Structure of turbulence in shelf seas: Autosub 2006 cruise report

John Simpson, Mattias Green, Tom Rippeth, Matthew Palmer

School of Ocean Sciences
University of Wales Bangor
Menai Bridge
Anglesey
LL59 5AB
UK

Contact information: Professor John Simpson, email: j.h.simpson@bangor.ac.uk; phone: +44-(0)1248-382 844

Scientific crew RV Prince Madog

Part I, mooring deploymen (July 9-12)t:
Professor John Simpson, PI
Dr Mattias Green
Mr Rory O'Hara Murray
Mr Matthew Palmer
Mr Ben Powell
Mr Michael Ridgill
Mr Ray Wilton

Part II, Autosub (July 12-21):
Professor John Simpson, PI (UWB)
Miss Louise Davies (DSTL)
Dr Mattias Green (UWB)
Miss Clare Jones (Sheffield University)
Mrs Stephanie McKeown (UWB)
Mr Matthew Palmer (UWB)
Mr Ben Powell (UWB)
Dr Tom Rippeth (UWB)
Dr Kate Stansfield (NOC)
Mr Phil Wiles (UWB)

Part III, mooring recovery (July 21-24):
Dr Tom Rippeth, PI
Dr Mattias Green
Mrs Stephanie McKeown
Mr Ben Powell

Cruise plan: overview

Vertical coverage of the data will be completed with measurements using FLY, CTD and ship borne ADCPs in combination with three moorings with ADCP and thermistors (see Fig. 1 for the locations and the appendix for a mooring outline)[1]. Note that this is a two-ship operation involving both the Prince Madog and the Terschelling. The FLY/CTD data will be sampled by the crew on the Prince Madog, who is also responsible for mooring deployment and recovery whereas the Autosub will operate from the Terschelling. Communication between the two vessels will mainly be maintained using VHF and, if necessary, satellite phone/fax.

The cruise can be divided into three parts: 1) mooring deployment, 2) the Autosub/FLY/CTD missions, and finally 3) mooring recovery. The Terschelling will be present during part 2, and Prince Madog will go to port between each part and change parts of the crew. The mooring deployments are not described in detail here, but see the appendix for an outline. During the mission part there will be one Autosub test deployment (TRIAL) and three missions (MLB, SWIS and FR), see the time-schedule at the end of the report. TRIAL will be followed by the 50-hour mission MLB located around the mooring north of Anglesey. During the 10 hour turnaround after MLB we will reposition from Liverpool Bay to the western part of the Irish Sea and run SWIS, a 60 hour mission. After another 10 hour turnaround at the end of SWIS, we will start the final mission FR in which Autosub is to repeatedly cross the Irish Sea front. This mission is also 60 hours long. ***NOTE!*** It is possible that we will NOT do a recovery between these missions, but just let Autosub transfer between SWIS and FR on its own. The final decision on this will be made later, and depends on the performance of the sub and the turbulence package during the previous missions, on weather conditions, and on battery power in the sub. There will still be a turnaround though, although it may be shorter than the scheduled 10 hours. All missions run near one of the moorings, ensuring we get a good resolution in time and space. The aim of each mission varies. MLB is planned to give us a time-series over a tidal cycle at four different depths throughout the water column, although focus is on the lower part where the dissipation is strongest. At SWIS the mission is deigned to give us information on the horizontal variability at different depths over a tidal cycle, whereas FR is planned to give us information about the spatial and temporal changes within a slab of water on both sides of the front. FR is also to give data on the evolution of the front during the tidal cycle.

The missions were planned using tidal currents and topography from Alan Elliott's tidal model TIDVEC (see Fig. 2 for some output) and the numerical values in Table 1 in a Matlab package (AUTOPLAN) simulating the characteristics of Autosub. The output from the model consists of hourly values of the tidal currents on a 2x2 km grid, although the output was interpolated to a 10-minute time resolution in AUTOPLAN. 2-dimensional linear interpolation was also used to get the currents at Autosub's location at each time-step. The model does not include any baroclinic effects; however, the dynamics in the Irish Sea is almost completely dominated by the tide meaning that other processes can safely be neglected.

[1] From Autosub we would like data from all the sensors, including navigation. From the ADCPs we want the highest possible vertical resolution, preferably a 1-2 m bin size.

Prince Madog-Terschelling Autosub Campaign July 9-23 2006

Report of Proceedings

Aims and Programme Rationale

This cruise, which was funded through NERC grants NER/D/S/2002/00965 and NER/J/S/2001/0814, was motivated by the need to obtain improved measurements of turbulence in environments characteristic of different shelf sea regimes. Such measurements are required to provide insights into the turbulent mixing processes which are crucial in controlling the structure and biogeochemistry of shelf seas and to test developing models of turbulent mixing. The programme involved measurements of the horizontal and vertical structure using (i) shear sensors mounted on the Autosub autonomous vehicle, (ii) the FLY free-fall dissipation profiler and (iii) Acoustic Doppler Current Profilers mounted on the seabed and on the research vessel.
Because of the heavy demands of the programme, two vessels were employed for the campaign: the Prince Madog deployed the moorings and undertook the FLY profiling while the Terschelling acted as mother vessel for the deployment and recovery of Autosub and accommodated the Autosub technical team.

Programme

The two vessels worked to a carefully planned programme which was arranged around three extended Autosub missions in the well mixed, stratified and frontal regimes as detailed in Table 1. Prior to the start of the Autosub missions Moorings were to be deployed at all three observational sites (MLB, SWIS and FR in figure1) by the Prince Madog using Holyhead as the base for storage and loading of mooring equipment.
The plan called for a bottom mounted ADCP to be deployed at each of the sites with a vertical string of temperature sensors at the SWIS and FR positions(see appendix 2 for mooring details) while a bottom-mounted sidescan sonar was to be placed close to the ADCP at MLB. Following completion of the Autosub missions, the PM was to recover all moorings.

