Reference:
van Haren, H., 2004. LOCO-IW04-Canary Basin: R.V. Pelagia cruise 64PE231, 14 October-08 November 2004, NIOZ, 39 pp.

Cruise Report

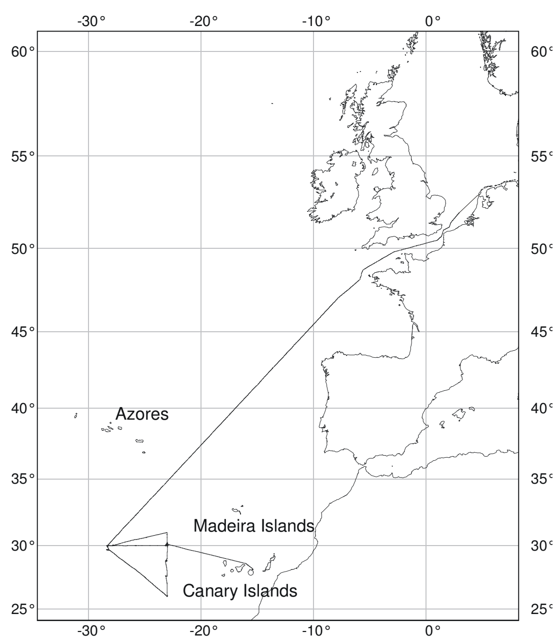
LOCO-IW04

Canary Basin
R.V. Pelagia cruise 64PE231

14 October – 07 November 2004
Las Palmas (Gran Canaria) - Texel

19 November 2004

Hans van Haren
(with contributions from participants)



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0. Contents

1. Summary of R/V Pelagia LOCO-IW04 cruise

In October 2004 the R/V Pelagia (NIOZ, The Netherlands) sailed to the Canary Basin, mainly to receover and deploy long-term moorings within Long-term Ocean-Climate Observations (‘LOCO’). LOCO is a large investment programme funded by N.W.O., the Netherlands Organization for the advanceent of scientific research. LOCO aims to investigate ocean physics process variations on time scales of years using long-term moorings. In the Canary Basin we study detailed variations in waves in the ocean interior (‘internal waves‘, IW), especially the most energetic ‘near-inertial’ waves, and their impact on deep-ocean mixing and the large-scale ocean circulation.

The working area of LOCO-IW is the abyssal plain in the Canary Basin near 30º N, 23º W (~5200 m depth). In March 2003 four long moorings and one bottom lander were deployed at mutual distances of 5-100 km for the duration of 1.5 years. The long moorings reached up to 3700 m above the bottom. They consisted of 5 current meters sampling at least once per 15 minutes. Two of them also carried a 75 kHz ADCP in the top buoyancy element. During LOCO-IW04 three of these moorings were successfully recovered, although only about 40% of the instruments provided good data: all Valeport current meters came on deck exploded, and Nortek AquaDopp and RDI ADCP were programmed too sensitively (using too little power). One long-term mooring was reported missing in March 2004, and the bottomlander was not found back during this cruise. Dredging attempts were unsuccessful.

Four long moorings were re-equipped mainly with Aanderaa RCM-11, two RCM-8 and the two re-programmed RDI ADCP’s. These moorings were successfully deployed. One short-term mooring was on a 12% bottom slope near the top of Great Meteor Seamount (GMS). This mooring held a NIOZ built fast and accurate thermistor string sampling at 1 Hz. This instrument failed. During the cruise several CTD-LADCP-stations mapped the background hydrography. Additionally, many FLY-microstructure were launched to estimate several turbulence parameters like dissipation rate and eddy diffusivity in the upper 1100 m of the water column. CTD-LADCP, FLY and ship’s winches worked flawlessly. Finally, two 75 kHz ADCP’s were mounted in a frame and successfully towed at depths down to 800 m to monitor internal tidal beams above GMS.

The cruise was moderately successful. On the one hand, weather conditions were extremely good causing no delays. All overboard operations went very well, including the recovery and deployment of the long moorings, except for deep-dredging. The re-deployment of moorings was never further than 100 m from the intended latitude, well within the aim. On the other hand, not a single special mooring instrument provided good data.

2. General research summary.

LOCO

The N.W.O.-financed large investment programme Long-term Ocean-Climate Observations (LOCO) aims to carry out some regional experiments which are required for the development of an ocean observation system for CLIVAR and other related global monitoring programmes. The instruments will be used to obtain long-term observations of the current field and transport of heat and fresh water in some critical areas of the global ocean circulation. Observations are also obtained of processes in the ocean interior providing energy for diapycnal mixing, for example due to internal waves, a key parameter in controlling the large-scale circulation. In order to observe low-frequency variations these moorings will be deployed for periods of at least 3 to 7 years, so that also variations due to the El-Niño cycle and the North Atlantic Oscillation may be covered. The experiments with moored sub-surface measuring systems build upon previous WOCE (World Ocean Circulation Experiment) and CLIVAR projects, carried out by Dutch oceanographers. It will extend existing time series and/or monitoring programmes and will be carried out in the framework of internationally co-ordinated research programmes.

LOCO-IW

Within LOCO two sets of four moorings are used to study in more detail the climate mean of spatial and temporal variability of internal-wave intensity. This is done for different types of basins (above sloping topography and far away from boundaries in deep-ocean basins). The first set of these moorings will be located for medium-long periods (~1½ years) at mid-latitudes in the North Atlantic Ocean, and the second set near the LOCO-throughflow sites in the Irminger Basin and the Mozambique Channel to study specific processes like internal wave focusing and effects of convection. Together these sites are exemplary for most internal wave appearances.

LOCO-IW Canary Basin

The purpose of the LOCO-IW04 cruise is to study the climate effects of internal waves on the deep-ocean. Specifically, we study near-inertial internal motions generated by atmospheric disturbances and those by diurnal tides (~30° N). During the cruise three moorings are recovered and four deployed. Most moorings extend 3.7 km above the bottom (1.5 km below the sea surface), containing current meters and temperature sensors. The moorings will remain in position for 1.5-3 years. In addition, short-term hydrographic and mixing information is collected using CTD, microstructure profiler and LADCP in the vicinity of the moorings.

3. LOCO-IW04 overview.

Internal wave mixing is thought to be the key in maintaining the general ocean circulation, induced about half by tidal motions and half by atmospheric (wind) induced (inertial) motions. As waves do not mix, non-linear interaction between internal waves is assumed to transfer energy to smaller scales, eventually leading to wave breaking, and mixing. Near-inertial internal waves are considered to be important because of their strong shear, tidal motions because of persistent generation and focusing in basins. Recent observations over the abyssal plain in the Bay of Biscay (van Haren et al., 2002) suggest that non-linear interaction between internal waves occurs not only in topographically-dominated areas, but, due to the presence of strong, deep-ocean near-inertial motions, also well away from sloping boundaries. During this cruise of LOCO the aim is on studying the variability with time of deep-ocean near-inertial and internal tidal motions in an area (Fig. 1) where deterministic (diurnal tidal) forcing of near-inertial motions may be important. Most moorings are above the abyssal plain, and some of the attention is focused on large-scale topography of Great Meteor Seamount (GMS; 30.0°N, 28.5°W).

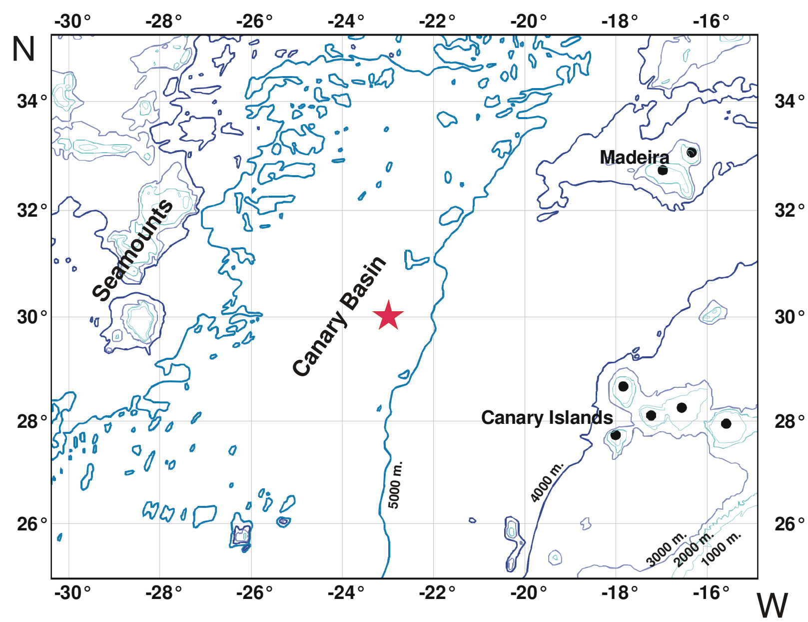

Fig. 1. Map of the Canary Basin (M. Hiehle). Presently, moorings are along 30°N and 23°W.

LOCO-IW03 moorings

In March 2003 an array of four closely spaced (5-20 km) and long (~3.7 km) moorings LOCO11-14 and one bottom lander were deployed near 30ºN, 23ºW in the Canary Basin (~5 km deep), halfway between the continental slope and seamounts of the Mid-Atlantic Ridge (Fig. 2; Table 1). During the upcoming cruise LOCO-IW04 one of these moorings is relocated to a position at the foot of steep topography (the nearby GMS), where mixing is expected to be relatively strong.

Table 1. Mooring positions and corresponding local inertial frequencies (with harmonic diurnal tidal names between brackets). (In m the horizontal distance North(+) or South(-) off the intended latitude). Moorings were deployed between* 12 and 17 March 2003. *1 cycle per day (cpd) = 2*π/86400 s^{-1}.
†lost mooring

LOCO11	30°10.864'N (+27 m)	023°00.968'W	5209 m	1.008214 cpd (φ_1)
†DOC03-2	30°05.420'N (+18 m?)	022°58.011'W	5130 m	1.005476 cpd (ψ_1) mixBB
LOCO12	30°00.090'N (+165 m)	023°02.420'W	5171 m	1.002738 cpd (K_1)
LOCO13	29°58.983'N (+90 m)	022°58.300'W	5160 m	1.002200 cpd
†LOCO14	28°47.958'N (-50 m)	023°01.029'W	5026 m	0.966137 cpd (M_1)

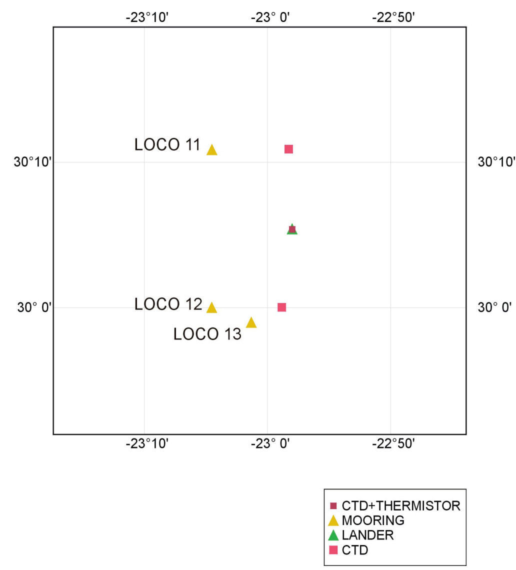

Fig. 2. Map of the core of LOCO-IW03 site (M. Hiehle).

As the aim is to study inertial internal wave motions near the latitude where their frequency is close to diurnal tidal frequencies, the moorings were located sharply at and very close to 30ºN (Table 1) to establish near-inertial internal wave propagation directions. Some of the latitudinal distances between moorings were less than one mooring length (between moorings LOCO12 and LOCO13). Others correspond to theory on down- and poleward propagation of near-inertial waves focusing on a spherical shell (Maas, 2001; ~10 km, between moorings LOCO11 and LOCO12). These distances are less than theoretical predictions on near-inertial wave propagation from the surface down- and equatorward in a flat ocean (Garrett, 2001; ~300 km). The latter theory seems an overestimate as it predicts a shift of ~9% in inertial frequency between surface and bottom, whilst preliminary analysis of the present data retrieved from LOCO11-13 and of historic data from IfM Kiel (Siedler and Paul, 1991) shows that vertical frequency shifts are ~1-2%f, much less than 9%f.

