Talisker (Seaglider 156) Mission 002

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Publication date:
2011

Talisker (Seaglider 156)

Mission 002

Scotland to Faroe

03 May 2011 to 03 September 2011

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A survey of the NE Atlantic

Internal Report No 279

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Summary

Talisker (SAMS Seaglider 156) was deployed west of Tiree on 3 May 2011 to undertake a survey of the Rockall Trough and Iceland Basin approximately following the route of the Extended Ellett Line. She was equipped with a Seabird CTD, Seabird SBE 43F and Aanderaa Optode oxygen sensors as well as a Wetlabs fluorometer with red and blue backscatter sensors. Before recovery on 3 September 2011 she had made 841 dives, travelled from Scotland to Iceland and on into Faroese waters. By then she had covered over 2290 km. The original programme was intended to end with a repeated crossing of the southern end of the Faroe-Shetland Channel but this part had to be abandoned because Talisker had to be recovered from sea by the *FRV Magnus Heinason* when the battery pack started to fail. The mission was thus a partial success, and demonstrated the ability of a Seaglider to survey the Extended Ellett Line in summer.

Contents

1. Introduction

The full record of all actions taken and commands given during mission 2 can be found in the relevant Talisker log book. This narrative provides a brief summary of the main activities and milestones that were achieved during Mission 2. As with Mission 1 this work was funded by NERC under its Oceans2025 programme.

The objectives of the Mission were

1. Achieve the first Ellett Line section by a glider from Scotland to Iceland as part of SAMS Ellett Line obligations, and
2. Undertake a series of sections across the southern end of the Faroe-Shetland Channel in support of measurements being made there by the Faroes Institute of Marine Research (FIMR), Marine Science Scotland and SAMS.

Unfortunately it was not possible to complete the second objective because during the mission Talisker developed a main battery fault. Instead the mission was terminated SW of Faroe when she was recovered by FIMR's *RV Magnus Heinason*. We are very grateful to the staff of FIMR (and in particular to Professor Bogi Hansen) and to the crew of the ship for ensuring a safe outcome to the mission. Despite this disappointment the mission was still a success in that the primary objective of navigating an underwater glider from Scotland to Iceland was achieved, thereby demonstrating beyond doubt the potential for gliders to monitor the Ellett Line section of the North Atlantic.

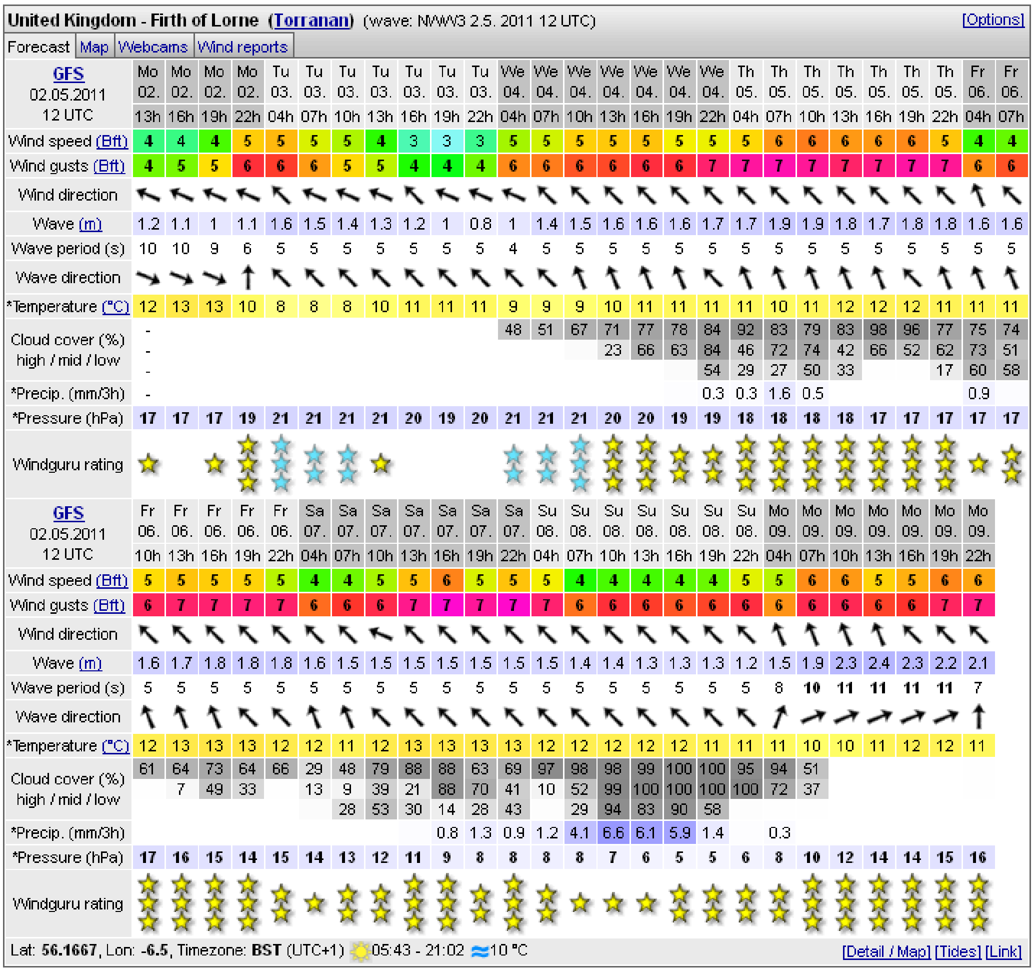
The first few weeks of the mission coincided with the *RRS Discovery* cruise D365 which had the purpose of conducting the annual Extended Ellett Line survey between Iceland and Scotland. It had been hoped that there would be opportunities to undertake some comparative CTD profiles close to Talisker. However, a combination of mechanical problems and bad weather precluded any opportunity for a systematic exercise although it has nevertheless been possible for some serendipitous comparisons between glider and ship borne observations below the surface layers to be made.

A complete summary of the mission data can be found at http://velocity.sams.ac.uk/glider/ and BODC.

2. Preparation

Talisker was returned from iRobot via Seaglider Fabrication following servicing after Mission 1 on 6 Jan 2011 (10 months after the end of Mission 1). We had been informed by Seaglider that the secondary 10 v battery had already used 10% of its power before it was returned to SAMS. By 21 Jan a new basestation and database were set up to use a new virtual server ('velocity') that was part of the SAMS IT suite of servers. They replaced the previous physical basestation and server ('dalriada'). 'velocity' was backed up with a physical basestation 'speed' that was located in the AUV laboratory. After a bad experience with NAL Research during Mission 1 we transferred our RUDICS Iridium account to Joubeh Technologies in Dartmouth, Canada which was successfully tested on 10 Feb. Support staff commitments and leave delayed further work until the latter part of March when a basic test of the compass calibration was undertaken. This revealed large non-linear deviations which required an extensive recalibration exercise. But finally on 18 April Talisker was ready for Mission 2.

The RHIB operators Coastal Connection were put on standby to deploy from *Power of Scotland* west of Tiree again and all that remained was to find a suitable weather window. This opportunity arose on 3 May 2011 when after a period of unsettled weather relatively low winds were forecast (Fig. 2.1).



United Kingdom - Firth of Lorne (Torranan) (wave: NWW3 2.5. 2011 12 UTC) [Options]

Forecast | Map | Webcams | Wind reports

GFS 02.05.2011 12 UTC	Mo 02.	Mo 02.	Mo 02.	Mo 02.	Tu 03.	Tu 03.	Tu 03.	Tu 03.	Tu 03.	Tu 03.	Tu 03.	We 04.	We 04.	We 04.	We 04.	We 04.	We 04.	We 04.	Th 05.	Th 05.	Th 05.	Th 05.	Th 05.	Th 05.	Th 05.	Fr 06.	Fr 06.
	13h	16h	19h	22h	04h	07h	10h	13h	16h	19h	22h	04h	07h	10h	13h	16h	19h	22h	04h	07h	10h	13h	16h	19h	22h	04h	07h
Wind speed (Bft)	4	4	4	5	5	5	5	4	3	3	3	5	5	5	5	5	5	5	5	6	6	6	6	6	5	4	4
Wind gusts (Bft)	4	5	5	6	6	6	5	5	4	4	4	6	6	6	6	6	6	7	7	7	7	7	7	7	7	6	6
Wind direction																											
Wave (m)	1.2	1.1	1	1.1	1.6	1.5	1.4	1.3	1.2	1	0.8	1	1.4	1.5	1.6	1.6	1.6	1.7	1.7	1.9	1.9	1.8	1.7	1.8	1.8	1.6	1.6
Wave period (s)	10	10	9	6	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Wave direction																											
*Temperature (°C)	12	13	13	10	8	8	8	10	11	11	11	9	9	9	10	11	11	11	11	10	11	12	12	12	11	11	11
Cloud cover (%) high	-											48	51	67	71	77	78	84	92	83	79	83	98	96	77	75	74
mid	-														23	66	63	84	46	72	74	42	66	52	62	73	51
low	-																	54	29	27	50	33			17	60	58
*Precip. (mm/3h)	-																	0.3	0.3	1.6	0.5					0.9	
*Pressure (hPa)	17	17	17	19	21	21	21	21	20	19	20	21	21	21	20	20	19	19	18	18	18	18	17	17	17	17	17
Windguru rating																											