Terschelling's primary role was to support and service the Autosub for her three missions and to track the vessel as needed. The missions were planned to start in the mixed regime at springs and then to move to the stratified regime as the tidal range decreased and finishing with the frontal study at neaps tides (figure 2). During any time when the vessel was not needed for Autosub support it was planned that she would serve as a platform for trials of a new PIV system for measuring turbulence by particle tracking.

Table 1: Summary of the mission

	TRIAL Liverpool Bay	**MLB** Liverpool Bay	**SWIS** Western Irish Sea	**FR** Western Irish Sea front
Mission start	13/07/06, 0600	13/07/06, 1000	15/07/06, 2200	18/07/06, 2000
Mission end	13/07/06, 0800	15/07/06, 1200	18/07/06, 1000	21/07/06, 0800
Mission length	2 hrs	50 hrs	60 hrs	60 hrs
Turnaround time, Recovery near	2 hrs	10 hrs, 53°41.00, -4°7.00	10 hrs 53°44.00, -5°32.00	N/A, 53°40.30, -5°11.60
Navigation mode	WP	WP	WP	Fixed heading for 5 hours
Waypoints:	53°39.60, -4°10.70 53°39.60, -4°07.30	53°39.60, -4°10.70 53°39.60, -4°07.30 53°42.40, -4°07.30 53°42.40, -4°10.70	53°48.40, -5°32.50 53°36.80, -5°32.50	Start at 53°41.00, -5°25.00, 104°/284° fixed heading
Start depth	20 m	40 m	15 m	15 m
Depth gain	5 m	Varying, decreasing 5/10 m	5 m	30 m
Depth change after	Passing one WP	Passing 7 WP	Passing WP 1	5 hours, repeated cycle of depths
Max dive depth	30 m	40 m	40 m	45 m
Bottom depth, safety limit	45 m, 10 m	45 m, 5 m	100 m, 10 m	85 m, 10 m
Speed	1.2 m/s			
FLY locations, FLY session length	N/A N/A	53° 40.00, 4°09.00 25+2+2 hours	53° 43.00, 5°30.00 25+25 hours	53° 40.25, 5° 14.60, 13 hours 53° 40.35, 5° 17.50, 13 hours 53° 41.50, 5° 12.40, 13 hours 53° 44.50, 5° 05.40, 13 hours

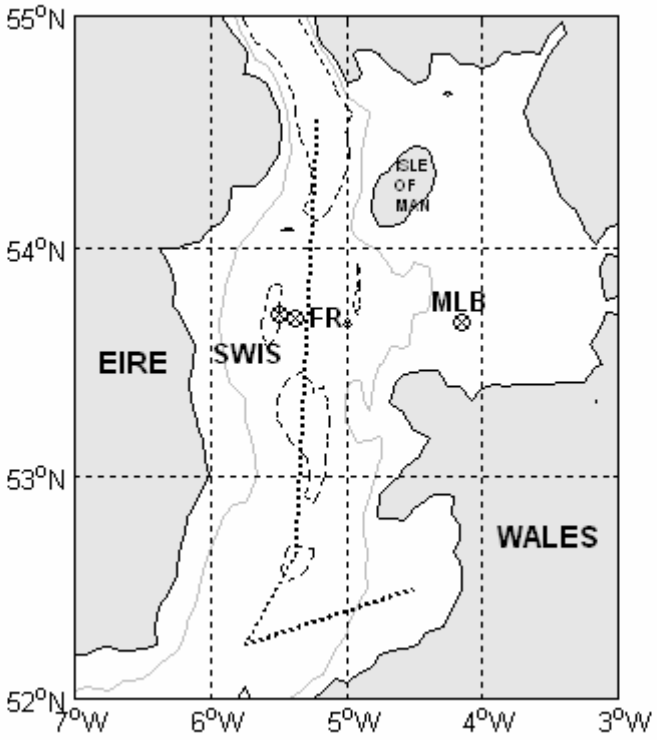


Figure 1. Map of the Irish Sea with the positions of the moorings at the mixed site (MLB), the stratified (SWIS) and the frontal site (FR) shown. The heavy dotted line is the transect done over the region at the end of the cruise. The grey and thin dashed lines are the 50 and 100m isobaths, respectively.

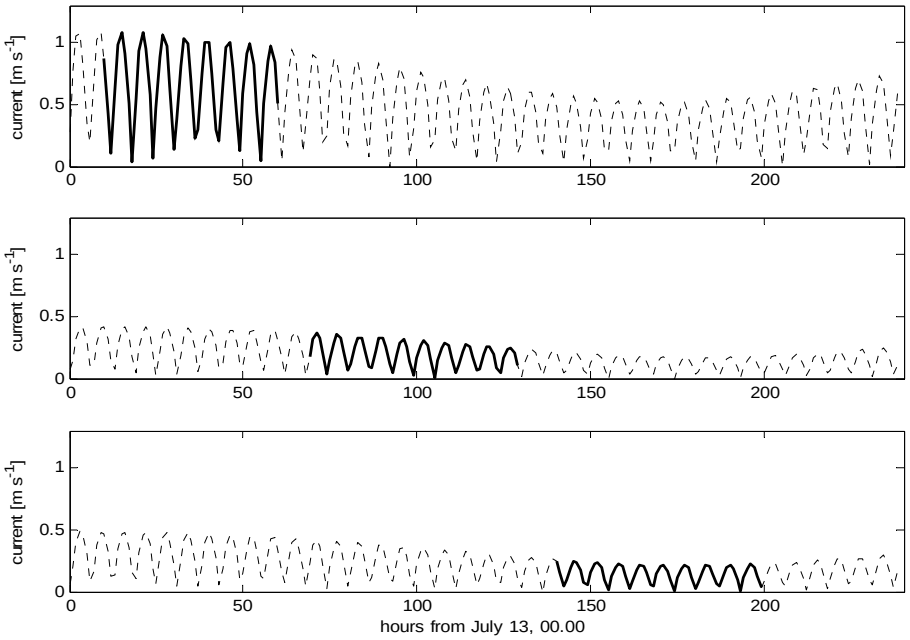


Figure 2 Tidal currents at the MLB, SWIS and FR sites with mission periods in bold

Narrative

9/7/06 Prince Madog (PM) was alongside in Holyhead for loading of mooring gear delivered by lorry from UKORS. Second mooring buoys and Aries frame had to be left on quay because of storage limitations.