Such spectral variations are well resolved using yearlong measurements and they are not caused by mooring motions. The moorings are designed to have minimal deflection in the vertical and horizontal, using ellipse shaped main buoyancy elements and a thin (6.5 mm diameter) mooring cable. For typical speeds of 0.25 m s^{-1} the expected maximum deflection will be 30-40 m in the vertical and 350-450 m in the horizontal (or ~0.01%f when in latitudinal direction, well within the frequency resolution of 0.002 cpd or 0.2%f after 500 days of deployment). See Fig. 3. The measured motions were about a tenth of these estimated values (<5 m in vertical measured using pressure sensor and tilt meters). As a result the design was very well suited for its purpose.

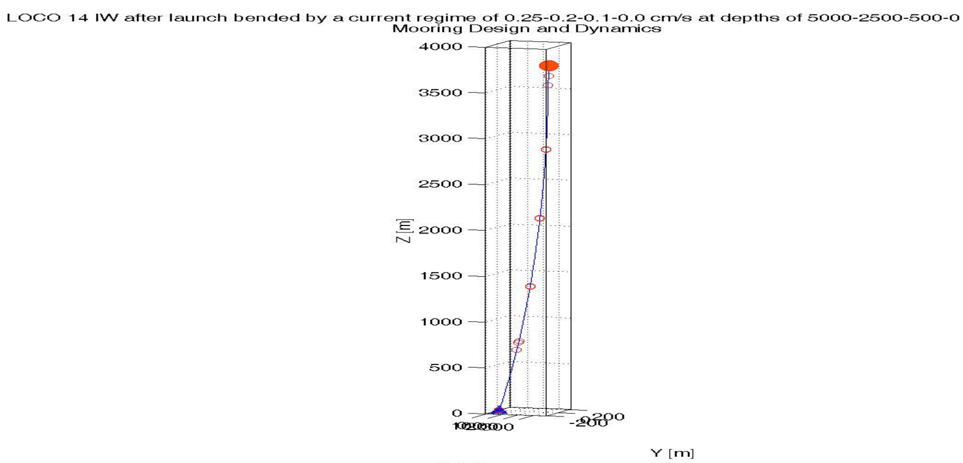

Fig. 3 Mooring deflection as computed by T. Hillebrand using program package designed by R. Dewey (UVic, Canada).

Like during LOCO-IW03, the moorings of LOCO-IW04 will also mainly contain ~5 current meters that are more or less evenly distributed along the mooring line, so that currents and temperature can be monitored across a large range in the vertical (Appendix A; see van Haren, 2003 for details). The distribution of the current meters is adapted after inspection of deep CTD-data obtained during previous cruises (see also Fig. 4). These profiles show a strong pycnocline near 100 m, a nearly constant intermediate stratification between 100-1000 m, a step-like density profile between 800-2000 m and a decreasing stratification below 2000 m, with sometimes very weak stratification (N → f) between 4500 and 5000 m. In the top of two moorings a 75 kHz acoustic Doppler current profiler (ADCP) is deployed, so that 10 m vertical shear (relevant for mixing induced by shear instability) is resolved over a range of about 500 m. Two moorings contain 3 contamination meters each.

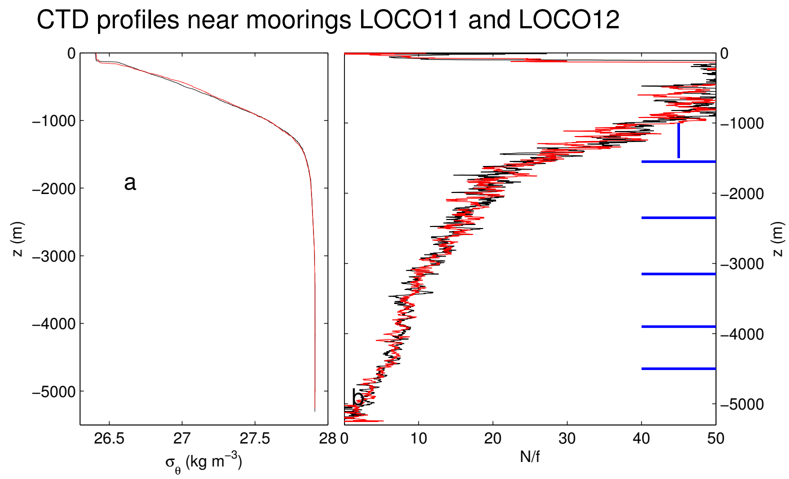

Fig.4. Density and 40 m smoothed stratification with depth measured during LOCO-IW03. In right panel horizontal lines indicate proposed current meter locations; vertical line extent of 75 kHz ADCP.

With regards to the LOCO-IW03 mooring locations (Table 1) the following modifications have been made. All new names will have extension /2. Mooring **LOCO11/2** is moved to a ~500 m shallower position near the foot of Great Meteor Seamount (at the latitude where f = K_1) to study the effects of topography on mixing; mooring **LOCO13/2** is moved southwards to the latitude where f = O_1, the second largest diurnal tidal constituent. Moorings **LOCO12/2** and **LOCO14/2** remain at the same position. As moorings need to be deployed at horizontal distances less than ~1 km when one wants to continue a time series (van Haren, 2004) and as this is not achievable with 3.7 km long moorings, **LOCO12/2** is fitted to remain in position for 3 years to increase the frequency resolution to maximum achievable values. This implies sampling at once per 30 min instead of once per 15 min, but warrants a long un-interrupted time series, which is hard to get otherwise. In general, instruments are adapted for long-term monitoring (extra batteries and, for some, extra memory) and they are programmed to last at least 1.5 years whilst sampling relatively fast, at least once/15 min to resolve most of high-frequency internal wave motions in the deep ocean (where the buoyancy period is typically 60 min or more below 1500 m). In addition to current, temperature and pressure measurements, moorings **LOCO12/2** and **LOCO13/2** also hold several passive organic contaminant samplers.

Additional measurements

Some additional CTD and lowered-ADCP (LADCP) measurements provide indirect estimates of deep-ocean mixing all the way to the bottom, albeit to a limited temporal extent.

Additionally, in the upper 1000 m of the water column turbulence dissipation measurements are made using a modified and modernised FLY-II, a microstructure profiler. These measurements are made near all moorings and on transects along 23°W (between 26° - 31°N) and between 30°N, 28°W and 31°N, 23°W.

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4. Participants.

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NIOZ departments

FYS physical oceanography
DEL electronics
DZT sea technology
DMG data management group

5. Data acquisition and instrumentation.

a. LOCO-IW04 (/2) moorings (Appendix A for diagrams).

All four large moorings **(LOCO11/2-14/2)** have a single BMTI ellipse-shaped buoyancy element at the top, which also holds an ARGOS-satellite beacon. The moorings extend about ~3700 m above the bottom (~1500 m below the surface, to avoid fisheries), except for mooring **LOCO11/2** (length ~3200 m above the bottom, so that the buoy is still ~1200 m below the surface). All moorings contain 5 current meters with temperature sensors. In the moorings at the deepest sites **(LOCO12/2, 14/2)** the current meters are positioned at ~1550, 2350, 3150, 3900 and 4500 m (for water depth of 5200 m). Most current meters are acoustic Aanderaa RCM-11, also because only these can sample for 3 years (at a rate of once/30 min). In the moorings at shallower sites **(LOCO11/2, 13/2)** the current meters are positioned at 1350, 2050, 2950, 3700 and 4300 m (for water depth of <5000 m). In these moorings (at position for 1.5 years) the RCM-11 sample at once per 900 s (15 min). Two RCM-8 mechanical current meters sample once per 1800 s. No other current meter types are used in /2 moorings because of problems found upon recovery of LOCO-IW03 moorings (see Section 7.a.1.)

LOCO11/2 and **LOCO12/2** are two moorings that contain an upward looking 75 kHz ADCP in the ellipsoidal top buoyancy element. The range of the ADCP (now set in High Power; narrow band) will cover 400-500 m of the water column, between 1000-1500 m (Fig. 4), and sampling once per 900 s (15 min) and 1800 s (30 min), respectively, every 10 m vertically.

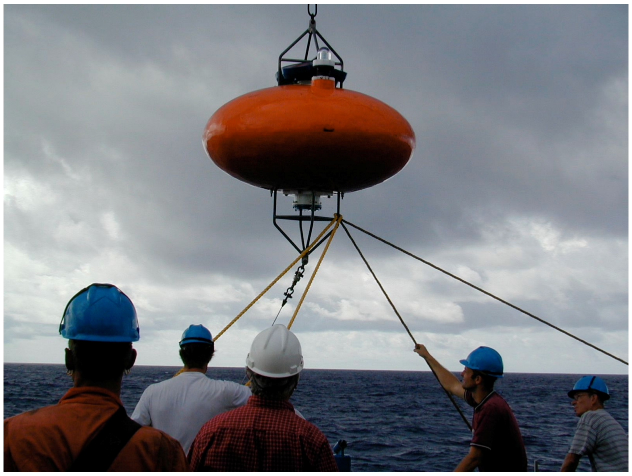

Photo (M. Hiehle): Elliptically shaped buoy with ADCP and ARGOS beacon .

b. Organic contaminants sampling (K. Booij)

Knowledge of organic contaminant transport in the environment primarily stems from measurements in terrestrial and coastal systems, particularly in the vicinity of densely populated areas. Data from remote areas are much less abundant. The evidence available for open ocean systems shows that distinct north-south gradients exist in atmosphere, water, and organisms. The general picture is that the more volatile compounds show an increase in concentration between the equator and the poles, and that the less volatile compounds show a decrease in concentration. The reason for this difference is believed to be related to the fact that the less volatile compounds need more time to establish a steady-state distribution. The existing models on global transport of organic contaminants identify the poles as the final sink where most of these compounds will condensate. Very little is known, however, to what extent the oceanic circulation plays a role in redistributing organic contaminants. The scarce information that is available for concentrations in the open ocean is limited to surface waters and the lower atmosphere. It is assumed that the ocean is vertically well-mixed with respect to organics, but no data is available to check whether this assumption makes sense at all. The situation is further complicated by the fact that the aqueous concentration (which is the quantity of interest, because it is closely related to the thermodynamic potential) of most organic contaminants is in the low pg/L range, necessitating large water volumes and low blank values. With the recent developments in the field of passive sampling of organic contaminants new methods have become available to address these issues. The samplers are typically small (which allows for low blank values) and the effective water volume that can be extracted with these devices can be quite high (m^3 range, depending on the compound). The effecting sampling rates are often the limiting factor, however (~ 10 L/d). The long-term mooring deployments within LOCO (> 1 year) create new opportunities to deploy passive samplers for prolonged time periods in remote areas in the deep oceans.

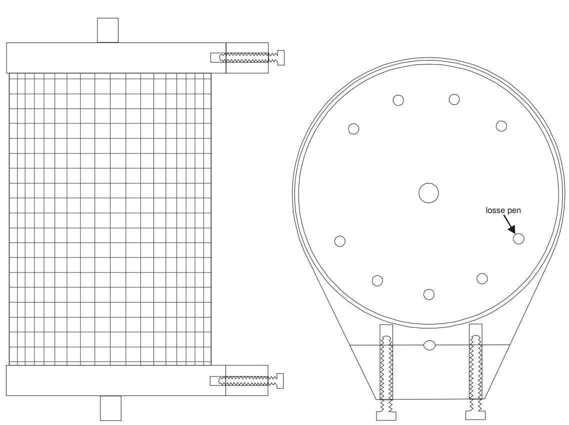

Fig. 5. *Contaminant Sampler cage: sideview (left) and view from above/below (right).*

c. DOC mooring

DOC04-1 is a short-term mooring with the NIOZ-2 fast thermistor string, two AquaDopp and an Aanderaa RDCP attached to and mounted in a newly built NIOZ bottom lander (Photo). It is moored at waterdepth ~530 m, in a strongly tidal regime, on the eastern slope of GMS. The purpose of the thermistor string is to sample during 10 days at a fairly high temporal (1 Hz) and spatial (0.5 m) resolution the water temperature above a deep steep slope. In order to associate the temperature variations to density variations a proper estimate of the temperature-density relationship is required by some local CTD sampling. The current measurement instruments sample at once per 60-120 s.

