Cruise Report

POSEIDON 234a

(CANIGO Strait of Gibraltar Experiment)

Portimão-Malaga,
13-20 October 1997

Uwe Send, Chief Scientist

August 2, 1999

1 Introduction

The *Poseidon* cruise *p234a* was conducted from 13-20 October 1997 (Portimão-Malaga) in the Strait of Gibraltar as part of the intensive Experiment of the EU-project CANIGO (Canary Island Azores Gibraltar Experiment). The objectives of the cruise were:

- Recovery and redeployment of current meter/pressure gauge monitoring array at the sill.
- Deployment of additional moorings and pressure gauges at the eastern entrance of the strait, in order to enhance the CANIGO sampling for the intensive observational period.
- Ship-board observations (sections, time-series stations) of flow and water mass properties to support the moored observations.
- Ship-board observations of hydraulic features and internal bores, to help understand high-frequency variability in the time-series, moored observations and acoustic transmissions from the pilot experiment.
- Search for a mooring from WHOI/IHM which was integrated into the sampling during the pilot phase.

The techniques employed for the ship-board observations were sections, repeated stations, and rapidly cycling "yoyo" stations with the CTD, as well as rosette-mounted lowered ADCP ("lADCP") observations, rapid vessel-mounted ship-ADCP ("vmADCP") sections, and XBT temperature profiles.

The cruise was a joint effort of the 'Institut für Meereskunde Kiel' (IfM) and the 'Southampton Oceanography Centre' (SOC), with additional participants from 'Scripps Institution of Oceanography' (SIO), and the 'Instituto Hidrografico de la Marina' (IHM).

The participants were

Name	Affiliation
Send, Uwe	IfM
Baschek, Burkard	IfM
Begler, Christian	IfM
Cornuelle, Bruce	SIO
Goy, Keith	SOC
Hartman, Mark	SOC
Ibarrondo, Joaquin	IHM
Neumann, Thomas	IfM
Reich, Michael	IfM
Tsimplis, Michael	SOC
Waddington, Ian	SOC

The following sections of this report summarize the various types of operations conducted, provide technical details of mooring and stations work, and give an account of the day-to-day activities.

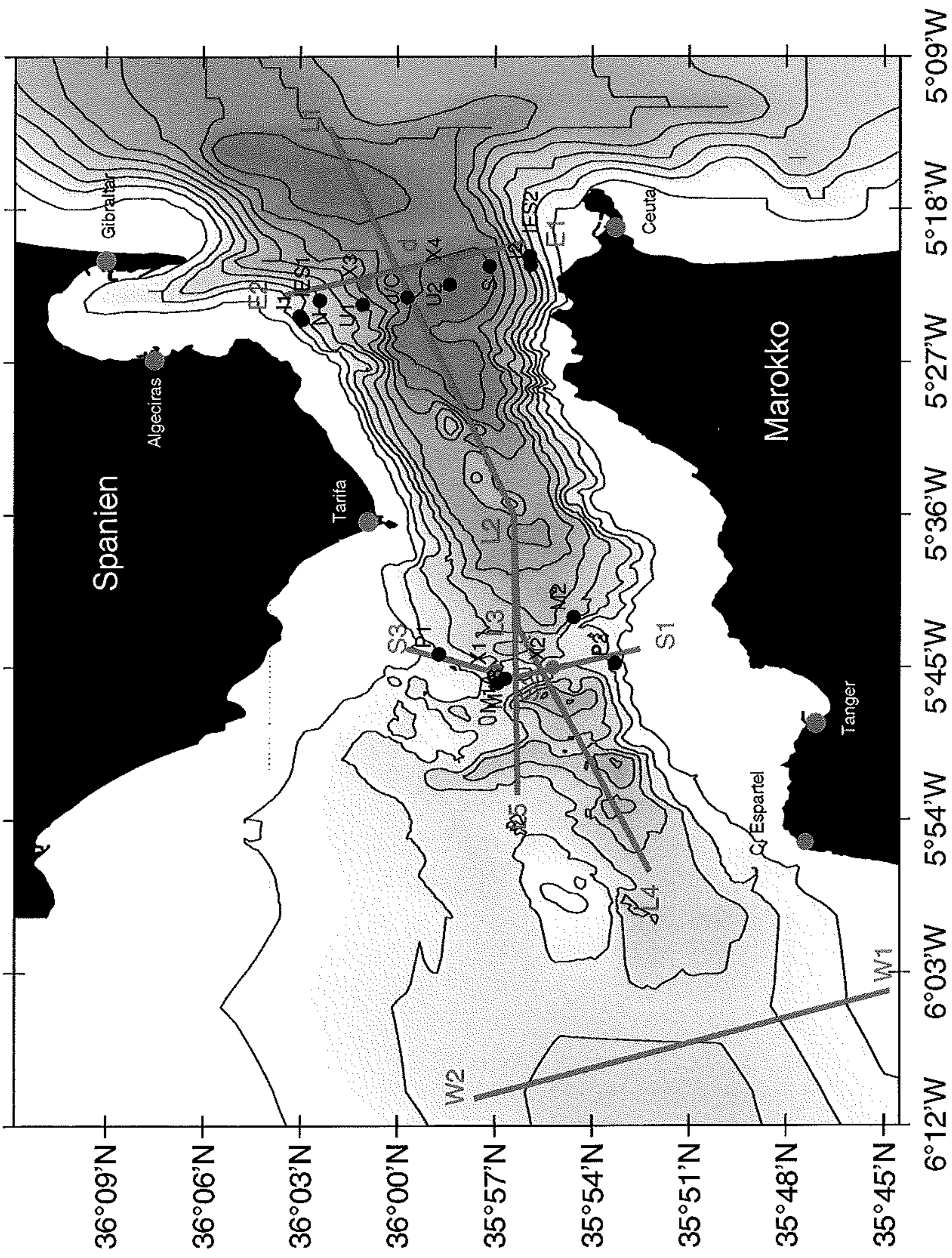

Figure 1: *Positions of the moorings (black dots), XBT-stations (green dots), and vmADCP-sections (red lines).*