10/7 ADCP and thermistor chain moorings deployed at SWIS site in good weather conditions. Wind increased to force 6/7 on return passage to Holyhead which imited CTD transect to 3 stations. Hard-drive for E/S computer failed.

11/7 Second set of moorings deployed at the FR site with weather (4/5) improving. CO2 analyser shows consistent changes on frontal crossing. Completed CTD transect to verify frontal position.

12/7 Changeover of personnel before leaving Holyhead for the MLB station. Bed frame ADCP and Aries moorings deployed without difficulty in winds ~18 knots. Trials of FLY system successful although we found a defective conductivity sensor on the veteran FLY. Contact with the Autosub team on Terschelling. They should arrive by 2100.
Excursion in to the Mersey bar overnight to see if pCO2 varied in the ROFI.

13/7 Autosub launched from T. soon after 0600 for an initial trial of the vehicle and shear sensor package which was successful. First Autosub Mission commenced at 1200
with FLY profiling an hour later.

14/7 FLY cable changed overnight after pigtail failure. After completion of 25 hour FLY series, we sought calm conditions behind the Great Orme to test the ADCP spar
which is working well although its use will impose a speed restriction of ~3knots.

15/7 ADCP spar deployed for short FLY series to look at strongest flows during the flood. Autosub has not made all the way points because of lack of speed so sampling is biased to deeper legs but mission terminated as planned at 1230. Aries mooring and ADCP bedframe(acoustic release) recovered before passage to Holyhead to offload
hardware. Rendez-vous with T. at the start of the second mission after checking FR and SWIS moorings were in order. FLY series commenced two hours after Autosub with a re-terminated cable.

17/7 FLY series continues without interruption and parallel ADCP measurements from the spar. Nutrient samples from CTD rosette before bottles removed to improve T/S measurements for Thorpe scales. T. reports Autosub slow on the first two legs of Mission 2 because of opposing tidal streams.

18/7 FLY series completed in flat calm conditions. Passage to Holyhead to disembark Ben Powell who has to attend a funeral in Wrexham. Concern about rising CO2 values from the new Analyser prompted calls to CASIX personnel at PML who have not been receiving the data. Alongside in Holyhead until 1800 before passage back to FR position for Mission 3. Programming error necessitated recovery of Autosub shortly after deployment. Re-deployed at 2209 so mission delayed by ~ 2 hours.

19/7 First of four 12.5 hour FLY series at FR1 completed but some problems with
FLY 3. Changed over to FLY 4 and switched to second twisted pair in the cable.
Results satisfactory thereafter but doubts remain about the batteries in FLY 3.

Autosub is being displaced to the north by the mean flow so we are nudging the positions for the FLY series also to the north.

20/7 FR2 station (almost mixed at times) completed and commenced FR3 which has again been displaced to the north to try and keep up with Autosub. Station FR3 completed successfully in the afternoon, repositioned to station FR 4 northeast of FR3. Work commenced at FR4 (well mixed site). During the evening the wind reached a force 5, making CTD-casts impossible

21/7 Finished 13 hours of work at FR 4, recovered mooring FR in the morning. Some minor problems with entangled lines, but the recovery went smoothly. Steamed to Holyhead for scientific crew change. Started a transect into the North Channel with CTD and onboard continuous observations.

22/7 Continued transect, reached mooring SWIS in the morning for recovery. The mooring was heavily entangled and we lost 10 thermistors during the recovery. Continued transect along Irish Sea towards the Celtic Sea. Transect cancelled at 1830 GMT due to rough sea conditions. A return transect to SWIS via Cardigan Bay was started.

23/7 Transect completed, returned to Holyhead at 11.30 for demobilization.

