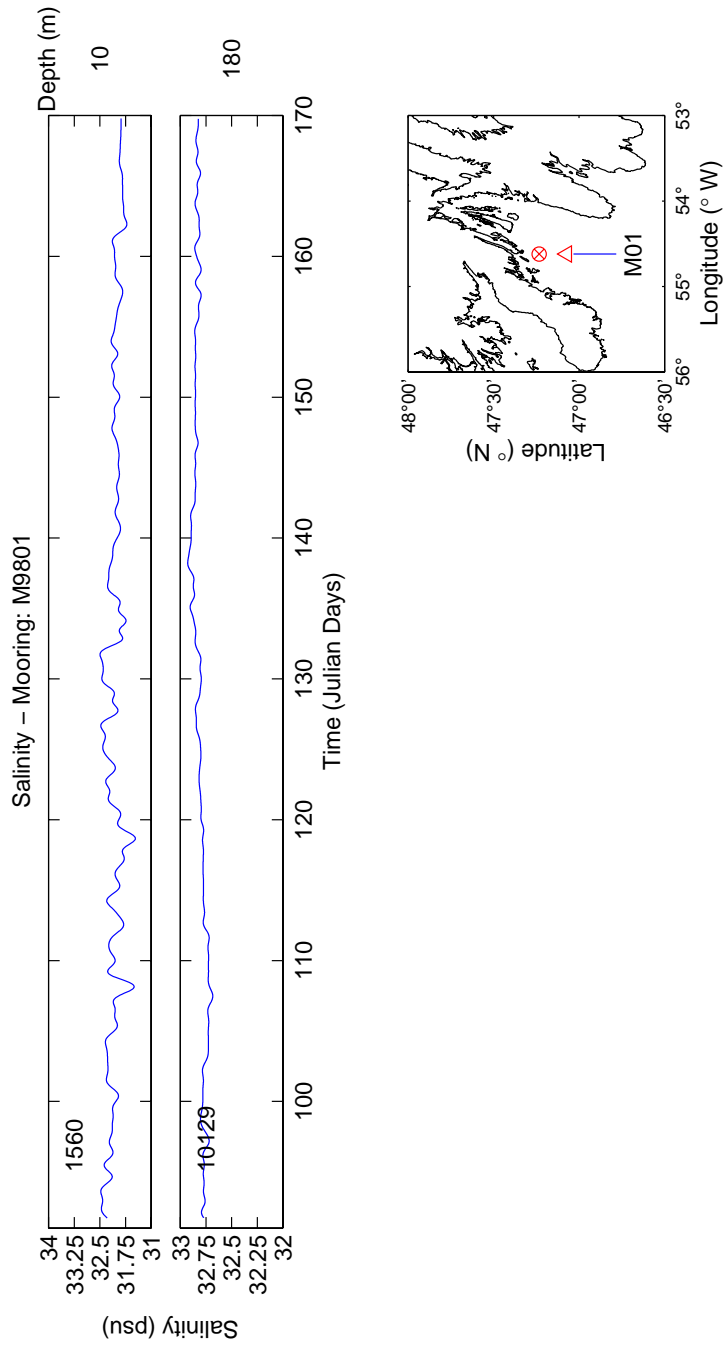


Figure 5: Time series of detided salinity at Mooring M1. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

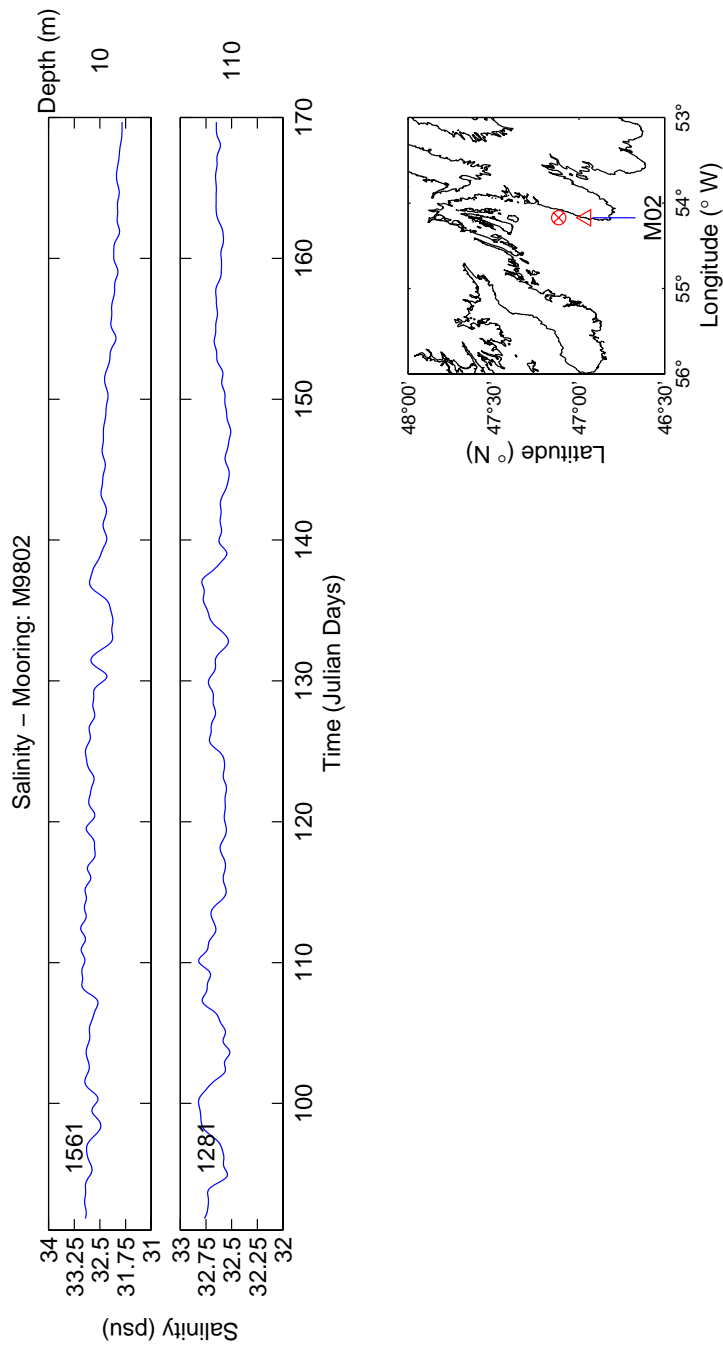


Figure 6: Time series of detided salinity at Mooring M1. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

Residual Velocity U, V

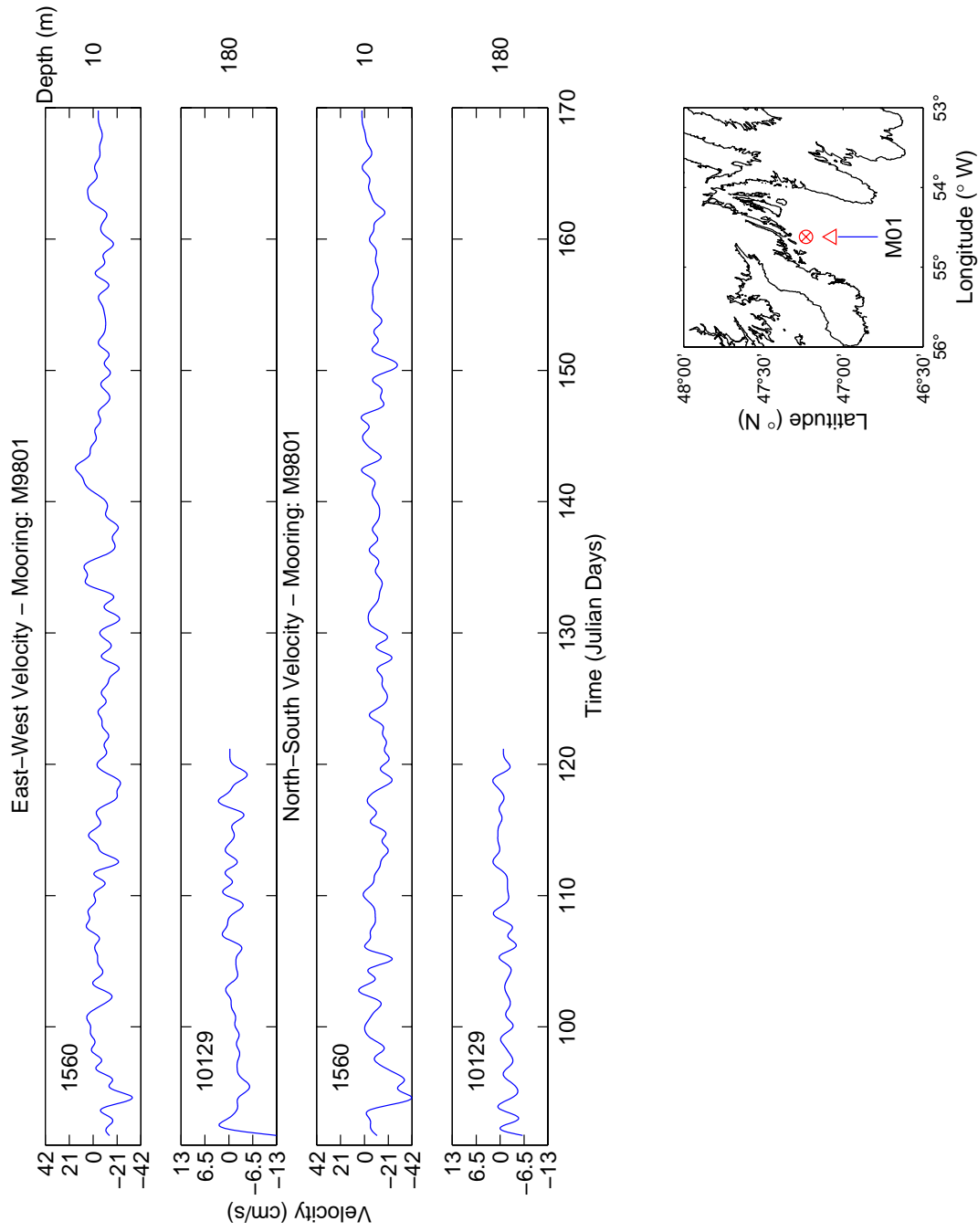


Figure 7: Time series of east-west and north-south components of velocity at Mooring M1. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

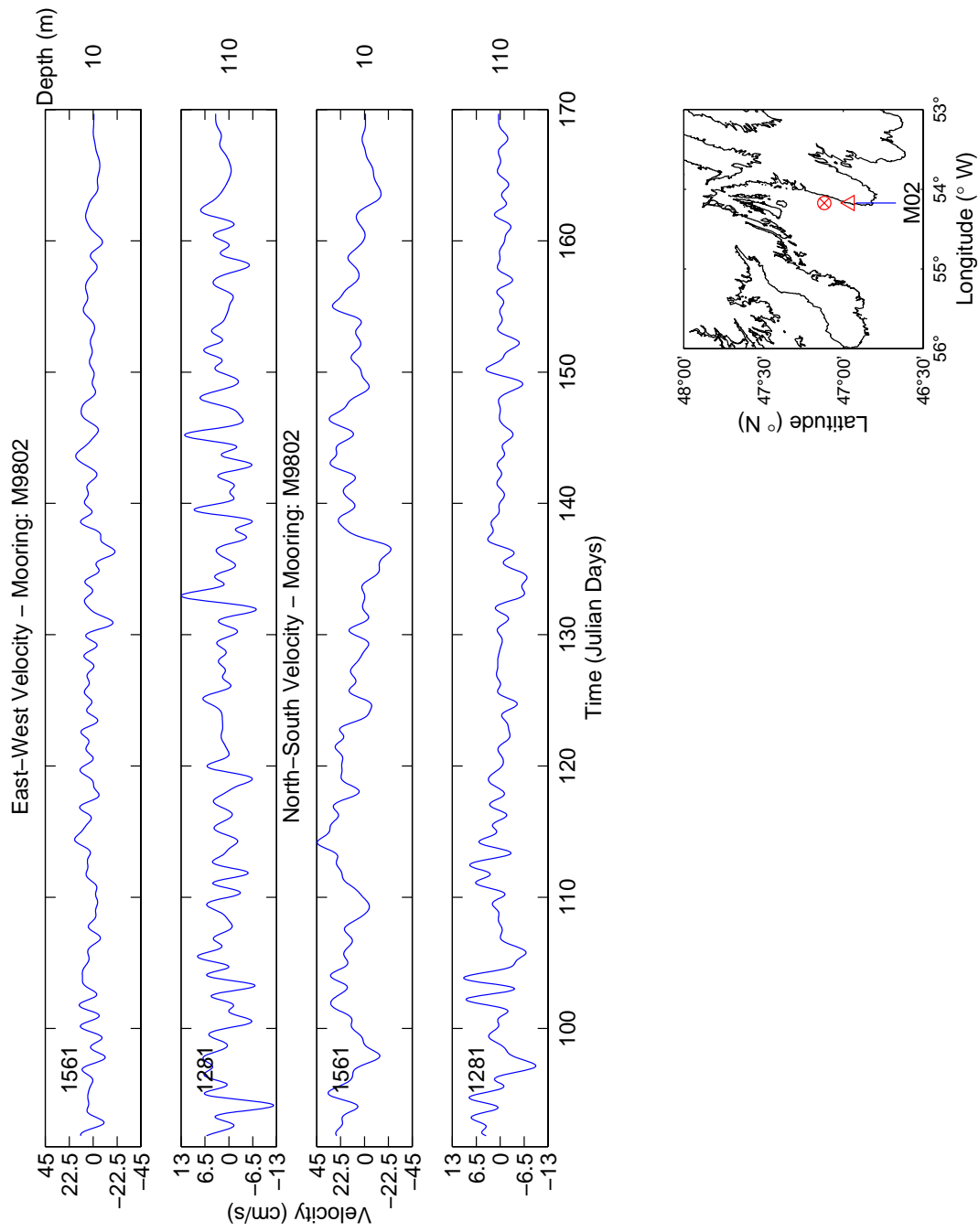


Figure 8: Time series of east-west and north-south components of velocity at Mooring M2. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

Residual Velocity – Vector Plots

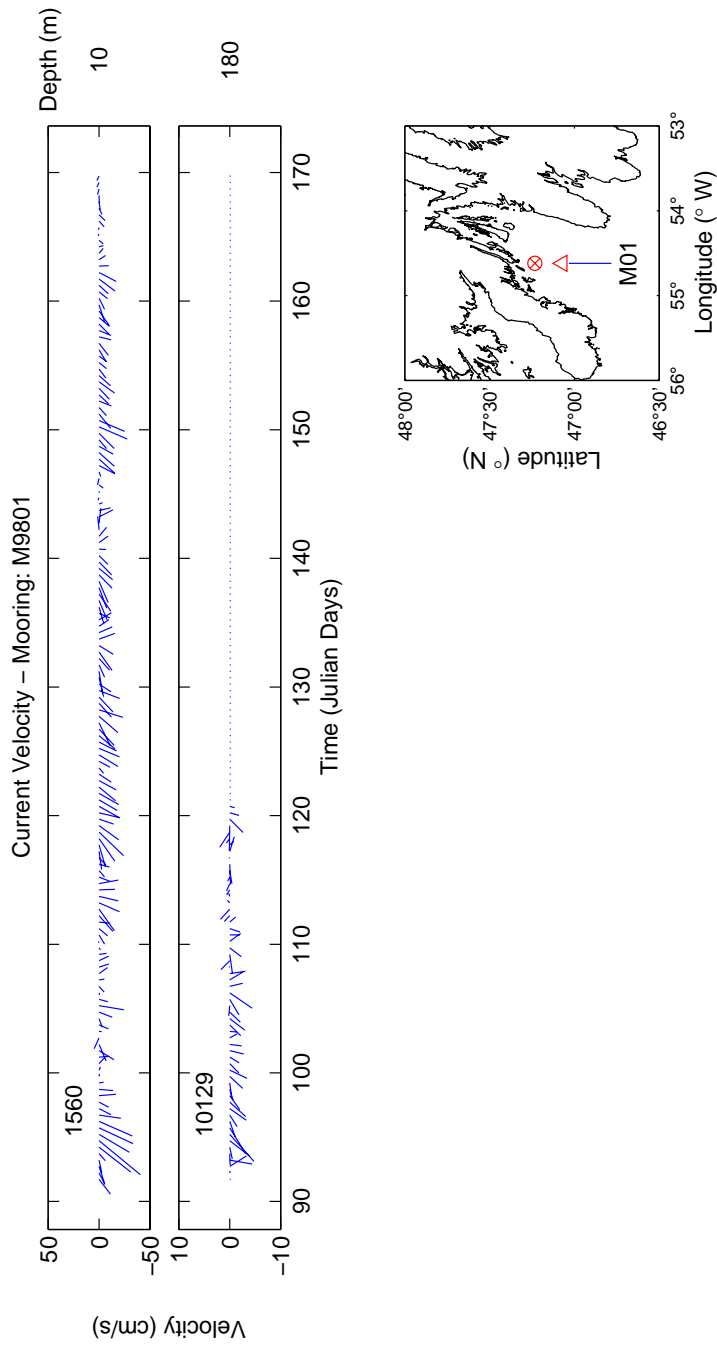


Figure 9: Velocity at Mooring M1. North directional vector to top of diagram. Vectors plotted at twelve-hour intervals. Instrument name is listed in top left-hand corner of each plot. Recorded depth of each instrument is listed on the right-hand side.