GFS 02.05.2011 12 UTC	Fr 06.	Fr 06.	Fr 06.	Fr 06.	Fr 06.	Sa 07.	Sa 07.	Sa 07.	Sa 07.	Sa 07.	Sa 07.	Sa 07.	Su 08.	Su 08.	Su 08.	Su 08.	Su 08.	Su 08.	Su 08.	Mo 09.	Mo 09.	Mo 09.	Mo 09.	Mo 09.	Mo 09.	Mo 09.
	10h	13h	16h	19h	22h	04h	07h	10h	13h	16h	19h	22h	04h	07h	10h	13h	16h	19h	22h	04h	07h	10h	13h	16h	19h	22h
Wind speed (Bft)	5	5	5	5	5	4	4	5	5	6	5	5	5	4	4	4	4	4	5	5	6	6	5	5	6	6
Wind gusts (Bft)	6	7	7	7	7	6	6	6	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	7	7
Wind direction																										
Wave (m)	1.6	1.7	1.8	1.8	1.8	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.2	1.5	1.9	2.3	2.4	2.3	2.2	2.1
Wave period (s)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	8	10	11	11	11	11	7
Wave direction																										
*Temperature (°C)	12	13	13	13	12	12	11	12	13	13	13	13	12	12	12	12	12	11	11	11	10	10	11	12	12	11
Cloud cover (%) high	61	64	73	64	66	29	48	79	88	88	63	69	97	98	98	99	100	100	95	94	51					
mid		7	49	33		13	9	39	21	88	70	41	10	52	99	100	100	100	100	72	37					
low							28	53	30	14	28	43		29	94	83	90	58								
*Precip. (mm/3h)										0.8	1.3	0.9	1.2	4.1	6.6	6.1	5.9	1.4		0.3						
*Pressure (hPa)	17	16	15	14	15	14	13	12	11	9	8	8	8	8	7	6	5	5	6	8	10	12	14	14	15	16
Windguru rating																										

Lat: 56.1667, Lon: -6.5, Timezone: BST (UTC+1) 05:43 - 21:02 10 °C [Detail / Map] [Tides] [Link]

Figure 2.1. Windguru wind forecast for the Firth of Lorne during the deployment week. Talisker was launched on the only (moderately) calm day.

3. Mission Diary

The main events during the mission are given below. For more complete information consult the log book.

Date	Dive	Location	Comment
3 May	1	56.67 N, 7.12 W	First dive completed at 14:21 h. Battery levels were 23.9v 8.39 Ah; 10.3v 11.07 Ah
11 May	302	56.99 N, 9.19 W	First deep dive in RT 22.2 v: 23.98 Ah. 1.7v drop in main battery. Unusual wiggle in the climb first noticed.
13 May	311	57.26 N, 10.17 W	Furthest N before encountering a cyclonic current driving towards the south
17 May	328	56.75 N, 10.80 W	Furthest S in large mesoscale feature (is it an eddy?)
19 May	332		Reset target towards the Anton Dohrn Seamount, away from Rockall
23 May	354	57.40 N, 11.13 W	On top of Anton Dohrn Seamount. New target ICE_BAS in the Iceland Basin at 60° N 20° W.
23 to 28 May	353	56.66 N, 9.02 W	Encountered very strong NE currents that backed NW and then W as Talisker crossed the western side of the Trough. This obstructed her from reaching Rockall
2 June	398	58.82 N, 14.44 W	Crossing southern side of the George Bligh Bank. Front encountered with cooler water towards the west.
9 June	428	59.19 N, 16.51 W	Reached the western side of the Hatton-Rockall Plateau. Very weak (tidal) currents on the plateau, but speeds increased on the southern flank of Hatton Bank
14 June	450	59.58 N 17.87 W	Over 990 m on N side of Hatton Bank in Iceland Basin. Website now shows NRL global NCOM model predictions
19 June	469	60.05 N, 18.97 W	In Iceland Basin, struggling to get to ICE_BAS. NCOM model shows opposing eastward currents in a front. Cut losses and decided to make directly for the Iceland Shelf.
23 June	486	60.77 N, 18.64 W	Encountered intense anti-cyclonic eddy pushing Talisker south. Invoked some novel commands to get her out. In so doing managed to drive Talisker round in circles!
25 June	492	60.68 N, 18.68 W	Heading north again. Problems with understanding the relationship between $NAV_MODE and $HEADING.
30 June	513	61.43 N, 18.61 W	24v battery dropped rapidly to 20.5 v. This is a cause for concern and sent emails to Fritz etc and have contacted Hedinn Valdimarsson in case an Icelandic recovery is necessary.
	after 514		Thereafter the condition of the 24 v battery is an on going concern
12 July	561	63.25 N, 19.68 W	Reaches ICE_SHELF2 at the Icelandic shelf edge
13 July	565	63.31 N, 19.70 W	Furthest north position. Problems with navigating because of strong currents and variable topography. Much discussion in log book.

Date	Dive	Location	Comment
14 July	571	63.20 N, 19.59 W	Start to fly eastward along Icelandic Shelf edge with $HEADING,100 (and $NAV_MODE,0)
17 July	597	63.22 N, 18.49 W	Hit bottom at 182 m. Move S into deeper water.
20 July	611	63.07 N, 17.95 W	Hit bottom at 911 m. Low salinities near the surface. High backscatter values causing concern.
30 July	650	62.35 N, 15.09 W	Turned off Wetlabs puck because all frequencies appear contaminated
31 July	655	62.27 N, 14.75 W	Reached ICE_BAS_NE, now heading for Iceland-Faroe Ridge (IFR).
1 Aug to 5 Aug	666 - 676		Strong southwards currents preventing northward progress
16 Aug	727	62.99 N, 12.20 W	Furthest point on ridge. Strong tides. Bottom at 482 m. Redirected towards ICE_BAS_NE
18 Aug	740	62.39 N, 11.53 W	Bottom temperature < 2° C at 825 m.
to 22 Aug	744 - 755	62.23 N, 11.38 W 62.02 N, 11.29 W	24v battery voltage declined from 20.6 v (744) to 19.9 v (748) to 19.6 v (755). Contacted Bogi Hansen to see if FFL can rescue Talisker.
24 Aug	763		Turned off all sensors and altimeter. Set dive depth to 700 m.
25 Aug to 2 Sep	764 - 841		Variously put Talisker on surface or got her to dive to shallow depths depending on wind drift conditions
3 Sep		61.33 N, 9.78 W	0617 GMT: Talisker finally on board Magnus Heinasen. Set $T_RSLEEP to 1 day to save Iridium charges.
Finally			
26 Jan 2012		FIMR lab Torshavn	Batteries 23.42 v and 8.81 v on external power, 22.73 v and 10.22 v on own power. OK for shipping.

4. Performance

4.1 Website and archive

Several changes were made in the organization of the website and data archive were introduced prior to the mission. Specifically, Talisker was managed from SAMS virtual server ‘velocity’ which was accessed through RUDICS. In case the link to ‘velocity’ went down a backup basestation ‘speed’ was housed in the AUV laboratory and was accessed from Iridium via a pstn – pstn telephone communication. In the event ‘speed’ was not required.

	Main basestation	Secondary basestation
Name	velocity	speed
Port	22	22
type	ssh	ssh
address	velocity@sams.ac.uk	speed@sams.ac.uk
phone no	+881 600 00558	+44 1631 559013
communication type	RUDICS	pstn - pstn

Table 4.1 Details of the main and secondary basestations at SAMS

Sound velocity contour plots and a tabulated summary of the latest dive were added to the web site for each dive. In addition forecasts from the US NRL NCOM ocean model were produced on the website for after dive 450. These forecasts showed surface currents overlaid on dynamic height and whilst not sufficiently accurate that they could be used blindly were nevertheless useful in providing insights into the general nature of the local environment that helped with navigation decisions.

During Mission 2 all scientific data were relayed to BODC in a user friendly Ascii format that was suitable for near real time transmission via the Global Transmission System. Although the BODC side of things was not fully ready for onward transmission these files set a precedence for future missions.

4.2 Compass calibration

Following the issues with Talisker's compass encountered during mission 1, the compass readings were checked before this deployment. To do this, the glider was laid flat in its aluminium cradle, and manually orientated according to a hand-held compass. This procedure could have introduced an error of a few degrees in orientating the glider.

The first check was done on 22 Mar, in an area away from buildings and large metallic objects. This test showed a very large difference between the hand-held compass and Talisker's "calibrated" readings (up to 25 degrees). To make sure these results were not affected by the area chosen the same checks were conducted in a different area (also clear of buildings and other metallic interferences) on 28 Mar. This second test showed very similar results. Both datasets are plotted in figure 4.1.

A compass calibration was then performed on 15 Apr, which involved rotating the glider whilst pitched and rolled ta different angles. The succession required was as followed:

- roll = -30˚, pitch = -60˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = -30˚, pitch = -30˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = -30˚, pitch = 0˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = -30˚, pitch = 30˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚

- roll = -30˚, pitch = 60˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 0˚, pitch = -60˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 0˚, pitch = -30˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 0˚, pitch = -0˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 0˚, pitch = 30˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 0˚, pitch = 60˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 30˚, pitch = -60˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 30˚, pitch = -30˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 30˚, pitch = 0˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 30˚, pitch = 30˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚
- roll = 30˚, pitch = 60˚, rotated successively at headings of 0˚, 90˚, 180˚ and 270˚

During this process, it is not mandatory to get the pitch and roll exact as these could be extracted from the glider readings, if assuming these were correct. It was decided to trust the pitch and roll readings, the actual values recorded are shown in Table 4.1 below. The roll used was close to the values suggested (-28 ˚, 0˚ and 40˚), however the pitch could not be achieved due to the lack of a proper calibration stand, and the positions achieved were about half of those suggested (about 30˚ and 15˚ instead of 60˚ and 30˚).

