**Reference:**
**van Haren, H., 2006. Cruise report bsik/LOCO-IW06: R.V. Pelagia cruise 64PE248, 17 May - 12 June 2006, NIOZ, 40 pp.**

## Cruise Report

# bsik/LOCO-IW06

## R.V. Pelagia cruise 64PE248

### 17 May – 11 June 2006

### Santa Cruz (Tenerife, E) – Funchal (Madeira, P)

**Hans van Haren**
(with contributions from participants)

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*(Photo: L.Boom)*

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## 1. Summary of R/V Pelagia LOCO-IW06 cruise

In May 2006 the R/V Pelagia (NIOZ, The Netherlands) sailed to the Canary and Cape Verdes Basins (North-Atlantic Ocean), mainly to recover 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 advancement of scientific research. LOCO aims to investigate ocean physics process variations on time scales of years using long-term moorings. In the deep North-Atlantic basins 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. In some details, tidal IW are studied above a single underwater volcano.

The working area of LOCO-IW is the abyssal plain and Great Meteor Seamount (GMS) in the Canary Basin near 30º N, 23º W (~5200 m depth). In October 2004 four long moorings were deployed 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 generally once per 15 minutes. Two moorings also carried a 75 kHz acoustic Doppler current profiler (ADCP) in the top buoyancy element. During LOCO-IW06 three of these moorings were successfully recovered delivering 95% good data. Unfortunately, one long-term mooring could not be retrieved. Dredging attempts were unsuccessful.

Eight long moorings were re-equipped with on average five current meters each; five moorings carry ADCP’s in the top. This time, the Canary Basin array is extended to the Cape Verdes Basin to study internal tide variations. These moorings were successfully deployed. Two short-term moorings were on a 8% bottom slope near the top of Great Meteor Seamount (GMS). These moorings held NIOZ built fast and accurate thermistor strings sampling at 1 Hz. One of these (NIOZ3) delivered generally good data during its maiden deployment. The other (NIOZ2) failed after half a day. During the cruise several conductivity-temeparture-depth (CTD) profiles were obtained in conjunction with lowered-ADCP (LADCP) to map the finescale and background hydrography. Additionally, many Fly-microstructure casts were launched to estimate turbulence dissipation rate and eddy diffusivity in the upper 1900 m of the water column. CTD-LADCP, FLY and ship’s winches worked nearly flawlessly, except for shortage twice. 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, followed by 25 hours of yoyo-CTD.

The cruise was successful. Weather conditions were extremely good causing no delays. All overboard operations went very well, including the recovery and deployment of the long moorings. The re-deployment of moorings was never further than 100 m from the intended latitude, well within the aim.

## 2. General research aim.

*LOCO*

The N.W.O.-financed large investement 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 and 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 coordinated research programmes.

*LOCO-IW*

Within LOCO two sets of four moorings will be used to study in more detail the climatological mean of spatial and temporal variability of internal-wave intensity. This will be 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, the Cape Verde Basin towards the Equator to study specific processes like near-inertial wave propagation. Together these sites are exemplary for most internal wave appearances.

*LOCO-IW Canary Basin*

The purpose of the LOCO-IW06 cruise is to study the climatologic effects of internal waves on the deep-ocean. Specifically, we study near-inertial internal motions generated via geostrophic adjustment due to the Earth’s rotation, for example following atmospheric disturbances, and those by diurnal tides (between 15-33° N, ~along 25° W). During the cruise 4 moorings will be recovered and 8 (re)deployed. Most moorings extend 3.7 km above the bottom (1.5 km below the sea surface). These moorings contain current meters and temperature sensors. The moorings will remain in position for 1.5 years. In addition, short-term hydrographic and mixing information will be collected using CTD, microstructure profiler, LADCP, towed ADCP and fast-sampling moored instruments like NIOZ thermistor strings.