Mooring plans

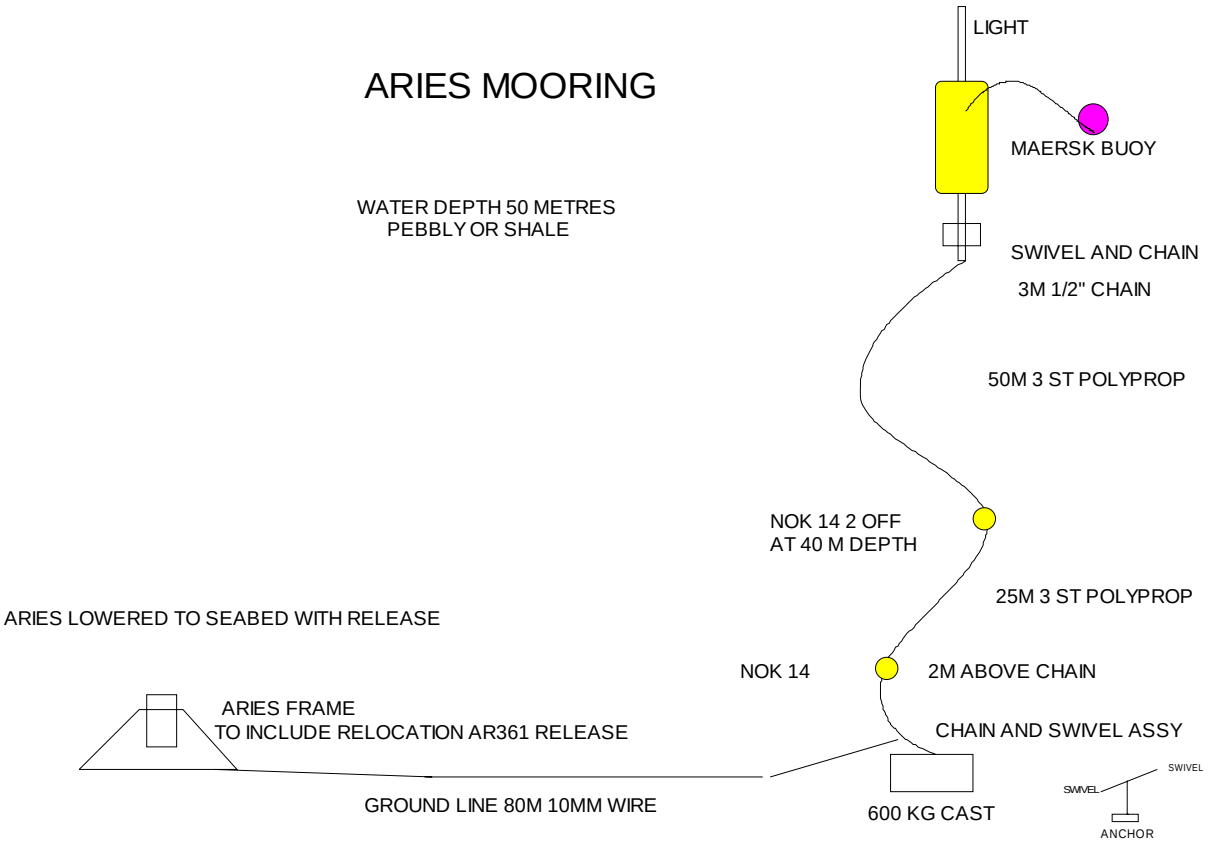
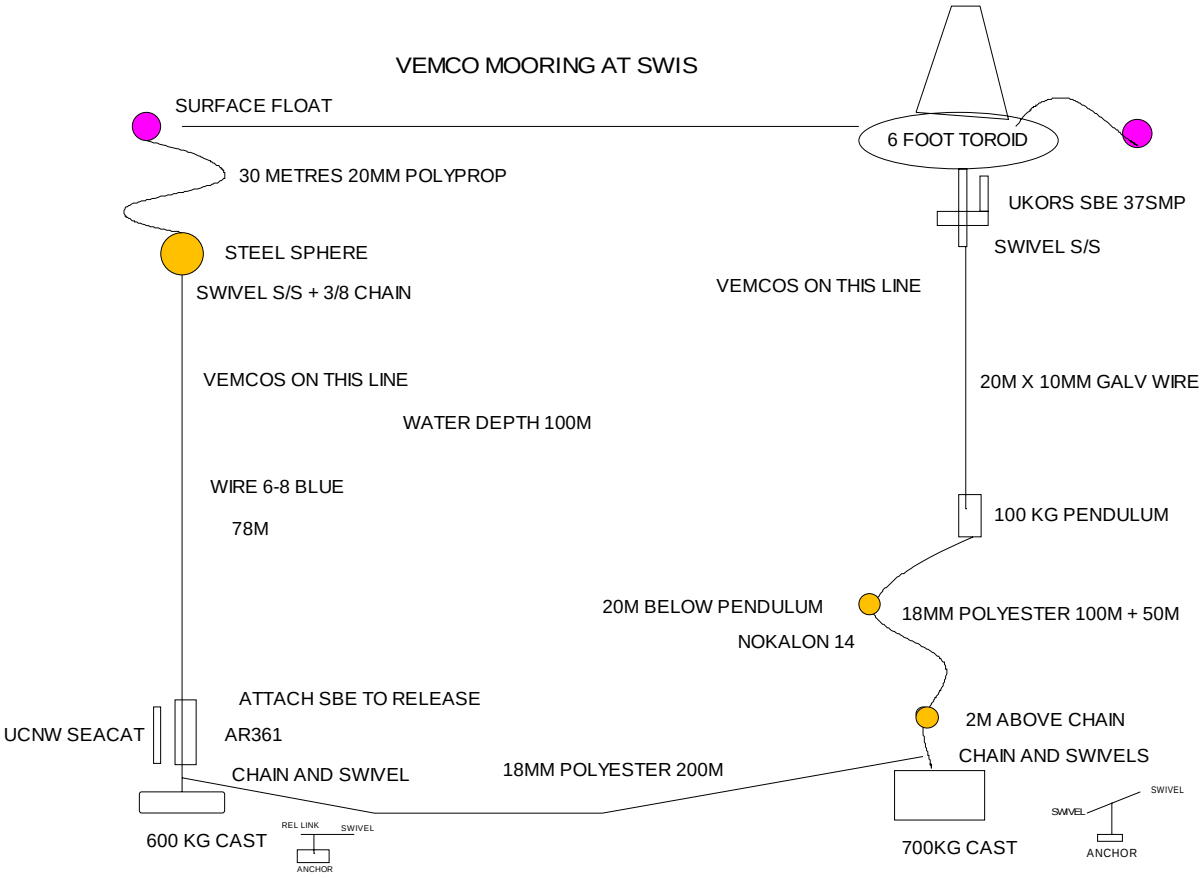


Figure 1: Mooring outline for the Aires, to be deployed at MLB.