Actual Heading	req Roll	req Pitch	**TCM2 Heading**	**TCM2 Pitch**	**TCM2 Roll**	Mag x	Mag y	Mag z	Acc x	Acc y	Acc z
0	-30	-60	**11.83**	**-30.84**	**-29.94**	449.9	-198.05	249.85	512	-428	742.75
90	-30	-60	**77.25**	**-31.73**	**-26.16**	301	-359.45	267.7	525.15	-374.3	761.9
180	-30	-60	**163.37**	**-31.51**	**-27.42**	151	-256.05	412.9	522.25	-392.55	755.45
270	-30	-60	**288.44**	**-30.65**	**-25.55**	289.05	-53.15	418.9	509.2	-370.65	775.15
0	-30	-30	**8.6**	**-15.9**	**-28.3**	352.85	-221	336.95	273.95	-456.45	846.65
90	-30	-30	**76.45**	**-16.41**	**-26.91**	182.7	-385.15	305.8	282.35	-434.3	855.25
180	-30	-30	**163.62**	**-16.16**	**-28.51**	15	-267	416.05	278.2	-458.75	844.1
270	-30	-30	**289.69**	**-15.2**	**-27.53**	170.1	-90	458.2	262	-446.35	856.3
0	-30	0	**9.45**	**-0.83**	**-27.42**	234	-246.1	391.35	14.5	-461.3	889.1
90	-30	0	**76.15**	**-1.99**	**-27.67**	66.5	-397.85	315.85	34.7	-464.95	886.45
180	-30	0	**165.14**	**-2.46**	**-25.82**	-107	-234.05	407.05	42.45	-435.6	900.75
270	-30	0	**291.9**	**-1.6**	**-25.47**	65.35	-80	472.85	27.55	-430.75	904.1
0	-30	30	**10.43**	**11.91**	**-23.7**	121.95	-233	428.9	-206.45	-394.45	897.95
90	-30	30	**78.46**	**11.91**	**-24.94**	-52	-378	322	-206.6	-413.75	889.05
180	-30	30	**164.06**	**12.23**	**-26.94**	-227.7	-222.45	353.1	-212.25	-443.85	872.9
270	-30	30	**287.67**	**12.12**	**-29.23**	-54.25	-107.15	459.45	-210.15	-478.35	855.05
0	-30	60	**10.78**	**27.12**	**-25.41**	-14.25	-245.15	423.75	-457.1	-383.25	806
90	-30	60	**78.79**	**26.54**	**-28.12**	-162.5	-379.3	269.9	-447.7	-423.05	791.1
180	-30	60	**165.97**	**27.39**	**-28.63**	-333.35	-190.65	275.15	-461.1	-426.25	780.75
270	-30	60	**281.45**	**27.32**	**-29.5**	-181	-88.75	420.5	-459.45	-438.45	774.4
0	0	-60	**8.32**	**-30.8**	**-0.74**	446.05	-37.2	295.2	511.9	-10.85	858.55
90	0	-60	**72.56**	**-31.08**	**0.16**	302	-201.15	378.95	516.15	2.25	856.25
180	0	-60	**162.3**	**-30.61**	**-2.55**	141	-57.95	467	508.9	-38.05	859.35
270	0	-60	**292.15**	**-30.56**	**-0.73**	288.95	126.9	385	508.3	-10.9	860.65
0	0	-30	**8.51**	**-16.03**	**-1.54**	350	-44.95	382	276.2	-25.8	962.5

Actual Heading	req Roll	req Pitch	TCM2 Heading	TCM2 Pitch	TCM2 Roll	Mag x	Mag y	Mag z	Acc x	Acc y	Acc z
90	0	-30	**74.99**	**-16.51**	**0.71**	183	-197.2	430	284.4	11.8	960.45
180	0	-30	**163.34**	**-15.89**	**-2.25**	9	-54.5	473.55	274.25	-38.05	962.4
270	0	-30	**291.14**	**-16.05**	**-0.65**	176.15	127.2	430	276.75	-10.65	962.65
0	0	0	**9.19**	**-1.32**	**-0.93**	234.95	-43.4	441.9	23.05	-16.35	1002.85
90	0	0	**77.52**	**-2.04**	**-1.2**	60.45	-212.9	442	35.55	-20.9	1003.2
180	0	0	**165.14**	**-2.34**	**-1.27**	-110.25	-44	451	40.85	-21.95	1002.2
270	0	0	**290.99**	**-1.62**	**-1.08**	62.95	122.9	447.9	27.85	-19.05	1003.1
0	0	30	**12.2**	**11.86**	**1.73**	119	-32	470.4	-206.35	29.5	981.95
90	0	30	**78.36**	**11.57**	**-2.59**	-46.85	-223.6	428.1	-201.4	-44.15	982.4
180	0	30	**165.65**	**11.67**	**0.27**	-226.7	-33.1	400	-203.2	4.65	983.9
270	0	30	**286.07**	**11.88**	**-3.39**	-52.5	104.25	444	-206.7	-58.1	980.9
0	0	60	**13.07**	**27.47**	**0.34**	-21	-42.95	470.4	-462.9	5.2	890.65
90	0	60	**83.98**	**27.2**	**-0.27**	-177.2	-206	391	-459.55	-3.75	893.45
180	0	60	**166.92**	**26.95**	**-1.27**	-332.95	-42	315.95	-455.2	-19.75	894.75
270	0	60	**279.14**	**27.4**	**-1.54**	-179.3	120	396	-462.45	-23.65	891.5
0	30	-60	**4.73**	**-31.51**	**42.21**	447	165.95	213	523.55	574.2	632.45
90	30	-60	**71.13**	**-31.56**	**43.5**	293.95	112.6	387	524.9	588.65	619.45
180	30	-60	**174.01**	**-31.68**	**40.66**	145	280.85	343.9	526.5	556.15	646.65
270	30	-60	**294.07**	**-30.99**	**41.99**	292.8	350.05	164	516.5	575.65	638.8
0	30	-30	**5.12**	**-16.43**	**43.03**	348.15	229	275.95	283.6	657.5	703.3
90	30	-30	**72.18**	**-16.99**	**43.46**	185.05	144.55	419.95	293	660.35	695.9
180	30	-30	**173.99**	**-17.22**	**41.57**	15.6	290.9	346.3	297.1	636.65	716.8
270	30	-30	**289.9**	**-16.12**	**41.01**	173.9	379.7	206.65	278.95	633.15	727.8
0	30	0	**5.49**	**-1.88**	**41.09**	234.15	259	329.05	32.7	660.45	756.5
90	30	0	**78**	**-2.54**	**40.01**	58	130.95	445	44.4	645.55	768.85
180	30	0	**172.16**	**-2.88**	**38.47**	-111.2	253.9	348.85	50.3	624.3	785.65
270	30	0	**286.33**	**-2.19**	**39.37**	59.9	384.4	231	38.15	636.55	775
0	30	30	**4.72**	**11.33**	**42.61**	119	290.05	340.95	-197.2	667.45	725.1
90	30	30	**82.03**	**11.16**	**41.15**	-55	133.95	433.45	-194.4	649.3	742.4
180	30	30	**174.31**	**11.51**	**40.23**	-229.65	233.2	298.9	-200.8	636.1	751.65
270	30	30	**279.48**	**11.42**	**39.08**	-57.15	377.1	225.3	-198.9	621.3	764.9
0	30	60	**6.93**	**26.76**	**43.1**	-19.9	290	343	-452.35	612.55	654.15
90	30	60	**87.62**	**25.8**	**37.81**	-173.1	83	411.25	-437.7	555	714.7
180	30	60	**175.04**	**26.8**	**41.08**	-336	182.95	231.25	-453.2	589.45	675.4
270	30	60	**274.5**	**26.76**	**37.24**	-175.05	345.7	207.2	-452.15	543.25	713.9

Table 4.1: Compass calibration data. "TCM2" columns indicate the data reported by the compass, trusted for the pitch and roll, and headings to be calibrated.

The data was then processed by a Matlab routine provided by the SFC, and a new calibration file produced. The file was uploaded to the glider's CF card and a new compass check was performed (in the same area as on 22 Mar). Results are presented in Figure 4.1. The largest difference between the glider and hand-held compass headings was then reduced to 6.0 degrees, which was deemed acceptable.

No compass check was done after recovery as Talisker was shipped straight from the Faroe Islands to the SFC. Generally, gliders are most at risk of magnetic interference during long-distance transport (by plane or ship), therefore checking the compass on arrival at the SFC would have probably not provided any trustworthy data. Moreover, Talisker was transported to her deployment site by RHIB directly from SAMS so we can assume that the risk for any changes in the compass behaviour after the re-calibration was rather low.