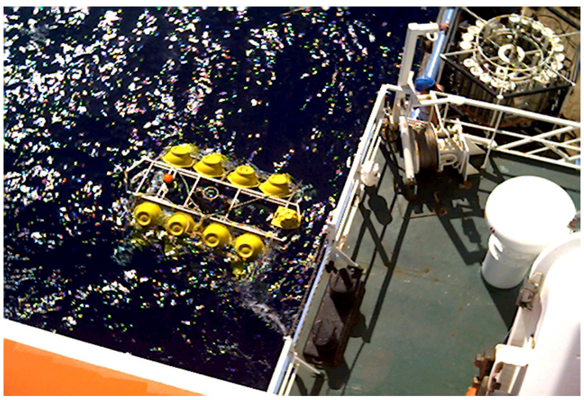

Photo: The new NIOZ bottom lander mixBB-002 shortly before recovery.

Photo (E. van Sebille): FLY-II.

d. Shipborne sampling

The Pelagia CTD/Rosette system contains a Seabird 911-*plus* Conductivity Temperature Depth sensor, with a Seapoint STM Optical BackScatterer (OBS). The CTD samples at a 24 Hz rate. The Rosette frame holds a down- and an upward looking 0.3 MHz RDI ADCP, together forming the lowered ADCP (LADCP).

A second Rosette frame is prepared to hold the NIOZ fast-thermistor string. With the core of the Pelagia CTD inserted, this frame is used for in-situ calibration of the thermistor string. The aim of the measurements with the FLY (Photo) is to determine the vertical structure and distribution of several turbulence quantities at all the stations. The measurements were done with a free-falling velocity shear probe (type FLY-II, originally manufactured by Sytech (Canada), but internally completely re-designed by Martin Laan (Royal NIOZ)). A secondary aim was the test of the electronics of the instrument and of the new fast temperature probes.

e. Deep towed ADCP's

During LOCO-IW04 24 hours are used to attempt to monitor internal tidal wave beams above steep topography using for the first time a deep-towed vehicle equipped with two 75 kHz RDI ADCP's (one up-, other down-looking). This neutrally buoyant vehicle is attached

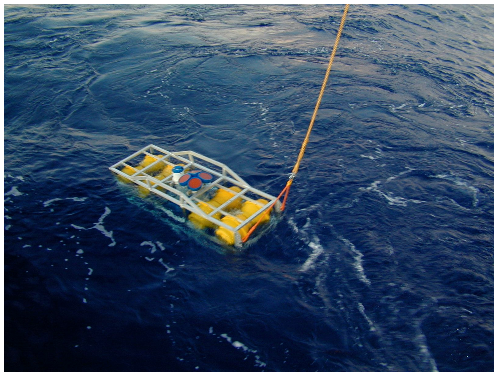

Photo (M. Hiehle): Deep-towed body with two ADCP's.

to a 1500 kg pistoncorer weight and an extra 1000 kg weight with pressure sensor that are towed using a Kevlar + electric cable. The ADCP's store data internally, but pressure information is available on-line through the electric cable. The aim is to cover a range between 0-1400 m depth and between 300-3300 m water depth to extend previous measurements (Lam et al., 2004) in the Bay of Biscay (dashed box in detail plot 'a' in Fig. 6). It was intended to do this deep-towing along the same transect as in the previous measurements. Unfortunately the french authorities did not grant us permission to do so on short notice. As a second best, it was decided to tow during 2 tidal periods above GMS.

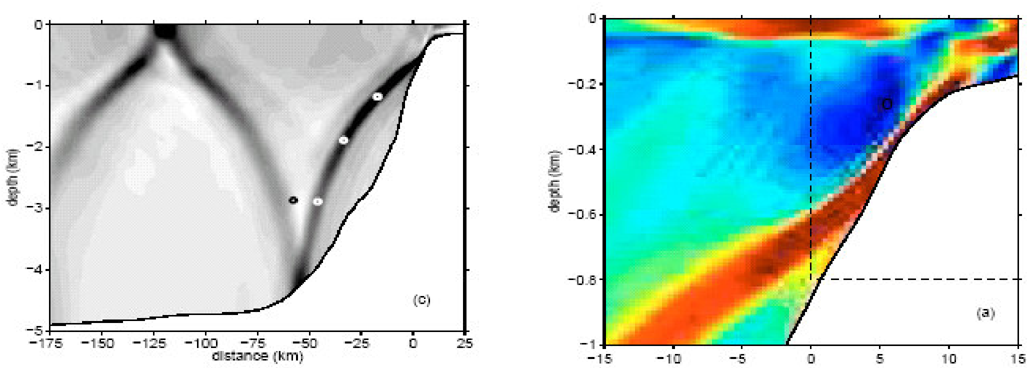

Fig. 6. Numerical model (T. Gerkema) of internal tidal beams in the Bay of Biscay: left overview; right detail.

f. Deep dredging

Since April 2004 mooring LOCO14 was on the loose. Its top buoy, ARGOS beacon and (exploded) Valeport current meter were recovered by the RRS Charles Darwin. Upon recovery it seemed that the mooring was cut, probably by a fisherman, which was odd because the mooring design was thought to be safe for fishing hazards with its upper element at ~1400 m below the surface. Recent experience during LOCO-IW04 provided alternative explanations (see Section 7.a.1). Attempt was made to recover the remainder of the mooring by dredging at ~5000 m depth using the large Kevlar cable winch.

6. Daily summaries of LOCO-IW04.

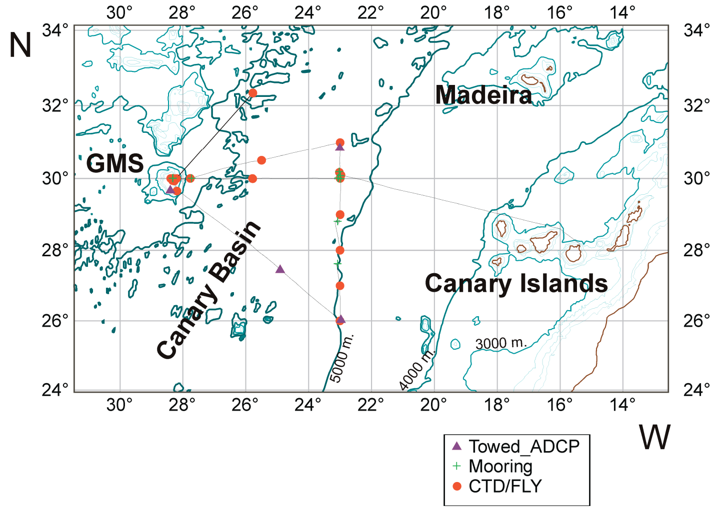

Fig. 7. LOCO-IW04 cruise track and activity locations (M. Hiehle)

Thursday 14 October

16.15 UTC departure from Las Palmas, Gran Canaria. Good weather conditions. Soon first sightings of dolphins (Risso).

Friday 15 October

ENE3-4. Transit to Canary Basin.

Saturday 16 October

S4. 10 UTC. First mooring recovery attempt DOC03-2 fails: no contact with the acoustic releases and no surfacing of the bottom lander. Around 12 UTC successful recovery of LOCO12. Valeport current meter is exploded. In the afternoon CTD and calibration thermistor string.

Sunday 17 October

SW6-7. 08.45 UTC. Mooring deployment of LOCO12/2, followed by CTD.

Monday 18 October

SW7-8. 09 UTC. Under somewhat rough conditions recovery of mooring LOCO11, followed by recovery of LOCO13 in the afternoon. From both moorings the Valeport current meter is exploded under water. Transit to GMS.

Tuesday 19 October

SW8-5. Transit to GMS. Around 16 UTC stop for CTD thermistor string calibration and first FLY microstructure profile.

Wednesday 20 October

W5-calm. 08:30 UTC. Deployment of LOCO11/2 at the foot of GMS. At 18 UTC deployment of bottom lander + thermistor string mooring DOC04-1 near the top of GMS. Start CTD/FLY transect from GMS to 31°N, 23°W.

Thursday 21 October

Calm. Continue CTD/FLY transect.

Friday 22 October

SW2. 16:30 UTC end first CTD/FLY transect. 17 UTC first test deep-towed ADCP's. Many flaws are noticed. A second test is prepared. Start second CTD/FLY transect (southbound along 23°W).

Saturday 23 October

W3. Continue CTD/FLY transect. In the morning: first dredging attempt (DOC03-02) fails because cable breaks. 1000 m dredging steel cable, several dredge anchors and heavy weights are lost. Because of lack of sufficient material and because of failure t contact both lost moorings acoustically, it is decided to suspend further dredging and focus on additional measurements.

Sunday 24 October

Calm. Continue CTD/FLY transect. 09 UTC deployment LOCO14/2.

Monday 25 October

E3. Continue CTD/FLY transect. 08:30 UTC deployment LOCO13/2.

Tuesday 26 October

E2. Continue CTD/FLY transect until 19 UTC. 11 UTC second test deep-towed ADCP's. Almost all problems discovered during first test are now solved. Special test for turning with towed body at maximum depth (800 m). In the evening message received that french authorities do not permit deep-towing in the Bay of Biscay.

Wednesday 27 October

W3. Transit to GMS. Decision made to change program: cancellation port-call Madeira, deep-towing will be performed above GMS. 09 UTC third and final test deep-towed ADCP's.

Thursday 28 October

W3. Perfect conditions for deep-towing. 13:51 UTC start of GMS transect D (south-east edge) of deep-towed ADCP's.

Friday 29 October

NW3, springtide. In the very early morning the celebration of Yvo's birthday starts with a motorola serenade and a soccer game on the aft deck. 13:40 UTC end of deep-towed ADCP's transect. Around 09 UTC e-mail contact is lost. Part of the network on board is lost too. Later in the day the onboard network crashes completely.

Saturday 30 October

NW2. 08 UTC series of FLY profiles around bottom lander mooring near top of GMS. 12 UTC recovery of mooring DOC04-1. Thermistor string has not delivered good data. Set course for Texel. Onboard network is repaired with help from NIOZ. E-mail connection is never restored until arrival in NIOZ harbour.

Sunday 31 October

Calm. 08 UTC Final FLY and CTD casts with thermistor string attached to CTD. Thermistor string fails again to log data properly. Around 18 UTC jumping killer whale sighted by some of us.

Friday 05 November

N6-3. During transit VMADCP is switched on pinging from halfway between Finisterre-Ile d'Ouessant: 00 UTC start; 18 UTC stop. Ship sails at ~10.5 knots, course 48°TN.

Sunday 07 November

22:30 UTC. Arrival Texel NIOZ harbour

7. Scientific summary and preliminary results

a. Long-term mooring recoveries.

The first mooring recovery was performed approaching the surface buoy from the stern. All later recoveries were done approaching the buoy from the starboard side, with a line from the stern-winch laid out on the startboard side to the side-winch. From the side-winch a small dredge was thrown to catch the line between a small float and the surface buoy. This 10 m line turned out somewhat small, and it was enlarged to ~20 m during redeployment. As was already noticed during mooring recovery in the Irminger Sea a few weeks earlier, detachment of the elliptical buoys from the mooring line was not easy. This is now remedied in the redeployed moorings by attaching a small, ~0.8 m, chain below the upper buoy and on both sides of the inline buoy.