## 3. LOCO-IW06 overview.

Internal wave mixing is thought to be the key in maintaining the general ocean circulation, induced about half by tidal motions and half inertial motions, which are generated following Earth's rotational geostrophic adjustment of sudden variations (e.g. due to wind). 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. 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 at latitudes (Fig. 1) where the inertial frequency matches that of deterministic diurnal tides so that the latter may reinforce near-inertial motions. Also, at these 'diurnal critical latitudes' energy at the diurnal tidal/inertial frequency may be enhanced due to transfer of energy from semidiurnal tidal frequencies to smaller scales at half their frequency via parametric subharmonic instability (PSI). The associated reduction in vertical scales may imply larger shear-induced mixing.

Most moorings are above the abyssal plain to avoid topographic effects complicating the study of free internal wave motions, but some attention is focused on large-scale topography from a mooring near Great Meteor Seamount (GMS) and from small-scale sampling near its top where vigorous non-linear breaking waves can occur (van Haren, 2005a).

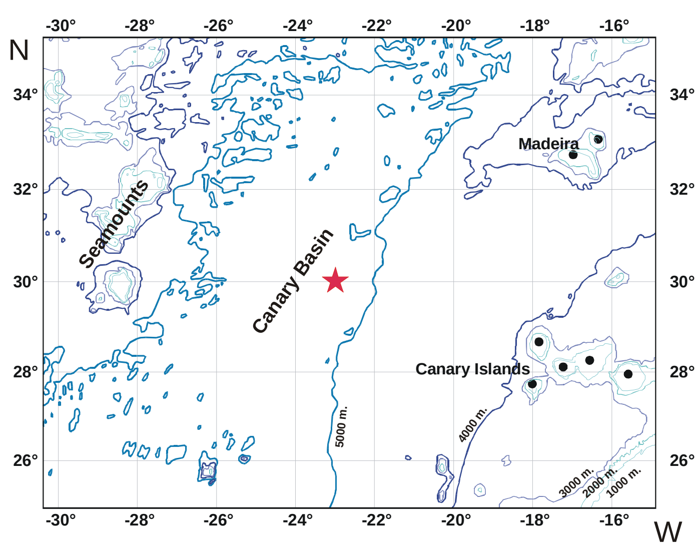


Fig. 1. Map of the Canary Basin (M. Hiehle). Main moorings are along 30°N and 23°W.

*LOCO-IW moorings*

Since October 2004, an array of four closely spaced (5-20 km) and long (~3.7 km) moorings LOCO11/2-14/2 are deployed near 30ºN, 23ºW in the Canary Basin (~5 km deep) halfway between the continental slope and the seamounts of the Mid-Atlantic Ridge (Fig. 2; Table 1). One mooring is at the foot of underwater vulcano GMS (30ºN, 28ºW). During LOCO-IW06 the latter mooring is relocated to a position West of Madeira. In addition, the four 'traveling' LOCO-IW moorings LOCO15-18 are deployed roughly around 28ºW, between near 15-25ºN to study in more detail variations in tidal and inertial energy south of the diurnal critical latitude (van Haren, 2005b).

***Table 1.*** *Mooring positions LOCO-IW04 from October 2004 and corresponding local inertial frequencies (with harmonic diurnal tidal names between brackets). Depths are echo sounder estimates. 1 cycle per day (cpd) = $2\pi/86400$ s$^{-1}$.*

| | | | | |
|---|---|---|---|---|
| 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 ($K_1$) |
| 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 ($M_1$) |