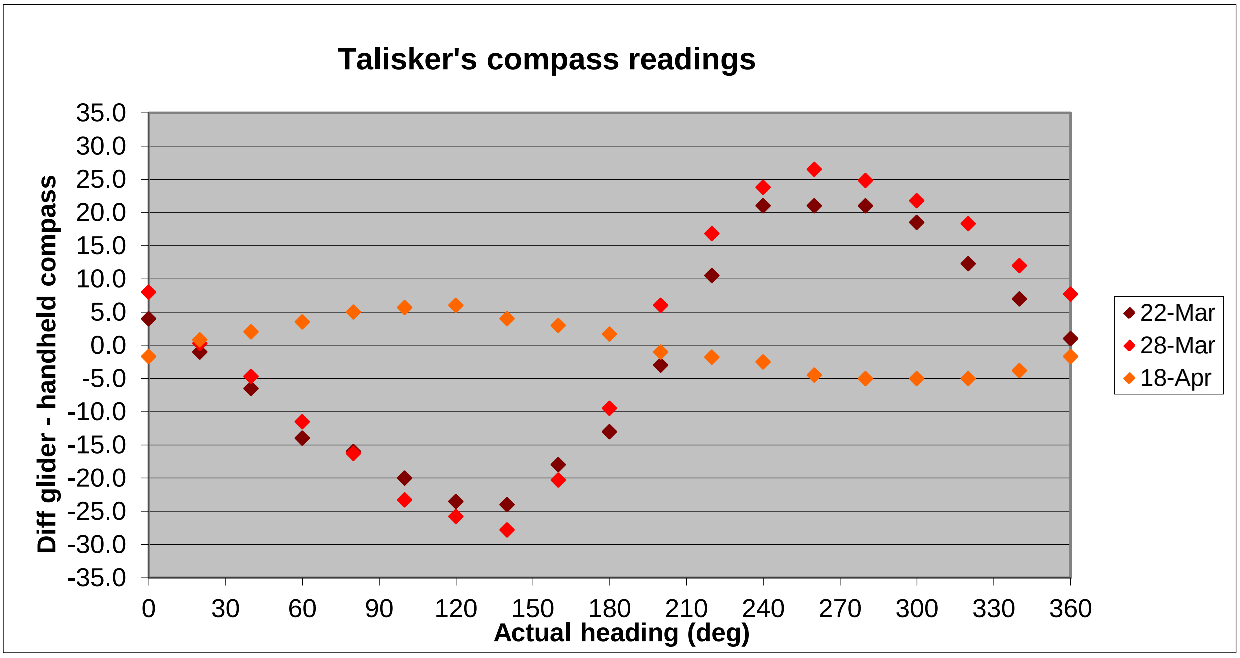


Figure 4.1: Talisker's compass readings vs actual heading, pre-calibration (22 and 28 Mar) and post-calibration (18 Apr).

4.3 Performance of the sensors

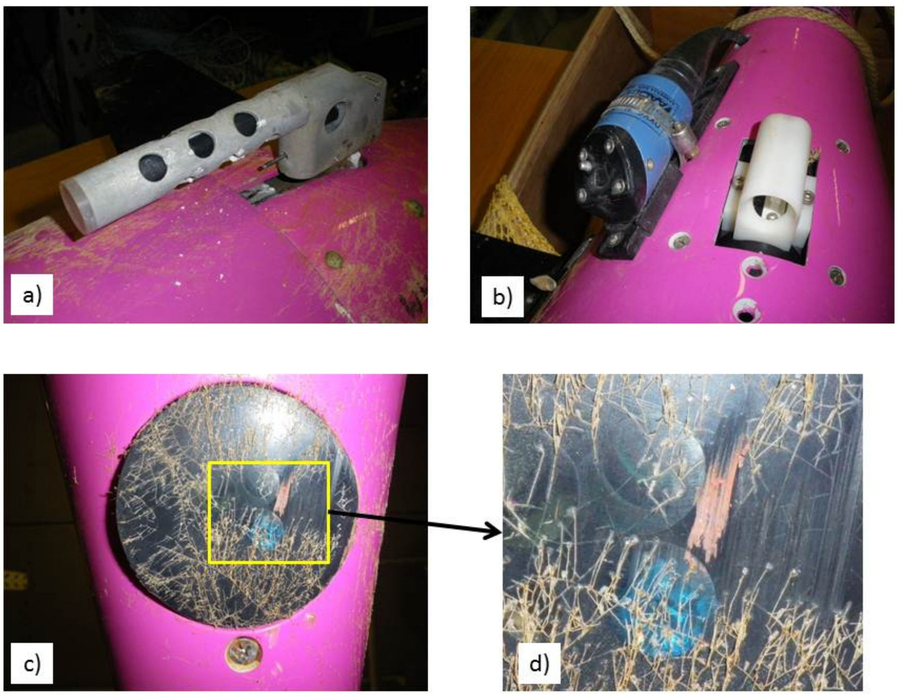
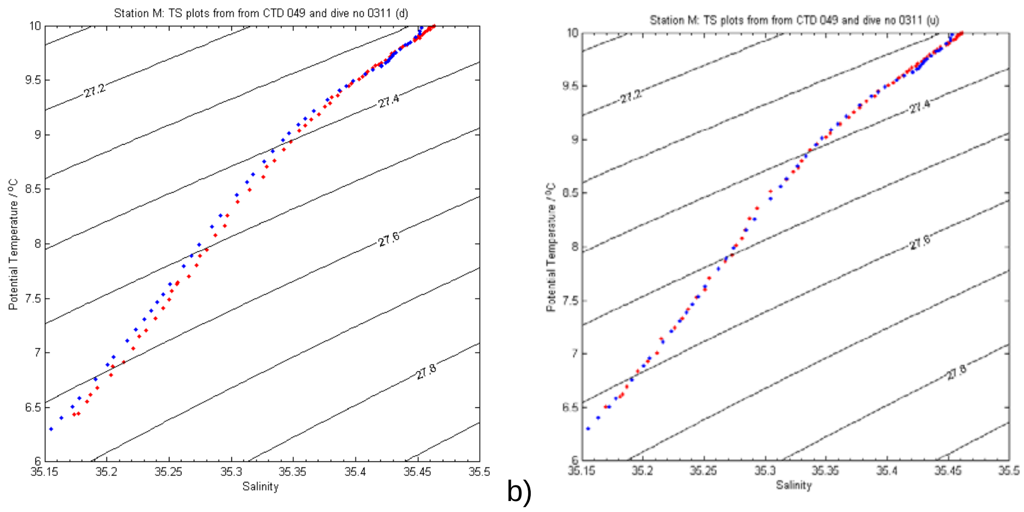


Figure 4.2 Condition of a) Conductivity sensor, b) Aanderaa optode (left) and Seabird SBE oxygen (right) sensors, c) Wetlabs puck and d) detail of biofouling of the puck.

4.2.1 Temperature and salinity



a) b)

Figure 4.3. Comparison of TS plots from the D365 at Sta. M (57° 17.29' N, 10° 23.15' W) between 0146 and 0235 on 31 May 2011, and dive 311 (57.25° N, 10.11° W) starting at 2327 on 12 May 2011. a) Dive; b) Climb

On recovery the temperature and conductivity sensors appeared to be reasonably clean (Fig. 4.2). Although it was not possible for Discovery and Talisker to undertake any profiles next to each other, comparative TS plots for temperatures below 10° C from two casts that were fairly close in time and space show good agreement (Fig. 4.3). In particular there is no discernible difference between the glider's climb data and the CTD profile from D365 (Fig. 4.3b). The slight difference between the profile on the dive (Fig. 4.3a) may be explained by environmental factors.

4.2.2 Dissolved oxygen (DO)

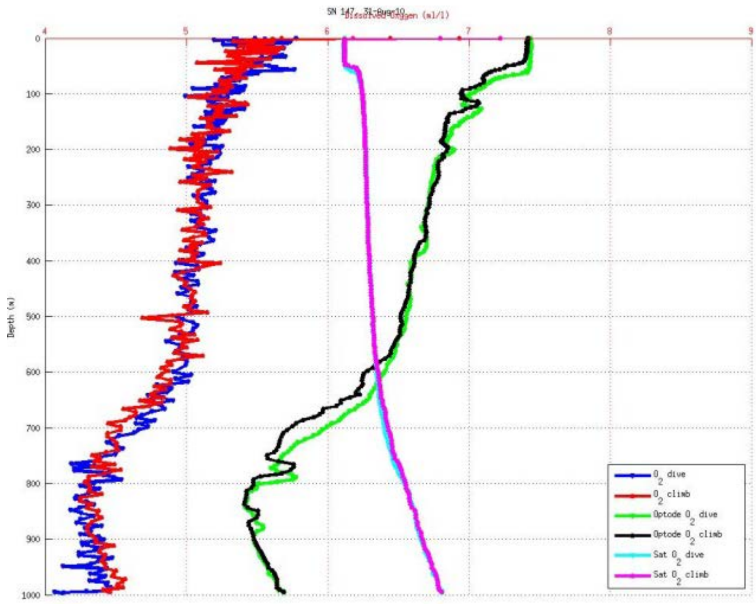


Figure 4.4. Dissolved oxygen profiles from Dive 311. Blue and red lines: dive and climb from the Seabird sensor; green and black lines: dive and climb from the Aanderaa Optode sensor; cyan and magenta lines: saturation values computed from the temperature, salinity and pressure data.