Mooring SWIS (53 43.0N ; 5 30.0W; depth ~100m)
1 x 300kHz ADCP+ temperature micrologger chain (22 units, 32.5-5 m separation) +2 seacats



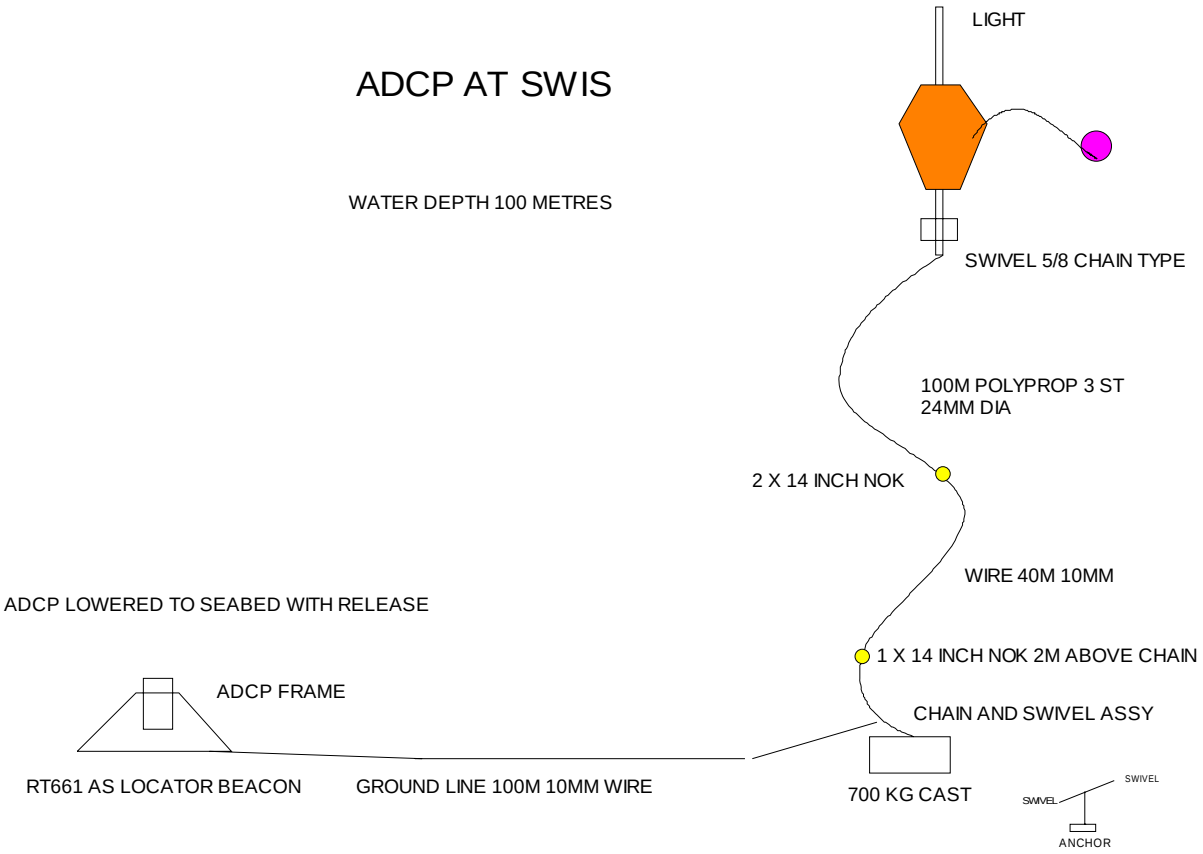
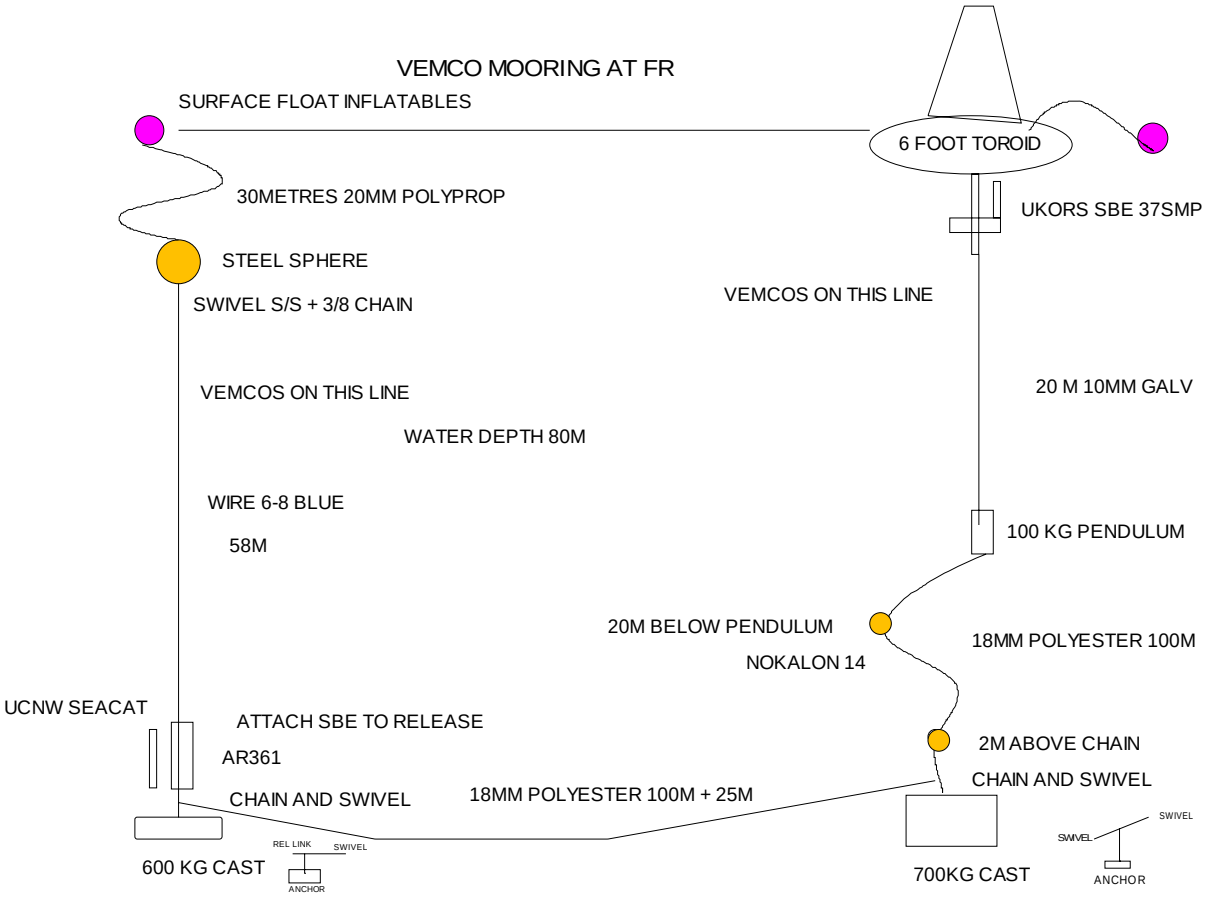