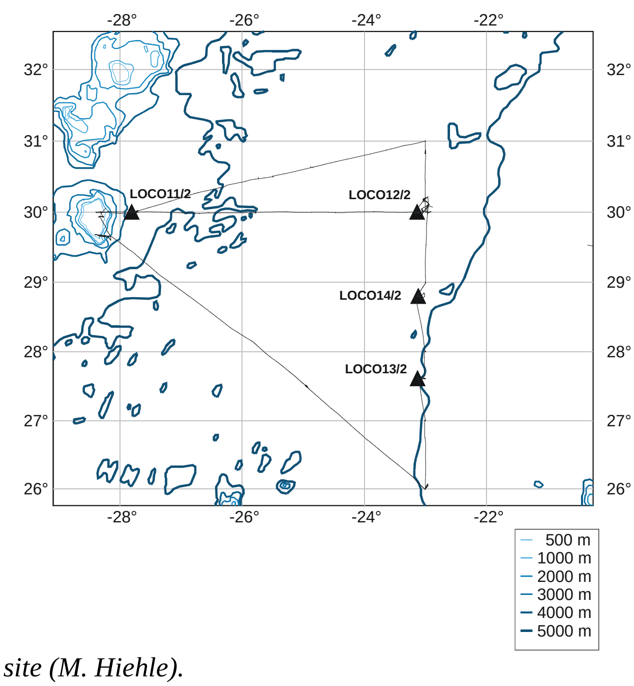


*Fig. 2. Map of LOCO-IW04 mooring site (M. Hiehle).*

As the aim is to study inertial internal wave motions near the latitude where their frequency is close to diurnal tidal frequencies, some of the moorings are located sharply at and very close to those corresponding to tidal harmonic frequencies (Table 1). The distances between moorings are less than theoretical predictions on near-inertial wave propagation from the surface down- and equatorward in a flat ocean (Garrett, 2001; ~300 km). They correspond to theory on down- and poleward propagation of near-inertial waves focusing on a spherical shell (Maas, 2001). The former theory seems an overestimate as it predicts a shift of ~7% in inertial frequency between surface and bottom, whilst analysis on data from IfM Kiel (Siedler and Paul, 1991) shows vertical frequency shifts much less than this (van Haren, 2005b).

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 are about a tenth of these estimated values (<5 m in vertical measured using pressure sensor and tilt meters). As a result the design is well suited for its purpose.

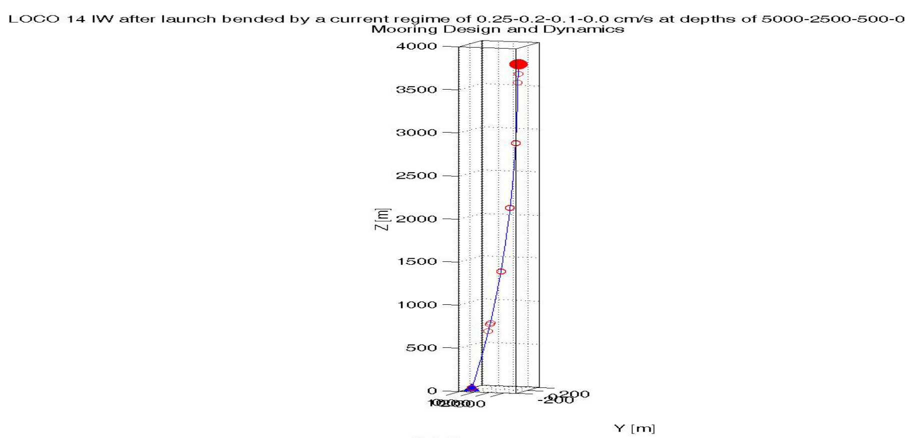


*Fig. 3 Mooring deflection as computed by T. Hillebrand using program package designed by R. Dewey (UVic, Canada).*

The moorings basically 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). The distribution of the current meters is chosen after inspection of deep CTD-data obtained during previous cruises (Fig. 4). These profiles show a strong seasonal pycnocline near 100 m, a nearly constant intermediate stratification between 100-1000 m, step-like density profile (partially due to double diffusive mixing) between 800-2000 m and slowly decreasing stratification below 2000 m, with sometimes negligible stratification (N = 0) between 4000 and 5000 m. Current meters are planned in the step-profile layer and in the weak N → 0 layer, besides the even distribution over the mooring line.