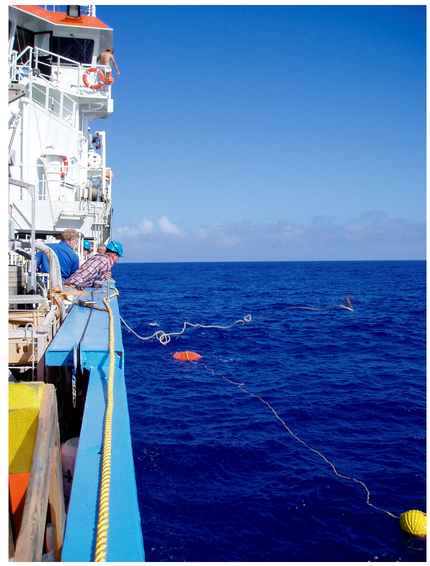

Photo (L. Boom): Throwing the dredge to catch the float line.

a.1. Moorings LOCO11-13

Only three out of five moorings deployed during LOCO-IW03 were succesfully recovered. Also, some instrumental performance of these three moorings **LOCO11-13** was rather poor (see Table 2). This performance was not due to biofouling, as the instruments came out very clean after 1.5 years of deployment. Also, no exterior damage or corrosion was found, except in one shackle and except in all Valeport current meters (see below).

The two ADCP's worked the entire intended period, but the current data are bad, because the instruments were programmed in broadband, medium power, which results in too low signal/noise ratio in these waters. Such fine programming is not possible in these waters. Instead, narrowband high-power settings are used now.

Nortek's AquaDopp's were programmed in a similar way as the ADCP's, in the hope to obtain a much better performance than Aanderaa RCM-11 current meters, especially on high-frequency internal waves. This turned out an illusion, and the instruments did not give good data, again because of too low signal/noise ratios. Some data from mooring LOCO11 may be useful after severe corrections; especially amplitude may be saved (cf. Fig. 8 below), but direction probably not. (Later AquaDopp's were programmed much more 'insensitive' at high power and deployed in the Irminger Sea. There, signal/noise ratio is much improved, but data quality is not higher than Aanderaa's RCM-11, still with a flaw remaining on the great sensitiveness of AquaDopp's for mooring motions).

It is noted that all additional sensors p, T, tilt in the ADCP's and AquaDopp worked well. These data are useful. Furtermore, the AquaDopp has a powerful tool in registering a diagnostics of 1 Hz sampled data during a brief period every 12 hours, say. From these data it is learned that the mooring line vibrated, even in the low current speed environment of the Canary Basin (0.15 m s^{-1} typically, 0.25 m s^{-1} maximum). When located in the middle of the mooring line the AquaDopp heading oscillated by some 40-80° (top-trough) with a typical period of 5 s. No motions were observed near the upper and lower ends of the mooring line. The AquaDopp suffered heavily from such motions, whilst RCM-11 and ADCP (Irminger Sea) did not show any noticeable effects. For future improvement two suggestions are given: 1. change the AquaDopp design, internally or its suspension in a mooring line, 2. change the mooring design.

The mooring design will not be changed, as the present taught-wire design is very successful: we learned from the tiltmeter and pressure sensors in the AquaDopp and the ADCP's that the moorings never tilted more than 2°. As a result maximum deviations due to current drag were 2 m in the vertical and 130 m in the horizontal, which is extremely good and much better than model estimates (Fig. 3). In addition, pressure decreased some 1-4 m gradually over time. This is attributed to stretching of the mooring, by about 1 mm/m, over a period of about 100 days.

The Valeport current meters came to deck exploded. All of them. This was concluded because all rear ends including electronics and sensors were missing and the inside of the electronics compartment was blackened. Detailed inspection of one of the instruments learned that a small leakage (likely through the connector) had created hydrogen and oxygen gases through electrolysis of seawater. This gas ignited causing explosion. This explosion created pressure built-up inside the electronics compartment, which blew off the entire rear end of the instrument. These findings, in association with the fact that during both cruises LOCO-IW03 and LOCO-IW04 not a single fishing vessel was seen in the area, now leaves us with the suggestion that the exploding Valeport current meter may have caused breaking of the mooring line and final loss of LOCO14. This is different from the initial idea that the mooring was fished and cut. If our present analysis is true, we are lucky that not all LOCO-IW03 moorings were blown apart.

All Aanderaa RCM-11 worked well, providing the intended data.

Table 2. Moored instrument details of IW03 current measurements: A=Aanderaa; N=Nortek; R=RDI; V=Valeport. Sensors, A:C,R,T; N: C,R,T,p,tilt; R: C,R,T,p,tilt; V: C,R,T. (C=speed, R=direction, T=temperature, p=pressure).
The poor performance of ADCP and AquaDopp is due to our setting of instruments.

Moorings deployed between 12 -17 March 2003, **recovered during LOCO-IW04**

Mooring	Instrument	Serial#	depth [m]	sampl. int. [s]	remarks
LOCO11	R 75 kHz ADCP	3174	1471	900	C,R failed (broadband)
	N AquaDopp	1/02	1573	450	C reas., R mod. (mi-lo power)
	V BFM-308	20636	1574	450	exploded
	A RCM11	187	1575	900	
	N AquaDopp	2/02	2376	450	C,R mod.-poor (mi-lo power)
	A RCM11	188	3127	900	
	A RCM11	189	3875	900	
	A RCM11	190	4470	900	
LOCO12	R 75 kHz ADCP	3175	1433	900	C,R failed (broadband)
	LPDE/SPMD	1	1434		contam. meter
	V BFM-308	20637	1537	450	exploded
	A RCM11	191	2335	900	
	N AquaDopp	3/02	3086	450	C,R poor (mi-lo power)
	LPDE/SPMD	2	3088		contam. meter
	A RCM11	192	3834	900	
	A RCM11	193	4431	900	
	LPDE/SPMD	3	5151		contam. meter
LOCO13	LPDE/SPMD	1	1423		contam. meter
	V BFM-308	20638	1514	450	exploded
	A RCM11	194	2316	900	
	A RCM11	195	3067	900	
	LPDE/SPMD	5	3069		contam. meter
	N AquaDopp	4/02	3817	450	C,R poor (mi-lo power)
	A RCM11	196	4415	900	
	LPDE/SPMD	6	5140		contam. meter

The perfect positioning of the moorings, so that positions were known to within 10 m horizontally and less than 100 m from intended latitude, makes any changes in inertial frequency easily verifiable to within the spectral resolution. Also, the 2 s variation in RCM-11 clocks (and much less in AquaDopp clocks) fell well within the spectral resolution. This was verified using the major semidiurnal tidal constituent M_2. Nevertheless, a peculiarity was observed in the diurnal frequency band, where the tidal constituent K_1 was not always observed in RCM-11 data, except for one (Fig. 8). However, a spectral peak was commonly observed at K_1 in the generally poorer AquaDopp data. This observation is presently under investigation.

The best AquaDopp resembled a near RCM-11 in internal wave spectral peaks (Fig. 8), but its direction was less accurately determined, as the internal wave band polarization was

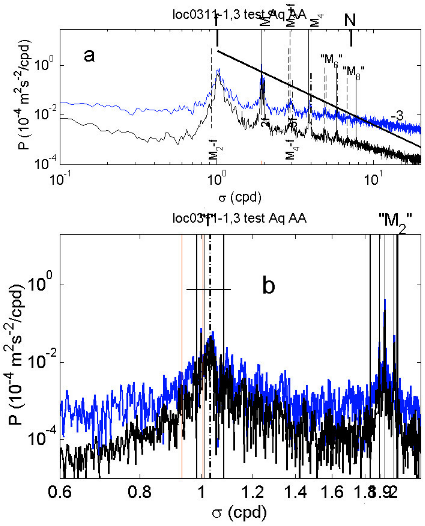

Fig. 8.. Kinetic energy spectra of current meters near 1570 m depth in mooring LOCO11. In blue amplitude 'corrected' AquaDopp and in black RCM-11. Note the corresponding spectral shapes, but the larger 'noise' level of the AquaDopp. Smoothed spectrum in upper panel; raw spectral detail in lower panel.

less well resolved. In general the known internal wave polarization was well-measured by the RCM-11 (Fig. 9), the shift near the inertial frequency probably due to barotropic diurnal tidal currents. In general, in both the kinetic energy and polarization spectra internal waves are mostly found at non-linear inertial-tidal frequencies, as reported previously for historic Canary Basin data (van Haren, 2004).

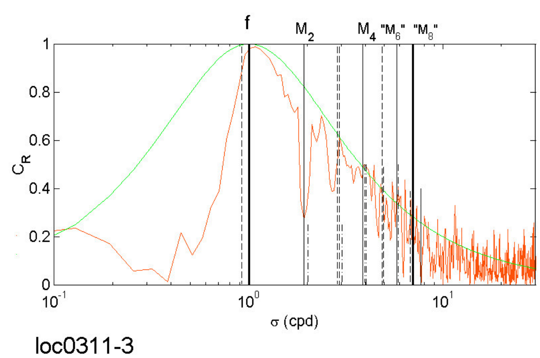

Fig. 9. Smoothed rotational spectrum of RCM-11 data from ~1570 m depth in mooring LOCO11. In green the symmetric theory for symmetrically forced waves, in the internal wave band for frequencies larger than f (van Haren, 2003 for definitions).

All 6 organic contaminant samplers were succesfully retrieved from moorings **LOCO12** and **LOCO13**. They were stored deep-frozen.

a.2. Deep-dredging LOCO14 and DOC03-2

During LOCO-IW04 no contact could be made with the acoustic releases of **LOCO14**. Bottom lander mooring **DOC03-2** could also not be released acoustically. It is suggested that this mooring is upside down at the bottom. It was decided to dredge for both moorings (at depths greater than 5000 m) using a weight with 5 dredge anchors on one end, 1000 m steel cable, a second weight, which led to an inline-weight with pressure sensor attached to the Kevlar cable of the Kley France winch. The idea was to put the two weights and the 1000 m cable at the sea floor and then sweep passed the original mooring locations. Unfortunately, the very first attempt failed, because the weigthed line broke just before attaching it to the Kevlar cable. No further attempts were undertaken due to lack of sufficient dredging materials remaining.

b. Short-term mooring deployment and retrieval

b.1.High-frequency current and temperature measurements DOC04-1

Bottom lander mooring **DOC04-1** was moored near the top of the eastern slope of Great Meteor Seamount (Table 3). The newly designed bottom lander held an AquaDopp (programmed high power and with new firmware implemented to improve signal/noise ratio), and an Aanderaa RDCP for test. Attached to the centre of the lander was a line with the fast thermistor string NIOZ-2 below a second software-modified AquaDopp under a sub-surface elliptical float.

The mooring was deployed for 10 days. Unfortunately, only the two AquaDopp worked satisfactorily. The NIOZ-2 thermistor string nearly completely failed, despite its collection of some 155 MB of data: it stopped sampling after ~5 days, with 3 complete segments of 16 sensors and some 10 other sensors down, that is about 60 out of 128 sensors. Besides the still unsolved casting problem, we now also face a recording problem. The test-RDCP also did not work satisfactorily, as it stopped sampling after ~6 days and 10 out of 83 data files collected were corrupted.

Table 3. Moored instruments details short-term deployment (A=Aanderaa; N=Nortek).

LOCO-IW04 mooring between **20/10/04 - 30/10/04 at** 30°00.008'N 028°18.843'W 531 m

Mooring	Instrument	Serial#	depth [m]	sampl. int. [s]	remarks
DOC04-1	N AquaDopp	3/02	447	60	a 30 s;l 43%; hi; v1.17
	FT-string	NIOZ-2	528.15(lows.)	1	failed; sect. 3,5,7 down; 5d data
	A RDCP	?	529.20	120	failed (6 d data)
	N AquaDopp	4/02	529.25	60	a 30 s;l 43%; hi; v1.17

c.Long-term mooring deployments (Appendix A for mooring diagrams)

The mooring deployment from the stern worked again fine due to proper preparation and good weather conditions. For the long moorings the instrument preparation table (see photo) and the mooring line capturer ('stopper') worked satisfactorily, except when an elliptical buoy was mounted. Then, the table was removed. Also, as noted upon recovery, 0.8 m of chain was attached above and below the buoys to be able to reach the capturer when the buoy was on deck.

Photo (L. Boom): Preparation table for attaching instrument to mooring line. At the stern the mooring line capturer can be seen (just behind the necessary supply of 'gele tape').

c.1. Moorings LOCO11/2-14/2

Four long (~3.7 km) moorings were deployed along 30ºN and 23ºW (Fig. 10; Table 4). Mooring **LOCO11/2** is located near the foot of GMS, where mixing due to internal waves is thought to be different from the open ocean.