2 Moorings

A major objective of the cruise was the recovery and deployment of moored instruments in the framework of the CANIGO project. At the sill, instruments of SOC had been in the water for 6 months prior to the cruise at four sites: current meter moorings at sites M1A/B and M2 and pressure gauges at sites P1, P2 (see Figure 1). Across the eastern section (Algeciras-Ceuta), the University of Malaga (UMa) had deployed 3 current meter moorings before this cruise. The plan was to recover and redeploy the above SOC moorings at the sill, and to add 4 moorings (of IfM Kiel, SOC) plus inverted echosounders combined with pressure gauges at the eastern section. This would provide the enhanced sampling during the intensive observation period, and give the coverage on the eastern line which was deduced from the pilot phase to be necessary to integrate the transport.

section	mooring	owner	latitude	longitude	water depth (uncorr.)	release type	releaser: Interrogate Release	ARGOS beacon
sill	P1	SOC	35°58.72N	5°44.23W	194 m	Pyro	I: B561 R: B591	23833
sill	M1A	SOC	35°56.90N	5°45.92W	284 m	Oceano	I: 95D1 R: 9511	23829
sill	M1B	SOC	35°56.68N	5°45.68W	287 m	Oceano	I: 95A1 R: 9511	01533
sill	M2	SOC	35°54.56N	5°44.43W	274 m	Oceano	I: 82C1 R: 8211	23832
sill	P2	SOC	35°53.28N	5°44.77W	200 m	Pyro	I: B566 R: B591	11033
east	I1	SOC	36°03.02N	5°24.27W	203 m	Pyro	I: 9535 R: 9591	23831
east	IES1	IfM	36°02.96N	5°24.48W	258 m	EG&G	I: 507406 R: 526366	n.a.
east	N	UMa	36°02.45N	5°23.7W	450 m			
east	U1	IfM	36°01.01N	5°23.62W	600 m	Oceano	I: 9647 R: 9645	ID2254
east	C	UMa	35°59.8N	5°22.6W	900 m			
east	U2	IfM	35°58.40N	5°22.44W	850 m	Oceano	I: E962 R: E964	ID2255
east	S	UMa	35°56.9N	5°21.3W	700 m			
east	IES2	IfM	35°55.93N	5°20.80W	192 m	EG&G	I: 507440 R: 526401	n.a.
east	I2	SOC	35°55.91N	5°21.03W	205 m	Pyro	I: B571 R: B591	01534

Table 1: *Moorings in the Strait of Gibraltar during CANIGO.*

With the exception of mooring M2, which could not be recovered, all operations took place as planned, including the deployment of a new M2 mooring. A small problem had occurred, since 2 current meters rented from GTG/Hydromod did not have pressure sensors as required, but fortunately the participants from SOC had a spare pressure sensor which could be installed in one of the instruments. This assured that each mooring had a pressure sensor in the topmost instrument.

Table 1 gives the details of the newly deployed moorings, and also contains the 3 UMa moorings which are part of the array.

2.1 Dredging for mooring J

At the center of the eastern section, a mooring (J) was deployed by IHM/WHOI during the CANIGO pilot phase in 1996. It had had originally been intended for observations from April until October 1996, but broke during that deployment period and lost the uppermost part (floatation and 1 current meter). The remainder still missing consisted of $800\,m$ of wire, 5 current meters, 14 Benthos balls and an acoustic release. Only the bottom $25\,m$ (release and floatation) were expected to be upright in the water with the remainder lying on the bottom. After unsuccessful interrogation and release commands, a dredging operation was carried out on 15 October.

This was done in $920\,m$ of water depth, with $100\,m$ of "Kurrdraht", $1000\,m$ of biological dredging wire, $250\,m$ of mooring wire, a grappling hook, another $10\,m$ of mooring wire, and finally a bottom weight of approx. $200\,kg$ smooth chain. With the short total length of wire, the expectation was that everything except the chain would be off the bottom, including the hook, with hook and chain trailing some $500\,m$ behind the ship. Dynamical calculations suggested that for ship motion of up to $3-4\,kn$ through the water, the weight would stay on the bottom. Several loops were steered around the mooring location, with estimates and 'mechanical simulations' of the path of the bottom weight on a high-resolution GPS ship-track display. Even though at times the wire showed extreme excursions to one side, as if something was hooked on it, in the end nothing was found. The whole wire, grappling hook and bottom weight chain was recovered intact.

Another attempt at dredging for the mooring was carried out on 19 October. This time, the entire "Kurrdraht" wire was used plus the above pieces of wire, giving a total length of $2800\,m$. No hooks were attached in order to avoid getting caught on rocks (or cables). Instead the hope was to lay a sling around the mooring on the bottom an pull it tight. It is estimated that the Kurr-wire was mainly off the bottom, with a first weight attached at its end, trailing some $800\,m$ behind the ship. The dredging wire of $1000\,m$ length was then lying on the bottom behind this, plus another $300\,m$ of mooring wire, and finally another weight at the end (each weight was $100\,kg$ of large chain links). A course was steered to lay 1.5 loops of wire around the mooring on the bottom, using new mechanical simulations. Then the ship stopped and the wire was pulled in. Unfortunately, it turned out that the dredging wire ($12\,mm$ steel cable) had broken during this operation, so again nothing was recovered.