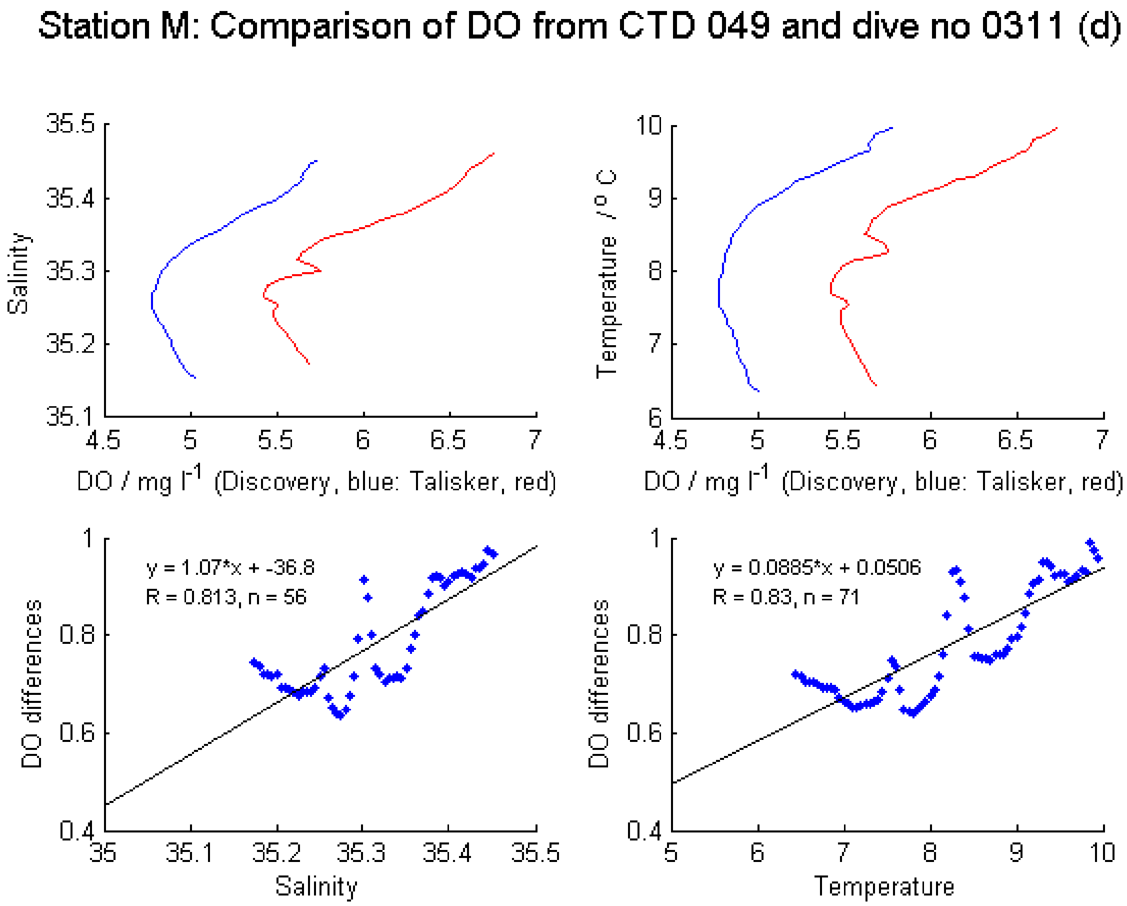


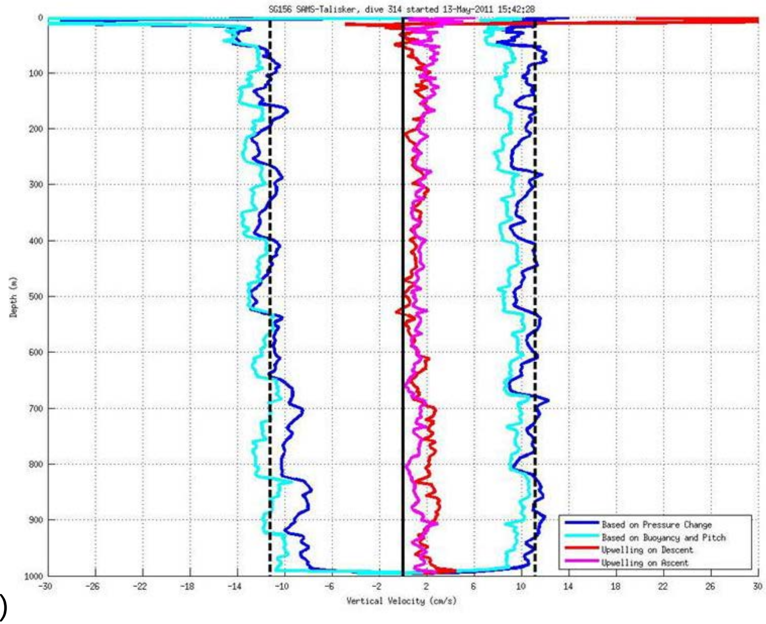
Figure 4.5. Comparison of DO observed during D365 at Sta. M, and the down cast of dive 311. Upper panels: DO vs salinity and temperature (at depths where temperature was less than 10° C; lower panels: scatter plots of the differences between these data with regression lines and coefficients.

The Aanderaa optode sensor was added to Talisker during servicing because in Mission 1 the Seabird oxygen sensor had appeared to produce low values in comparison to saturation values at the sea surface. Since *RRS Discovery* was working the Ellett Line at near the same time as Talisker and so a rough calibration is possible. Figure 4.5 shows that in contrast to the Seabrid the Optode gave over readings. A preliminary investigation, which compared dive values with those from a nearby Discovery CTD cast (CTD049) at Sta. M in the Rockall Trough, confirms that the Optode was over reading by between 0.6 mg l^{-1} at 1000 m and 1 mg l^{-1} near the surface. A comparison of 6 D365 stations and 6 neighbouring Talisker dives (3 of each in the Iceland Basin and 3 from the Rockall Trough) suggests that on average the glider Optode read 0.72 mg l^{-1} too high. A formal correction algorithm awaits further investigation.

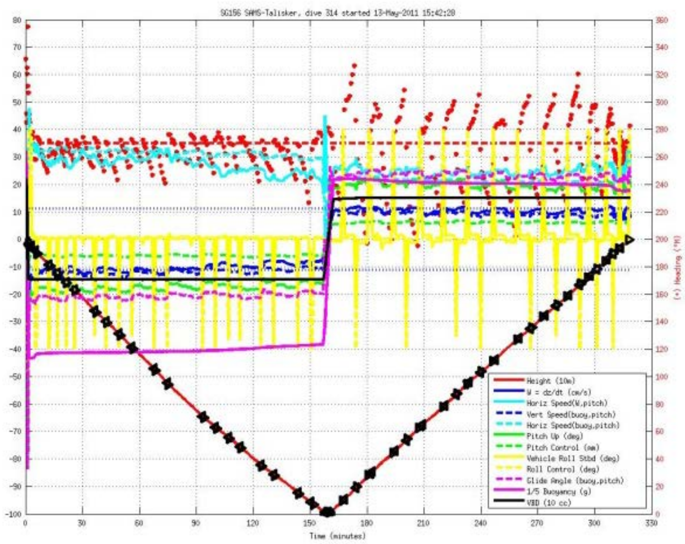
4.2.3 The Wetlabs puck

The Wetlabs puck started to show signs of biological fouling from about 15th July (Dive 580) and it was switched off about two weeks later on July 15. Figures 4.1c and d, which were taken when Talisker was back on land, shows evidence of the problem. A string-like wispy growth was attached to the surface of the puck itself.

4.3 Flight path anomalies



a)

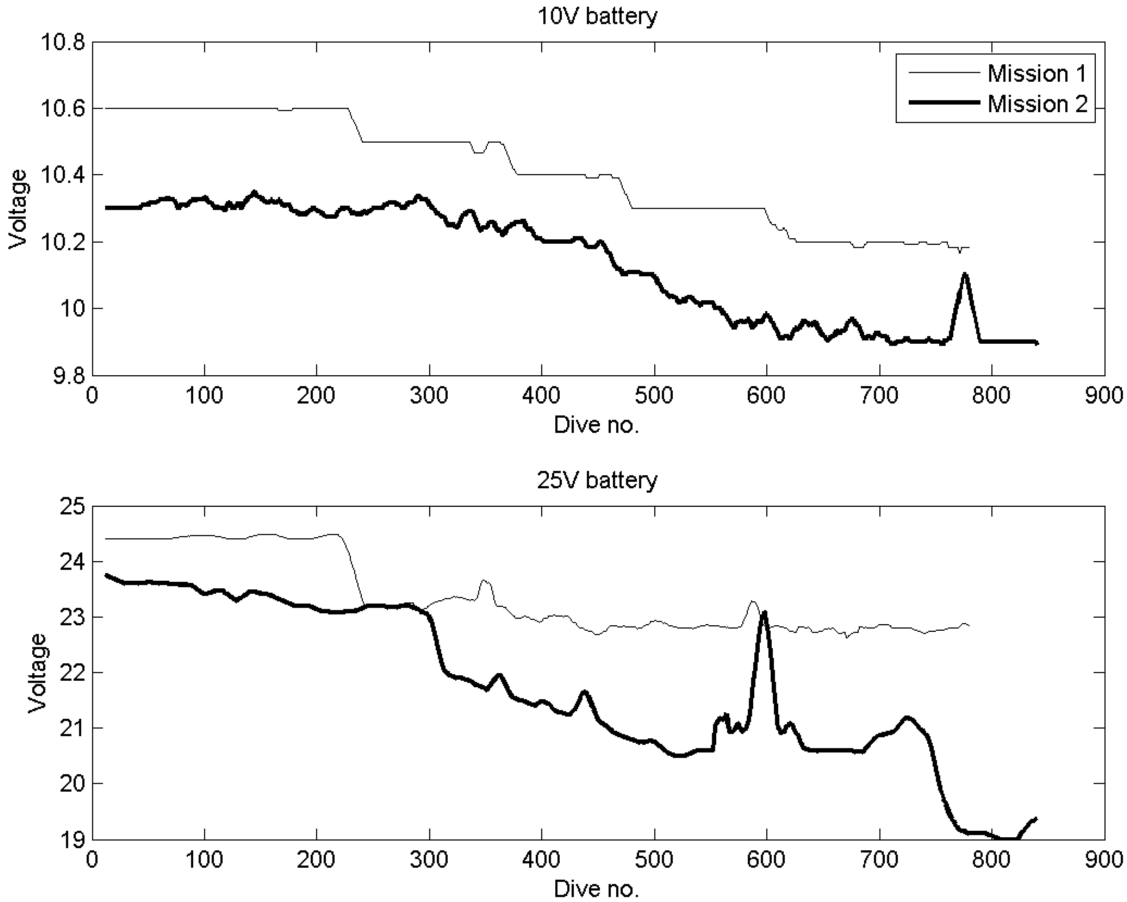


b)