As evidenced from the recovered moorings (see under Section 7.a), mooring motions were minimal. As a result, the mooring design was not changed, despite the vibrations in the line as measured by AquaDopp. No AquaDopp was deployed, because these instruments have to modified by the factory.

Table 4. Mooring positions LOCO-IW04 and corresponding local inertial frequencies (with harmonic diurnal tidal names between brackets). Depths echo sounder estimates .

LOCO11/2	30°00.016'N	027°48.627'W	4550 m	1.002738 cpd (K_1)
LOCO12/2	30°00.070'N	023°08.250'W	5137 m	1.002738 cpd (K_1) (3 yr)
LOCO13/2	27°36.781'N	023°07.750'W	4932 m	0.929536 cpd (O_1)
LOCO14/2	28°47.994'N	023°07.103'W	4993 m	0.966137 cpd (M_1)

Positioning of moorings is done as during LOCO-IW03: starting ~3-4 miles East or West of the intended longitude and sailing along a fixed latitude at a speed varying between ~0.5 knots (when instrument is attached and put overboard) and ~1.5 knots (when line is paid out). Release of anchor is sometimes suspended by continuing to sail to an intended position. On average, the final position of the anchor was about 500 m behind the ship's position at the moment of release of the anchor due to the retarded swing and the bent line during towing (Fig. 11). The final position was always well within ±100 m north/south of the sailed latitude.

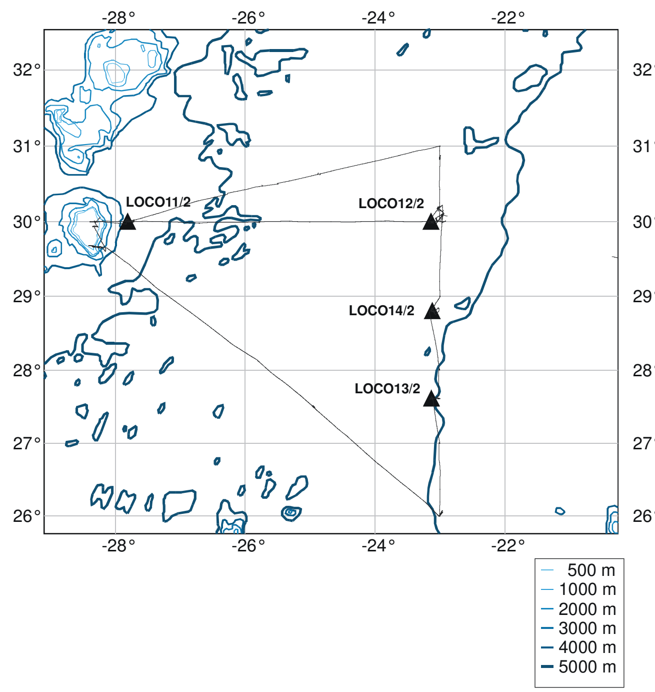

Fig. 10. LOCO-IW04 long-term mooring positions (M. Hiehle), see also Table 4. Also indicated is the cruise track.

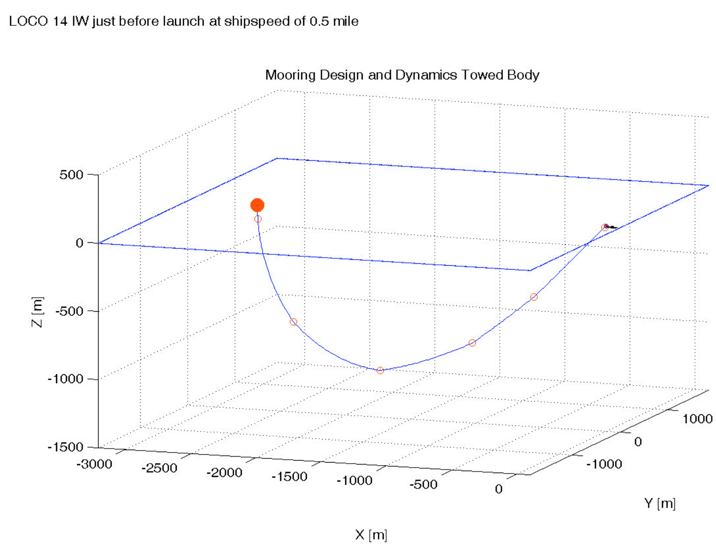

Fig. 11. Estimated mooring line at moment of release of anchor (computed by T. Hillebrand using program by R. Dewey,Uvic Canada).

Table 5 gives an overview of the instruments, their sampling rates and their positions in the moorings.

Table 5. Long-term moored instruments details IW04 (A=Aanderaa; R=RDI).

Moorings deployed between **17 - 25 October 2004**

Mooring	Instrument	Serial#	depth [m]	sampl. int. [s]	remarks
LOCO11/2	R 75 kHz ADCP	3174	1312	900	50 10m bins; NB; hi
	A RCM11	187	1414	900	T-LOW?
	A RCM8	11826	2217	1800	T-LOW
	A RCM11	188	2968	900	T-Arctic
	A RCM11	189	3716	900	T-Arctic
	A RCM11	190	4311	900	T-Arctic
LOCO12	R 75 kHz ADCP	3175	1399	3600	50 10m bins; NB; hi
3 yr	LPDE/SPMD	20	1409		contam. meter
	A RCM11	416	1500	1800	T-LOW
	A RCM11	414	2301	1800	T-Arctic
	A RCM11	405	3052	1800	T-Arctic
	LPDE/SPMD	21	3054		contam. meter
	A RCM11	415	3800	1800	T-Arctic
	A RCM11	406	4397	1800	T-Arctic
	LPDE/SPMD	22	5117		contam. meter
LOCO13	LPDE/SPMD	23	1285		contam. meter
	A RCM11	417	1391	900	T-LOW
	A RCM11	404	1992	900	T-Arctic
	A RCM11	408	2739	900	T-Arctic
	LPDE/SPMD	24	2749		contam. meter
	A RCM11	192	3491	900	T-Arctic
	A RCM11	193	4087	900	T-Arctic
	LPDE/SPMD	25	4912		contam. meter
LOCO14	A RCM8	11824	1498	1800	T-LOW
	A RCM11	196	2300	900	T-Arctic
	A RCM11	195	3052	900	T-Arctic
	A RCM11	194	3651	900	T-Arctic
	A RCM11	191	4249	900	T-Arctic

d. CTD sampling

The CTD operations were ‘normal’. The instrument, deck unit and the winch worked very fine. The density-depth profiles were quite simple, with a main pycnocline between 100-1100 m and weak stratification below 1500 m (Fig. 12). In detail down- and upcast occasionally showed differences in steppiness of the profiles (with typical step sizes of about 10 m only), evidence of high-frequency wave activity or short-scale layering. In the salinity profiles (not shown) Mediterranean Sea water was visible between 1000-1500 m, evidence of remnants of ‘Meddies’. Below this depth down to about 2000 m rather frequently varying stepstructures and overturning were observed. Along a North-South transect the small-scale variations show a weak tendency for enhancement at 29 and 30°N (between 2000-3000 m). Variations are also small when the present profiles are compared with those obtained during LOCO-IW03 (Fig. 4). Further investigation is required. Extremely weak stratification (N ~ f; ~0.7 10^{-4} s^{-1}) was not found in the profiles of Fig. 12, except very near the bottom.

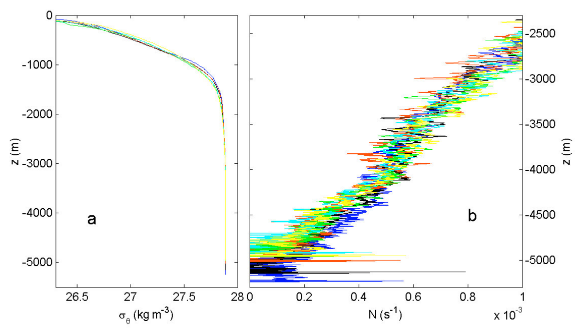

Fig. 12. Examples of CTD profiles along NS transect, σ_θ (a) and 40 m smoothed buoyancy frequency N (b).

e. LADCP (by C. Veth)

The LADCP worked fine and profiles were made to the bottom during all CTD-casts. The velocity profile was calculated for depth intervals of 8 and 20 m. The estimated accuracy of the velocity measurement is of the order of 0.05 m/s (right-most panel in Fig. 13) after post-processing. From these profiles, and in particular from the spatial vertical shear spectra, estimates of the vertical diffusivity Kz will be made. The results will be related to the FLY results, but regretfully individual LADCP profiles give only very crude estimates of Kz.

f. FLY microstructure profiler (C. Veth & M. Laan)

In combination with salinity, temperature and density profiles as determined by the CTD-system the following quantities will be derived from the FLY microstructure data:

1. the rate-of-dissipation of turbulent kinetic energy (epsilon)
2. the vertical length scale of turbulence (The Ozmidov scale and the Thorpe scale)
3. estimate of the turbulent kinetic energy (TKE)
4. estimate of the vertical exchange coefficient.

5. coincidence between CTD-parameters and the occurrence of enhanced turbulence (shear zones, zones with double diffusion, wind stirring and bottom friction, ...)

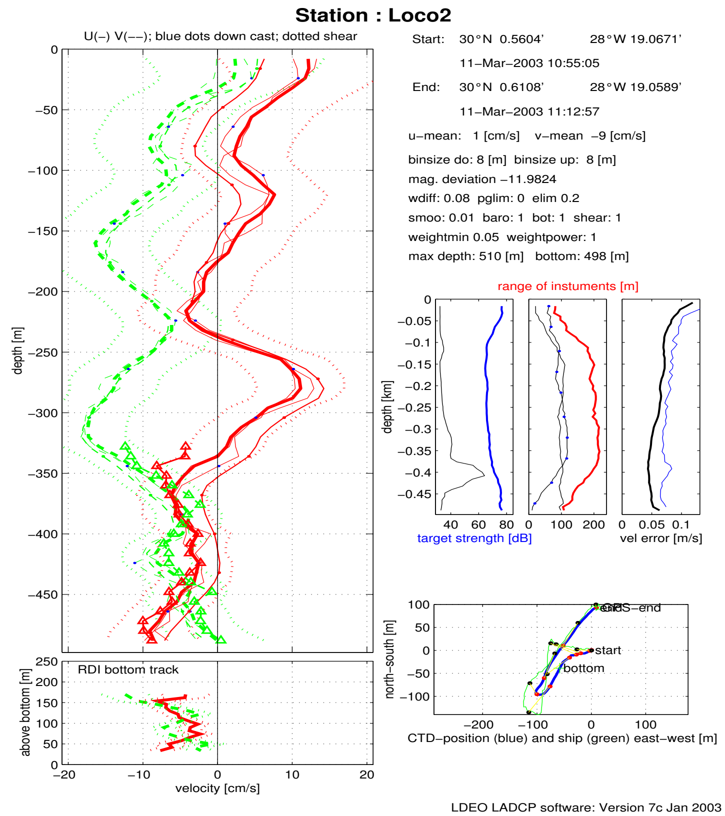

Fig. 13. Example of near-surface LADCP profile

In a technical sense the FLY system has performed well. Except for one failing temperature sensor, the replacement turned out to work very well. The conductivity cell and pressure sensor worked well. This means that, in principle, the FLY now contains its own CTD system. Comparison with the data of the CTD cast that preceded the FLY cast showed a strong correspondence.

The shear sensors have worked for the whole of the cruise. A test with another type showed a failure in a limited pressure range. In a future cruise this problem must be sorted out. The electronic re-design resulted in a far better electronic noise level. In principle this noise level permits measurements at the epsilon = 1e-10 W/kg level. Regretfully one cannot expect to find such low levels in the upper 1000 m in the Canary Basin. The measured TKE-dissipation levels seem to be of the expected order of magnitude. An experiment to dampen possible mechanical vibrations of the hull of the FLY with spoilers made of pieces of robe didn't lower the levels visibly.