3 Shipboard observations

In the Strait of Gibraltar the current speed and hydrographic data change rapidly, especially due to the strong tidal currents and the internal bore. In addition to that longperiodic processes can not be neglected and the currents also show a high spatial variablity.
Measuring the mass transport through the strait is therefore difficult and needs good temporal and spatial coverage with data. For this reason time series stations with moored instruments and from ship observations (CTD, vmADCP, lADCP) were combined with ship observations for covering the spatial structure of flow and of the water mass characteristics. For this, especially rapid 'quasi-synoptic' cross-strait sections with vmADCP were carried out at different locations and over a complete M_2-tidal cycle ($12.4\,h$).

3.1 CTD

A Neil-Brown CTD system (NB2 of IfM Kiel) plus a water sampling rosette was used during the cruise for observation of the hydrographic structure and of the water masses, as a function of location, phase in the tidal cycle, and as a result of the internal bore and mixing processes. The CTD only carried depth, temperature, and conductivity sensors. Water samples were taken with reversing thermometers, and salinometry was carried out with an Autosal system on the ship.

The CTD was used in two different modes. One consisted of single casts at given locations along a section or of repeated stations at a given location over a complete M_2-tidal cycle to measure the temporal changes of the hydrographic structure. These are referred to as 'sections' and 'timestations' in table 3. This was usually combined with lADCP-measurements (see section 3.4), running at the same time (see Appendix). Usually the whole water column was covered and water samples were taken for calibration.
In the other mode the CTD was used for continously repeated rapid up- and down cast ("CTD-yoyo", Table 3, Appendix). This was done to get a good impression of the temporal changes in the water mass characteristics and the depth of the interface between upper and lower layer (isohaline) as the internal bore (see section 3.5) passed by (at a given location). The CTD casts covered only the upper $300\,m$. No water samples were taken and no lADCP measurements were done.

3.2 XBT

The XBT's were used for high-frequency or rapid under-way sampling of the water mass structure, in support of vmADCP measurements, complemented by CTD data where possible.
15 boxes of T-6 XBT's (max. depth $460\,m$) were available, i.e. a total of 180 probes. A Sippican MK12-System was used for the XBT deployments. This consists of a PC-card with an external interface, which connects to the probe launcher. Good grounding of the interface box is essential, since this represents the return path for the electric XBT signal.
The launcher, wiring, etc. can be used with the 'test canister', which can simulate an XBT during loading, launch, and measuring. The calibration this way is not highly accurate but gives an idea of the functioning of the system. The Sippican aquisition software takes care of data collection, display, archiving, and exporting into ASCII files (raw data files are *.rdf, ascii data are *.edf).

3.3 Vessel-mounted ADCP

The vmADCP was used for rapid cross-strait sections over a complete M_2-tidal cycle at the eastern entrance of the strait, at the sill, and at the outflow section as well as for along strait sections (see Figure 1 and Tables 2, 3) in order to understand better the spatial and temporal variations of the current speed and to support the moored observations at the eastern section. In addition to that the vmADCP was used for measuring the internal bore (see section 3.5), but was also running during the whole cruise.

During the rapid 'quasi-synoptic' cross-strait sections (N–S direction) the ship steamed as fast as possible (if this was possible in account of the traffic in the strait) with a speed of approx. $12\,kn$, taking about $50\,min$ for one crossing. When the ship turned and headed back again, the gyro compass, which was used for determining the ships heading, oscillated due to the acceleration of the ship (Schuler-oscillations). These oscillations can be corrected with the data of a 3-D Ashtec GPS.
The vessel-mounted ADCP was a $150\,kHz$ instrument with beam angles of 30°. The range was generally $400 - 450\,m$, so that the current speed in the upper layer, the interface layer, and parts of the lower layer could be measured. For the determination of the position an accurate GPS (GLONASS/3-D Ashtec) navigation system was used. The PC clock was continously corrected by the GPS signal. For the first part of the cruise (13 October, 09:54:46 to 14 October, 09:18:49) an ensembles length of $180\,s$ was used, in the second part (14 October, 13:44:59 to 20 October, 09:04:54) the ensemble length was $120\,s$.

Waypoint	Latitude	Longitude
L1	36N 02.70	5W 13.50
L2	35N 57.12	5W 37.80
L3	35N 57.00	5W 43.20
L4	35N 52.20	5W 59.40
L5	35N 56.28	5W 54.60
E1	35N 55.14	5W 20.28
E2	36N 04.32	5W 23.94
W1	35N 45.00	6W 03.60
W2	35N 58.20	5W 10.80
S1	35N 51.72	5W 44.98
S2	35N 55.92	5W 47.04
S3	36N 00.00	5W 44.22
d	35N 59.70	5W 20.94

Table 2: *Waypoints of vmADCP-sections and time-stations during p234a.*

3.4 Lowered ADCP

The ADCP mounted in the rosette ("lADCP") was on loan from Geomar, Kiel. It has a transducer angle of 30° and therefore the deployment files and the processing software needed adjusting. All CTD stations, which were not rapid yoyo profiles, also had the lADCP running (see Appendix).