Figure 2: Mooring outline at SWIS. Note that two moorings are deployed: one U-shape with two thermistors/CTD strings, and one L-shaped ADCP mooring.

Mooring FR (53 41.5N; 5 22.0W; depth ~80 m)
300kHz ADCP+ temperature micrologger chain (18 units, 2.5-5 m separation)+2 seacats



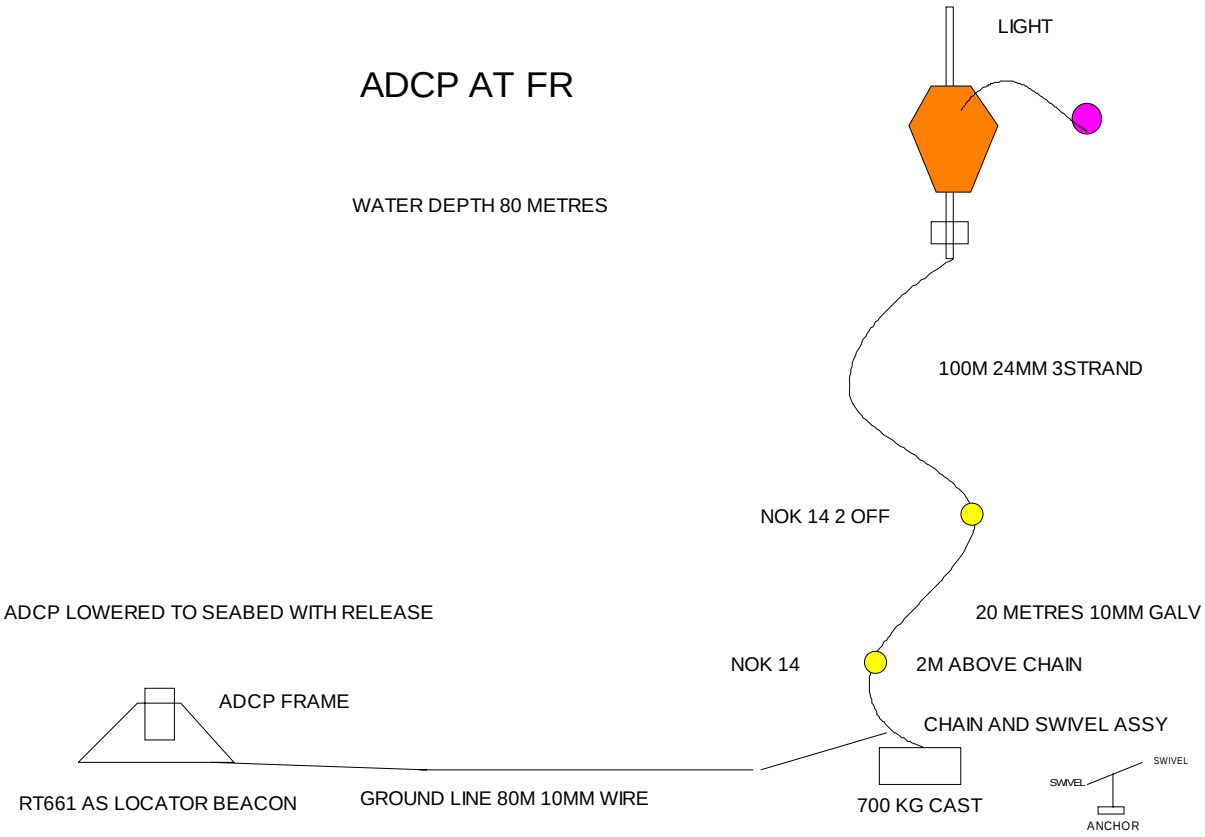


Figure 3: Mooring outline at FR. Note that two moorings are deployed: one U-shape with two thermistors/CTD strings, and one L-shaped ADCP mooring.

Configuration files:
ADCP configuration files Autosub 2006

MLB
CR1
CF11101
EA0
EB0
ED450
ES35
EX11111
EZ1111111
WB0
WD111100000
WF88
WM1
WN44
WP2
WS100
WV150
TE00:00:01.00
TP00:00.50
TF06/07/12 11:00:00
CK
CS
;
;Instrument = Workhorse Sentinel
;Frequency = 614400
;Beam angle = 20
;Temperature = 10.00
;Deployment hours = 120.00
;Battery packs = 1
;Automatic TP = YES
;Memory size [MB] = 1000
;
;Consequences generated by PlanADCP version 2.01:
;First cell range = 2.07 m
;Last cell range = 45.07 m
;Max range = 44.49 m
;Standard deviation = 4.35 cm/s
;Ensemble size = 1028 bytes
;Storage required = 444.10 MB
;Power usage = 211.72 Wh
;Battery usage 0.5