Photo (M. Hiehle): preparing FLY-spoilers.

The winch system for the FLY has performed well from the moment the correct line-pulling speed was found. This line-pulling speed is depending on the fall speed of the FLY profiler and the speed of the ship. The weather was generally fair enough to have good control over the very low ships speed during lowering of the FLY.

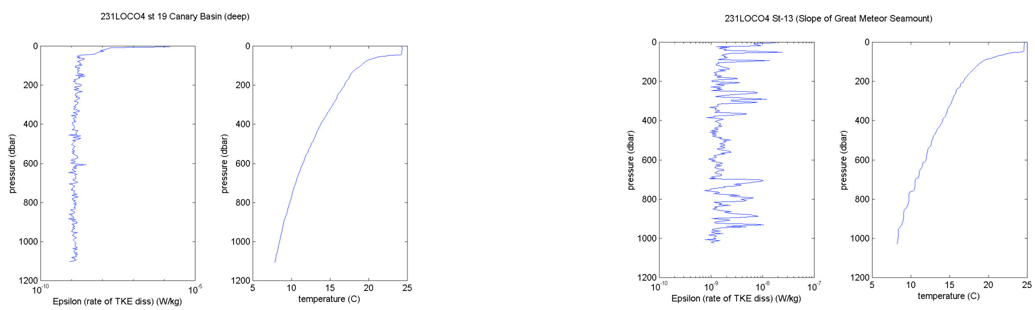

Fig. 14. Examples of FLY profiles: Canary Basin (left) and near GMS (right).

g. Deep-towed ADCP's above GMS

During the first weeks of the cruise in the Canary Basin, tests of the novel deep-tow system were made to learn about possible interference between the ship's VMADCP and the towed ADCP's; to learn about the towed vehicle behaviour and to learn about the cable length/depth ratio when the system was at ~1000 m depth in association with ship's speed and manoeuvring.

Three tests were performed, which learned that: 1. The cable drag was three times larger than estimated, due to cable vibrations, 2. The weight had to be doubled to 2500 kg, 3. 800 m was the maximum depth reasonably reachable, with 1350 m cable out (and the towed body some 1100 m behind the ship) 4. The ADCP's in the frame operate in narrow band and they had to be programmed asynchronously, 5. The VMADCP operates in broadband, causing no interference with the frame ADCP's, 6. The CTD signal was heavily disturbed by theristors along the way of the Kevlar-electric cable to the deck-unit, 7. The towed-body has to be neutrally buoyant (weakly sinking) and the line has to be attached at the lowermost position, 8. Sailing speed has to be constant to within ±0.1knots, so that vertical motions are kept to within ±5 m, 9. On-line depth knowledge is necessary for commanding ship speed variations, 10. Good weather is a prerequisite. The tests also learned the particular times and manners to lower the cable from a particular depth to the next, and how to sail best a 180° turn between sections (Fig. 15). The entire procdure is rather complex, and a manual has now been written (van Sebille, Loeve and Huisman, 2004).

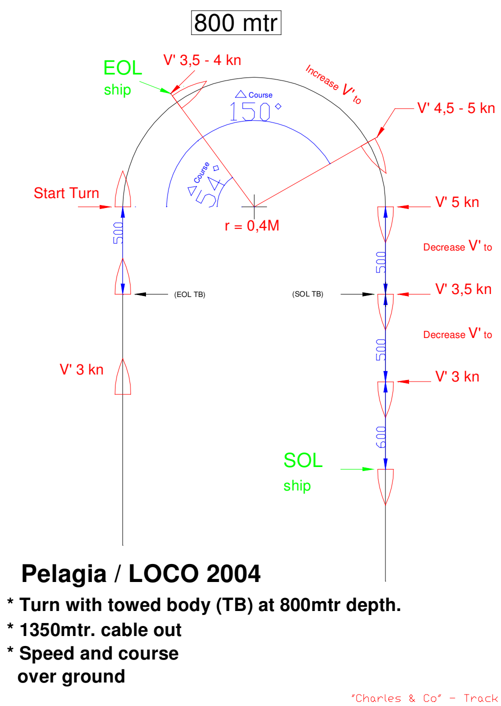

Fig. 15. Diagram of U-turn with towed body at 800 m depth (Charles & co.)

Instead of above the forbidden Bay of Biscay continental slope, a sequence of the deep towed-ADCP was performed for a consecutive period of 24 hours (2 tidal periods) above the steep south-eastern slope of GMS. According to previous studies by Mohn and Beckmann (2002) the southside of the seamount experienced strongly enhanced tidal motions, with largest enhancements for diurnal tidal components. The narrow band ADCP's in the towed body were set to sample 7 pings of 1 s every 20 s, with starting times 10 s apart. The VMADCP sampled each ping every 3.81 s. Tow speed was 3 knots and two sections of ~12 km length were sampled 5 times each. The towing depths were 200 and 800 m. Due to the steepness of the slope, the tow transects overlapped by about 8 km. The advantage is that for this overlapping stretch the diurnal tidal component can also be resolved, for a limited depth range of about 800 m from the surface. The direction of the transect was 273°TN (return: 93°TN), with starting point at 29°40.679´N, 28°23.311´W (water depth 301 m). Final water depth was ~3300 m. During the entire measurement period, weather conditions were indeed very favourable.

Preliminary inspection of the data learned that all instruments worked well. During the towing with the frame at a depth of 200 m the online CTD readings were occasionally hampered, but these data are not of primary use during the analysis. With the VMADCP reaching to about 640 m depth and the towed body ADCP's ranging at least 550 m, a total depth is reached of 1350 m (body at 800 m), with several ranges of overlap. Data quality is good, except for occasional bad data between 200-400 depth in VNADCP series. This bad sector (~3 of every 10 pings bad between these depths) seems to occur always, not just when towing. This requires further attention. Depth variations were generally within reasonable limits. Instrumental tilt was never more than 5° ensuring the good data quality and sufficient depth range. Already in the raw data a banding of enhanced and weakened currents can be seen, but it is too early to conclude observational evidence of internal tidal beams.

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8. Achnowledgments

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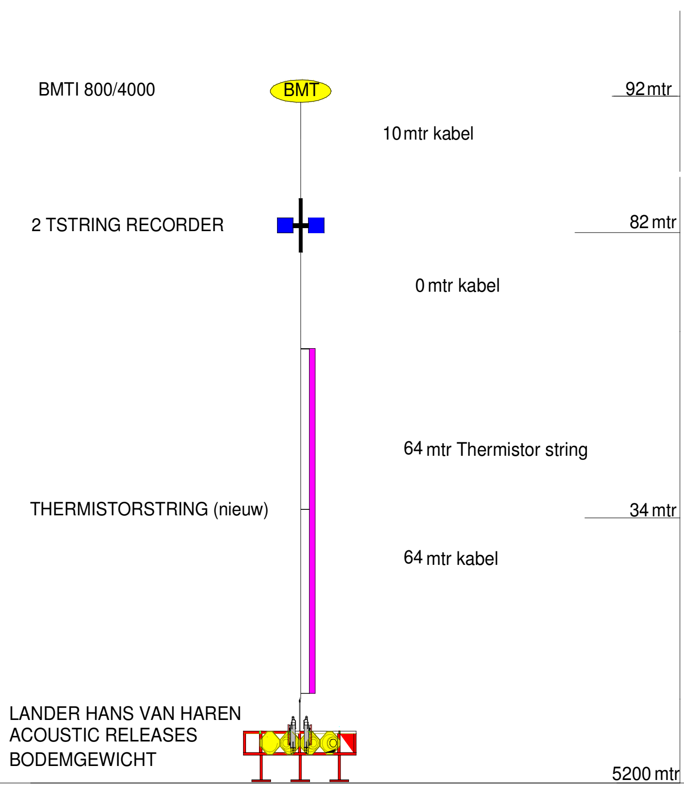
November 2004,

Hans van Haren

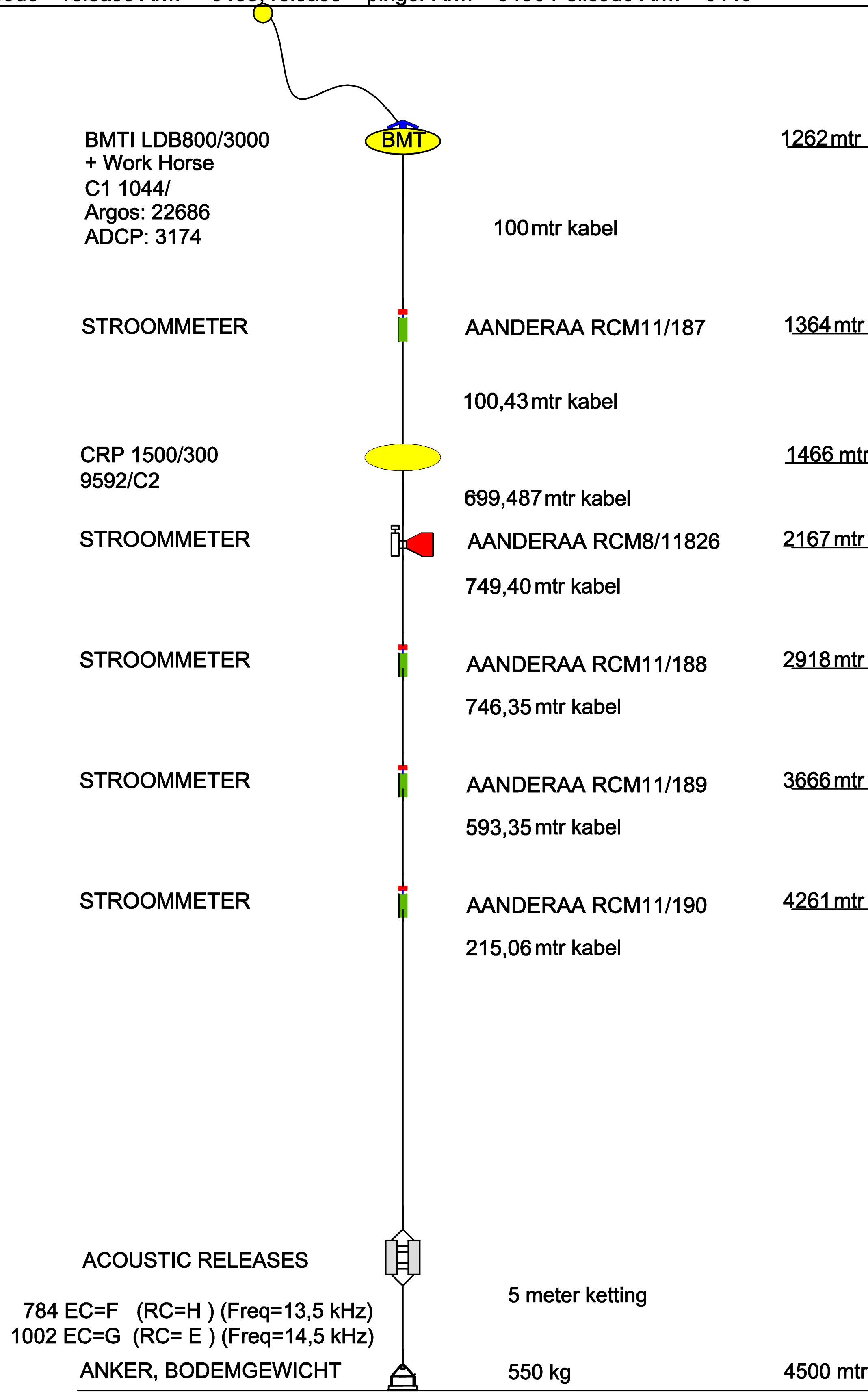
Appendix A Mooring diagrams LOCO-IW04 (*by Dept. Sea Technol. & T. Hillebrand*)