Instrument	Location	Start		End		Comment
		Date	Time (UTC)	Date	Time (UTC)	
	Departure Portimão	13.10.	09:00			
ADCP, CTD-yoyo	sill (L3)	14.10.	00:03	14.10.	04:00	bore, (11 CTD-cycles) time-station
ADCP, XBT	cross-strait, sill (S1-S2-S3)	14.10.	14:06	15.10.	02:40	13 sections
ADCP, XBT	along-strait (L5-L2-L1)	15.10.	03:29	15.10.	07:06	1 section
ADCP, XBT	along-strait (L1-L2-L5)	15.10.	17:46	15.10.	20:38	1 section
ADCP, XBT /CTD-yoyo	along-strait (L3-L2-L1)	16.10.	13:51	16.10.	21:57	bore, 3 time-stations (23 XBT, 10/9 CTD-cycles)
ADCP, XBT	cross-strait, east (E1-E2)	16.10.	22:33	17.10.	11:03	14 sections
ADCP, XBT	along-strait (L1-L2-L3-L4)	17.10.	19:16	17.10.	22:10	1 section
ADCP	along-strait (L3-L5)	17.10.	21:28	18.10.	13:50	1 section
ADCP, XBT, CTD	cross-strait, west (W1-W2)	18.10.	15:34	19.10.	05:00	8 sections
ADCP	along-strait (L3-L2-L1)	19.10.	07:12	19.10.	08:38	1 section
ADCP, CTD, lADCP	east (d)	19.10.	15:04	20.10.	03:08	time-station 10 profiles
	Arrival Malaga	20.10.	10:00			

Table 3: *vmADCP-sections and time-stations during the research cruise Poseidon p234a. For locations see Figure 1 and Table 2.*

However, extreme wire angles rendered some of the profiles unuseable. This was especially the case for the cast during which the winch broke and the rosette was trailing far away from the ship during repair attempts. After changing the CTD to the stern winch and lowering it from the "Schiebebalken", it was very difficult from the bridge to judge the wire angle in the forward/aft direction. This certainly contributed to the problems with excessive inclinations of the ADCP.

3.5 The internal bore

The bore, an internal wave with amplitudes up to $150\,m$, is a dominant feature in the Strait of Gibraltar. It is released usually at the sill when it is high tide at Tarifa, coinciding roughly with the time of zero flow after maximum outflow from the Mediterranean Sea at the sill, i.e. $3\,h$ after maximum outflow. From there it is propagating to the east into the Mediterranean Sea.
In April 1996, the bore was observed at the eastern section approx. $10\,h$ after maximum outflow, consistent with the order of $3\,km$ propagation speed.

It was an objective of the cruise to observe the bore at different locations in the strait in order to get an impression of the evolution of the bore during it's propagation into the Mediterranean Sea and to estimate the propagation speed.
The signals of the internal bore in current speed and hydrographic data were measured with vmADCP and CTD/XBT. First, white caps from the convergence could be observed at the sea surface. After that the ship-ADCP signature was observed, and the interface depression (XBT/CTD) even later. A useful ADCP signature is a change from less shear to a profile with strong eastward surface flow.

On 16 October the bore was followed from Camarinal Sill to the east and was measured threee times with XBT/CTD-yoyo in the upper $300\,m$ and vmADCP. In addition to that a single observation of the bore was done on 14 October at the sill with CTD-yoyo and vmADCP (for details see section 4, Table 3, Appendix).

4 Diary

(all times are local time, i.e. GMT+1, unless stated differently)

Monday, 13 October:

08:00 Finish loading of ship.

09:00 Departure from Portimão, Portugal. In transit to the Strait of Gibraltar the systems of CTD/rosette, vessel-mounted ADCP, lowered ADCP, and the GPS (GLONASS/3-D Ashtec) data aquisition were tested.
The CTD software only worked after it was discovered that in setup and header the identical data need to be entered. The auto-firing of the rosette could not be enabled, and the manual bottle-closing mechanism was chosen.

In order to arrive in time for the internal bore released at the Camarinal sill when the outflowing tide has slowed down to zero (approx. at high water at Tarifa), the test CTD/lADCP station was postponed, and the ship headed directly for the sill at the western entrance of the strait.

Tuesday, 14 October:

01:00 Start of CTD # 1 yoyo to $200\,m/300\,m$ (no bottle samples, no lADCP) with running the vmADCP, to observe the internal bore. The bore was already in progress, so the station was aborted (end 01:20) in order to catch up with the bore again. We were not allowed to steam significantly east for this, since the workplan had already been faxed to Tarifa Traffic. However, during the $5\,miles$ to the planned CTD test station, the bore was overtaken, so that a new CTD-yoyo was started.

01:49 Start of CTD #2 yoyo to $200\,m/300\,m$, (no lADCP) with vmADCP running. Initially the measured signals were quiescent for a few cycles, then suddenly large excursions in the interface depth were observed in the CTD and vmADCP data.

03:59 End of the CTD-yoyo, 11 yoyo cycles were carried out.

04:15 CTD #3, test station with bottles, lADCP, XBT #1 launch (which was done AFTER the CTD cast). End at 05:05.

07:00 Drift test for mooring M1B deployment.

08:17 Begin of deployment of SOC mooring M1B. The design depth of $250\,m$ could not be found, only a hump as shallow as $275\,m$. But by the time the anchor was released it was $290\,m$ again. End or mooring operation 08:46.

09:15 Begin of recovery of SOC mooring P1. The release and recovery of the mooring was completed by 09:34.