SWIS
CR1
CF11101
EA0
EB0

ED1050
ES35
EX11111
EZ1111111
WB0
WD111100000
WF176
WN48
WP2
WS200
WV130
TE00:00:02.00
TP00:01.00
TF06/07/10 10:00:00
CK
CS
;
;Instrument   = Workhorse Sentinel
;Frequency   = 307200
;Beam angle   = 20
;Temperature   = 10.00
;Deployment hours = 288.00
;Battery packs   = 1
;Automatic TP   = YES
;Memory size [MB] = 900
;
;Consequences generated by PlanADCP version 2.01:
;First cell range = 4.38 m
;Last cell range = 98.38 m
;Max range = 98.31 m
;Standard deviation = 3.76 cm/s
;Ensemble size = 1108 bytes
;Storage required = 574.39 MB
;Power usage = 416.72 Wh
;Battery usage 0.9

FR
CR1
CF11101
EA0
EB0
ED1050
ES35
EX11111
EZ1111111
WB0

WD111100000
WF176
WN48
WP2
WS200
WV130
TE00:00:02.00
TP00:01.00
TF06/07/11 10:00:00
CK
CS
;
;Instrument   = Workhorse Sentinel
;Frequency   = 307200
;Beam angle   = 20
;Temperature   = 10.00
;Deployment hours = 288.00
;Battery packs   = 1
;Automatic TP   = YES
;Memory size [MB] = 900
;
;Consequences generated by PlanADCP version 2.01:
;First cell range = 4.38 m
;Last cell range = 98.38 m
;Max range = 98.31 m
;Standard deviation = 3.76 cm/s
;Ensemble size = 1108 bytes
;Storage required = 574.39 MB
;Power usage = 416.72 Wh
;Battery usage 0.9

Autosub 2006
Data summary

CTD

Casts	Mission/transect	Station(s)	Dates	Comments
001-003	SWIS-HH	SWIS, FR, H1	10/7/06	
004-006	HH-SWIS	H4, H3, H2	10/7/06	
007-013	SWIS-HH	SWIS, H-1,H0, H1, H1.5, H2	11/7/06	
014-020	Mission 1	MLB	13-15/7/06	
021-087	Mission 2	SWIS	15-18/7/06	025-081 double dips for Thorpe scale analysis
088-091	Mission 3	FR1	18-19/7/06	
092-104	Mission 3	FR2	19/7/06	
105-117	Mission 3	FR3	20/7/06	
118-122	Mission 3	FR4	20/7/06-21/7/06	
123-127	IS north	IS1-IS5	21/7/06	
128-132	IS south	IS7-IS10	22/7/06	

FLY

Series	Drops	Mission/transect	Station(s)	Dates	Comments
1	1-5	TEST	MLB	13/7/06	FLY 3
2-33	6-442	Mission 1	MLB	13-15/7/06	FLY 3
34-83	443-749	Mission 2	SWIS	15-18/7/06	
84-95	750-838	Mission 3	FR1	18-19/7/06	FLY 3
96-108	839-904	Mission 3	FR2	19/7/06	FLY 4
109-121	905-970	Mission 3	FR3	20/7/06	FLY 4
122-134	971-(10)40	Mission 3	FR4	20/7/06-21/7/06	FLY 4, NOTE change of cruise name after cast 999

ADCP

File		Mission/transect	Station(s)	Dates	Comments

Nutrients and Chlorophyll

Cast	Depth	Mission/transect	Station(s)	Dates	Comments
21	103.00	Mission 2	SWIS		
	66.30	Mission 2	SWIS		
	32.64	Mission 2	SWIS		
	28.15	Mission 2	SWIS		

	22.08	Mission 2	SWIS		
	12.64	Mission 2	SWIS		
	1.35	Mission 2	SWIS		
22	105.30	Mission 2	SWIS		
	79.50	Mission 2	SWIS		
	34.90	Mission 2	SWIS		
	28.10	Mission 2	SWIS		
	21.40	Mission 2	SWIS		
	18.80	Mission 2	SWIS		
	1.50	Mission 2	SWIS		
23	100.00	Mission 2	SWIS		
	82.00	Mission 2	SWIS		
	44.70	Mission 2	SWIS		
	35.00	Mission 2	SWIS		
	30.43	Mission 2	SWIS		
	25.60	Mission 2	SWIS		
	20.95	Mission 2	SWIS		
	1.40	Mission 2	SWIS		
24	100.00	Mission 2	SWIS		
	70.00	Mission 2	SWIS		
	41.00	Mission 2	SWIS		
	30.70	Mission 2	SWIS		
	25.00	Mission 2	SWIS		
	18.20	Mission 2	SWIS		
82	101.30	Mission 2	SWIS		
	81.40	Mission 2	SWIS		
	44.71	Mission 2	SWIS		
	35.32	Mission 2	SWIS		
	25.65	Mission 2	SWIS		
	16.71	Mission 2	SWIS		
	11.38	Mission 2	SWIS		
	1.26	Mission 2	SWIS		
85	100.70	Mission 2	SWIS		
	75.50	Mission 2	SWIS		
	44.00	Mission 2	SWIS		
	19.40	Mission 2	SWIS		
	10.20	Mission 2	SWIS		
	1.70	Mission 2	SWIS		

Ship borne instrumentation: meteorology, through flow CTD and navigation

File	**Station/transect**	**Dates**	**Comments**
10-Jul-06, 11-Jul-06, 12-Jul-06	Holyhead-Irish sea	10-12/7/06	No humidity
13-Jul-06, 14-Jul-06, 15-Jul-06	MLB	13-15/7/06	No humidity
15-Jul-06,16-Jul-06, 17-Jul-06, 18-Jul-06	SWIS	15-18/7/06	No humidity
18-Jul-06, 19-Jul-06	FR1	18-19/7/06	No humidity
19-Jul-06	FR2	19/7/06	No humidity
20-Jul-06	FR3	20/7/06	No humidity
20-Jul-06, 21-Jul-06	FR4	20/7/06-21/7/06	No humidity
21Jul-06, 22-Jul-06	Irish sea		No humidity