DOC04-1

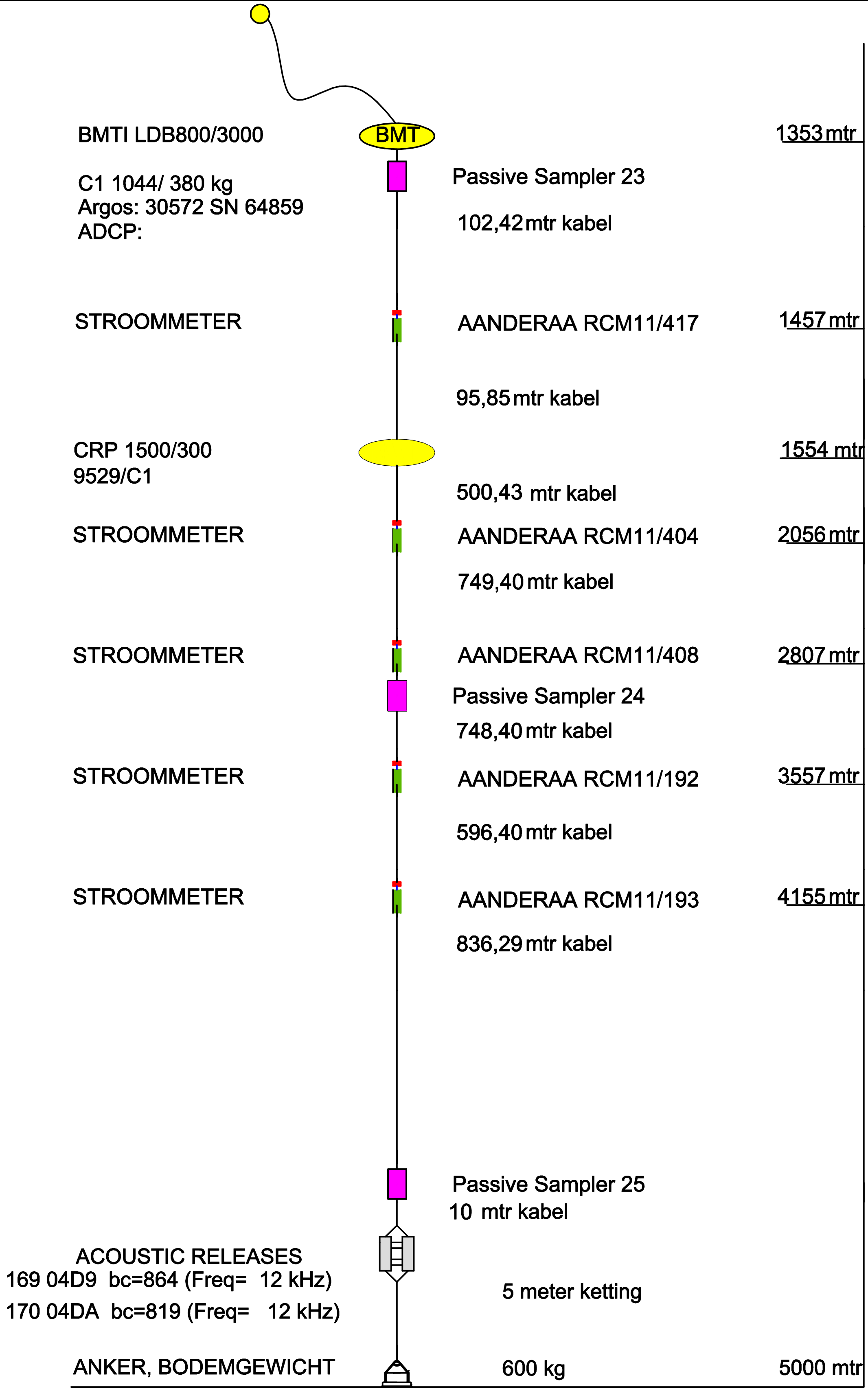
Verankering IDEE	LOCO, Internal Waves, N A., 2004-LANDER		
Scientific ontwerp	Hans van Haren	Voorbereiding	
Statisch ontwerp	Jack Schilling	Hardware verankering	Leon Wuis
Dynamisch ontwerp	Theo Hillebrand	Instrumenten	Theo Hillebrand
Deployment			
Datum/tijd		Verankerings technici	Lorendz Boom & Yvo Witte
Positie		Instrument technikus	Theo Hillebrand
Expeditieleider	Hans van Haren	Controller	
Archivering			
Vaste Oceanic code = release 0455, release + pinger 0456			



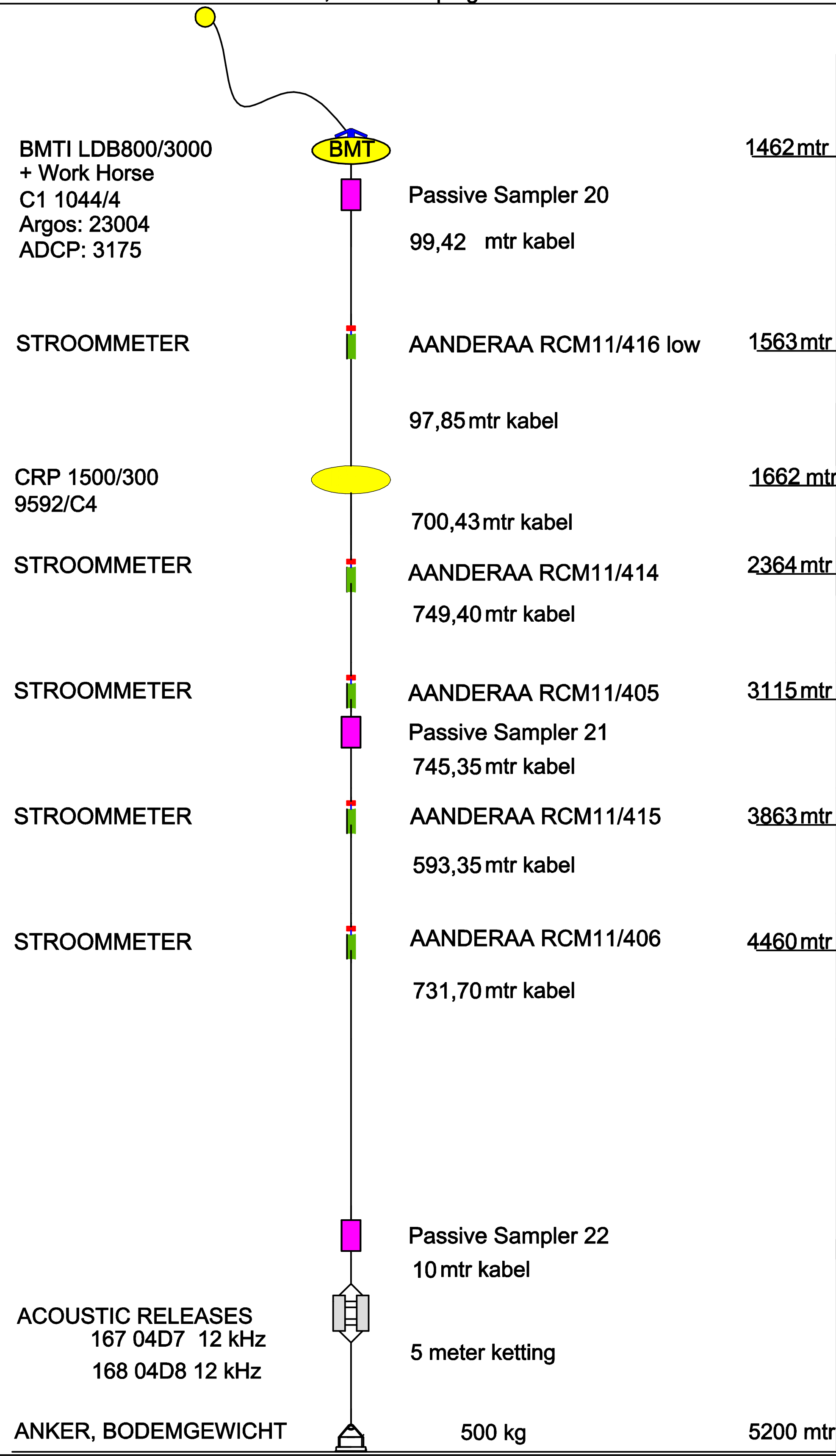
Verankering IDEE	LOCO, Internal Waves, N A., 2004-011-2		
Scientific ontwerp	Hans van Haren	Voorbereiding	
Statisch ontwerp	Jack Schilling	Hardware verankering	Leon Wuis
Dynamisch ontwerp	Theo Hillebrand	Instrumenten	Theo Hillebrand
Deployment			
Datum/tijd		Verankerings technici	Lorendz Boom & Yvo Witte
Positie		Instrument technikus	Theo Hillebrand
Expeditieleider	Hans van Haren	Controller	
Archivering			
Vaste Oceanic code = release Arm + 0455, release + pinger Arm + 0456 Peilcode Arm + 0448			



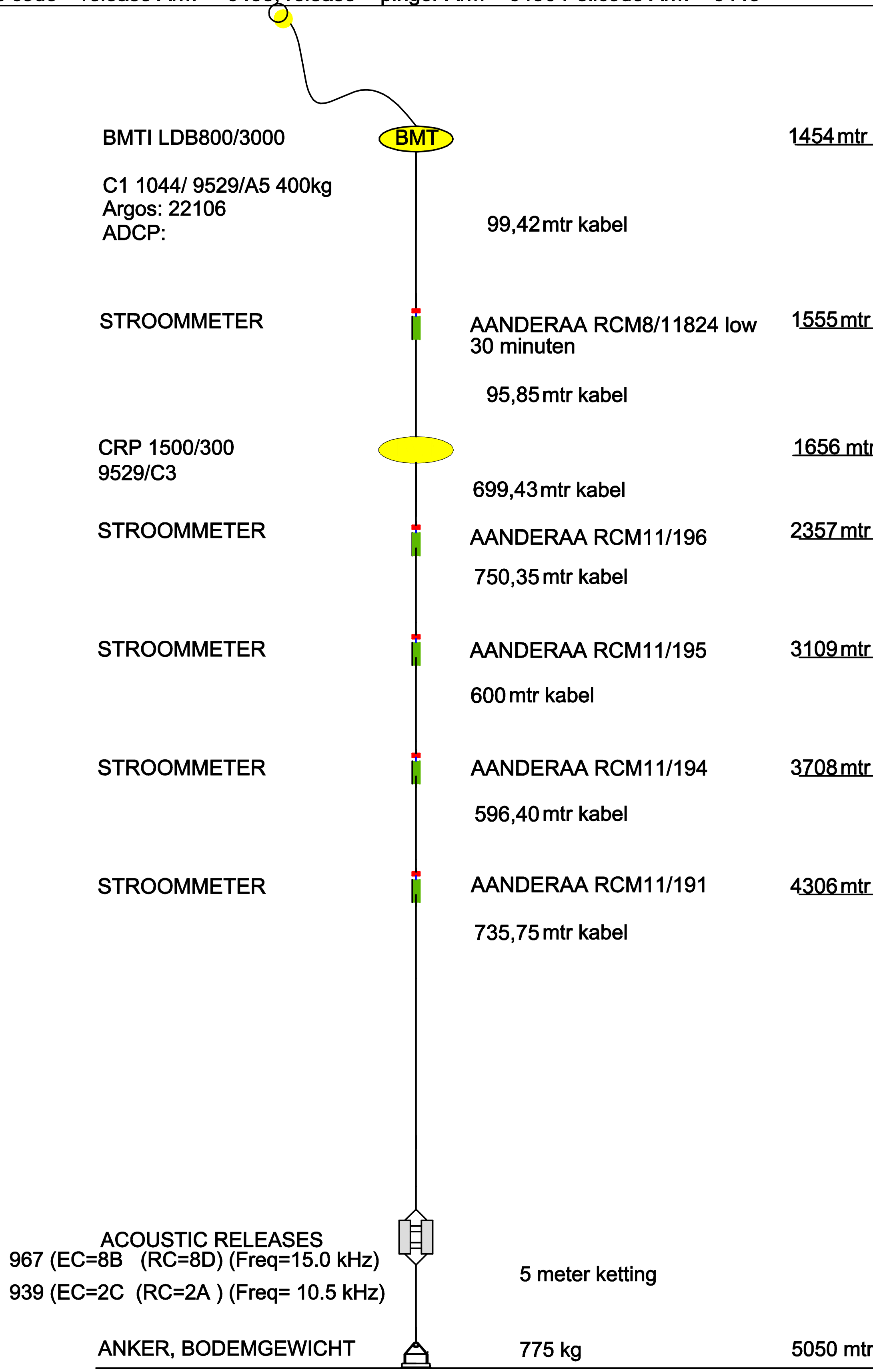
Verankering IDEE	LOCO, Internal Waves, NA., 2004-013/2		
Scientific ontwerp	Hans van Haren	Voorbereiding	
Statisch ontwerp	Jack Schilling	Hardware verankering	Lorendz Boom & Yvo Witte
Dynamisch ontwerp	The Hille Brand	Instrumenten	The Hillebrand
Deployment			
Datum/tijd		Verankerings technici	Lorendz Boom & Yvo Witte
Positie		Instrument technikus	Theo Hille Brand
Expeditieleider	Hans van Haren	Controller	
Archivering			
Vaste Oceanic code = release Arm + 0455, release + pinger Arm + 0456 Peilcode Arm + 0448			