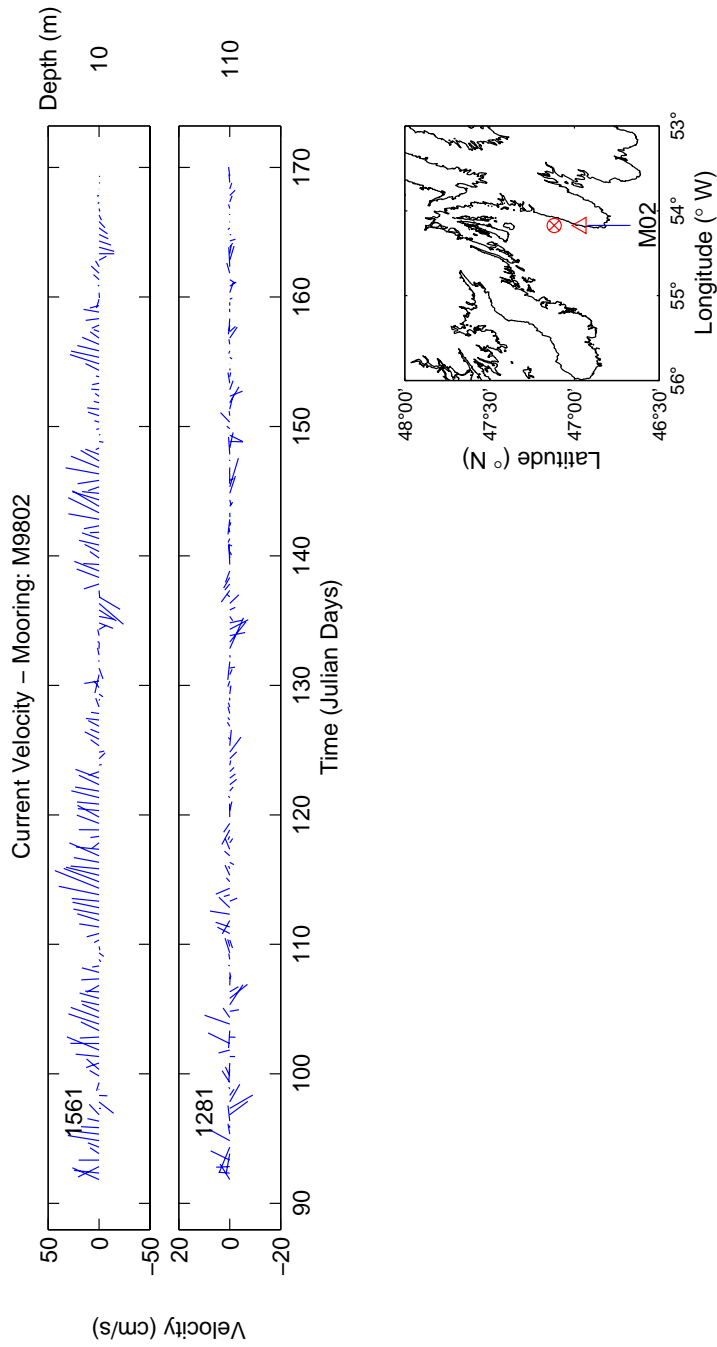


Figure 10: Velocity at Mooring M1. North directional vector to top of diagram. Vectors plotted at twelve-hour intervals. Instrument name is listed in top left-hand corner of each plot. Recorded depth of each instrument is listed on the right-hand side.

Main Tidal Constituents U, V

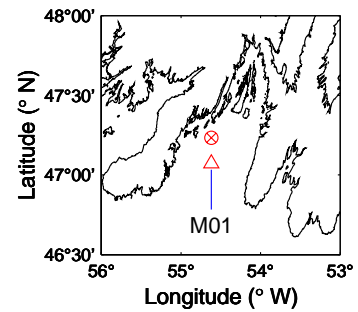
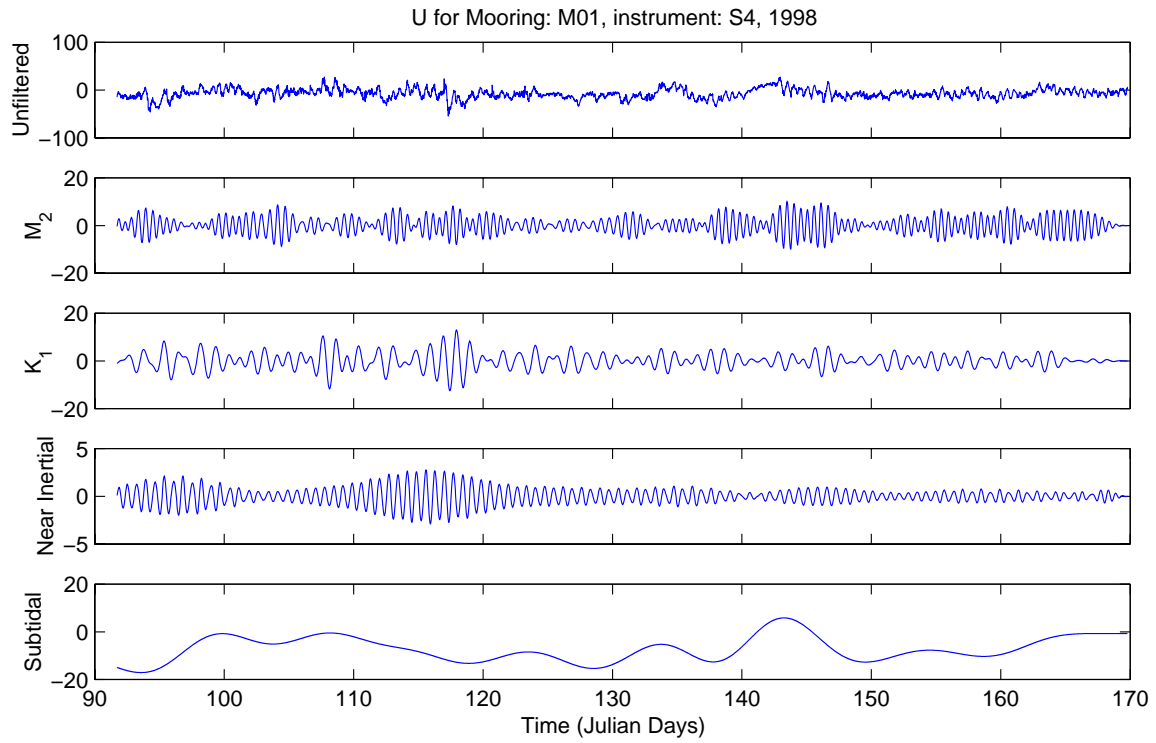


Figure 11: Plot of the main tidal constituents: u component of velocity, Mooring: M1 using an S4 instrument, which recorded at a depth of 10m.

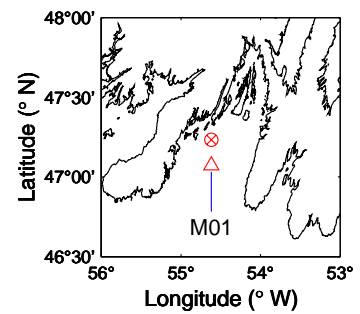
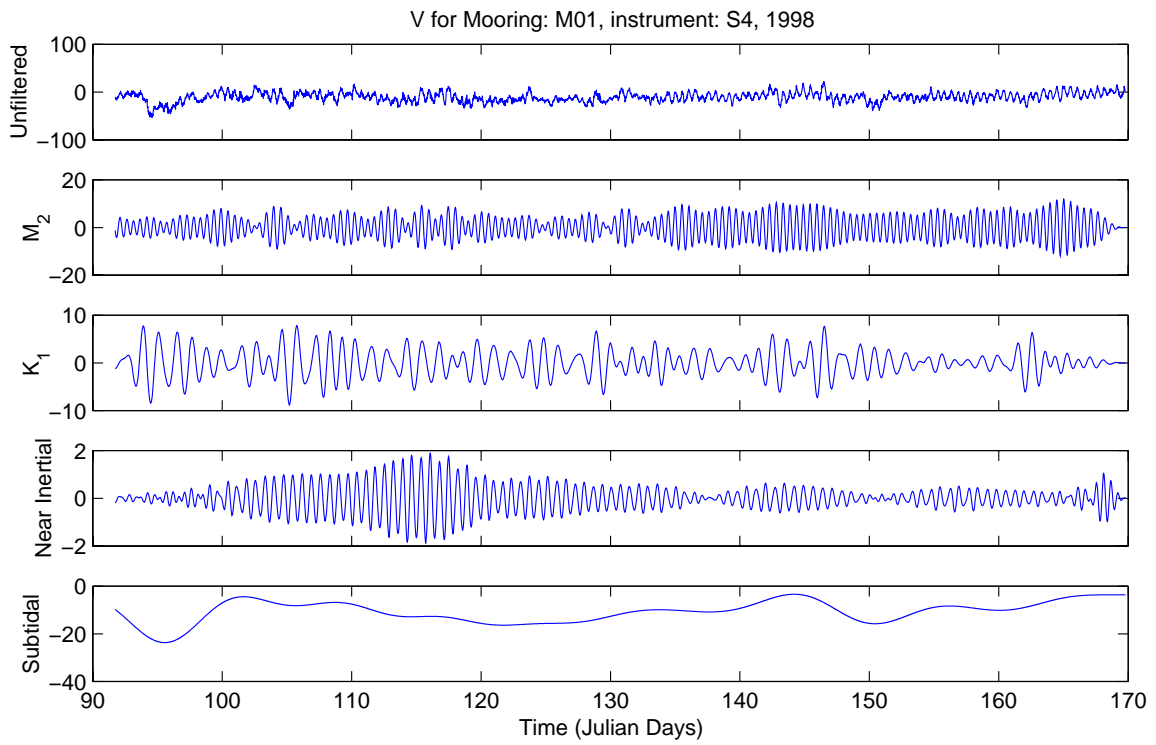


Figure 12: Plot of the main tidal constituents: v component of velocity, Mooring: M1 using an S4 instrument, which recorded at a depth of 10m.

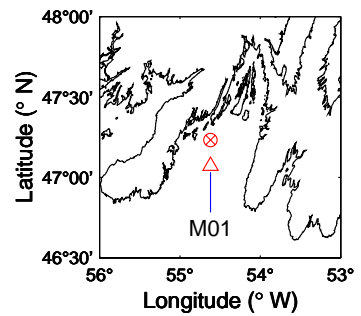
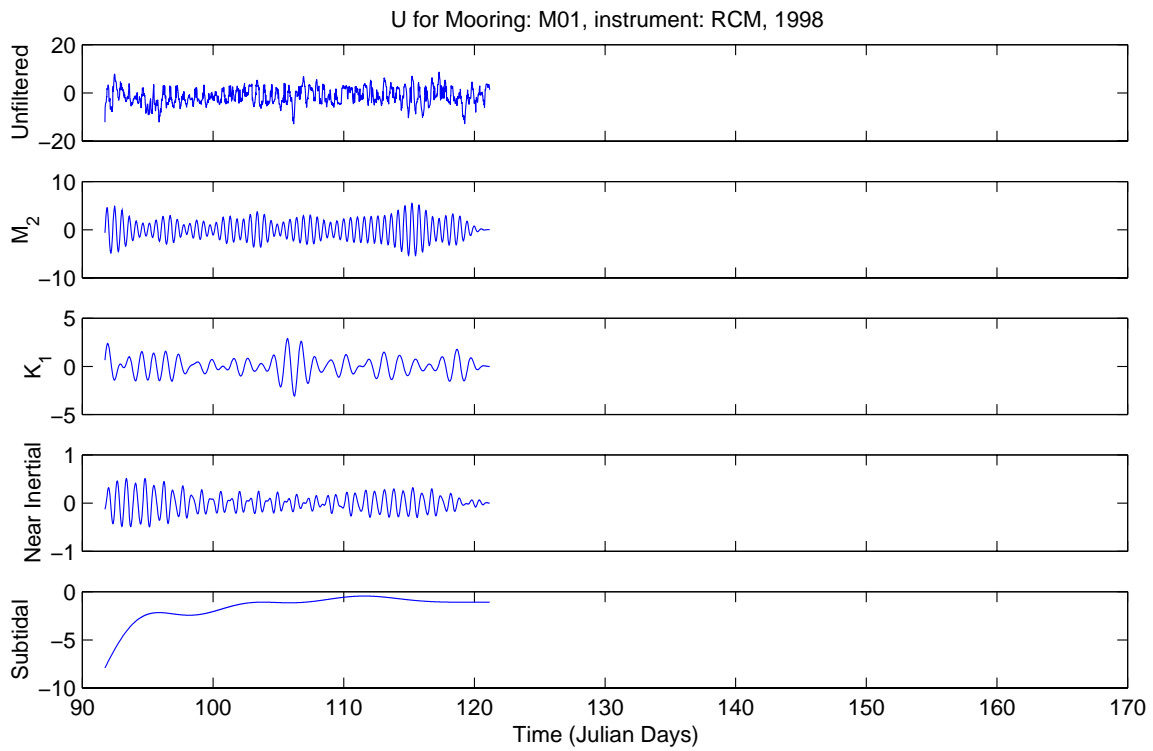


Figure 13: Plot of the main tidal constituents: u component of velocity, Mooring: M1 using a RCM instrument, which recorded at a depth of 180m.

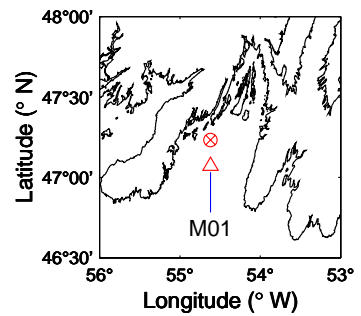
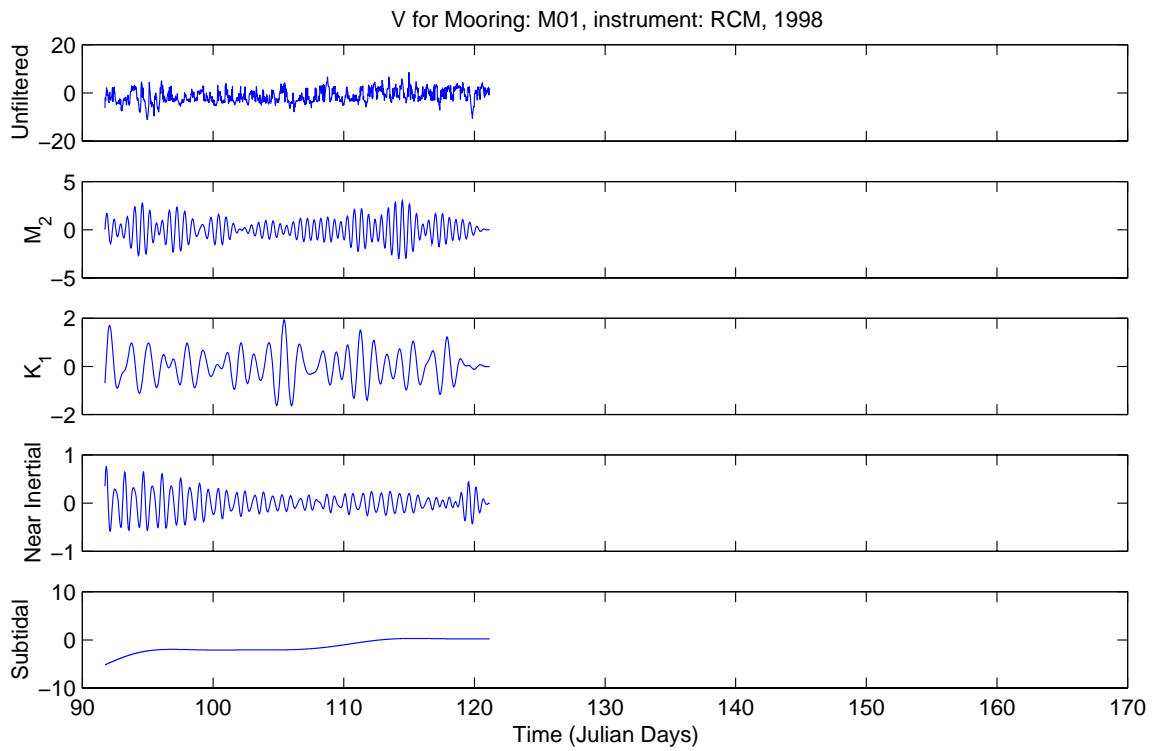


Figure 14: Plot of the main tidal constituents: v component of velocity, Mooring: M1 using a RCM instrument, which recorded at a depth of 180m.

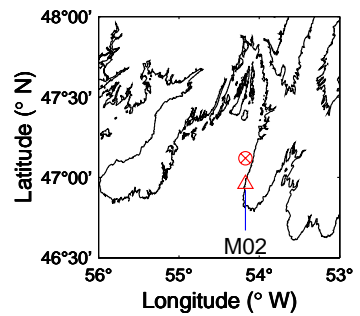
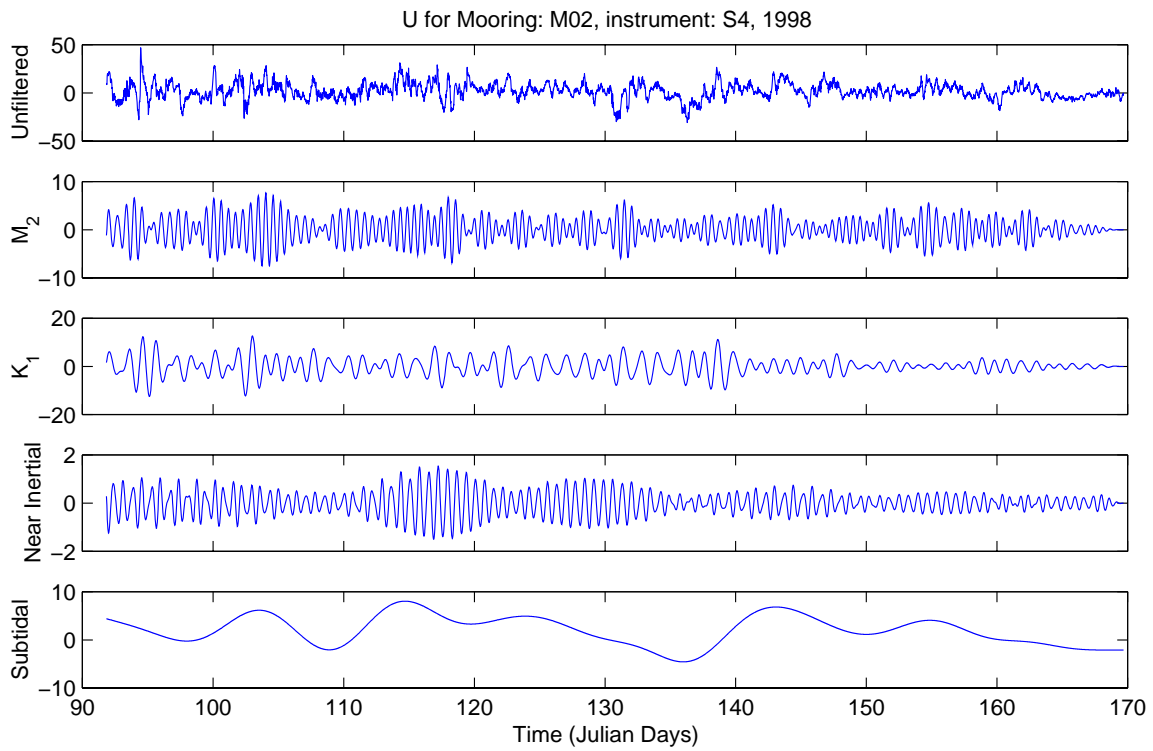


Figure 15: Plot of the main tidal constituents: u component of velocity, Mooring: M2 using an S4 instrument, which recorded at a depth of 10m.