10:02 Begin of recovery of SOC mooring M1A. The release and recovery of the mooring was completed by 10:23.

11:04 Begin of recovery of SOC mooring M2. The acoustic release could not be heard from any direction and from different distances, deck units, release codes, etc. Eventually, the release command was sent anyway, but neither visually nor with the ARGOS receiver the mooring could be located. End of attempts at 13:00.

13:42 Begin of recovery of SOC mooring P2. The release and recovery of the mooring was completed by 13:54.

15:08 Begin of a 12.5-hour sequence of rapid cross-strait sections at the sill with ship-ADCP and 2 XBT's per transect. 13 crossings were carried out, of which 12 with XBT's (#2-25). End at 03:38.

Wednesday, 15 October:

04:28 Begin of a W-E along-strait section with ship-ADCP and XBT's. Originally, a CTD station was planned at the beginning of the section, but had to be omitted due to winds above force 8. XBT's were dropped every $1.5\,nm$, from the sill to the eastern end of the strait (#26-50). End of section at 08:00.

08:00 Start of CTD station #4. During the upcast, the winch gave problems. It took until 10:15 to bring the CTD up again, with extreme wire angles, making the lADCP unusuable. Repairs were not possible without spare parts, but another winch was available, sufficient for the depths encountered in the strait.

11:30 Begin of searching for broken IHM/WHOI mooring J (for details see seperate section 2.1). Many modes of interrogating/releasing the acoustic release were attempted, all without success.

13:50 Begin dredging for the mooring (see separate section 2.1). End of operation around 18:25.

18:50 Begin of a E-W along-strait section with ship-ADCP and XBT's spaced $1.5\,nm$ (#51-69). End at 21:35. Originally, a CTD station was planned at the end of the section, but this had to be abandoned due to strong winds.

22:00 Heading back E to the sill, in the hope of weaker winds there. The original plan was to perform a CTD-yoyo together with ship-ADCP there. At 24:00 also this had to be abandoned, and all further work was postponed until morning. The ADCP was running, but the position was not held constant, so the time series will not be very useful.

Thursday, 16 October:

08:00 Begin of deployment of mooring P1 at the sill. End at 08:40.

09:30 Begin of deployment of mooring M1A at the sill. End at 09:40.

10:35 Begin of deployment of mooring M2 at the sill. End at 11:35.

12:45 Deployment of mooring P2 at the sill.

13:40 Start to follow the internal bore from the sill eastwards. First we waited for surface expression (white caps from convergence) to pass, then steamed ahead to start high-frequency XBT/vmADCP sampling.

15:44 Start of XBT sampling of bore (every $1.5\,min$), drifting westward at $2-3\,kn$ (XBT#70-92). The ship-ADCP signature came after the surface signature, and the interface depression (XBT) even later. End of sampling at 16:24, then we steamed ahead watching the ADCP and the surface until the bore was passed again.

17:20 Begin of rapid CTD #5 yoyo for sampling the bore (with vmADCP). This time we had strong eastward drift of ship with $2-3\,kn$ in order to control wire angle while in surface layer, with the concern that the ship speed was nearly the same as that of the bore. End of station at 19:40. Again we steamed ahead and try to catch up with bore.

20:27 Begin of rapid CTD #6 yoyo for sampling the bore (with vmADCP). Small ship drift. End at 22:50. By this time, the position was east of eastern section. After that we steamed back to eastern section in order to start $12\,h$ vmADCP sections.

23:30 Begin of $12.5\,h$-cycle of vmADCP across eastern section, with 2 XBT's per section (XBT #93-122).

Friday, 17 October:

12:00 End of $12.5\,h$ ADCP/XBT eastern section. A total of 14 crossings were performed. Steamed to mooring deployment location of mooring I1.

12:37 Deployment of mooring I1 at eastern section.

13:08 Deployment of mooring IES1 (inverted echo sounder, IES#75) near mooring I1.

15:04 Begin of deployment of mooring U1. End at 15:30.

16:35 Deployment of mooring I2 at eastern section.

17:14 Deployment of mooring IES2 (inverted echo sounder, IES#77) near mooring I2.

18:27 Begin of deployment of mooring U2. End at 19:10.

20:16 Begin of along-strait run from eastern section to beyond the sill, with vmADCP and XBT sampling. XBT every $1.5\,nm$ generally, but every $3\,min$ at/west of the sill to resolve hydraulic features (XBT#123-148).

Saturday, 18 October:

00:15 Originally, CTD stations and drifting CTD yoyo were planned over and west of the sill. Due to strong winds (force 8-9), this was not possible, and continuous vmADCP sections from the sill into the deep Tangier basin and back were performed until the morning. End at 08:25.

09:00 Four CTD stations (#7-10) working from Tangier basin toward sill. Due to drift back to previous station during each cast, we were not making much headway. Abandoned this sampling at 14:00.

15:35 Occupied section in the basin west of Spartel Sill, beyond all hydraulic features. Start with CTD #11, then covered whole channel between $200\,m$ (then $100\,m$) isobaths with ADCP/XBT, starting 16:27. A total of 4 CTD/lADCP stations (#11-14) and 4 southward XBT runs of the section were carried out (XBT #149-158, #159-166, #167-173, #174-181).

24:00 **Time is advanced by 1 hour.**

Sunday, 19 October:

07:00 End of "outflow" section (06:00 previous time). Start of run toward eastern entrance of strait, recording only the vmADCP.

10:30 Start of dredging again for broken/lost mooring J (see separate section 2.1). End without success and broken dredging wire at 16:08. Waited until 17:00 in case mooring surfaces.