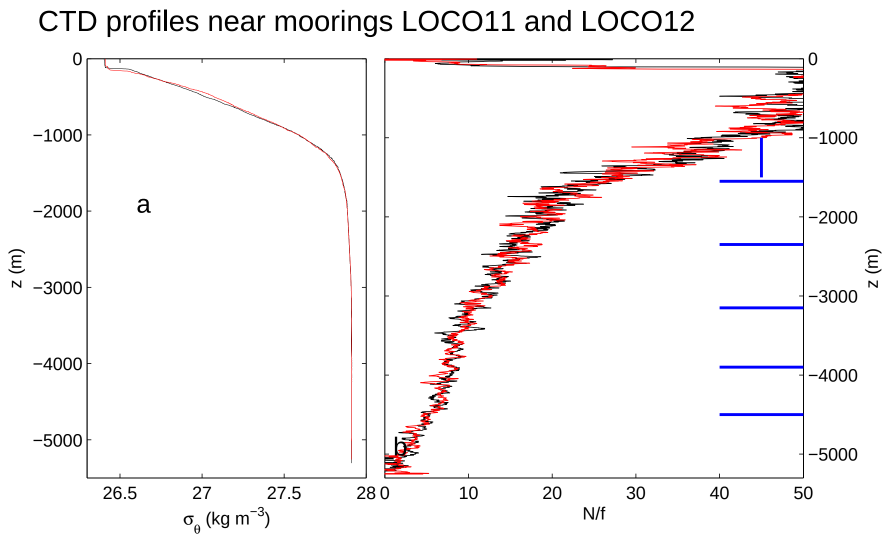


*Fig.4. Density and 40 m smoothed stratification with depth measured during LOCO-IW03. In the right panel horizontal lines indicate proposed current meter locations; vertical line shows the extent of the 75 kHz ADCP.*

In the top of two moorings a 75 kHz ADCP is deployed, so that ~25 m vertical shear (relevant for mixing induced by shear instability) is resolved over a range of ~500 m (Fig. 4).

The instruments are adapted for long-term monitoring (extra batteries and, for some, extra memory). They are programmed to last 2 years whilst sampling relatively fast, at least once/30 min, generally 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 (and ~30 min at 1000 m). The bulk of the current meters are acoustic measurement devices, like the ADCP. All such devices rely for good data on particles (plankton, suspended sediments) in the water for sufficient s/n ratio. Presently, these instruments are robust in their performance, but, unfortunately, their deep-ocean s/n allows some limited internal wave band resolution of only up to 5(10) cpd (cycles per day). In contrast, mechanical current meters can resolve frequencies up to about their Nyquist frequency, but these instruments do rely on sufficiently strong currents (>0.02 m $s^{-1}$) and risk entanglements with floating material like lines etcetera.

With regards to the LOCO-IW04 mooring locations (Table 1) the following modifications have been made. All new names have extension /3. Mooring **LOCO11/3** is moved from the foot of GMS to West of Madeira, to be well north of 30°N. Moorings **LOCO12/3,**

**LOCO13/3,** and **LOCO14/3** remain at the same latitudes but have slightly different longitudes (more into the basin). Mooring **LOCO14/3** now also carries an ADCP in its top-buoy. During LOCO-IW04 most instruments were acoustic current meters Aanderaa RCM11 (except for two mechanical Aanderaa RCM8); during LOCO-IW06 a balanced mix is restored between RCM11, acoustic Nortek AquaDopp and mechanical Valeport BFM-308. Additionally, **LOCO15/3 - LOCO18/3** are newly deployed in this area.

*Additional measurements*

CTD and LADCP measurements provide indirect estimates of deep-ocean shear and mixing (eddy diffusivity) all the way to the bottom, albeit to limited temporal resolution and to LADCP's limited vertical resolution (~25 m). These measurements are made near all moorings, on a transect roughly along 30°W (N-S), and near GMS. Additionally, in the upper 1900 m of the water column and mainly above GMS turbulence dissipation measurements are made using a completely refurbished FLYII microstructure profiler.