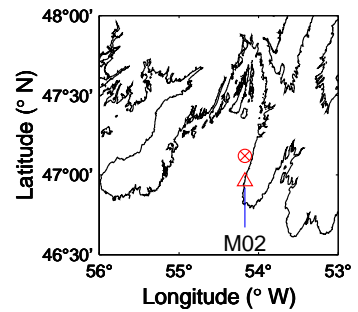
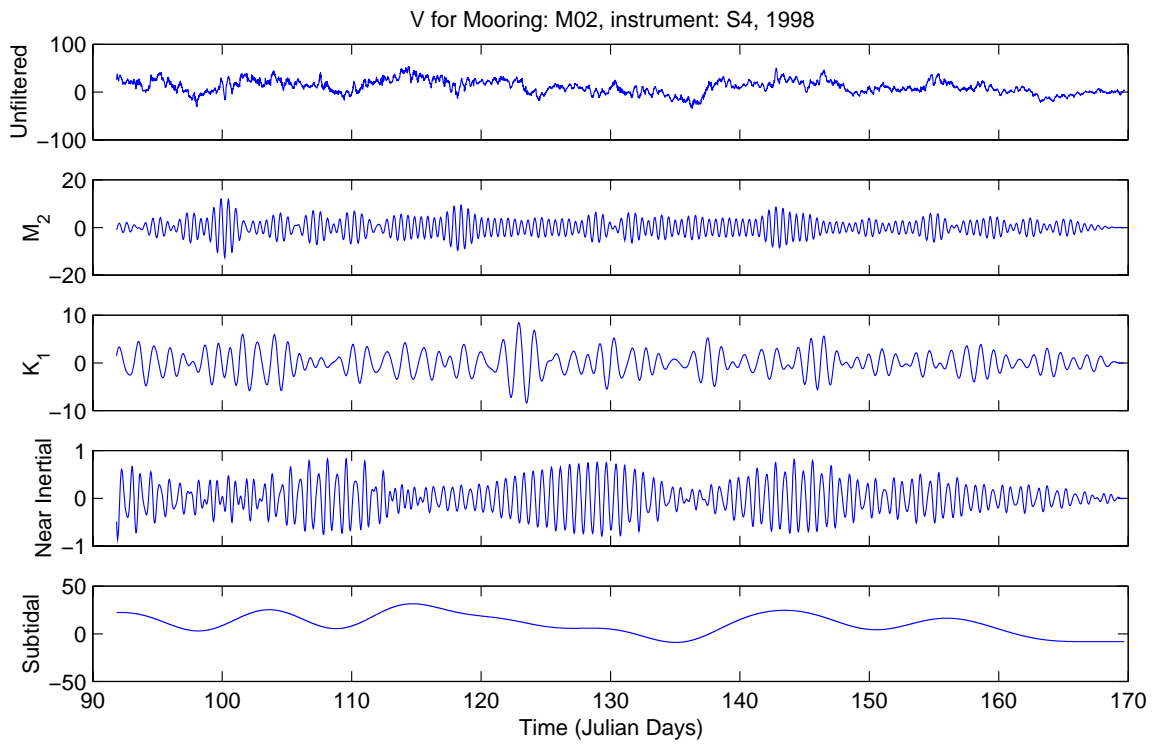


Figure 16: Plot of the main tidal constituents: v component of velocity, Mooring: M2 using an S4 instrument, which recorded at a depth of 10m.

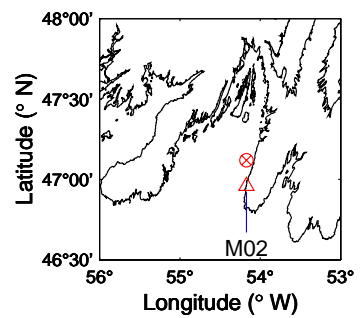
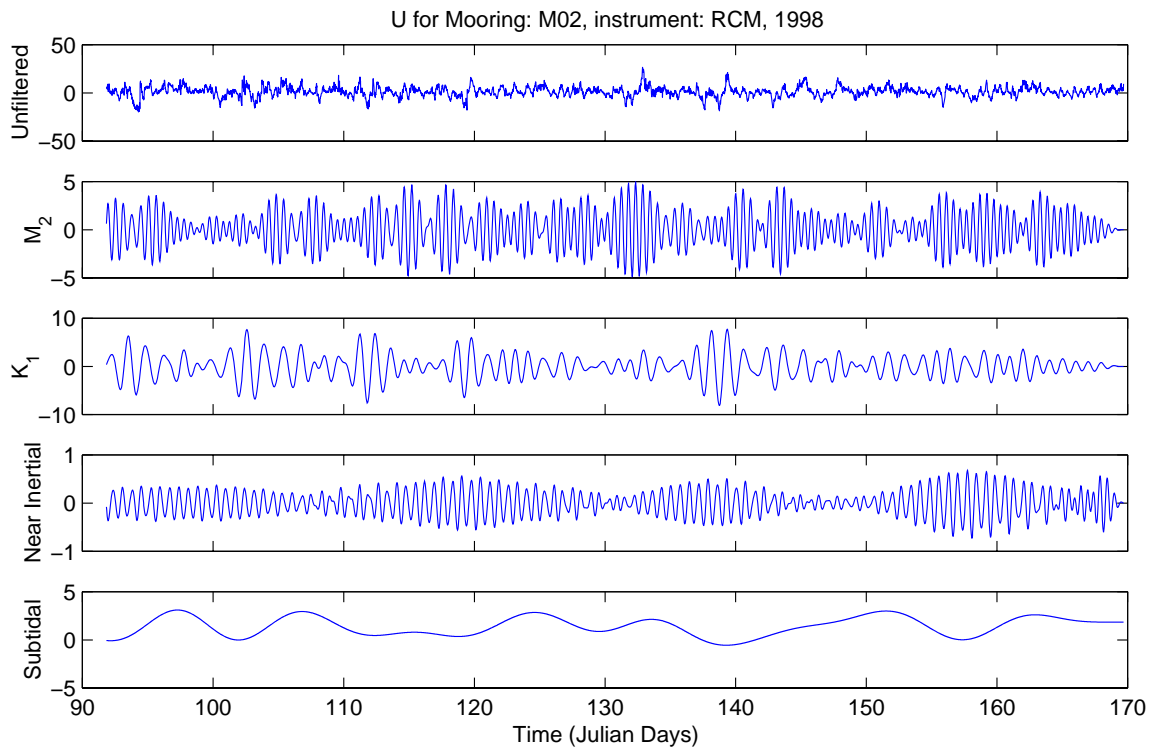


Figure 17: Plot of the main tidal constituents: u component of velocity, Mooring: M2 using an S4 instrument, which recorded at a depth of 110m.

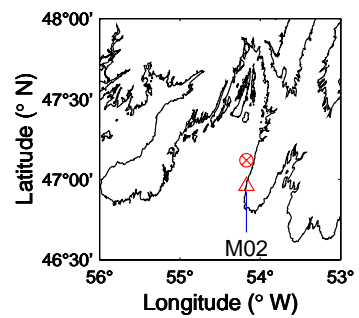
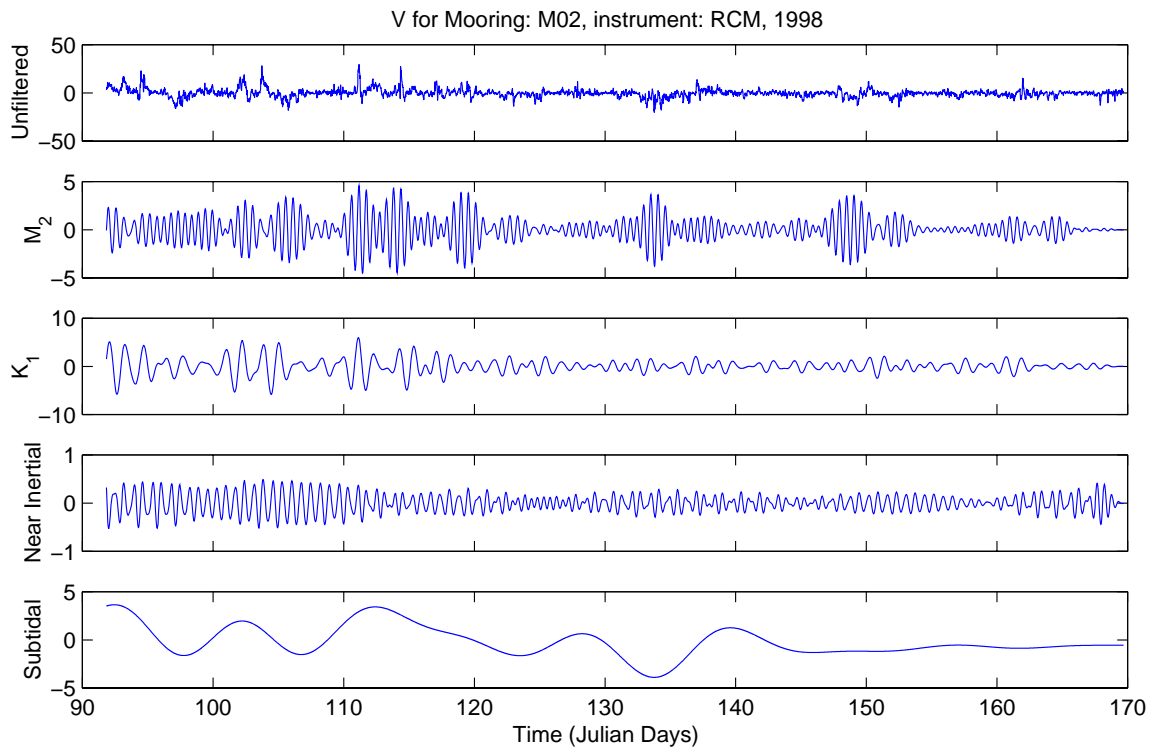


Figure 18: Plot of the main tidal constituents: v component of velocity, Mooring: M2 using an S4 instrument, which recorded at a depth of 110m.

The 1999 Data Set – Temperature

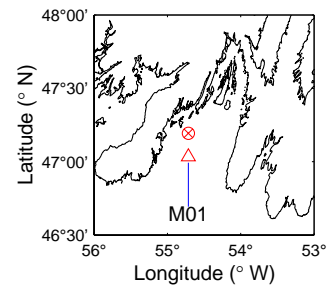
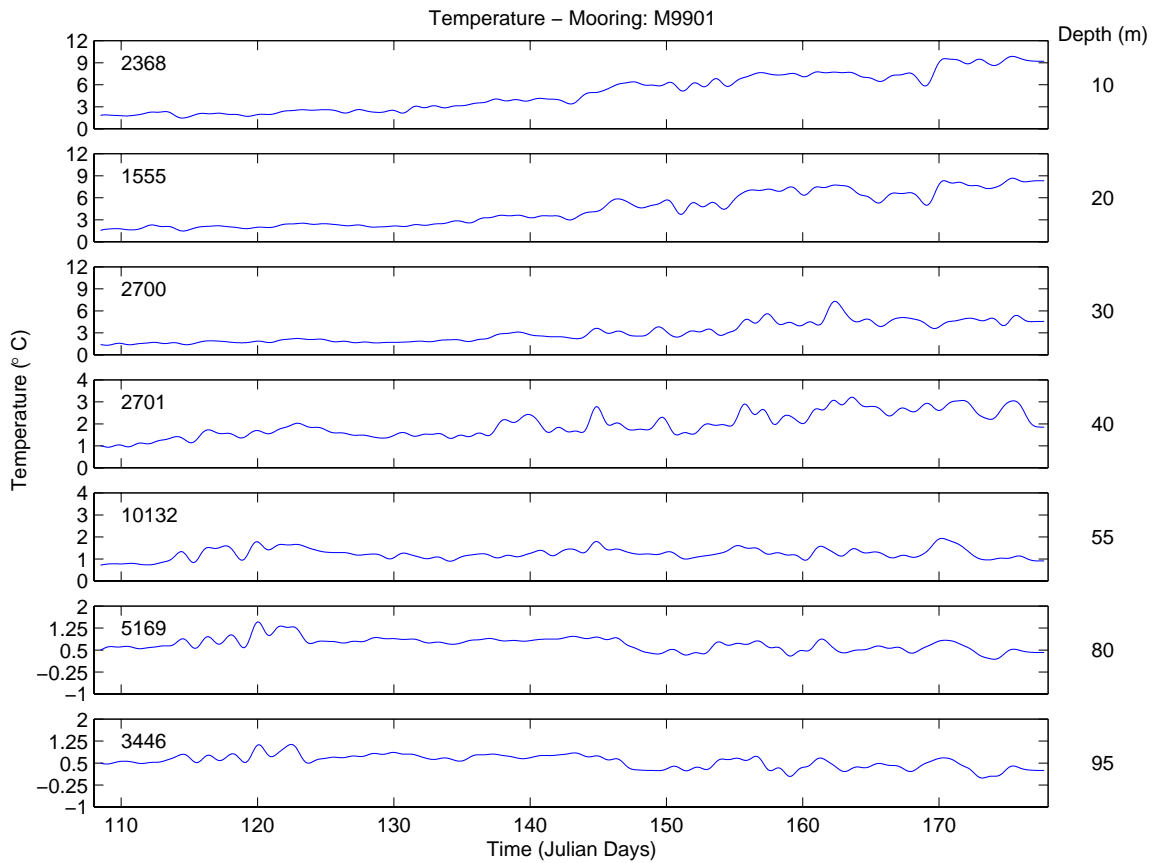


Figure 19: Time series plot of the detided temperature at Mooring M1. Instrument name is listed in the top left-hand corner of each plot. Recorded depth is listed down the right hand side of the figure.

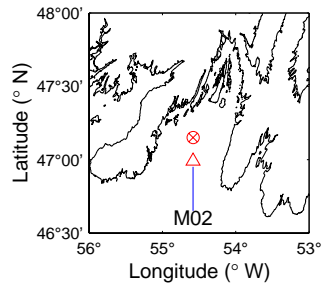
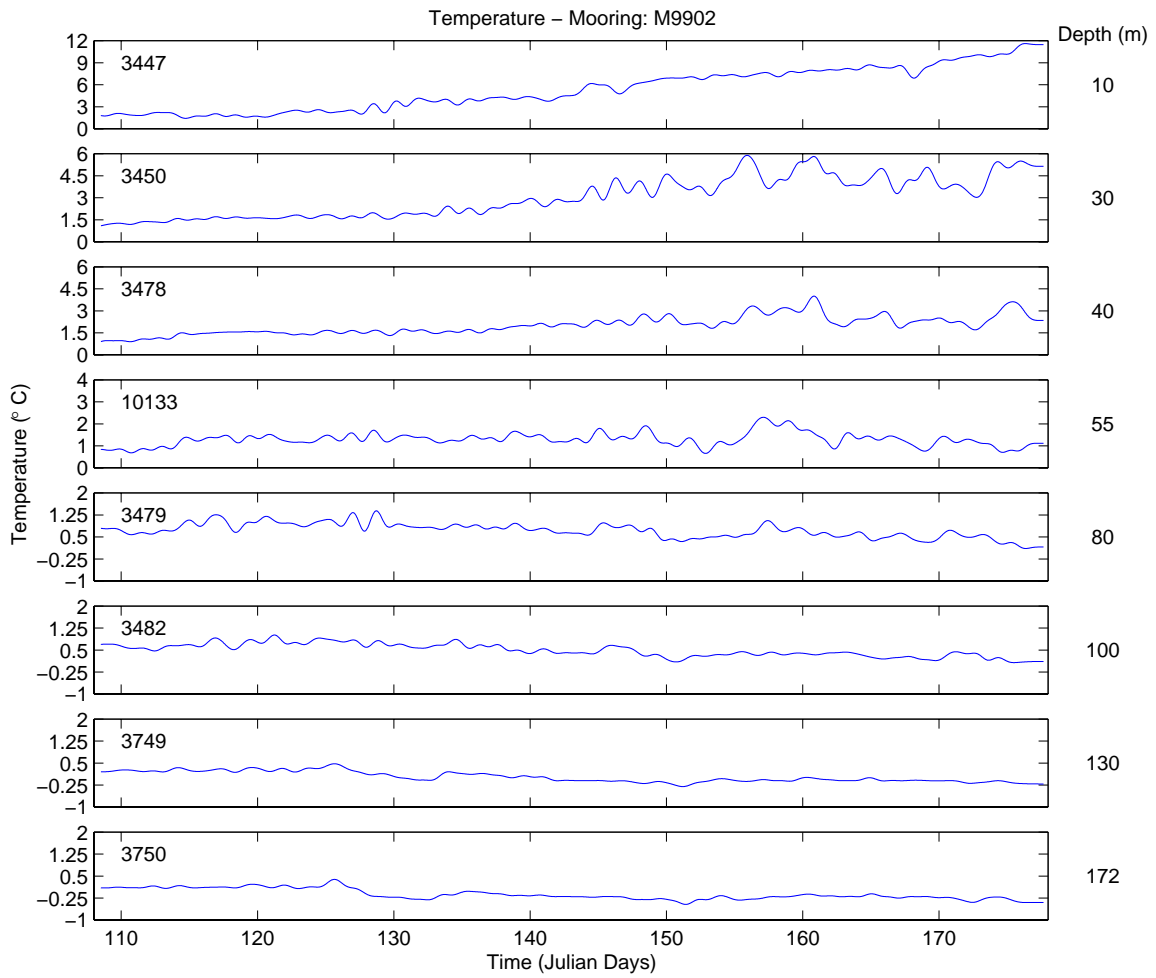


Figure 20: Time series plot of the detided temperature at Mooring M2. Instrument name is listed in the top left-hand corner of each plot. Recorded depth is listed down the right hand side of the figure.