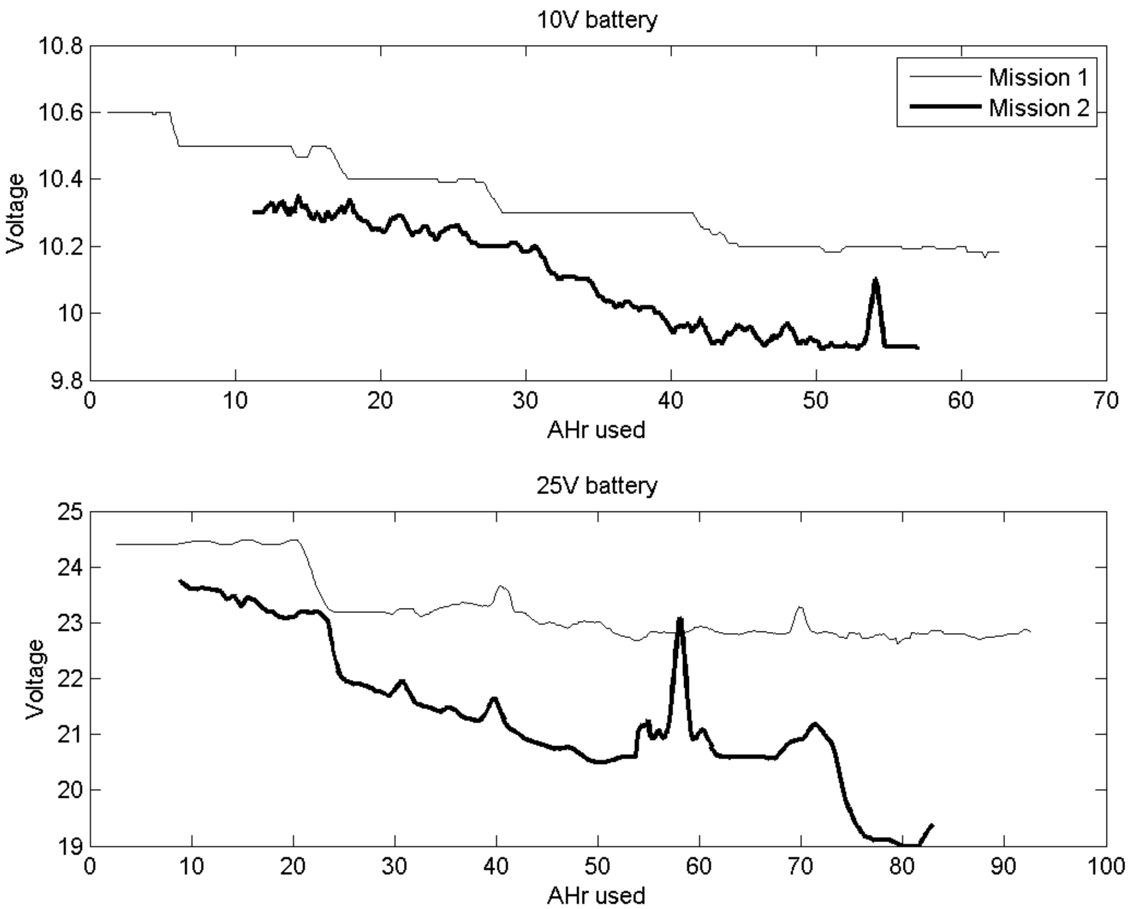
Figure 4.6. a) Vertical velocities from the flight path algorithm (cyan) and changes in pressure (blue) during descent and ascent on Dive 314. The red and magenta lines show the net vertical velocity for dive and climb computed from the difference between the blue and cyan lines. b) Engineering data from dive 314 showing that the oscillations were associated with a heading offset that was particularly pronounced on the climb.

As the mission progressed it became apparent that the flight of the Seaglider through the water had developed an slight oscillation over a distance of about 100 m on both the dive and the climb. It is unlikely that the cause of this oscillation will be properly understood, although the most likely cause is biological fouling.

4.4 Battery performance



a)



b)

Figure 4.7. Decline of voltage in 10v and 24 batteries as a function of a) dive number and b) Amp hours of use from Missions 1 and 2.

Both the 10 v and 24 v batteries delivered lower voltages than during Mission 1 (Figs 4.7). In part the reason the 10 v battery was lower was because it arrived from being serviced with 10 Amp hours of usage. The main concern, however, was with the 24 V battery where the voltage dropped by over 1 v at about dive 300. Thereafter the gradual decline in voltage to about 21 v at dive 500. A shallow dive at about dive 600 showed that the low voltage reading only occurred at the bottom of a dive (possibly because it was colder there). The second rapid drop to 19 v after dive 700 put paid to any remaining hope that we could navigate back to Scotland and necessitated an emergency call to the Faroese Institute of Marine Research to recover Talisker.

5. Statistics

5.1 Endurance

Talisker was at sea for a total of 124 days, or 4 months, completing 841 dives which is significantly more than the 789 dives of Mission 1. The total distance travelled was 2292 km, the average dive depth was 608 m and the average dive time 3.5 hours (there were a considerable number of shallow dives). The data give a mean speed over land of 21.4 cm s^{-1} which is slightly slower than the design cruising speed (~ 25 cm s^{-1}) but probably a fair indication that mesoscale currents in the North Atlantic have a retarding effect.

5.2 Costs

The costs for Mission 2 are itemised below. Iridium costs are based on RUDICS transmission. For comparison in Mission 1, when pstn to pstn was used and the exchange rate was also about $1.6 to £1, the typical transmission cost in deep water was more than twice as expensive (about £4.60 per dive).

Activity	**Contractor**	**Date**	**Cost (£)**	**Comment**
Deployment	Coastal Connection	3 May	£ 861.82	
Recovery	Magnus Heinasen	3 Sept	£ 0	Grace and favour
Iridium	Joubeh	May usage	USD 563.20	Dives 1:390 @ £0.90 per dive (on shelf to dive 300)
Iridium	Joubeh	June usage	USD 347.20	Dives 391:515 @ £1.73 per dive (deep water)
Iridium	Joubeh	July usage	USD 406.20	Dives 516:657 @ £1.78 per dive (deep water)
Iridium	Joubeh	Aug usage	USD 446.20	Dives 658:814 @ £1.78 per dive (deep to dive 702)
Iridium	Joubeh	Sept usage	USD 102.40	Dives 815:841 @ £2.34 per dive (recovery phase)
Email to SMS service	IntelliSoftware	9 May	£ 8.40	
Repatriation from the Faroes (inc. staff travel costs) to UK	Safari Transport + T&S staff	Jan 12	£ 2187.35	
Transport from UK to US	Expeditors		£ 986.15	
Insurance during transport	Carmichael & Partners		£ 106.00	
Post mission servicing / calibration	Seaglider Fabrication Centre		£ 8,655.92	
Insurance during transport	Carmichael & Partners		£ 106.00	
Total cost			**£ 14,076.84**	

The total cost for Iridium transmission between was about £1165.75 ($1865.20) or about £290 per month (or about 40% of the cost of Mission 1).

6. Log file

The log file from the last dive is given in the appendix.

7. Targets

The following targets were incorporated into the targets file as the mission progressed. However, only those marked with a '*' were the only ones actually used. The final rendez-vous with the *Magnus Heinason* was at V_19.

Name	lat =	lon=	radius=	goto=
DEP1	5643.0	-725	2000	DEP2
DEP2*	5624.0	-748	5000	SHELFE
SHELFE	5640.0	-900	1000	ROCK
SHELFS*	5630.0	-930	10000	ROCK
AD_CENTRE	5727.0	-1103	5000	ROCK
ROCK*	5722.8	-1252	1000	ICE_BAS
ROCK2	5630.0	-1230	10000	SHELFE
ROCK3*	5700.0	-1300	10000	ICE_BAS
ICE_BAS*	6000.0	-2000	5000	ICE_BAS
ICE_SHELF	6313.0	-2004	5000	ICE_SHELF
ICE_SHELF2*	6316.0	-1940	5000	ICE_BAS
ICE_BAS_NE*	6200.0	-1400	5000	AD_CENTRE
IFR*	6300.0	-1200	5000	ICE_BAS_NE2
ICE_BAS_NE2*	6150.0	-1100	5000	IFR
FBC_1	6158.3	-825	3000	FBC_2
FBC_2	6100.0	-750	5000	FBC_3
FBC_3	6003.0	-700	5000	FBC_3
V_19*	6123.3	-971.7	2000	V_19

8. Science files

During Mission 1 there had been very few edits of the science file. In Mission 2 many more adjustments had to be made i) to limit any unnecessary drain on the failing battery pack whilst at the same time maintaining scientific value, and ii) in response to the gradual fouling of the light sensors.