Above GMS a detailed internal tide generation and beam propagation study is performed, comprising of twice a section of CTD/LADCP and FLY measurements, a 25 hours cycle of yoyo-CTD and 50 hours of towed ADCP. During these measurements fast-sampling instruments are moored near the top of GMS on a bottom lander (Appendix A) with a 2GB-300 kHz ADCP, an accurate pressure sensor, NIOZ thermistorstring #3, 2 current meters, and, on a separate mooring, NIOZ2-thermistor string with 2 current meters.

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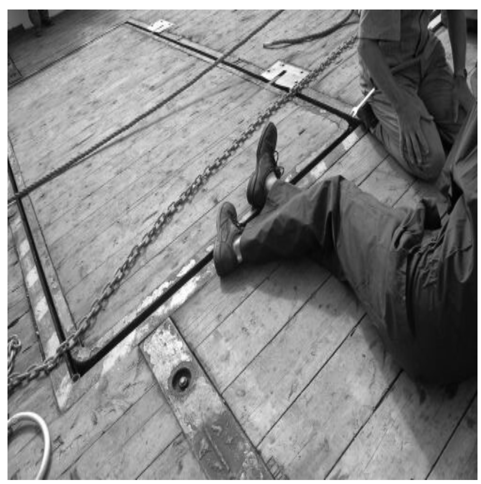
## 4. Participants.

| *Institute* | *Name* |
|---|---|
| FYS | Hans van Haren (PI) |
| FYS | Kees Veth |
| FYS | Theo Hillebrand |
| FYS/DMG | Margriet Hiehle |
| FYS | Theo Gerkema |
| FYS | Eline Verwer |
| MTE | Martin Laan |
| MTM | Lorendz Boom |
| MTM | Yvo Witte |
| IMAU Utrecht | Eleftheria Exarchou |
| IMAU Utrecht | Pieter van Breevoort |
| IMAU Utrecht | Chrysanthi Tsimitri |

***NIOZ departments***

| | |
|---|---|
| **FYS** | physical oceanography |
| **MTE** | electronics |
| **MTM** | sea technology |
| **DMG** | data management group |



*(Photo: C. Tsimitri)*

## 5. Data acquisition and instrumentation.

***a. LOCO-IW06 (/3) moorings (Appendix A for diagrams).***

All eight large moorings **(LOCO11/3-18/3)** have two ellipse-shaped buoyancy elements near the top, of which the upper also holds an ARGOS-satellite beacon. About 5 m above the steel weight (500-700 kg) two IXSea acoustic releases are mounted. Most current meters (CM) are acoustic Aanderaa RCM-11 and Nortek AquaDopp, with the upper mainly being a mechanical Valeport BFM308. We had problems with this current meter in the past (leakage, explosion, but it seems modified now and guranteed to 2000 m). As the moorings will be in position for 1.5 years, the RCM-11 sample at once per 1200 s (20 min) or 900 s (15 min; this is possible, but not all machines are modified to have this option), the Valeport at once per 5 min and the AquaDopp at once per 15 min, with burst sampling at 1 Hz once per day.

Moorings **LOCO11/3, 12/3, 14/3, 16/3 and 18/3** contain an upward looking 75 kHz ADCP in the top buoy. The range of the ADCP will cover 400-500 m (500-600 m set) of the water column every 10 m vertically, between 1000-1500 m (Fig. 4). It samples once per 1800 s (30 min). Mooring **LOCO11/3** holds 54 NIOZ-3 sensors on a 145 m long cable between the two ellipse buoys. Therefore, the ADCP is mounted downward looking, with a range between ~1350-1850 m.

Positioning of moorings is done like during LOCO-IW03 and IW04: starting about 3-4 km East or West of the intended longitude and sailing along a fixed latitude at a speed varying between ~0.5 knot (when instruments are attached and put overboard) and ~1.5 knots (when line is paid out). Release of anchor can be suspended by continuing to sail to the intended position. On average the final position of the anchor is about 700 m behind the ship's position at the moment of release of the anchor, because of the retarded swing and the bent line during towing (Fig. 5), and within ±100 m north/south of the sailed latitude. The drop speed of the weight reaches nearly 3 m $s^{-1}$, before slowing down to just over 1 m $s^{-1}$ when the buoys are pulled under water, so that the bottom landing is fairly smooth.