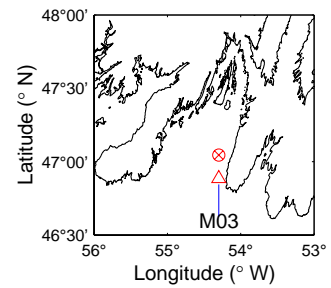
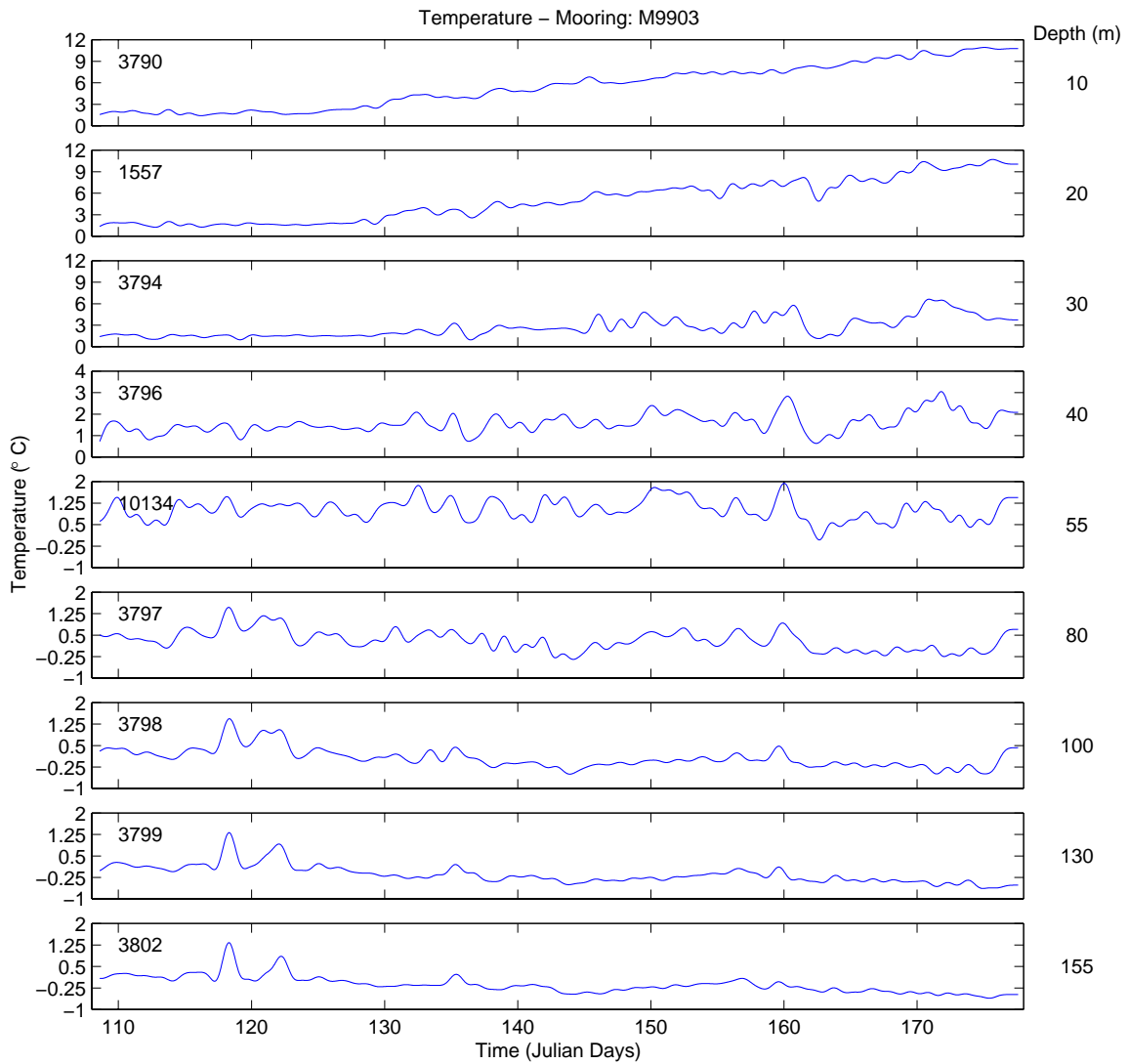


Figure 21: Time series plot of the detided temperature at Mooring M3. Instrument name is listed in the top left-hand corner of each plot. Recorded depth is listed down the right hand side of the figure.

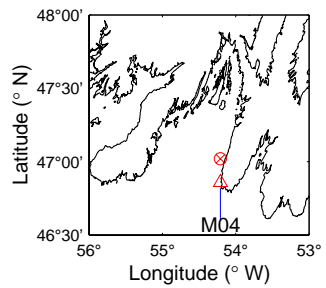
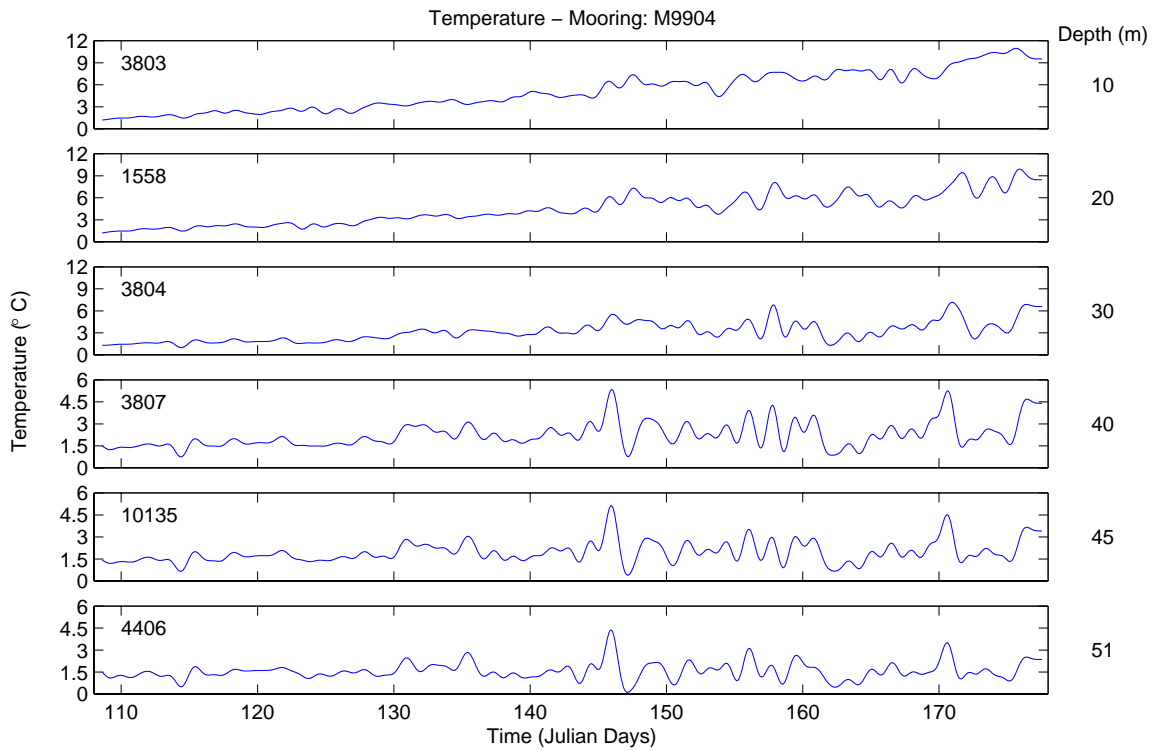


Figure 22: Time series plot of the detided temperature at Mooring M4. Instrument name is listed in the top left-hand corner of each plot. Recorded depth is listed down the right hand side of the figure.

Salinity

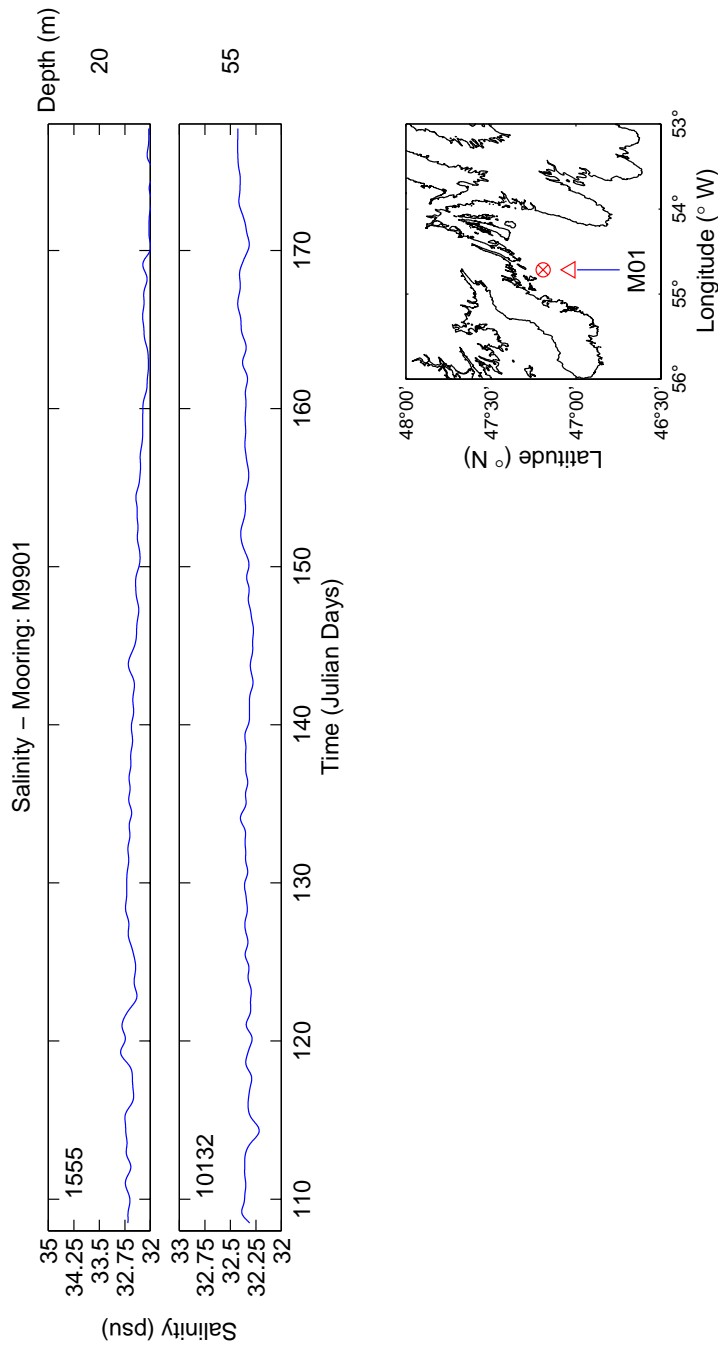


Figure 23: Time series of detided salinity at Mooring M1. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

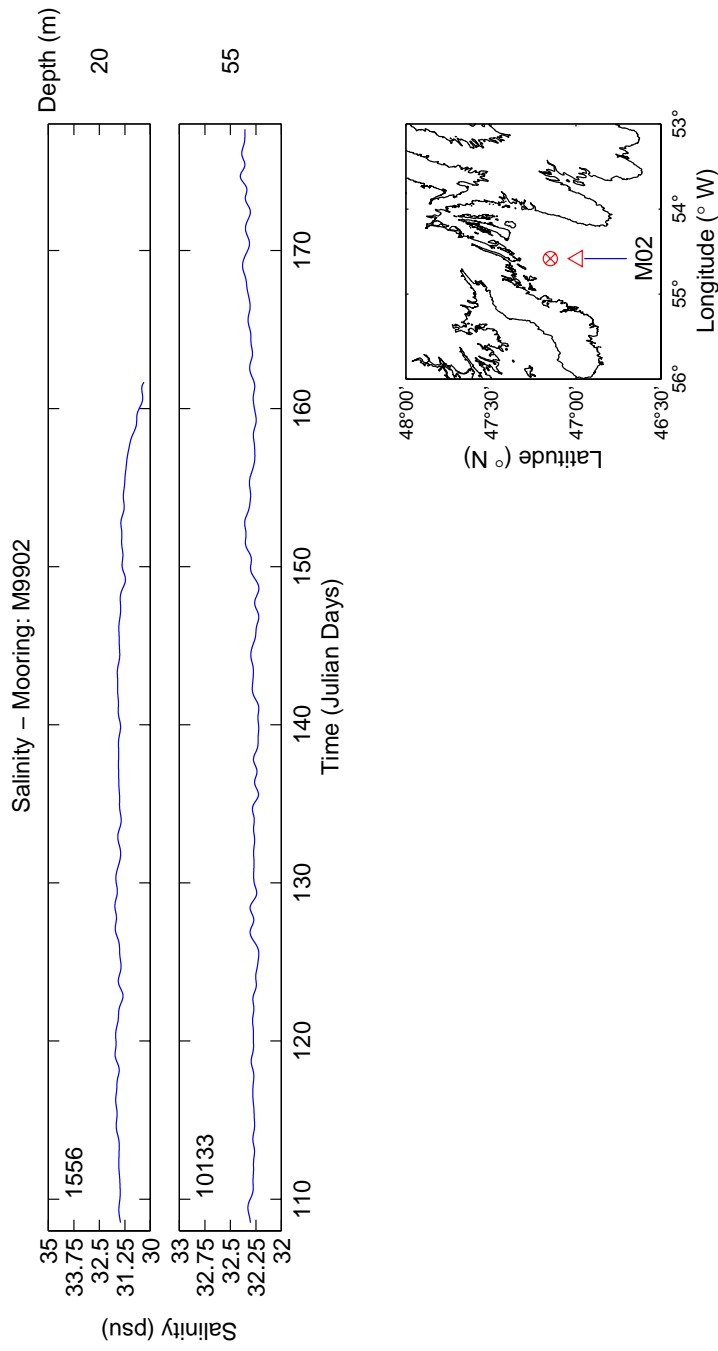


Figure 24: Time series of detided salinity at Mooring M2. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

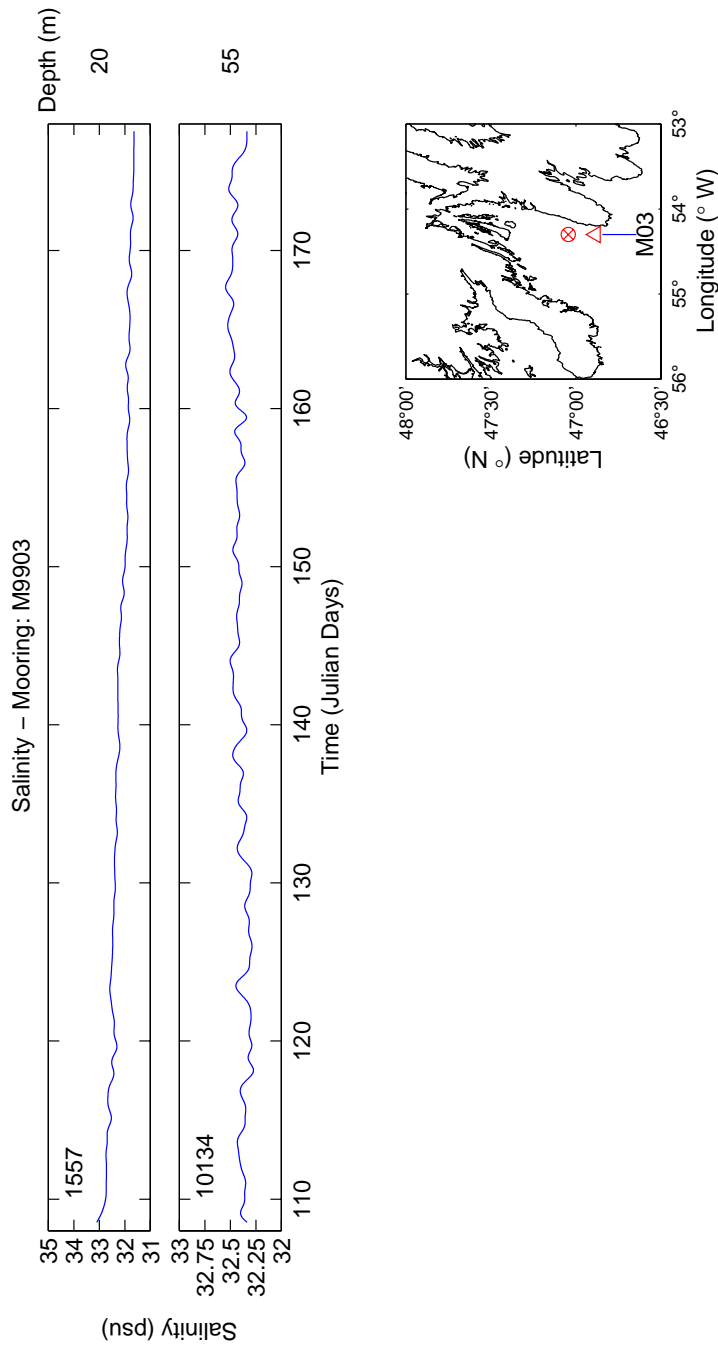


Figure 25: Time series of detided salinity at Mooring M9903. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

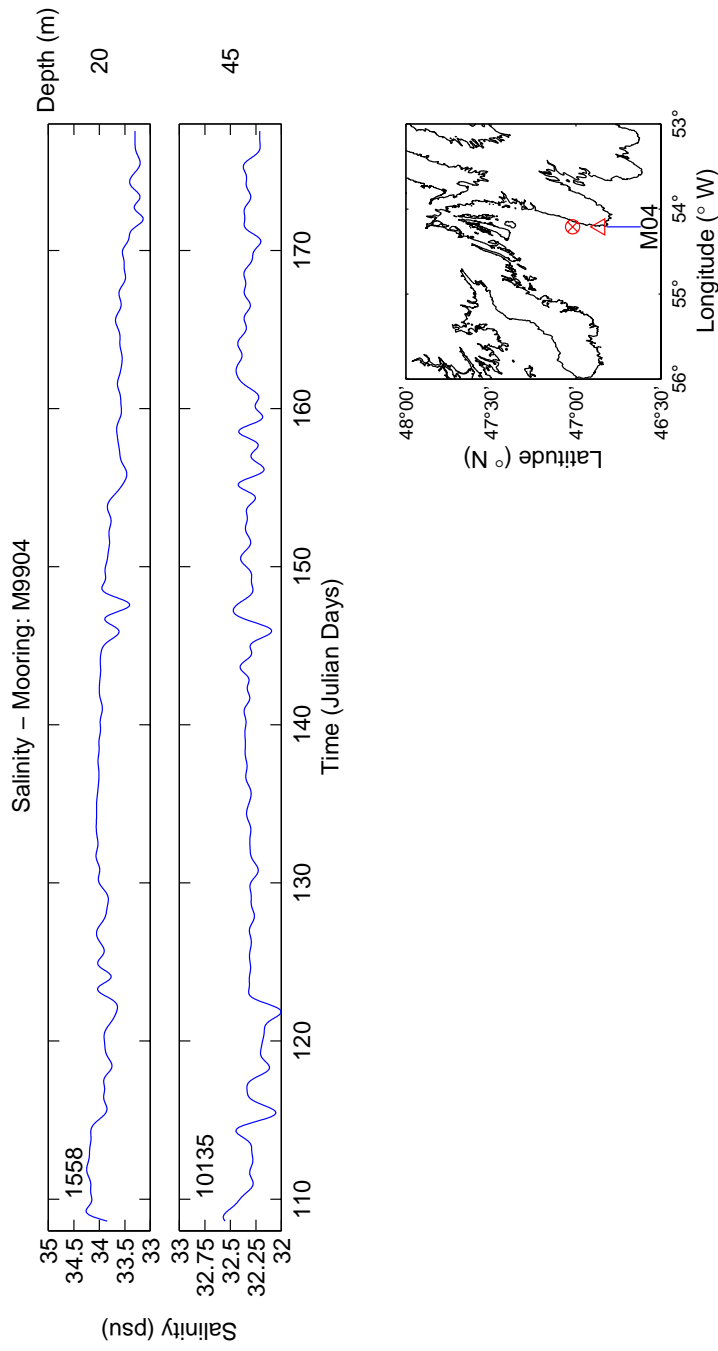


Figure 26: Time series of detided salinity at Mooring M4. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