Dive 0 (at the outset, with both oxygen sensors working):

Depth	Time	G&C Sensors
30.0m	10.0s	100.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	200.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	300.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
1000.0m	50.0s	500.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)

Dive 40 (attempt to force altimeter to ping):

Depth	Time	G&C Sensors
30.0m	10.0s	100.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	200.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	45.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
1000.0m	50.0s	500.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)

Dive 48 (reset to science requirements):

Depth	Time	G&C Sensors
30.0m	10.0s	100.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	150.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	150.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
1000.0m	50.0s	300.0s 1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)

Dive 120 (change to GC frequency)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	150.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	60.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
1000.0m	50.0s	300.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)

Dive 311

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	150.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	200.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
1000.0m	50.0s	300.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)

Dive 313 (switched off Wetlabs puck below 200 m)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	150.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	200.0s	1111 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 1 AA4330: 1)
1000.0m	50.0s	300.0s	1101 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 0 AA4330: 1)

Dive 325 (switched off Seabird oxygen sensor)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1011 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	150.0s	1011 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	200.0s	1011 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 1 AA4330: 1)
1000.0m	50.0s	300.0s	1001 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 1)

Dive 365 (reduced Wetlabs puck sampling below 80 m)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1011 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	150.0s	1011 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	200.0s	1021 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 2 AA4330: 1)
1000.0m	100.0s	300.0s	1001 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 1)

Dive 620 (Wetlabs puck back on to investigate possible false bottom)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1011 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	150.0s	1011 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	200.0s	1021 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 2 AA4330: 1)
1000.0m	100.0s	300.0s	1021 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 2 AA4330: 1)

Dive 636 (Wetlabs puck back off below 200 m)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1011 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 1 AA4330: 1)
80.0m	20.0s	150.0s	1011 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 1 AA4330: 1)
200.0m	30.0s	200.0s	1021 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 2 AA4330: 1)
1000.0m	100.0s	300.0s	1001 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 1)

Dive 649 (Wetlabs puck switched off permanently)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1101 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 0 AA4330: 1)
80.0m	20.0s	150.0s	1101 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 0 AA4330: 1)
200.0m	30.0s	200.0s	1101 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 0 AA4330: 1)
1000.0m	100.0s	300.0s	1101 (SBE_CT: 1 SBE_O2: 1 WL_BB2F: 0 AA4330: 1)

Dive 763 (All sensors off to save power)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	0000 (SBE_CT: 0 SBE_O2: 0 WL_BB2F: 0 AA4330: 0)
80.0m	20.0s	150.0s	0000 (SBE_CT: 0 SBE_O2: 0 WL_BB2F: 0 AA4330: 0)
200.0m	30.0s	200.0s	0000 (SBE_CT: 0 SBE_O2: 0 WL_BB2F: 0 AA4330: 0)
1000.0m	100.0s	300.0s	0000 (SBE_CT: 0 SBE_O2: 0 WL_BB2F: 0 AA4330: 0)

Dive 775 (Reduced energy usage further)

Depth	Time	G&C	Sensors
750.0m	250.0s	500.0s	1000 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 0)

Dive 777 (Re-introduced CTD measurements to satisfy web site plotting requirements)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1000 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 0)
80.0m	20.0s	150.0s	1000 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 0)
200.0m	30.0s	200.0s	1000 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 0)
1000.0m	200.0s	500.0s	1000 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 0)

Dive 816 (Re-introduced O_2 measurements for calibration at recovery)

Depth	Time	G&C	Sensors
30.0m	10.0s	100.0s	1001 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 1)
80.0m	20.0s	150.0s	1001 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 1)
200.0m	30.0s	200.0s	1001 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 1)
1000.0m	100.0s	300.0s	1001 (SBE_CT: 1 SBE_O2: 0 WL_BB2F: 0 AA4330: 1)

9. Miscellaneous figures

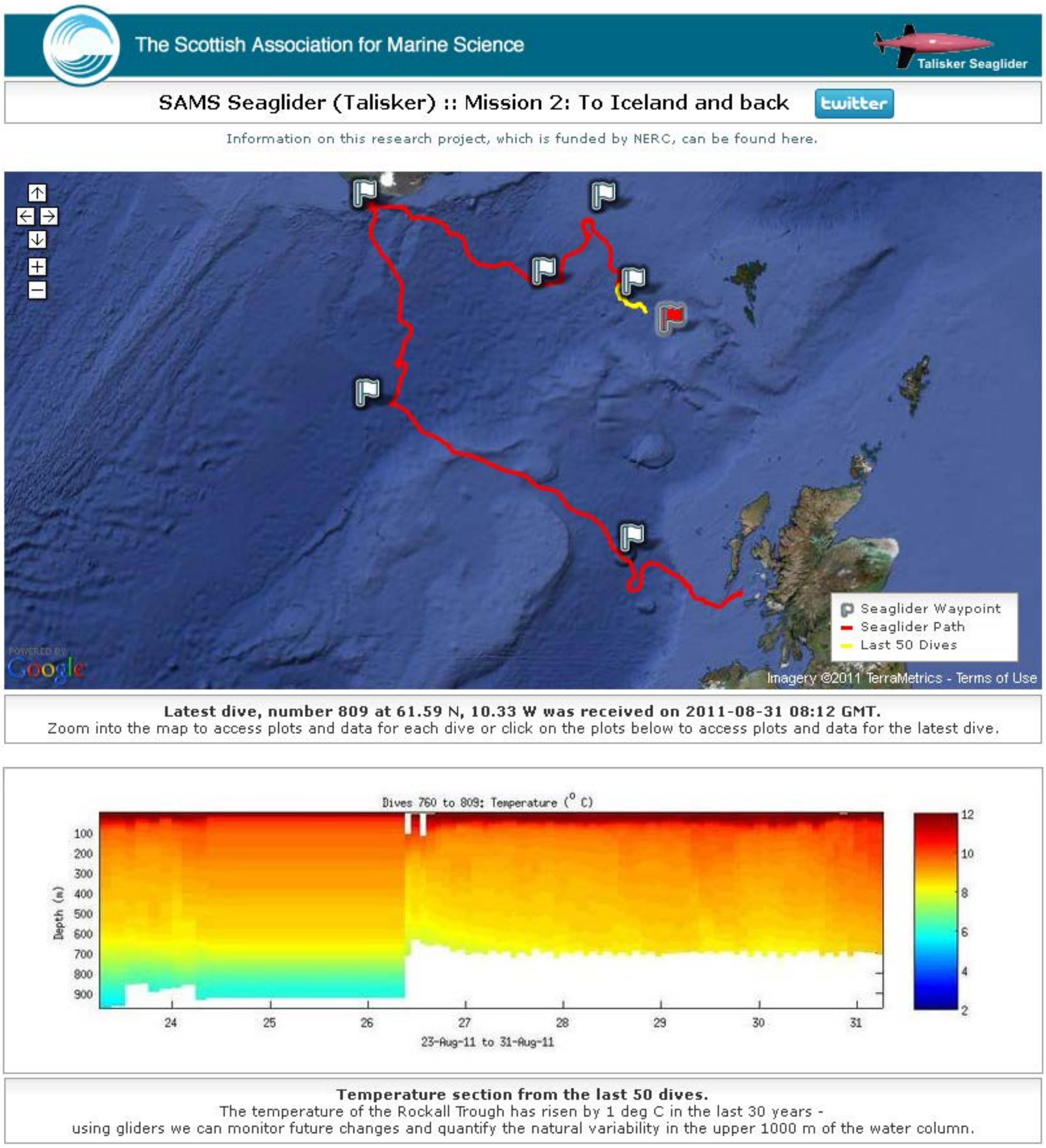


Figure 9.1 Webpage showing the track at the end of the mission.

Figure 9.2. Talisker in Torshavn at the end of the mission awaiting repatriation.