Moorings

Instrument	**S/N**	**Station, depth**	**Dates**	**Comments**
Seacat	3273	SWIS, 0	10/7/06-22/7/06	1 min sampling
VEMCO	9743	SWIS, 5	10/7/06-22/7/06	LOST
VEMCO	9763	SWIS, 7	10/7/06-22/7/06	LOST
VEMCO	9760	SWIS, 9	10/7/06-22/7/06	LOST
VEMCO	9772	SWIS, 11	10/7/06-22/7/06	LOST
SeaStar TD50	2823	SWIS, 13	10/7/06-22/7/06	1 min sampling
SeaStar	2844	SWIS, 15	10/7/06-22/7/06	LOST
SeaStar	2843	SWIS, 17	10/7/06-22/7/06	LOST
SeaStar TD50	2821	SWIS, 19	10/7/06-22/7/06	1 min sampling
Instrument	**S/N**	**Station, height from bottom**	**Dates**	**Comments**
SeaStar TD50	2820	SWIS, 80.7	10/7/06-22/7/06	1 min sampling
SeaStar	2842	SWIS 79.7	10/7/06-22/7/06	1 min sampling
SeaStar	2841	SWIS 76.7	10/7/06-22/7/06	1 min sampling
SeaStar	2840	SWIS 74.7	10/7/06-22/7/06	1 min sampling
SeaStar TD300	2832	SWIS 72.7	10/7/06-22/7/06	1 min sampling
VEMCO	9756	SWIS 70.7	10/7/06-22/7/06	1 min sampling
VEMCO	2701	SWIS 68.7	10/7/06-22/7/06	1 min sampling
VEMCO	9744	SWIS 66.7	10/7/06-22/7/06	1 min sampling
VEMCO	9714	SWIS 64.7	10/7/06-22/7/06	1 min sampling
VEMCO	9753	SWIS 60.7	10/7/06-22/7/06	LOST
VEMCO	9712	SWIS 55.7	10/7/06-22/7/06	1 min sampling
VEMCO	2702	SWIS 50.7	10/7/06-22/7/06	1 min sampling
VEMCO	2703	SWIS 45.7	10/7/06-22/7/06	LOST
VEMCO	9765	SWIS 40.7	10/7/06-22/7/06	LOST
VEMCO	2704	SWIS 35.7	10/7/06-22/7/06	1 min sampling
VEMCO	2707	SWIS 30.7	10/7/06-22/7/06	LOST
VEMCO	8511	SWIS 25.7	10/7/06-22/7/06	2 min sampling
VEMCO	8512	SWIS 20.7	10/7/06-22/7/06	2 min sampling
VEMCO	7169	SWIS 15.7	10/7/06-22/7/06	2 min sampling
VEMCO	3118	SWIS 10.7	10/7/06-22/7/06	2 min sampling
SeaCat	3250	SWIS 2.7	10/7/06-22/7/06	1 min sampling

Instrument	**S/N**	**Station, depth**	**Dates**	**Comments**
Seacat	3253	FR, 0	11/7/06-21/7/06	1 min sampling
SeaStar	2835	FR, 2	11/7/06-21/7/06	1 min sampling
SeaStar TD50	2827	FR, 4	11/7/06-21/7/06	1 min sampling
SeaStar	2836	FR, 6	11/7/06-21/7/06	1 min sampling
SeaStar TD50	2826	FR, 8	11/7/06-21/7/06	1 min sampling
SeaStar	2839	FR, 10	11/7/06-21/7/06	1 min sampling
SeaStar TD50	2329	FR, 12	11/7/06-21/7/06	1 min sampling
SeaStar	2837	FR, 14	11/7/06-21/7/06	1 min sampling
SeaStar TD50	2830	FR, 16	11/7/06-21/7/06	1 min sampling
SeaStar	2838	FR, 18	11/7/06-21/7/06	1 min sampling
SeaStar TD50	2819	FR, 20	11/7/06-21/7/06	1 min sampling
Instrument	**S/N**	**Station, height from bottom**	**Dates**	**Comments**
VEMCO	2700	FR, 63.1	11/7/06-21/7/06	1 min sampling

VEMCO	9758	FR, 62.1	11/7/06-21/7/06	1 min sampling
VEMCO	9746	FR, 60.1	11/7/06-21/7/06	1 min sampling
VEMCO	9774	FR, 58.1	11/7/06-21/7/06	1 min sampling
VEMCO	9752	FR, 56.1	11/7/06-21/7/06	1 min sampling
VEMCO	2706	FR, 54.1	11/7/06-21/7/06	1 min sampling
VEMCO	9723	FR, 52.1	11/7/06-21/7/06	1 min sampling
VEMCO	9762	FR, 48.1	11/7/06-21/7/06	1 min sampling
VEMCO	9716	FR, 43.1	11/7/06-21/7/06	1 min sampling
VEMCO	9747	FR, 38.1	11/7/06-21/7/06	LOST
VEMCO	2699	FR, 33.1	11/7/06-21/7/06	1 min sampling
VEMCO	9048	FR, 28.1	11/7/06-21/7/06	2 min sampling
VEMCO	8517	FR, 23.1	11/7/06-21/7/06	2 min sampling
VEMCO	8519	FR, 18.1	11/7/06-21/7/06	2 min sampling
VEMCO	8516	FR, 13.1	11/7/06-21/7/06	2 min sampling
SeaCat	3211	FR, 5.1	11/7/06-21/7/06	1 min sampling