Residual Velocity U, V

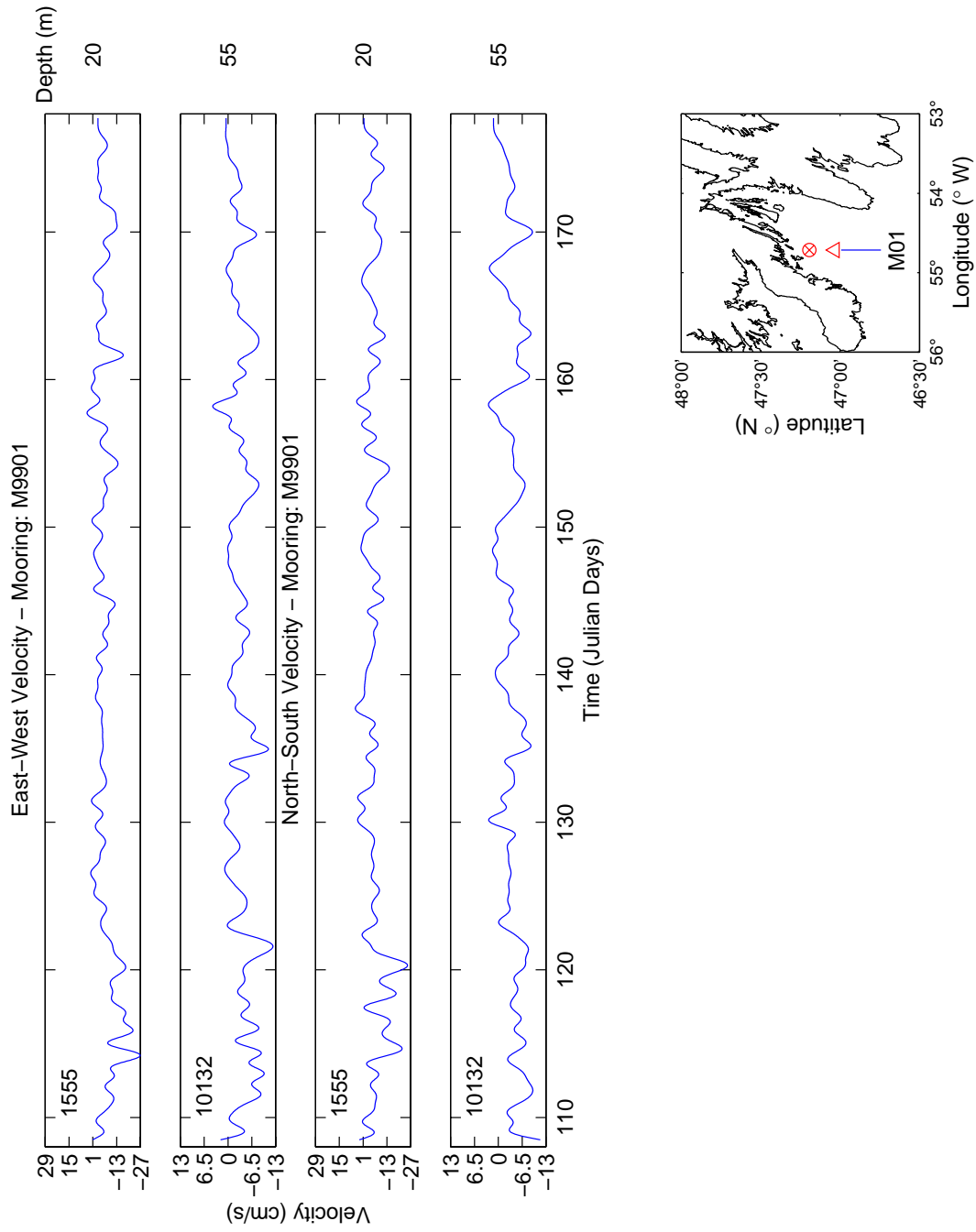


Figure 27: Time series of the east-west and north-south components of velocity at Mooring M1. Instrument name is listed in the top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

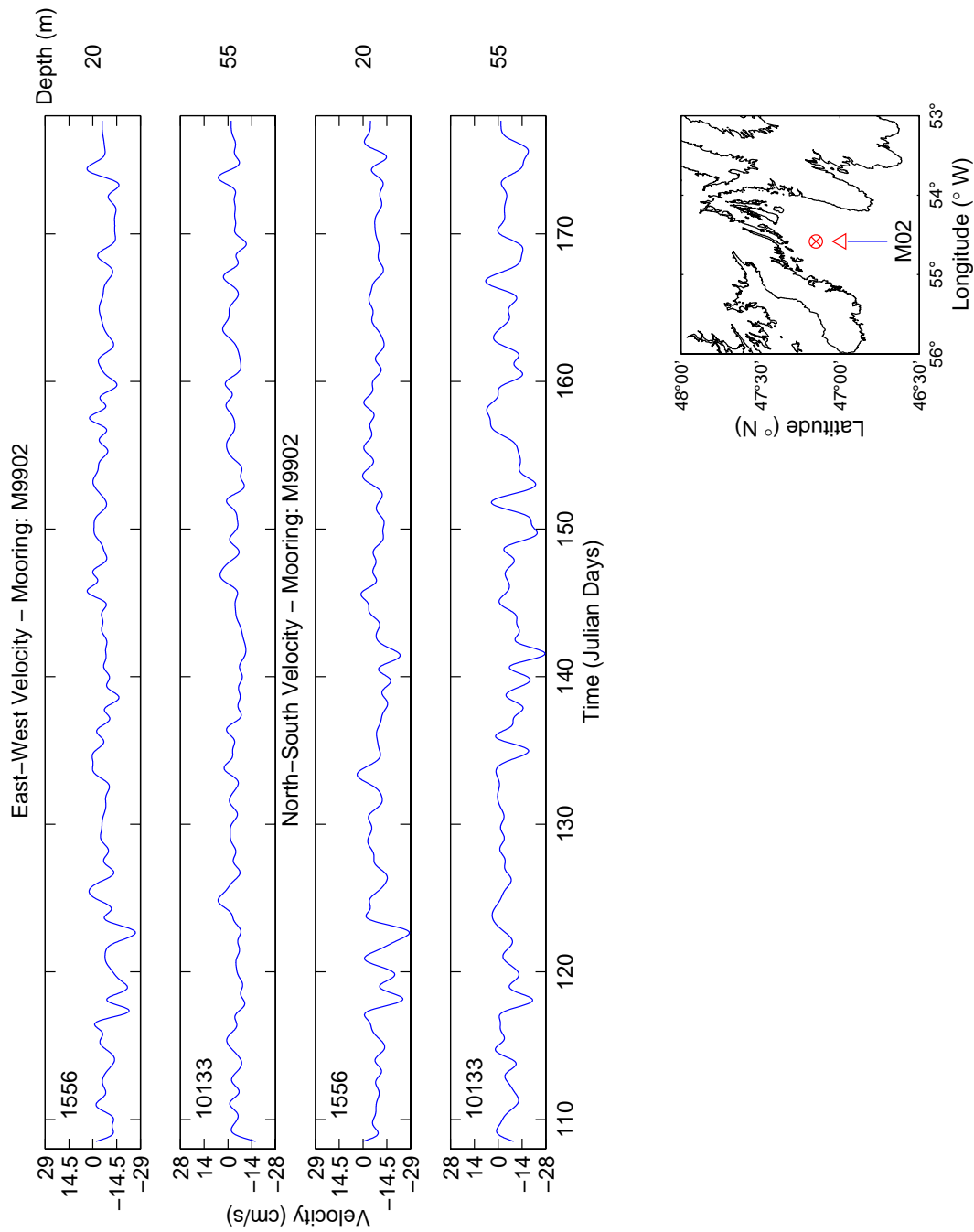


Figure 28: Time series of the east-west and north-south components of velocity at Mooring M2. Instrument name is listed in the top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

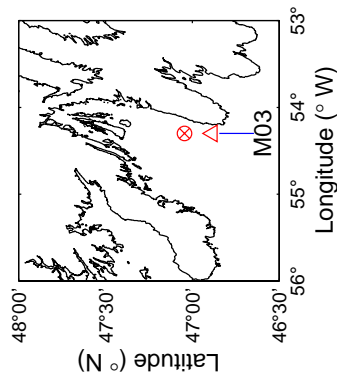
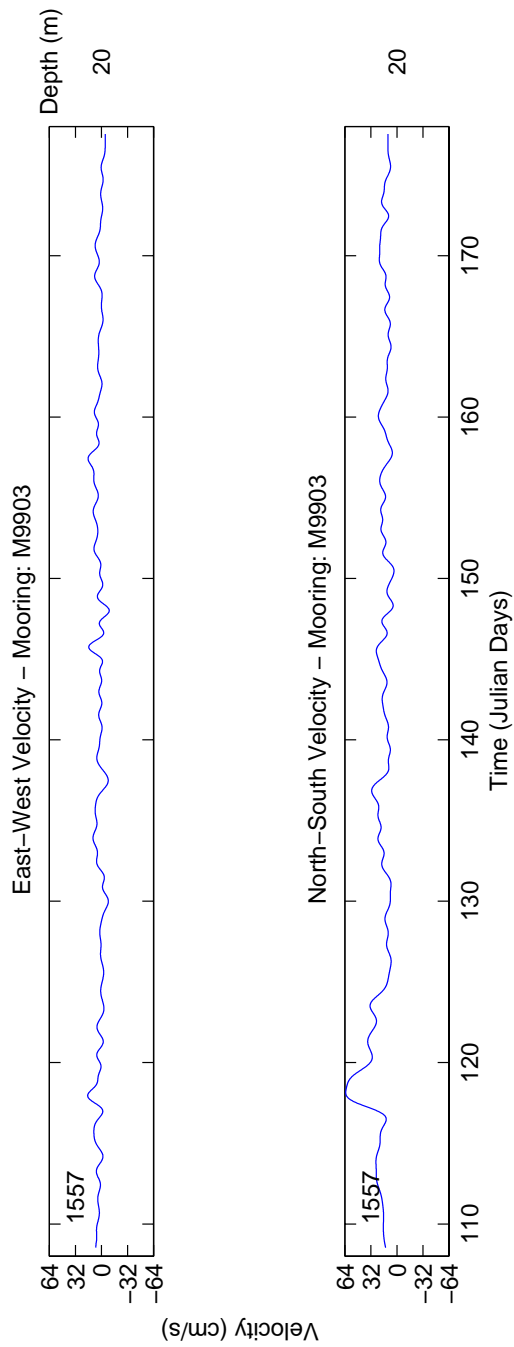


Figure 29: Time series of the east-west and north-south components of velocity at Mooring M3. Instrument name is listed in the top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

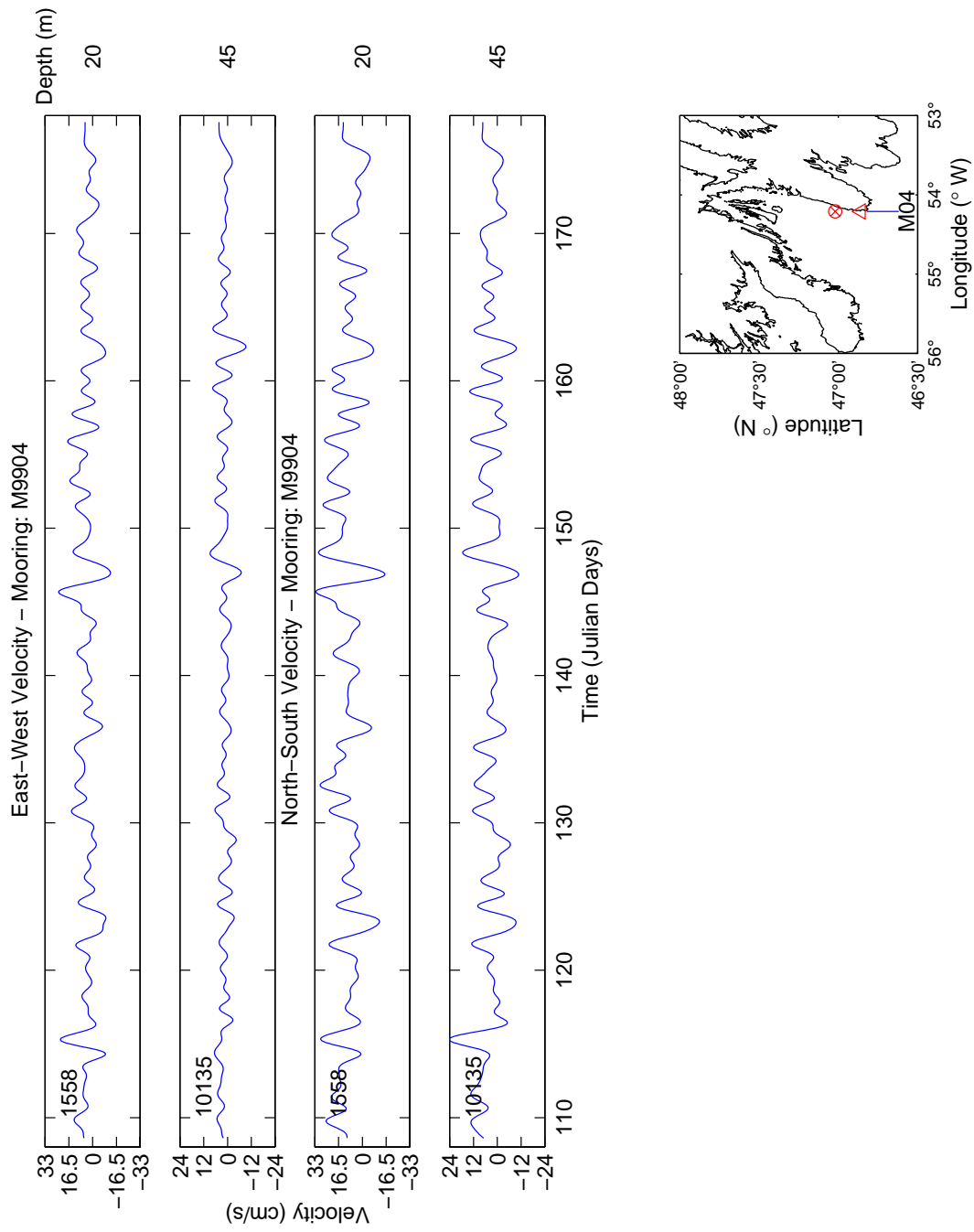


Figure 30: Time series of the east-west and north-south components of velocity at Mooring M4. Instrument name is listed in the top-left hand corner of each plot. Recorded depth of each instrument is listed down the right hand side of the figure.

Residual Velocity – Vector Plots

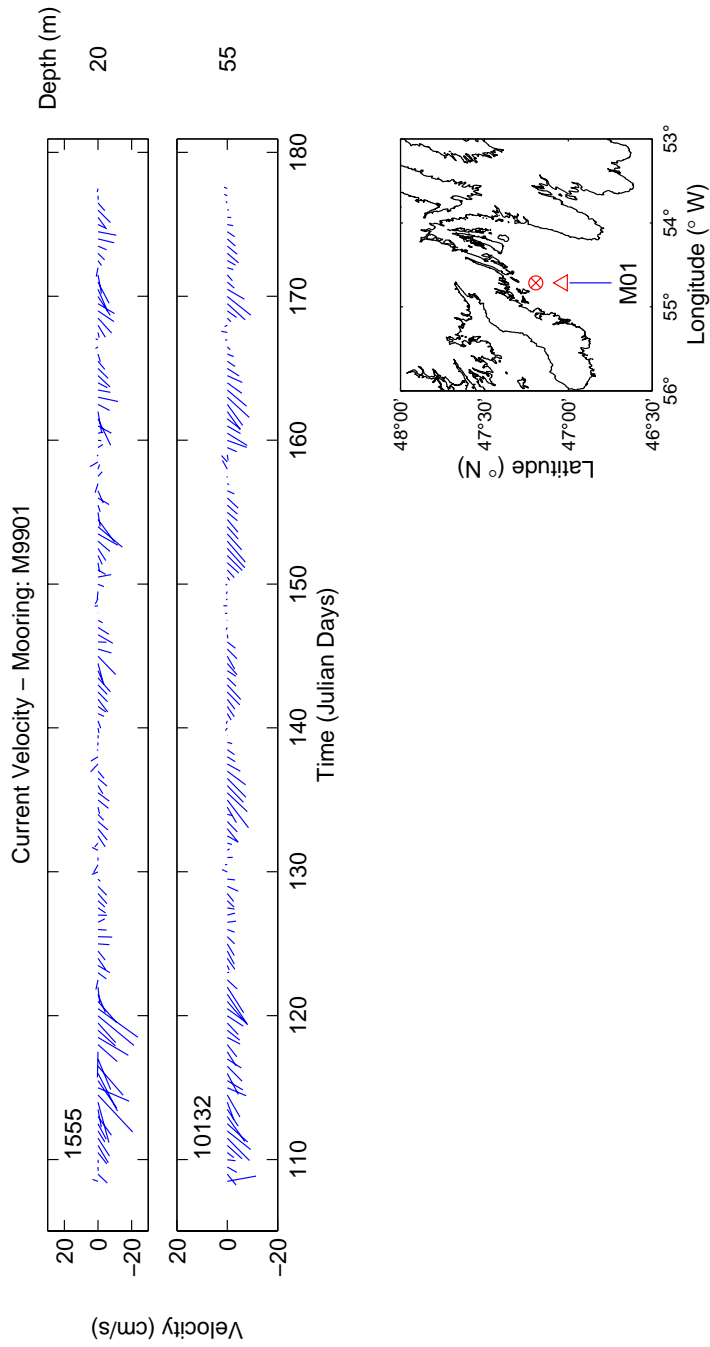


Figure 31: Velocity at Mooring M1. North directional vector to top of diagram. Vectors plotted at twelve-hour intervals. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed on the right-hand side.