Verankering IDEE	LOCO, Internal Waves, NA., 2004-012/2		
Scientific ontwerp	Hans van Haren	Voorbereiding	
Statisch ontwerp	Jack Schilling	Hardware verankering	Lorendz Boom & Yvo
Dynamisch ontwerp	Theo Hillebrand	Instrumenten	Theo Hillebrand
Deployment			
Datum/tijd		Verankerings technici	Lorendz Boom & Yvo
Positie		Instrument technikus	Theo Hllebrand
Expeditieleider	Hans van Haren	Controller	
Archivering			
Vaste Oceanic code = release Arm + 0455, release + pinger Arm + 0456 Peilcode Arm + 0448			



Verankering IDEE	LOCO, Internal Waves, NA., 2004-014/2		
Scientific ontwerp	Hans van Haren	Voorbereiding	
Statisch ontwerp	Jack Schilling	Hardware verankering	Lorendz Boom & Yvo Witte
Dynamisch ontwerp	Theo Hillebrand	Instrumenten	Theo Hillebrand
Deployment			
Datum/tijd		Verankerings technici	Lorendz Boom & Yvo Witte
Positie		Instrument technikus	Theo Hillebrand
Expeditieleider	Hans van Haren	Controller	
Archivering			
Vaste Oceanic code = release Arm + 0455, release + pinger Arm + 0456 Peilcode Arm + 0448			



***Appendix B Cruise summary of stations (activities) of LOCO-IW04* (M. Hiehle)**

Station	Cast	Type	Datum/ Tijd	Latitude	Longitude	Depth	Comments
1	1	Mooring recovery	Oct 16 2004 10:21:37	30.06613	-22.97772	5112	DOC 03-02 FAILED
2	1	Mooring recovery	Oct 16 2004 11:48:56	30.00452	-23.04128	5127	LOCO12
3	1	CTD01 no samples	Oct 16 2004 15:04:57	30.08655	-22.97607	5117	Near DOC 03-2
3	2	CTD02+Thermistor calibration	Oct 16 2004 19:23:47	30.09208	-22.96913	5076	
4	1	Mooring deployment	Oct 17 2004 08:43:11	30.00065	-23.05360	5132	LOCO12/2
5	1	CTD03 no samples	Oct 17 2004 16:10:56	30.16997	-23.02195	5153	Near LOCO11
6	1	Mooring recovery	Oct 18 2004 09:01:25	30.18107	-23.01613	5158	LOCO11
7	1	Mooring recovery	Oct 18 2004 13:28:02	29.98323	-22.96785	5112	LOCO13
8	1	CTD04+Thermistor calibration	Oct 19 2004 16:04:39	29.99942	-25.78700	5051	
8	2	Fly	Oct 19 2004 17:02:28	29.99742	-25.78123	3668	FAILED
8	3	Fly	Oct 19 2004 17:11:09	29.99393	-25.77958	3668	
9	1	Mooring deployment	Oct 20 2004 08:32:28	29.99675	-27.70983	4673	LOCO11/2
10	1	Mooring deployment	Oct 20 2004 17:43:04	29.99952	-28.31453	534	DOC04-1
11	1	CTD05 no samples	Oct 20 2004 19:07:12	30.00430	-28.31452	556	Near DOC04-1
12	1	CTD06 no samples	Oct 20 2004 20:14:18	30.00008	-28.39070	336	Top of GMS
12	2	Fly	Oct 20 2004 20:29:17	29.99958	-28.39110	336	
13	1	CTD07 no samples	Oct 20 2004 21:51:32	29.99995	-28.19700	2517	
13	2	Fly	Oct 20 2004 23:33:32	29.99988	-28.19882	2468	
14	1	CTD08 no samples	Oct 21 2004 02:39:34	29.99982	-27.76387	4615	Near LOCO 11-2
14	2	Fly	Oct 21 2004 05:55:34	30.00227	-27.76260	4621	
15	1	CTD09 no samples	Oct 21 2004 20:16:35	30.50017	-25.50008	4859	
15	2	Fly	Oct 22 2004 00:03:56	30.50013	-25.49467	5353	
16	1	CTD10 no samples	Oct 22 2004 13:30:12	31.00022	-22.99993	5201	
16	2	Fly	Oct 22 2004 17:11:51	31.00103	-22.99755	5201	
17	1	Towed ADCP	Oct 22 2004 19:01:08	30.84975	-22.99798	5195	Test
18	1	CTD11 no samples	Oct 23 2004 03:32:34	30.00000	-22.99977	5115	
19	1	Fly	Oct 23 2004 07:01:51	30.00055	-22.99680	5115	
20	1	Dredging	Oct 23 2004 10:56:07	30.08767	-22.96228	5091	DOC 03-2 FAILED
21	1	CTD12 no samples	Oct 23 2004 20:22:14	29.00078	-22.99982	4987	
21	3	Fly	Oct 23 2004 23:40:17	28.99780	-22.99822	4987	FAILED
21	4	Fly	Oct 23 2004 23:45:39	28.99572	-22.99955	4987	
22	1	Mooring deployment	Oct 24 2004 08:57:35	28.79977	-23.06187	4981	LOCO14/2
23	1	CTD13 no samples	Oct 24 2004 17:33:40	28.00033	-23.00122	4939	
23	2	Fly	Oct 24 2004 20:50:08	28.00313	-23.00417	4939	
24	1	Mooring deployment	Oct 25 2004 08:39:32	27.61312	-23.06588	4902	LOCO13/2
25	1	CTD14 no samples	Oct 25 2004 16:42:17	27.00007	-23.00070	4902	
25	2	Fly	Oct 25 2004 19:43:44	27.00030	-23.00213	4902	
26	1	Towed ADCP	Oct 26 2004 10:55:05	26.03843	-22.97073	4932	Test 2
26	2	CTD15 no samples	Oct 26 2004 15:11:24	25.99977	-23.00082	4932	
26	3	Fly	Oct 26 2004 18:41:04	26.00073	-23.00483	4939	
27	1	Towed ADCP	Oct 27 2004 09:16:33	27.45835	-24.90240	5182	Test 3
28	1	Towed ADCP	Oct 28 2004 13:51:53	29.67873	-28.40655	289	GMS "the Real Job"
28	1	Towed ADCP	Oct 28 2004 14:12:01	29.67798	-28.38852	301	
28	1	Towed ADCP	Oct 28 2004 16:34:04	29.66428	-28.25890	2686	
28	1	Towed ADCP	Oct 28 2004 16:42:26	29.66307	-28.26352	50	
28	1	Towed ADCP	Oct 28 2004 19:00:24	29.67680	-28.39292	296	
28	1	Towed ADCP	Oct 28 2004 19:07:50	29.67792	-28.38845	301	
28	1	Towed ADCP	Oct 28 2004 21:26:25	29.66427	-28.25903	2686	
28	1	Towed ADCP	Oct 28 2004 21:35:36	29.66323	-28.26345	2698	
28	1	Towed ADCP	Oct 28 2004 23:52:13	29.67673	-28.39265	298	
28	1	Towed ADCP	Oct 29 2004 00:29:32	29.67490	-28.35997	751	

Station	Cast	Type	Datum/ Tijd	Latitude	Longitude	Depth	Comments
28	1	Towed ADCP	Oct 29 2004 00:41:46	29.67340	-28.34897	1189	
28	1	Towed ADCP	Oct 29 2004 01:04:00	29.67135	-28.32618	1917	
28	1	Towed ADCP	Oct 29 2004 03:08:50	29.65707	-28.21205	3076	
28	1	Towed ADCP	Oct 29 2004 03:38:01	29.64845	-28.23642	2979	
28	1	Towed ADCP	Oct 29 2004 05:46:03	29.66347	-28.35000	1222	
28	1	Towed ADCP	Oct 29 2004 06:16:48	29.67143	-28.32623	1920	
28	1	Towed ADCP	Oct 29 2004 08:31:46	29.65680	-28.21317	3078	
28	1	Towed ADCP	Oct 29 2004 08:59:31	29.64850	-28.23630	2981	
28	1	Towed ADCP	Oct 29 2004 11:22:50	29.66333	-28.35033		
28	1	Towed ADCP	Oct 29 2004 11:24:36	29.67150	-29.32617		
28	1	Towed ADCP	Oct 29 2004 13:39:42	29.65950	-28.21183	3085	
28	2	Fly	Oct 29 2004 14:40:01	29.65450	-28.19267	2986	
29	1	Fly	Oct 30 2004 08:10:35	29.94000	-28.32783	429	
30	1	Fly	Oct 30 2004 08:38:48	29.93833	-28.30733	519	
31	1	Fly	Oct 30 2004 09:08:44	29.93300	-28.28217	623	
32	1	Fly	Oct 30 2004 10:07:06	29.93050	-28.27600	809	
33	1	Fly	Oct 30 2004 10:46:46	29.93133	-28.27833	698	
34	1	Mooring recovery	Oct 30 2004 12:12:38	29.99815	-28.30725	529	DOC04-1, 1st part
34	2	Mooring recovery	Oct 30 2004 13:46:55	29.98952	-28.30477	527	DOC04-1, 2nd part
35	1	Fly	Oct 31 2004 08:18:41	32.33432	-25.77552	4378	
36	1	CTD+Thermistor calibration	Oct 31 2004 09:09:40	32.34155	-25.77648	4378	

st	**CTD-file**	**LADCP-file**	**Fly-file**
3	**231pe001/001b**	**Cb01m000.000,Cb01s000.000**	
8	**231pe004**		**Fly 1700_1910.txt**
11	**231pe005**	**Ll05m000.000, Ll05s000.000**	**-**
12	**231pe006**	**Ll06m000.000, Ll06s000.000**	**Fly 2027_2010.txt**
13	**231pe007**	**Ll07m000.000, Ll07s000.000**	**Fly 2330_2010.txt**
14	**231pe008**	**Ll08m000.000, Ll08s000.000**	**Fly 0554_2110.txt**
15	**231pe009**	**Ll09m000.000, Ll09s000.000**	**Fly 0000_2210.txt**
16	**231pe010**	**Ll10m000.000, Ll10s000.000**	**Fly 1709_2210.txt**
19	**231pe011**	**Ll11m000.000, Ll11s000.000**	**Fly 0659_2310.txt**
21	**231pe012**	**Ll12m000.000, Ll12s000.000**	**Fly 2344_2310.txt**
23	**231pe013**	**Ll13m000.000, Ll13s000.000**	**Fly 2046_2410.txt**
25	**231pe014**	**Ll14m000.000, Ll14s000.000**	**Fly 1944_2510.txt**
		t/m Ll14s003.000	
26	**231pe015**	**Ll15m000.000, Ll15s000.000**	**Fly 1838_2610.txt**
28			**Fly 1439_2910.txt**
29			**Fly 0808_3010.txt**
30			**Fly 0837_3010.txt**
31			**Fly 0907_3010.txt**
32			**Fly 1005_3010.txt**
33			**Fly 1045_3010.txt**
34			
35			**Fly 0816_3110.txt**
36	**231pe016**