17:05 Start of a 12.5 repeat of CTD/lADCP casts at the center of the eastern section.

Monday, 20 October:

05:30 End of 12.5-hour cycle of CTD casts. After that we headed for Malaga, staying within $8\,nm$ of the coast in case the lost SOC mooring M2 is detected by the ARGOS receiver.

14:00 Arrival in Malaga, Spain.

Appendix

CTD/lADCP Stations								
#	Station	Date	Time (UTC)	Latitude	eLongitude	Water Depth	Profile Depth	Comments
1	675	97/10/14	00:15	35N 56.41	5W 44.42	411	263	aborted yoyo (bore), no lADCP
2	676	97/10/14	00:48	35N 56.24	5W 40.06	569	302	bore yoyo, 11 cycles, no lADCP
3	677	97/10/14	03:12	35N 56.24	5W 35.63	462	515	test station, lADCP, XBT#1
4	684	97/10/15	07:05	36N 02.07	5W 14.15	799	725	winch broken, lADCP unuseable
5	691	97/10/16	16:15	35N 57.14	5W 32.85	400	324	yoyo (bore), 10 cycles, no lADCP
6	691	97/10/16	19:26	36N 01.40	5W 16.90	842	312	yoyo (bore), 9 cycles
7	698	97/10/18	08:09	35N 52.32	5W 56.73	237	385	west of sill
8	700	97/10/18	09:09	35N 53.06	5W 53.47	490	516	"
9	701	97/10/18	10:39	35N 54.15	5W 49.61	370	445	"
10	702	97/10/18	12:18	35N 54.89	5W 47.32	562	453	"
11	703	97/10/18	14:43	35N 49.41	6W 06.44	413	377	outflow section repeat
12	703	97/10/18	17:52	35N 49.45	6W 06.18	413	396	"
13	706	97/10/18	21:33	35N 44.84	6W 06.12	412	391	"
14	708	97/10/19	01:40	35N 49.32	6W 06.30	410	399	"
15	713	97/10/19	15:03	35N 59.98	5W 21.98	907	847	eastern repeat, d
16	713	97/10/19	16:15	35N 59.99	5W 21.93	907	848	"
17	713	97/10/19	17:11	36N 00.00	5W 21.92	907	857	"
18	713	97/10/19	18:29	36N 00.07	5W 21.55	904	874	"
19	713	97/10/19	19:41	35N 59.84	5W 20.41	906	874	"
20	713	97/10/19	21:02	36N 00.04	5W 22.03	908	857	"
21	713	97/10/19	22:11	36N 00.01	5W 21.93	906	884	"
22	713	97/10/19	23:32	36N 00.15	5W 21.85	906	846	"
23	713	97/10/19	00:48	35N 60.00	5W 21.94	906	878	"
24	713	97/10/19	02:00	35N 59.92	5W 22.01	906	874	"

XBT casts

Cast	Date	Time (UTC)	Latitude	Longitude	Depth [m]	Comments
1	97/10/14	04:04:22	35N56.192	005W33.844	n.a.	CTD#3
2	97/10/14	15:42:00	35N56.855	005W45.295	270	X1, start section 1 (sill)
3	97/10/14	15:54:00	35N55.010	005W45.020	258	X2
4	97/10/14	16:38:40	35N55.210	005W44.905	258	X2
5	97/10/14	16:52:00	35N57.000	005W45.230	279	X1
6	97/10/14	17:30:44	35N57.050	005W45.220	274	X1
7	97/10/14	17:45:29	35N55.207	005W45.178	274	X2
8	97/10/14	18:24:33	35N55.202	005W45.064	271	X2
9	97/10/14	18:36:21	35N57.035	005W45.335	281	X1
11	97/10/14	19:28:37	35N55.197	005W45.093	271	X2
12	97/10/14	20:10:23	35N55.211	005W45.239	264	X2
13	97/10/14	20:28:56	35N56.974	005W44.660	279	X1
14	97/10/14	21:05:33	35N56.993	005W45.471	253	X1
15	97/10/14	21:16:20	35N55.203	005W45.691	265	X2
16	97/10/14	22:08:24	35N55.208	005W44.958	268	X2
17	97/10/14	22:21:38	35N57.013	005W45.030	297	X1
18	97/10/14	23:00:41	35N57.001	005W45.407	264	X1
19	97/10/14	23:20:14	35N55.093	005W46.218	471	X2
20	97/10/15	00:16:44	35N55.229	005W45.004	268	X2
21	97/10/15	00:29:23	35N57.195	005W45.455	286	X1
22	97/10/15	01:08:32	35N56.968	005W45.225	283	X1
23	97/10/15	01:21:52	35N55.171	005W45.257	275	X2
24	97/10/15	02:05:42	35N55.202	005W45.222	267	X2
25	97/10/15	02:18:26	35N57.050	005W45.255	280	X1, end section 1
26	97/10/15	03:29:22	35N56.283	005W51.528	342	start section 2 (along-strait)
28	97/10/15	03:37:24	35N56.350	005W49.971	371	
29	97/10/15	03:46:07	35N56.385	005W48.203	365	
30	97/10/15	03:54:51	35N56.379	005W46.449	222	
31	97/10/15	04:04:48	35N56.357	005W44.628	326	
32	97/10/15	04:14:49	35N56.357	005W42.710	451	
33	97/10/15	04:23:40	35N56.310	005W40.889	515	
34	97/10/15	04:32:49	35N56.315	005W39.007	617	
35	97/10/15	04:41:53	35N56.338	005W37.188	699	
36	97/10/15	04:53:08	35N56.626	005W35.239	500	
37	97/10/15	05:02:55	35N57.072	005W33.498	531	
38	97/10/15	05:12:34	35N57.642	005W31.784	700	
39	97/10/15	05:22:15	35N58.066	005W29.599	n.a.	
40	97/10/15	05:31:10	35N58.459	005W28.167	891	
41	97/10/15	05:39:53	35N58.802	005W26.357	914	
42	97/10/15	05:48:31	35N59.098	005W24.617	915	
43	97/10/15	05:59:22	35N59.596	005W22.770	916	
44	97/10/15	06:09:55	36N00.196	005W21.067	885	
45	97/10/15	06:21:00	36N00.886	005W19.398	864	