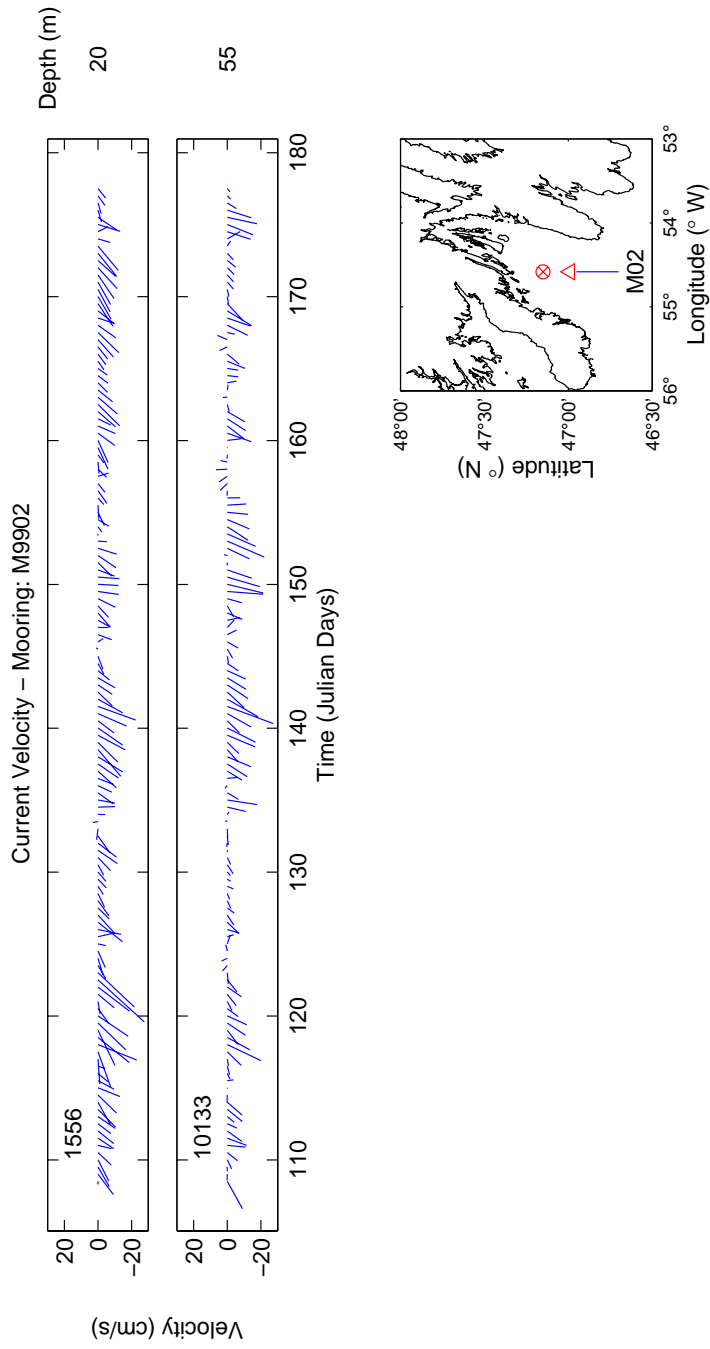


Figure 32: Velocity at Mooring M2. North directional vector to top of diagram. Vectors plotted at twelve-hour intervals. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed on the right-hand side.

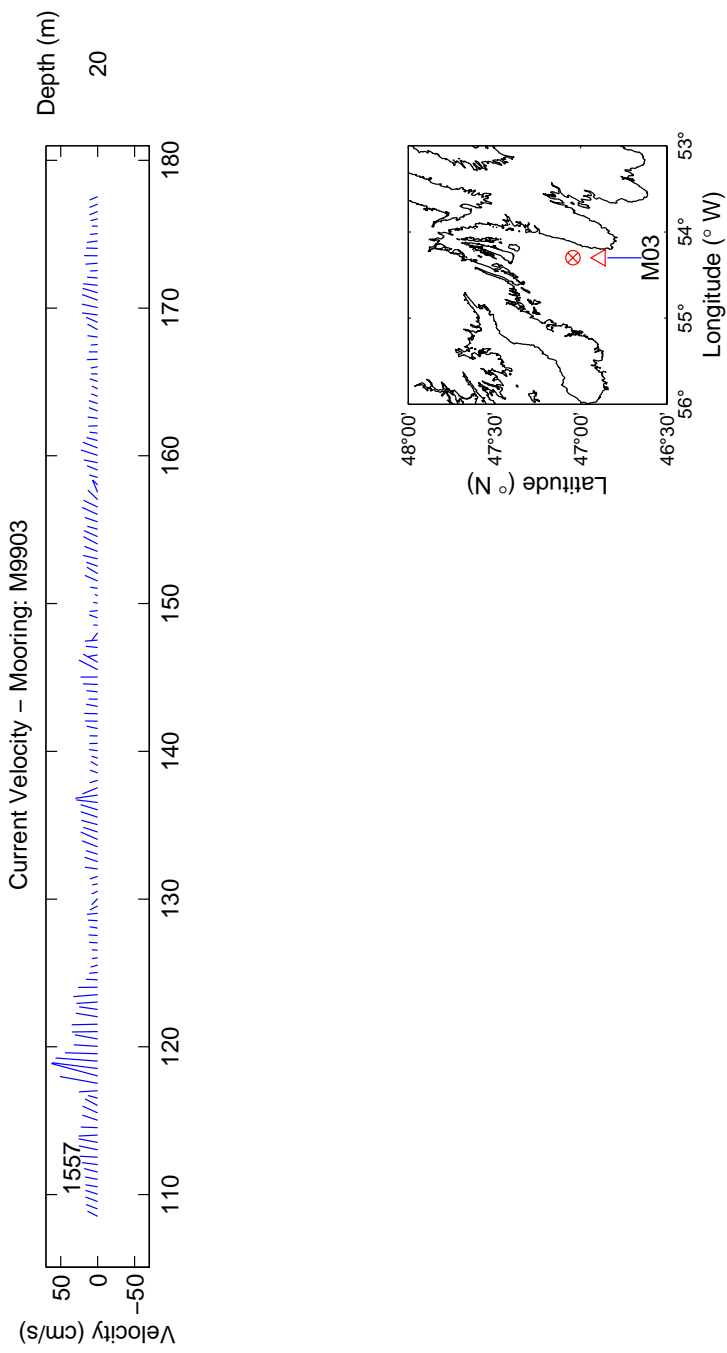


Figure 33: Velocity at Mooring M3. North directional vector to top of diagram. Vectors plotted at twelve-hour intervals. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed on the right-hand side.

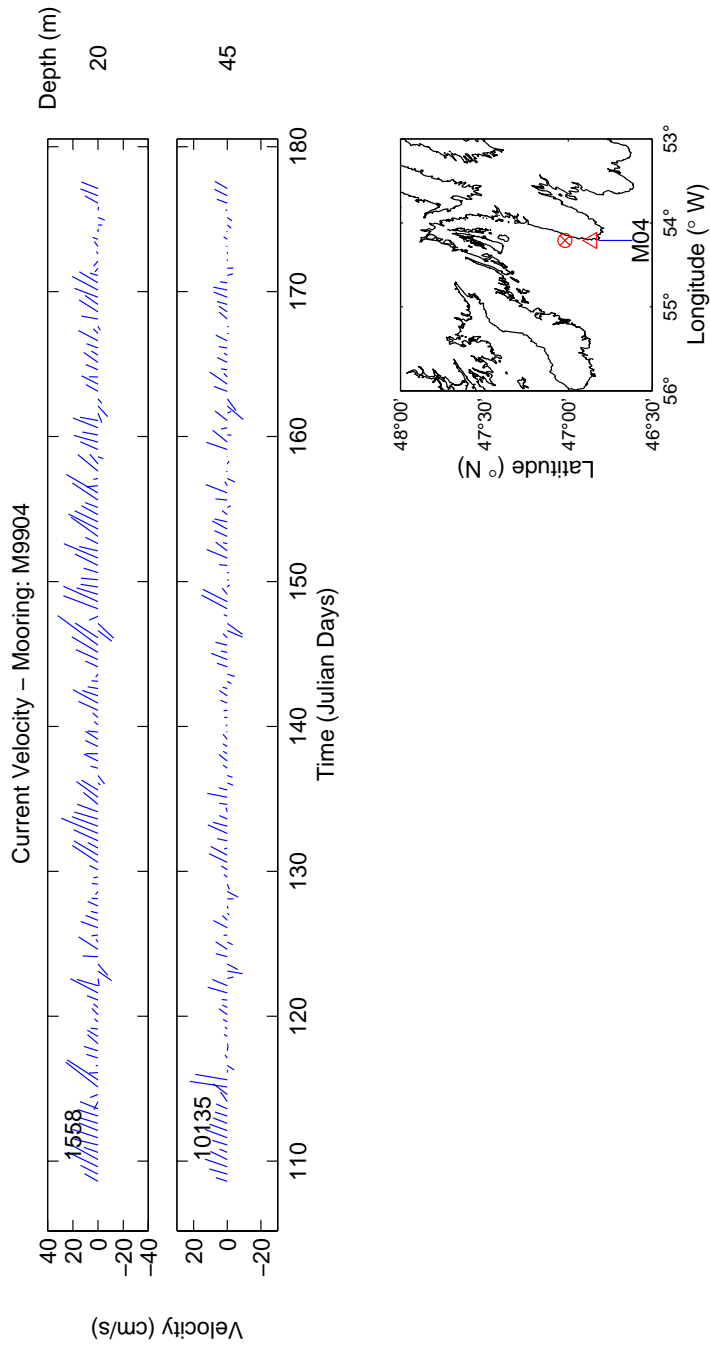


Figure 34: Velocity at Mooring M4. North directional vector to top of diagram. Vectors plotted at twelve-hour intervals. Instrument name is listed in top-left hand corner of each plot. Recorded depth of each instrument is listed on the right-hand side.

Main Tidal Constituents U, V

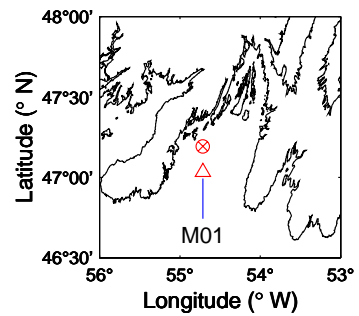
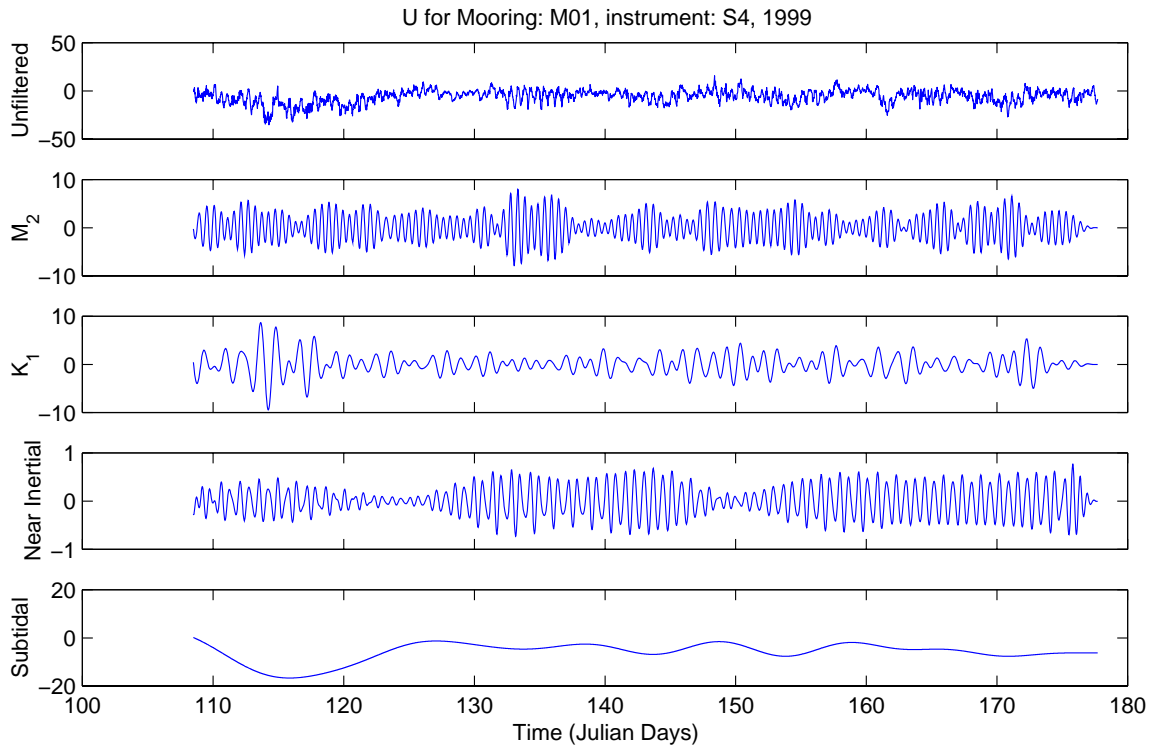


Figure 35: Plot of the main tidal constituents: u component of velocity, Mooring: M1 using an S4 instrument, which recorded at a depth of 20m.

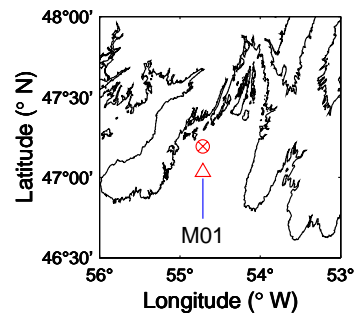
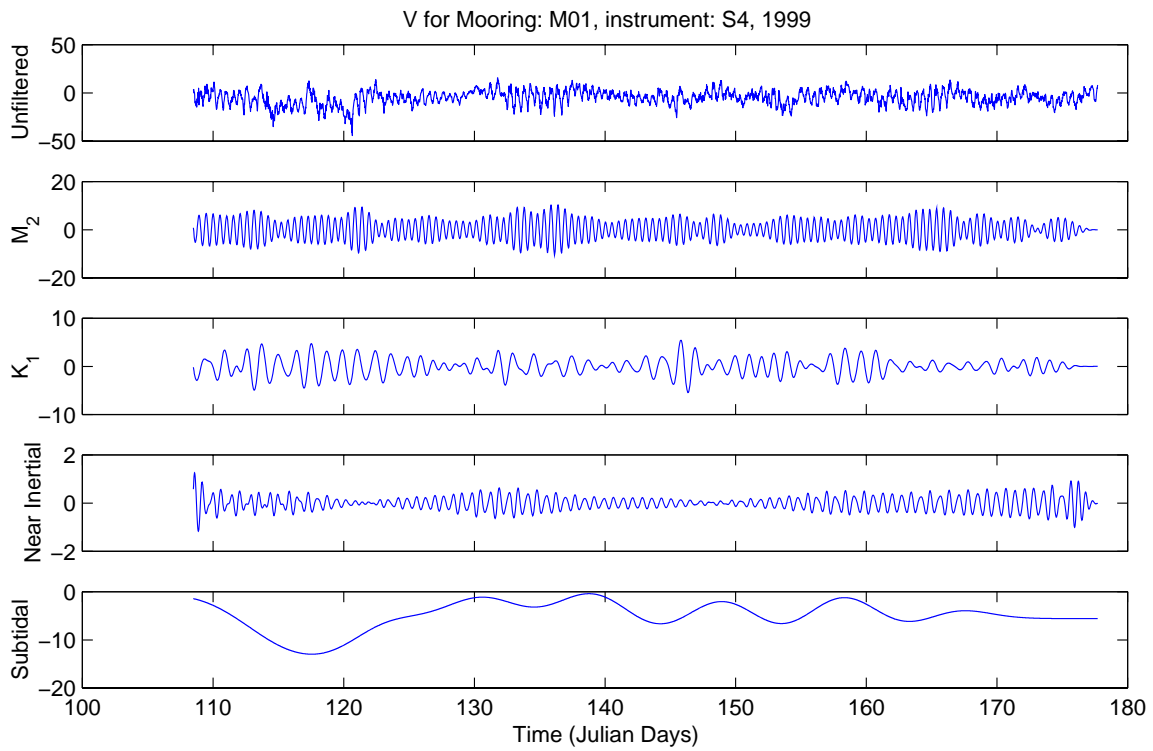


Figure 36: Plot of the main tidal constituents: v component of velocity, Mooring: M1 using an S4 instrument, which recorded at a depth of 20m.

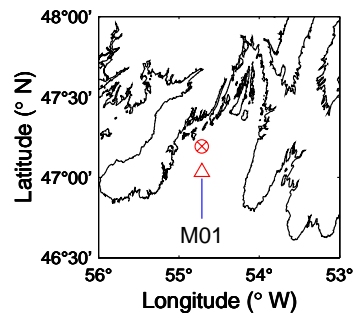
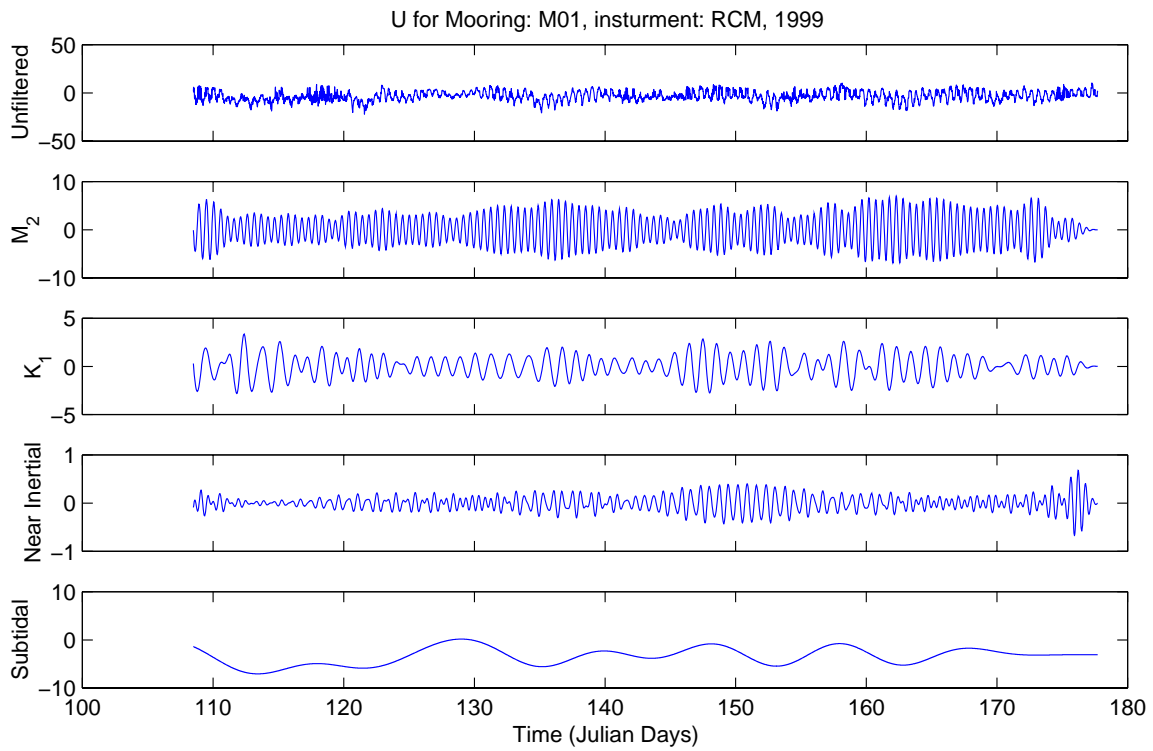


Figure 37: Plot of the main tidal constituents: u component of velocity, Mooring: M1 using an RCM instrument, which recorded at a depth of 55m.