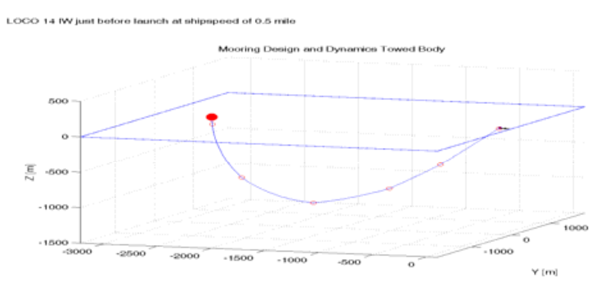



*Fig. 5. Estimated mooring line at moment of release of anchor (acc. progr. R. Dewey,Uvic Canada).*

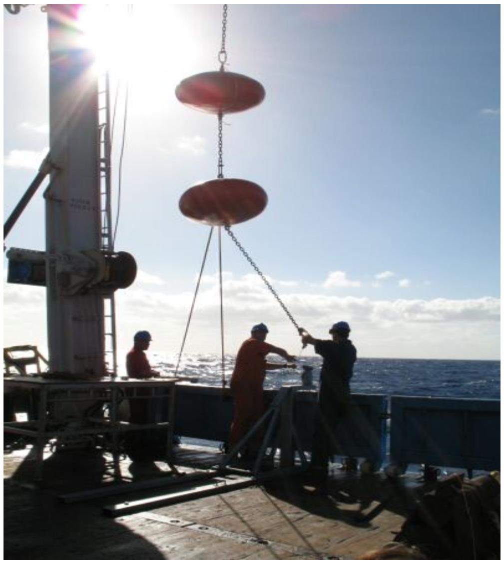
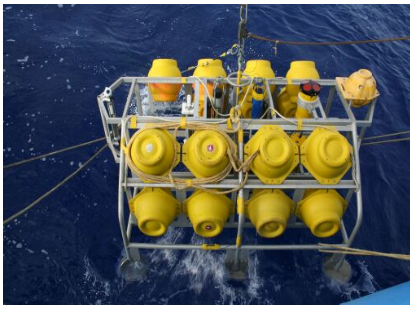


*Photo (P. van Breevoort): Elliptically shaped buoys in the mooring line.*

***b. DOC moorings***

**DOC06-1** is a separate mooring with the NIOZ-3 high-sampling rate thermistor string, which is moored for the first time at ~550 m on the eastern slope of Great Meteor Seamount (30°N, 28°W). NIOZ3 consists of 110 independently operating temperature sensors (~0.2 mK accuracy) that can sample 1.5 years at a 1-Hz rate. Their clocks are synchronized once per 5-10 hours using a high-precision clock at the top-end of the cable. The instrument, below a ~170 kg elliptic buoy and a Nortek CM is attached to NIOZ mix-BB002 bottom lander holding a 300 kHz RDI Sentinel, with 2 GB memory and 2 extra battery containers, a precision SBE53 pressure sensor and a Nortek CM. The purpose of the equipment is to sample during 15-20 days at a fairly high temporal (0.5-1 Hz) and spatial (0.5 m) resolution the water temperature and currents above a deep steep slope. The pressure sensor is used to attempt to resolve non-hydrostatic pressure (typically 100 Pa compared to $10^7$ Pa hydrostatic pressure) near the bottom at a rate of 0.3 Hz. In order to associate the temperature variations to density variations a proper estimate of the temperature-density relationship is obtained by some local CTD calibration sampling.