XBT casts

Cast	Date	Time (UTC)	Latitude	Longitude	Depth [m]	Comments
46	97/10/15	06:32:56	36N01.354	005W17.659	844	
47	97/10/15	06:43:19	36N01.720	005W15.839	842	
48	97/10/15	06:52:42	36N02.008	005W14.155	830	
50	97/10/15	07:12:54	36N02.195	005W13.248	500	end section 2, L1 partly ok?, CTD#2
51	97/10/15	17:49:12	36N00.369	005W20.663	864	start section 3, d
52	97/10/15	17:59:17	36N00.094	005W22.428	907	
55	97/10/15	18:17:51	35N59.153	005W25.430	914	
56	97/10/15	18:30:02	35N58.732	005W27.294	922	
57	97/10/15	18:42:10	35N58.189	005W29.060	896	
58	97/10/15	18:53:30	35N57.826	005W30.866	133	
59	97/10/15	19:03:49	35N57.288	005W32.531	554	
60	97/10/15	19:14:28	35N56.758	005W34.395	606	
61	97/10/15	19:23:36	35N56.347	005W36.107	604	
62	97/10/15	19:35:00	35N56.266	005W38.286	685	
63	97/10/15	19:44:46	35N56.313	005W40.112	556	
64	97/10/15	19:54:02	35N56.321	005W42.003	450	
65	97/10/15	20:01:50	35N56.358	005W43.816	484	
66	97/10/15	20:09:26	35N56.408	005W45.677	245	
67	97/10/15	20:17:14	35N56.424	005W47.532	348	
68	97/10/15	20:25:07	35N56.433	005W49.424	250	
69	97/10/15	20:38:24	35N56.348	005W52.339	292	end section 3, ~L5
70	97/10/16	14:44:52	35N56.518	005W41.239	505	start bore, sill
71	97/10/16	14:46:30	35N56.559	005W41.346	500	
72	97/10/16	14:48:38	35N56.627	005W41.465	485	
73	97/10/16	14:50:05	35N56.662	005W41.546	476	
74	97/10/16	14:51:53	35N56.696	005W41.643	470	depth ok?
75	97/10/16	14:53:25	35N56.724	005W41.719	460	
76	97/10/16	14:54:58	35N56.738	005W41.801	455	
77	97/10/16	14:56:50	35N56.768	005W41.839	451	
78	97/10/16	14:58:31	35N56.786	005W41.879	446	
79	97/10/16	15:00:00	35N56.776	005W41.934	441	
80	97/10/16	15:01:33	35N56.767	005W41.990	439	
81	97/10/16	15:03:03	35N56.759	005W42.050	443	
82	97/10/16	15:04:37	35N56.762	005W42.107	444	
83	97/10/16	15:06:15	35N56.761	005W42.177	435	
84	97/10/16	15:07:50	35N56.760	005W42.251	430	
85	97/10/16	15:09:20	35N56.771	005W42.318	419	
86	97/10/16	15:11:08	35N56.782	005W42.384	419	
87	97/10/16	15:13:43	35N56.758	005W42.490	420	
88	97/10/16	15:15:39	35N56.727	005W42.568	421	
89	97/10/16	15:17:45	35N56.686	005W42.640	435	
90	97/10/16	15:19:47	35N56.647	005W42.710	450	
91	97/10/16	15:21:51	35N56.604	005W42.784	450	
92	97/10/16	15:23:50	35N56.560	005W42.852	421	end bore