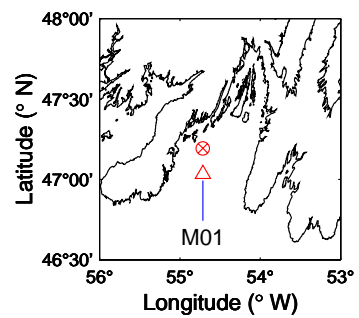
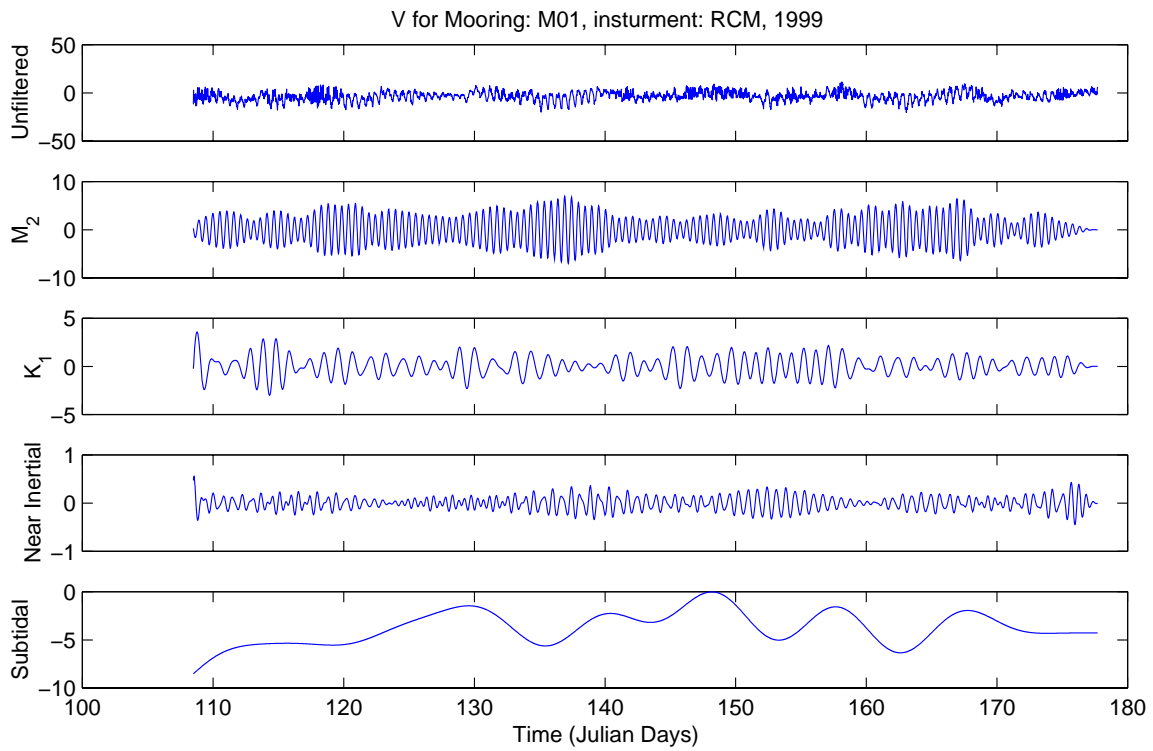


Figure 38: Plot of the main tidal constituents: v component of velocity, Mooring: M1 using an RCM instrument, which recorded at a depth of 55m.

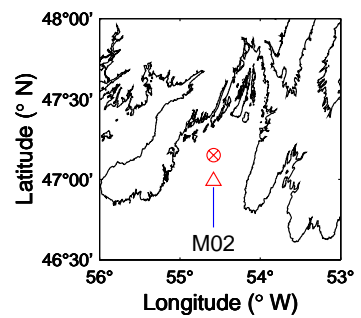
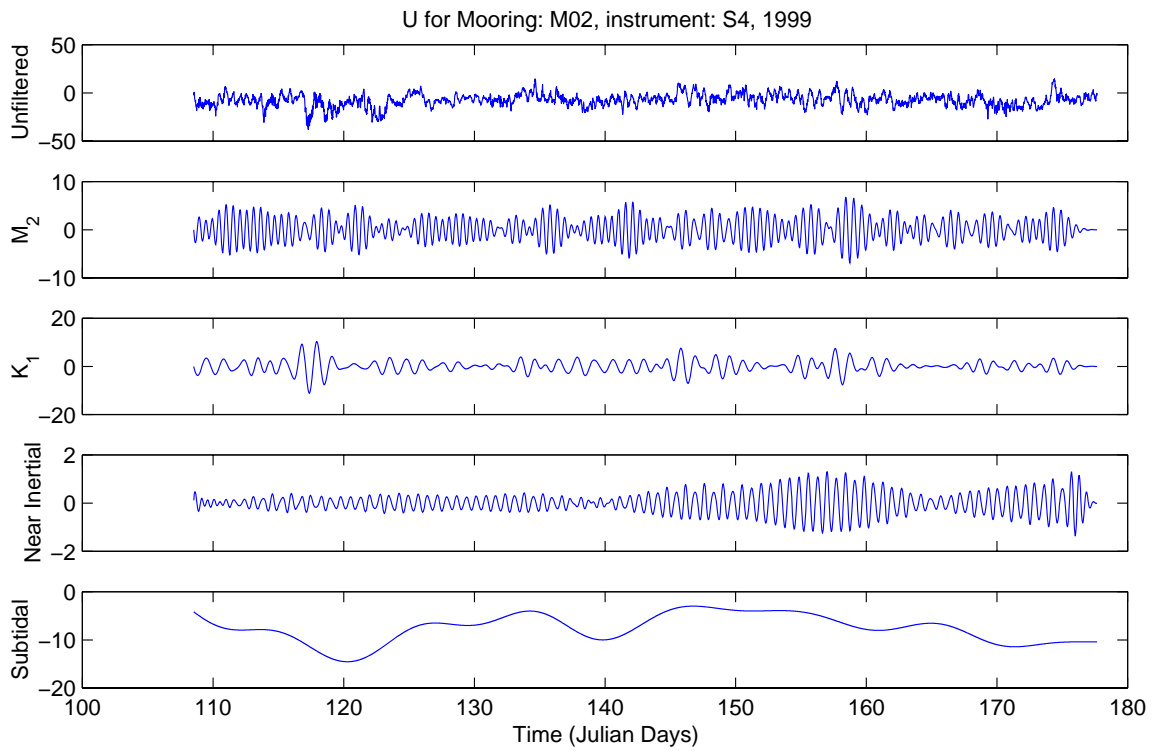


Figure 39: Plot of the main tidal constituents: u component of velocity, Mooring: M2 using an S4 instrument, which recorded at a depth of 20m.

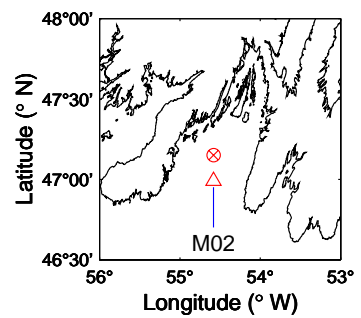
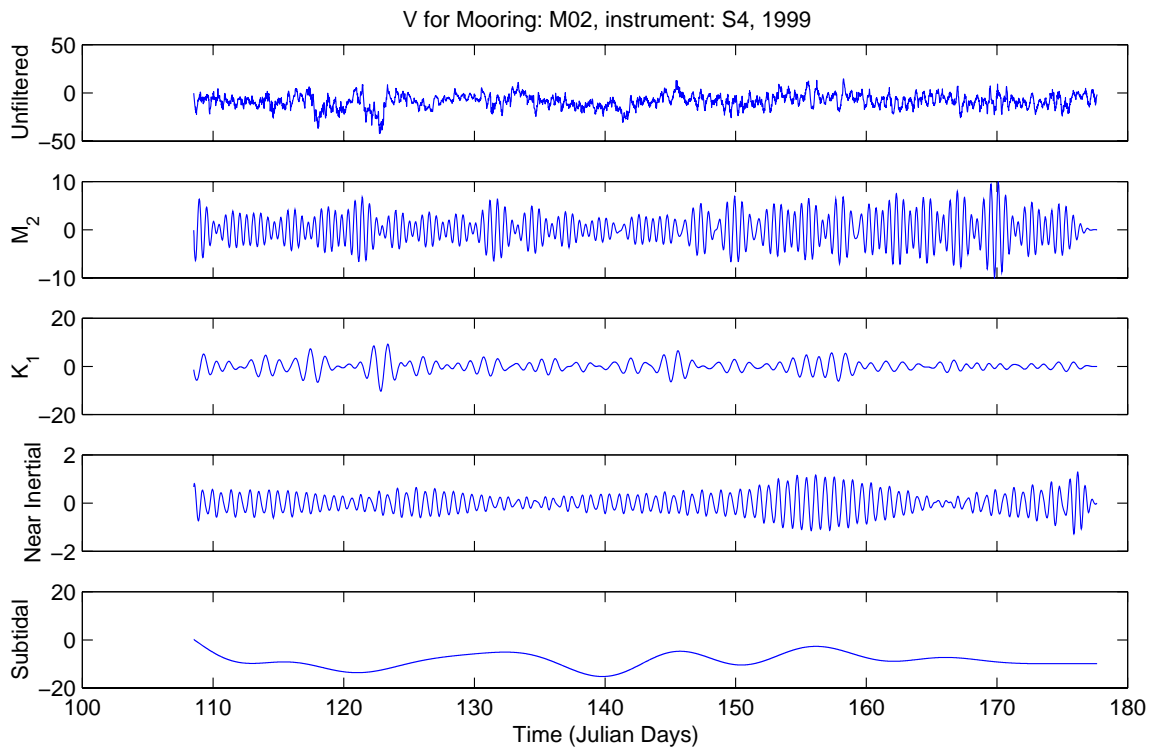


Figure 40: Plot of the main tidal constituents: v component of velocity, Mooring: M2 using an S4 instrument, which recorded at a depth of 20m.

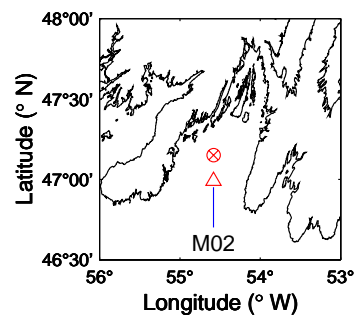
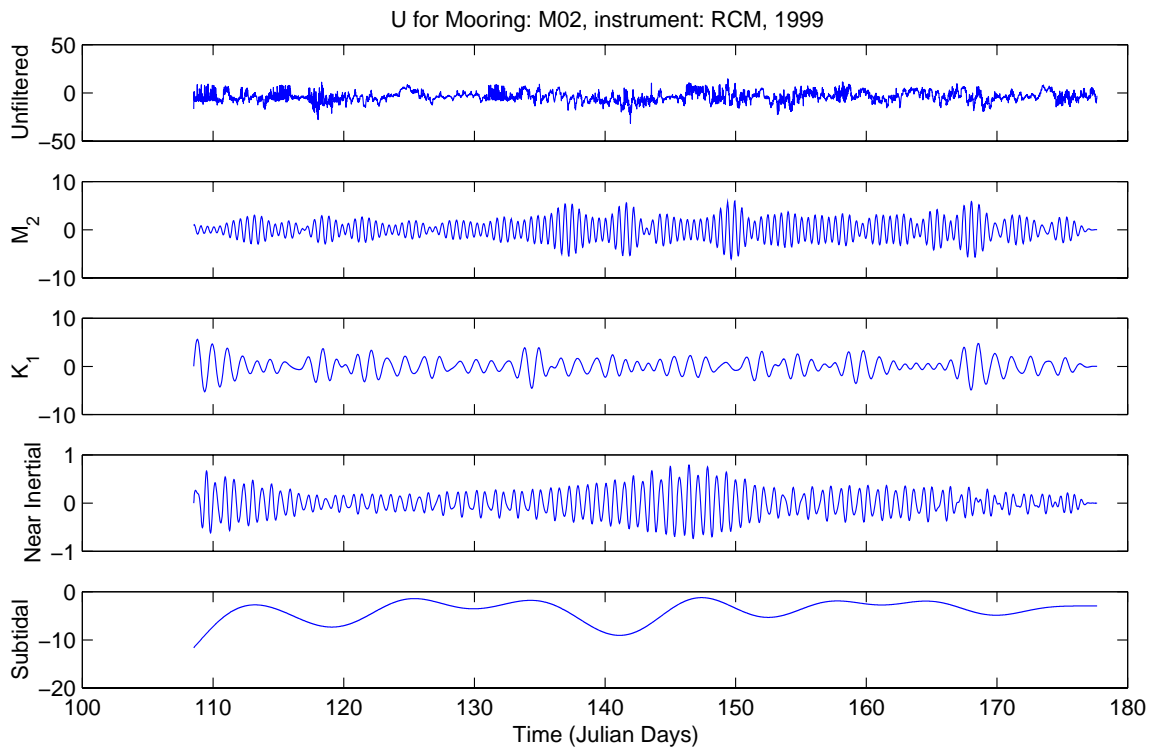


Figure 41: Plot of the main tidal constituents: u component of velocity, Mooring: M2 using an RCM instrument, which recorded at a depth of 55m.

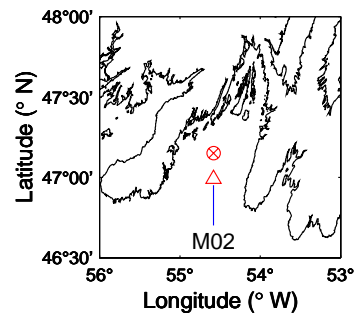
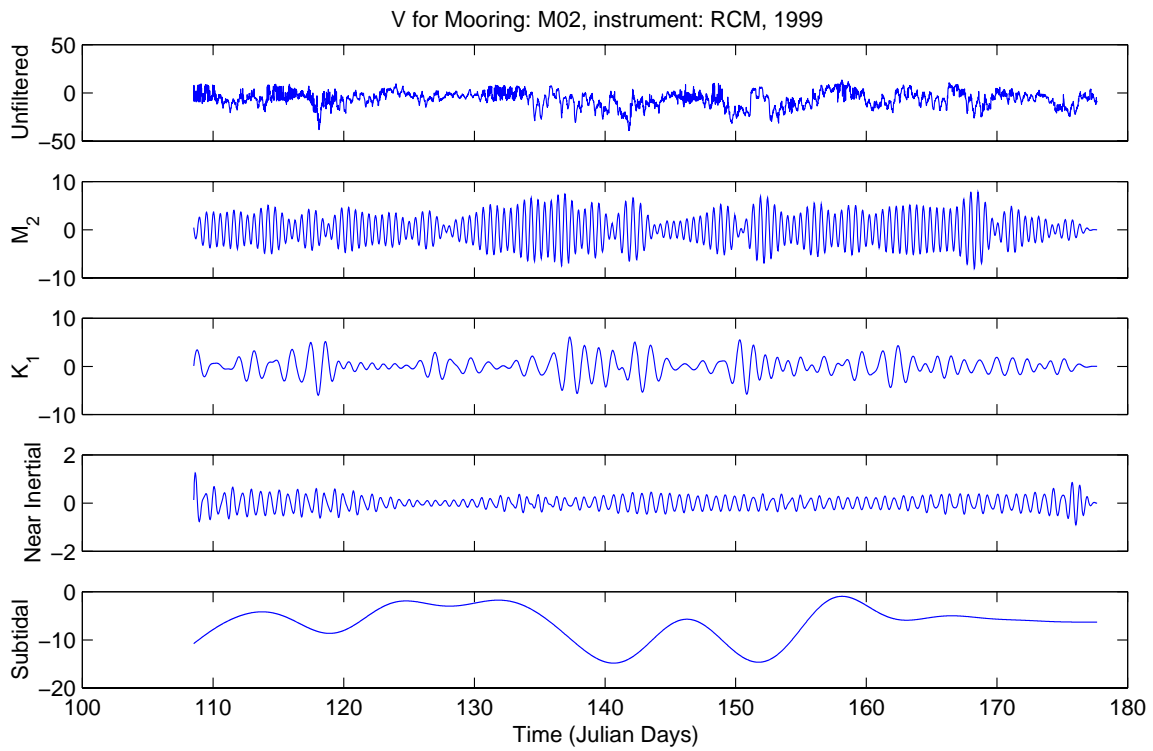


Figure 42: Plot of the main tidal constituents: v component of velocity, Mooring: M2 using an RCM instrument, which recorded at a depth of 55m.