10. Appendix A

Summary of log file 841. The first part is shown in two columns.

```
version: 66.07
glider: 156
mission: 2
dive: 841
start: 9 3 111 3 37 17
data:
$ID,156
$MISSION,2
$DIVE,841
$D_SURF,3
$D_FLARE,3
$D_TGT,80
$D_ABORT,1050
$D_NO_BLEED,80
$D_BOOST,4
$T_BOOST,0
$D_FINISH,10
$D_PITCH,0
$D_SAFE,0
$D_CALL,0
$SURFACE_URGENCY,0
$SURFACE_URGENCY_TRY,0
$SURFACE_URGENCY_FORCE,0
$T_DIVE,27
$T_MISSION,35
$T_ABORT,720
$T_TURN,225
$T_TURN_SAMPINT,5
$T_NO_W,120
$T_LOITER,0
$USE_BATHY,0
$USE_ICE,0
$ICE_FREEZE_MARGIN,0.30000001
$D_OFFGRID,100
$T_WATCHDOG,10
$RELAUNCH,1
$APOGEE_PITCH,-7
$MAX_BUOY,120
$COURSE_BIAS,0
$GLIDE_SLOPE,45
$SPEED_FACTOR,1
$RHO,1.0276999
$MASS,51682
$NAV_MODE,1
$FERRY_MAX,45
$KALMAN_USE,2
$HD_A,0.003
$HD_B,0.0099999998
$HD_C,9.9999997e-06
$HEADING,-1
$ESCAPE_HEADING,225
$ESCAPE_HEADING_DELTA,10
$FIX_MISSING_TIMEOUT,0
$TGT_DEFAULT_LAT,5627
$TGT_DEFAULT_LON,-748
$TGT_AUTO_DEFAULT,0
$SM_CC,250
$N_FILEKB,8
$FILEMGR,0
$CALL_NDIVES,1
$COMM_SEQ,0
$KERMIT,0
$N_NOCOMM,1
$N_NOSURFACE,0
$UPLOAD_DIVES_MAX,-1
$CALL_TRIES,5
$CALL_WAIT,60
$CAPUPLOAD,0
$CAPMAXSIZE,400000
$HEAPDBG,0
$T_GPS,15
$N_GPS,20
$T_GPS_ALMANAC,0
$T_GPS_CHARGE,-633445.38
$T_RSLEEP,8
$STROBE,0
$RAFOS_PEAK_OFFSET,1.5
$RAFOS_CORR_THRESH,60
$RAFOS_HIT_WINDOW,3600
$PITCH_MIN,160
$PITCH_MAX,3877
$C_PITCH,1944
$PITCH_DBAND,0.1
$PITCH_CNV,0.003125763
$P_OVSHOOT,0.039999999
$PITCH_GAIN,30
$PITCH_TIMEOUT,16
$PITCH_AD_RATE,175
$PITCH_MAXERRORS,1
$PITCH_ADJ_GAIN,0
$PITCH_ADJ_DBAND,0
$ROLL_MIN,221
$ROLL_MAX,3800
$ROLL_DEG,40
$C_ROLL_DIVE,2186
$C_ROLL_CLIMB,1953
$HEAD_ERRBAND,10
$ROLL_CNV,0.028270001
$ROLL_TIMEOUT,15
$R_PORT_OVSHOOT,25
$R_STBD_OVSHOOT,22
$ROLL_AD_RATE,350
$ROLL_MAXERRORS,2
$ROLL_ADJ_GAIN,1
$ROLL_ADJ_DBAND,0.029999999
$VBD_MIN,451
$VBD_MAX,3959
$C_VBD,2960
$VBD_DBAND,2
$VBD_CNV,-0.245296
$VBD_TIMEOUT,720
$PITCH_VBD_SHIFT,0.0012300001
$VBD_PUMP_AD_RATE_SURFACE,4
$VBD_PUMP_AD_RATE_APOGEE,4
$VBD_BLEED_AD_RATE,8
$UNCOM_BLEED,50
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$VBD_MAXERRORS,1
$CF8_MAXERRORS,20
$AH0_24V,150
$AH0_10V,100
$MINV_24V,18.799999
$MINV_10V,8
$FG_AHR_10V,0
$FG_AHR_24V,0
$PHONE_SUPPLY,2
$PRESSURE_YINT,-17.302351
$PRESSURE_SLOPE,0.00011457827
$AD7714Ch0Gain,128
$TCM_PITCH_OFFSET,0
$TCM_ROLL_OFFSET,0
$COMPASS_USE,0
$ALTIM_BOTTOM_PING_RANGE,0
$ALTIM_TOP_PING_RANGE,0
$ALTIM_BOTTOM_TURN_MARGIN,15
$ALTIM_TOP_TURN_MARGIN,0
$ALTIM_TOP_MIN_OBSTACLE,1
$ALTIM_PING_DEPTH,0
$ALTIM_PING_DELTA,25
$ALTIM_FREQUENCY,13
$ALTIM_PULSE,6
$ALTIM_SENSITIVITY,3
$XPDR_VALID,3
$XPDR_INHIBIT,90
$INT_PRESSURE_SLOPE,0.0097660003
$INT_PRESSURE_YINT,0
$DEEPGLIDER,0
$DEEPGLIDERMB,0
$MOTHERBOARD,4
$DEVICE1,2
$DEVICE2,20
$DEVICE3,35
$DEVICE4,101
$DEVICE5,-1
$DEVICE6,-1
$LOGGERS,0
$LOGGERDEVICE1,-1
$LOGGERDEVICE2,-1
$LOGGERDEVICE3,-1
$LOGGERDEVICE4,-1
$COMPASS_DEVICE,33
$COMPASS2_DEVICE,-1
$PHONE_DEVICE,48
$GPS_DEVICE,32
$RAFOS_DEVICE,-1
$XPDR_DEVICE,24
$SIM_W,0
$SIM_PITCH,0
$SEABIRD_T_G,0.0043913
$SEABIRD_T_H,0.00064457668
$SEABIRD_T_I,2.9442117e-05
$SEABIRD_T_J,3.6341848e-06
$SEABIRD_C_G,-10.157008
$SEABIRD_C_H,1.1437986
$SEABIRD_C_I,-0.00075999805
$SEABIRD_C_J,0.00015497212

$GPS1,030911,033201,6119.714,-956.794,10,1.0,15,-9.7
$_CALLS,1
$_XMS_NAKs,0
$_XMS_TOUTs,0
$_SM_DEPTHo,1.16
$_SM_ANGLEo,-57.2
$GPS2,030911,033656,6119.706,-956.806,15,1.2,15,-9.7
$SPEED_LIMITS,0.099,0.234
$TGT_NAME,V_19
$TGT_LATLONG,6114.000,-943.000
$TGT_RADIUS,2000.000
$KALMAN_CONTROL,0.000,0.000
$KALMAN_X,0.0,0.0,0.0,0.0,0.0
$KALMAN_Y,0.0,0.0,0.0,0.0,0.0
$MHEAD_RNG_PITCHd_Wd,140.4,16219,-19.5,-9.877
$D_GRID,80
$GCHEAD,st_secs,pitch_ctl,vbd_ctl,depth,ob_vertv,data_pts,end_secs,pitch_secs,r
oll_secs,vbd_secs,vbd_i,gcphase,pitch_i,roll_i,pitch_ad,roll_ad,vbd_ad,pitch_re
tries,pitch_errors,roll_retries,roll_errors,vbd_retries,vbd_errors
$STATE,12,end surface,CONTROL_FINISHED_OK
$STATE,12,begin dive
$GC,15,-0.79,-116.8,0.0,0.0,0,78,0.00,0.00,-
60.85,0.000,2,0.000,0.000,149,2196,3279,0,0,0,0,0,0
$GC,81,-0.79,-116.8,3.6,-5.4,6,99,8.18,2.53,-
3.72,0.000,4,0.235,0.059,1672,3606,3438,0,0,0,0,0,0
$GC,353,-0.79,-116.8,48.2,-
16.3,25,357,0.00,2.42,0.00,0.000,6,0.000,0.038,1672,2188,3438,0,0,0,0,0,0
$GC,532,-0.79,-116.8,73.7,-
13.5,34,536,0.00,2.50,0.00,0.000,4,0.000,0.053,1663,3597,3438,0,0,0,0,0,0
$STATE,574,end dive,TARGET_DEPTH_EXCEEDED
$STATE,574,begin apogee
```

$GC,584,-
0.23,0.0,80.5,14.6,36,696,0.80,0.00,108.57,0.542,6,0.151,0.000,1857,1937,2960,0
,0,0,0,0,0
$STATE,696,end apogee,CONTROL_FINISHED_OK
$STATE,696,begin climb
$GC,699,0.79,116.8,86.1,0.0,40,821,1.23,3.53,110.22,0.522,4,0.091,0.049,2199,54
6,2482,0,0,0,0,0,0
$GC,968,0.82,136.4,67.0,8.8,49,993,0.00,3.22,19.42,0.486,6,0.000,0.037,2199,195
4,2403,0,0,0,0,0,0
$GC,1162,0.86,170.2,51.0,8.0,58,1205,0.00,2.70,33.72,0.497,4,0.000,0.047,2199,3
368,2265,0,0,0,0,0,0
$GC,1222,0.88,183.8,46.2,9.1,60,1242,0.00,2.60,15.27,0.467,6,0.000,0.038,2208,1
946,2210,0,0,0,0,0,0
$GC,1406,0.88,183.8,27.3,11.1,70,1411,0.00,3.22,0.00,0.000,4,0.000,0.050,2221,5
46,2204,0,0,0,0,0,0
$GC,1491,0.88,183.8,16.5,13.7,77,1496,0.00,3.10,0.00,0.000,6,0.000,0.037,2221,1
937,2202,0,0,0,0,0,0
$GC,1605,0.88,183.8,3.2,11.5,87,1609,0.00,2.03,0.00,0.000,3,0.000,0.043,2220,30
75,2202,0,0,0,0,0,0
$STATE,1610,end climb,SURFACE_DEPTH_REACHED
$STATE,1610,begin surface coast
$FINISH,0.3,1.026750
$STATE,1638,end surface coast,CONTROL_FINISHED_OK
$STATE,1638,begin surface
$SM_CCo,1657,69.82,0.418,1,0,1939,250.20
$SM_GC,1.18,0.00,0.00,69.82,0.000,0.000,0.418,142,2167,1939,-5.63,-0.54,250.20
$IRIDIUM_FIX,6054.92,-954.25,030911,030320
$TT8_MAMPS,0.026215
$HUMID,47.28
$INTERNAL_PRESSURE,8.96519
$TCM_TEMP,20.50
$XPDR_PINGS,0
$24V_AH,19.5,83.311
$10V_AH,9.8,57.088
$FG_AHR_24Vo,0.000
$FG_AHR_10Vo,0.000
$DEVICES,Pitch_motor,Roll_motor,VBD_pump_during_apogee,VBD_pump_during_surface,
VBD_valve,Iridium_during_init,Iridium_during_connect,Iridium_during_xfer,Transp
onder_ping,GUMSTIX_24V,GPS,TT8,LPSleep,TT8_Active,TT8_Sampling,TT8_CF8,TT8_Kalm
an,Analog_circuits,GPS_charging,Compass,RAFOS,Transponder,Compass2
$DEVICE_SECS,16.725,32.425,287.225,69.825,0.000,0.000,0.000,0.000,0.000,0.000,1
6.769,292.118,751.799,396.176,313.170,53.114,0.000,607.220,0.000,291.841,0.000,
0.536,0.000
$DEVICE_MAMPS,234.855,58.905,541.620,418.455,0.000,0.000,0.000,0.000,420.000,0.
000,0.000,19.800,2.190,19.800,39.800,45.800,0.000,12.000,0.000,15.000,0.000,5.0
00,0.000
$SENSORS,SBE_CT,SBE_O2,WL_BB2F,AA4330,nil,nil,nil,nil,nil,nil
$SENSOR_SECS,59.636,0.000,0.000,136.862,0.000,0.000,0.000,0.000,0.000,0.000
$SENSOR_MAMPS,24.000,0.000,0.000,33.000,0.000,0.000,0.000,0.000,0.000,0.000
$MEM,328448
$DATA_FILE_SIZE,3728,90
$CAP_FILE_SIZE,40232,0
$CFSIZE,260165632,218759168
$ERRORS,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0
$GPS,030911,040722,6119.446,-956.955,13,3.1,32,-9.7