XBT casts

Cast	Date	Time (UTC)	Latitude	Longitude	Depth [m]	Comments
93	97/10/16	22:51:29	36N01.080	005W22.600	n.a.	X3, start section 4 (east)
95	97/10/16	23:10:01	35N58.099	005W20.837	800	X4
96	97/10/16	23:49:14	35N58.481	005W21.096	844	X4
97	97/10/17	00:09:33	36N01.039	005W22.429	n.a.	X3
98	97/10/17	00:46:47	36N00.966	005W22.427	n.a.	X3
99	97/10/17	01:07:42	35N58.367	005W21.078	835	X4
100	97/10/17	01:43:54	35N58.623	005W21.166	859	X4
101	97/10/17	02:00:13	36N01.131	005W22.369	n.a.	X3
102	97/10/17	02:39:16	36N00.999	005W22.319	n.a.	X3
103	97/10/17	02:56:07	35N58.304	005W20.891	812	X4
104	97/10/17	03:32:03	35N58.701	005W21.067	861	X4
105	97/10/17	03:47:01	36N01.001	005W22.114	n.a.	X3
106	97/10/17	04:26:46	36N01.147	005W22.411	565	X3
107	97/10/17	04:50:55	35N58.497	005W21.079	844	X4
108	97/10/17	05:27:14	35N58.662	005W21.049	883	X4
109	97/10/17	05:43:10	36N01.078	005W22.348	n.a.	X3
111	97/10/17	06:21:02	36N00.288	005W22.087	n.a.	X3
112	97/10/17	06:35:31	35N58.439	005W21.421	843	X4
113	97/10/17	07:04:21	35N58.503	005W21.302	848	X4
114	97/10/17	07:19:38	36N01.003	005W22.410	n.a.	X3
115	97/10/17	07:50:02	36N00.940	005W22.380	n.a.	X3
116	97/10/17	08:14:35	35N58.389	005W21.348	838	X4
117	97/10/17	08:44:35	35N58.525	005W21.342	852	X4
118	97/10/17	09:02:22	36N01.004	005W22.531	n.a.	X3
119	97/10/17	09:02:22	36N01.004	005W22.531	n.a.	X3
120	97/10/17	09:55:32	35N58.219	005W20.793	811	X4
121	97/10/17	10:25:39	35N58.502	005W21.256	852	X4
122	97/10/17	10:55:39	36N00.985	005W22.722	n.a.	X3, end section 4
123	97/10/17	19:18:56	36N00.830	005W19.189	867	start section 5, d (along-strait)
124	97/10/17	19:27:13	36N00.384	005W20.960	866	
126	97/10/17	19:35:35	35N59.990	005W22.746	912	
127	97/10/17	19:44:13	35N59.559	005W24.527	939	
128	97/10/17	19:53:41	35N59.014	005W26.288	938	
129	97/10/17	20:03:38	35N58.560	005W28.063	882	
130	97/10/17	20:13:10	35N58.137	005W29.790	702	
131	97/10/17	20:22:43	35N57.580	005W31.520	689	
132	97/10/17	20:32:03	35N57.028	005W33.240	200	
133	97/10/17	20:41:17	35N56.520	005W35.080	497	
134	97/10/17	20:50:04	35N56.330	005W36.860	708	
135	97/10/17	21:00:21	35N56.310	005W38.900	627	
136	97/10/17	21:09:00	35N56.270	005W40.690	530	
137	97/10/17	21:17:45	35N56.165	005W42.580	464	
138	97/10/17	21:24:37	35N55.907	005W44.165	418	

XBT casts

Cast	Date	Time (UTC)	Latitude	Longitude	Depth [m]	Comments
139	97/10/17	21:27:23	35N55.804	005W44.815	297	
140	97/10/17	21:30:26	35N55.694	005W45.579	207	
141	97/10/17	21:33:26	35N55.624	005W46.288	n.a.	
142	97/10/17	21:36:18	35N55.502	005W46.914	601	
143	97/10/17	21:39:21	35N55.281	005W47.642	487	
144	97/10/17	21:42:22	35N54.992	005W48.294	475	
145	97/10/17	21:45:22	35N54.641	005W48.916	445	
146	97/10/17	21:48:21	35N54.321	005W49.566	380	
147	97/10/17	21:54:51	35N53.668	005W51.041	512	
148	97/10/17	22:02:09	35N53.214	005W52.797	465	end section 5, $\sim$ L4
149	97/10/18	16:23:01	35N56.314	006W09.609	196	start section 6 (west), W2
150	97/10/18	16:32:06	35N54.888	006W09.175	253	
151	97/10/18	16:42:09	35N53.290	006W08.364	335	
152	97/10/18	16:52:13	35N51.753	006W07.573	314	
153	97/10/18	17:00:09	35N50.542	006W06.909	352	
157	97/10/18	17:18:14	35N47.738	006W05.496	315	
158	97/10/18	17:28:07	35N46.192	006W04.801	227	end section 6, W1
159	97/10/18	19:37:12	35N57.407	006W10.335	100	start section 7 (west), W2
160	97/10/18	19:51:35	35N55.303	006W09.264	265	
161	97/10/18	20:05:17	35N53.372	006W08.415	334	
162	97/10/18	20:19:07	35N51.471	006W07.128	316	
163	97/10/18	20:32:32	35N49.373	006W06.472	410	
164	97/10/18	20:43:30	35N47.681	006W05.684	311	
165	97/10/18	20:53:13	35N46.328	006W04.771	232	
166	97/10/18	21:03:15	35N44.843	006W04.127	111	end section 7, W1
167	97/10/18	23:15:59	35N57.486	006W10.268	98	start section 8 (west), W2
168	97/10/18	23:40:00	35N54.694	006W09.036	282	
169	97/10/19	00:05:26	35N52.065	006W07.734	312	
170	97/10/19	00:28:13	35N49.372	006W06.409	411	
171	97/10/19	00:40:59	35N47.697	006W05.569	312	needs editing
172	97/10/19	00:51:15	35N46.266	006W04.848	230	
173	97/10/19	01:01:11	35N44.829	006W04.051	107	end section 8, W1
174	97/10/19	03:20:44	35N57.623	006W09.976	100	start section 9 (west), W2
176	97/10/19	03:51:52	35N54.642	006W09.299	332	
178	97/10/19	04:29:42	35N49.430	006W06.305	414	
179	97/10/19	04:40:24	35N47.762	006W05.594	318	
180	97/10/19	04:50:59	35N46.300	006W04.839	232	
181	97/10/19	05:00:38	35N44.855	006W03.931	100	end section 9, W1

Misfires/missing/bad casts: 10,27,49,53,54,94,110,125,154,155,175,177; Test canister cast: 156
For locations see Figure 1.