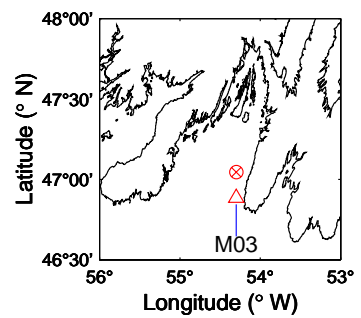
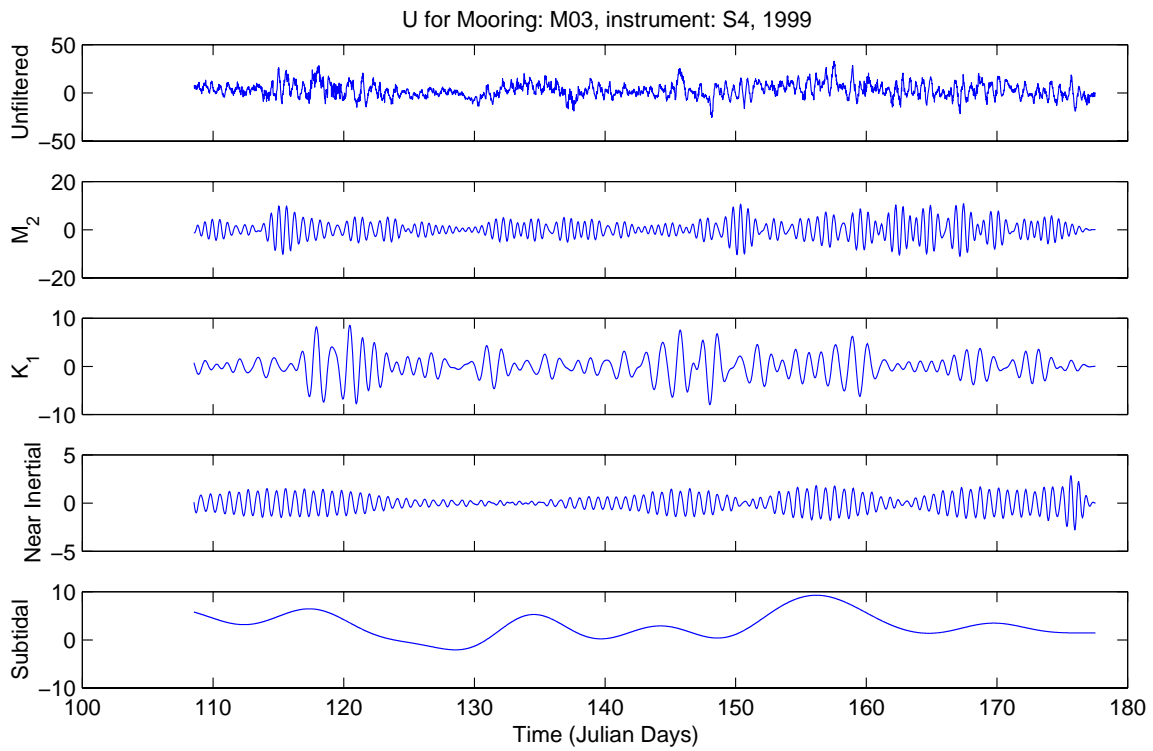


Figure 43: Plot of the main tidal constituents: u component of velocity, Mooring: M3 using an S4 instrument, which recorded at a depth of 20m.

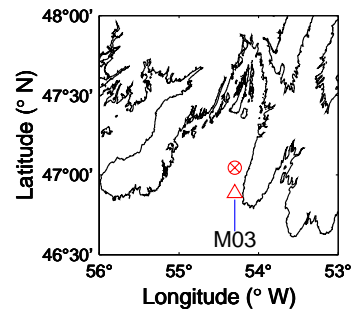
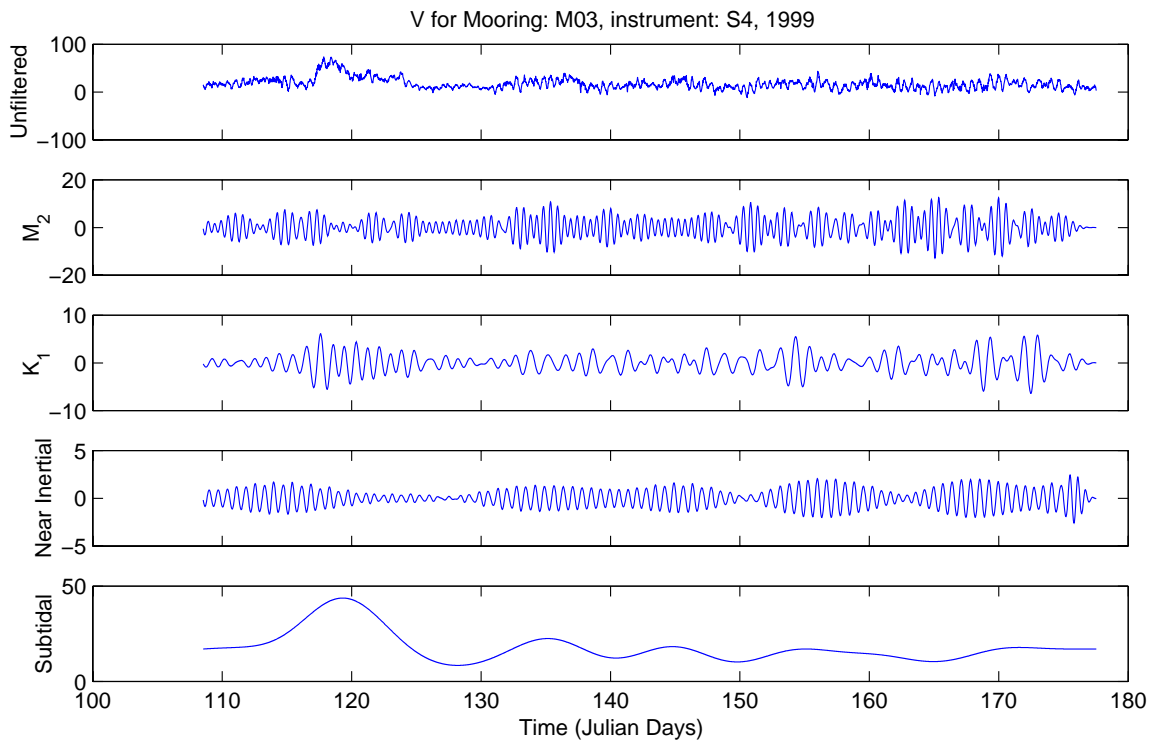


Figure 44: Plot of the main tidal constituents: v component of velocity, Mooring: M3 using an S4 instrument, which recorded at a depth of 20m.

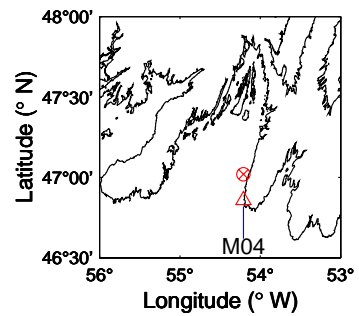
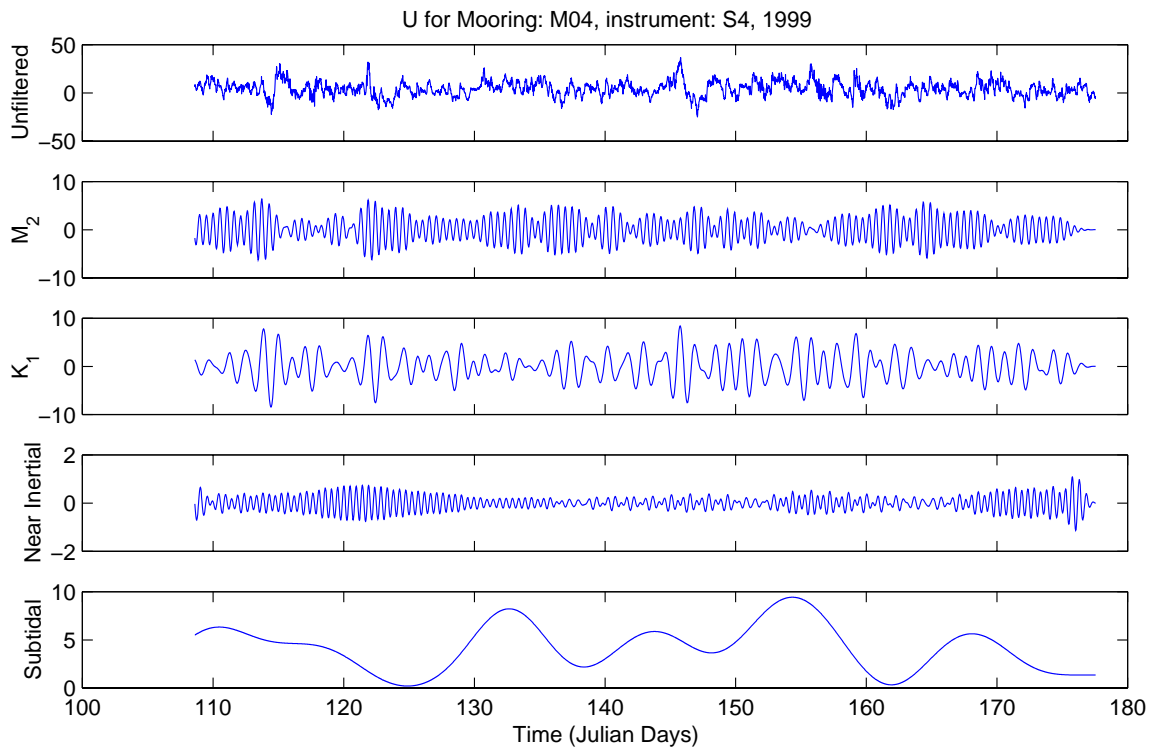


Figure 45: Plot of the main tidal constituents: u component of velocity, Mooring: M4 using an S4 instrument, which recorded at a depth of 20m.

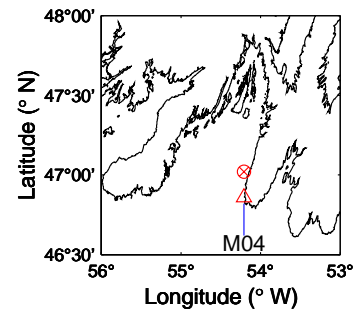
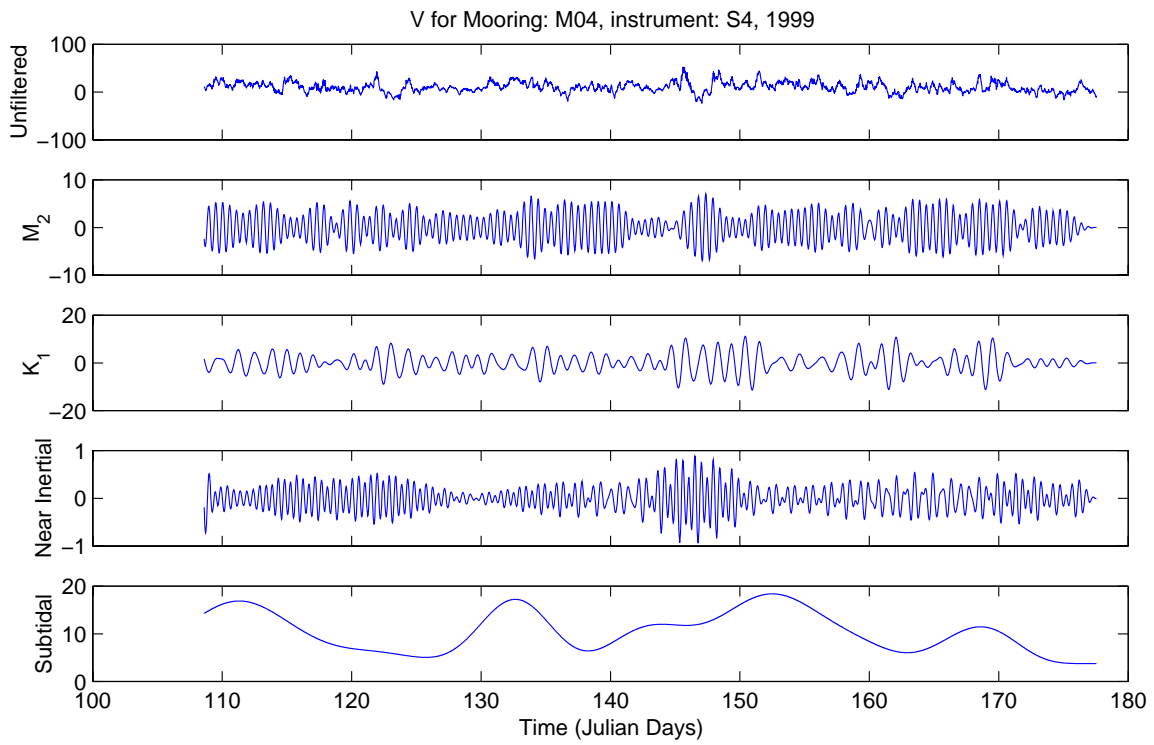


Figure 46: Plot of the main tidal constituents: v component of velocity, Mooring: M4 using an S4 instrument, which recorded at a depth of 20m.

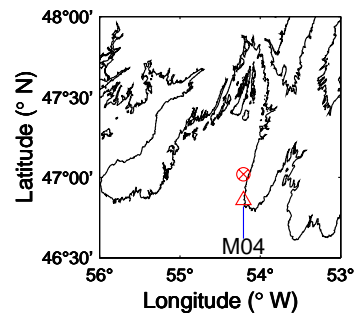
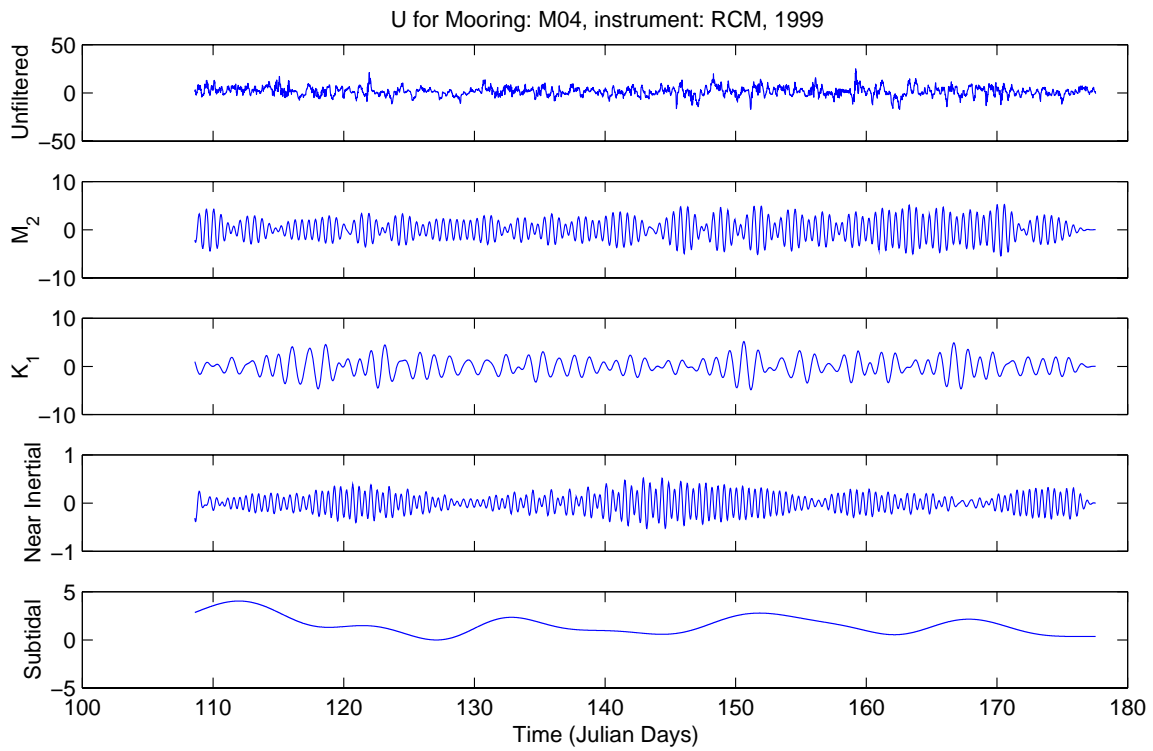


Figure 47: Plot of the main tidal constituents: u component of velocity, Mooring: M4 using an RCM instrument, which recorded at a depth of 45m.

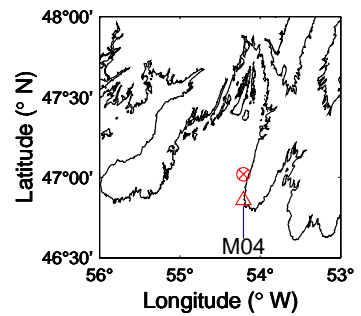
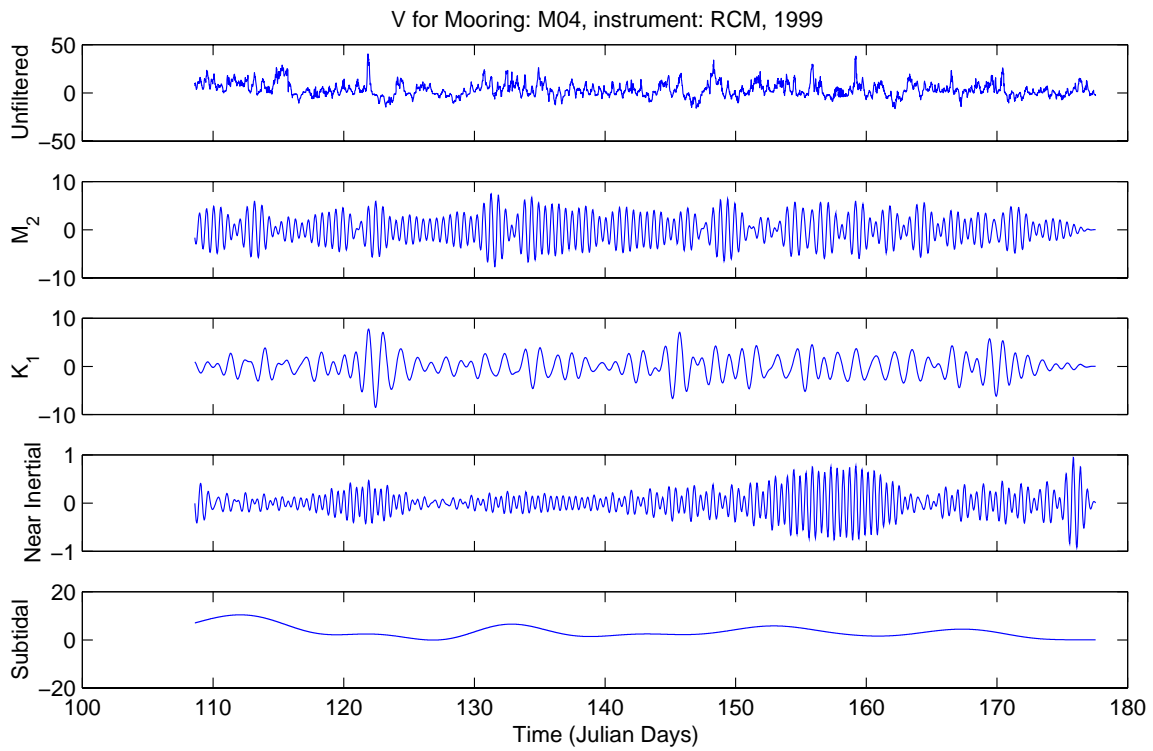


Figure 48: Plot of the main tidal constituents: v component of velocity, Mooring: M4 using an RCM instrument, which recorded at a depth of 45m.

Reference

Foreman, M. 1977, Manual for Tidal Currents Analysis and Prediction, Pacific Marine Science Report 78-6, Institute of Ocean Sciences, Patricia Bay, Victoria B.C., 57 pp.