*Photo( M. van Duijn): NIOZ bottom lander mixBB-002.*

**DOC06-2** is a separate mooring with the NIOZ-2 fast thermistor string (van Haren et al., 2005), which is deployed together with 2 Valeport CM on the southern slope of Great Meteor Seamount (29.6°N, 28°W, 460 m.

### *c. 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 LADCP.

The aim of the measurements with the FLY microstructure profiler 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 NIOZ-technicians).

### *d. Deep towed ADCP's*

During LOCO-IW06 50 hours are used to attempt to monitor internal tidal wave beams above steep topography using a deep-towed vehicle equipped with two 75 kHz RDI ADCP's (one up-, other down-looking). This neutrally buoyant vehicle is attached 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. Previous tests showed the tolerance of ship' speed (±0.1 knot) translated in depth variations (±10 m) of the instrument package, provided the effects of currents is low. The aim is to cover a range between 0-1400 m depth and between 300-3300 m water depth to extend previous measurements (van Haren, 2004). We focus on the southern side of GMS, with possibly enhanced diurnal tide.

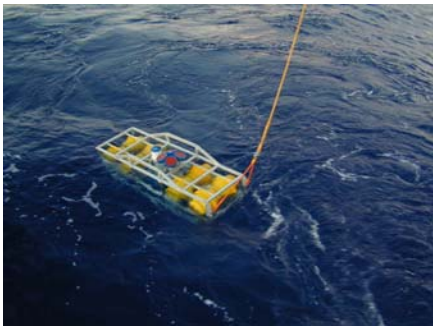


*Photo (M. Hiehle): Deep-towed body with two ADCP's.*

### *e. Argo floats*

KNMI (Royal Netherlands Meteorological Institute) asked us to deploy four long-term Argo-drifters, which measure a CTD-profile between surface-2000 m every week whilst freely drifting at 1000 m in between profiles.

## 6. Daily summaries of LOCO-IW06.

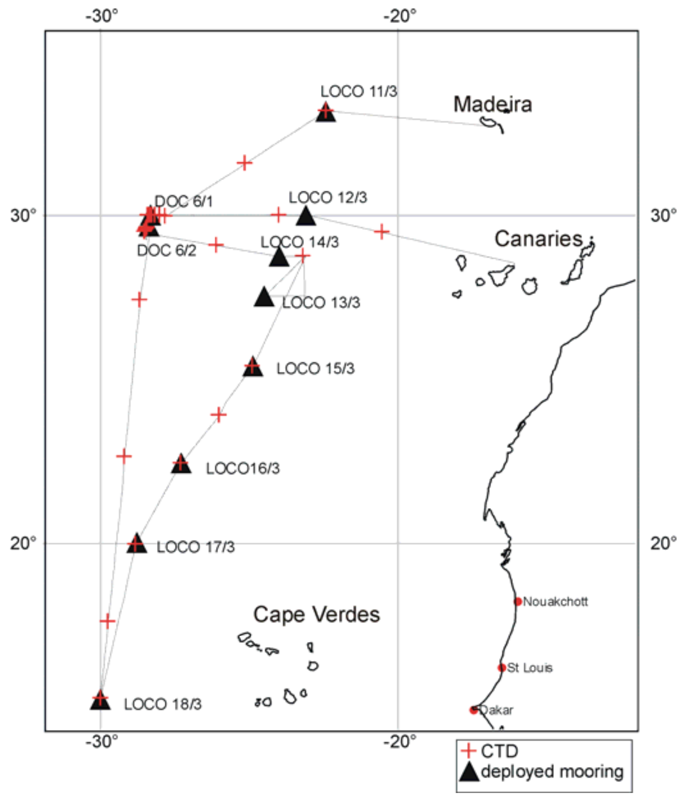



*Fig. 6. LOCO-IW06 cruise track and activity locations (M. Hiehle)*

**Wednesday 17 May**

16 UTC departure from Santa Cruz, Tenerife. Good weather conditions. Soon first sightings of dolphins.

**Thursday 18 May**

NE5. Transit to Canary Basin. 16 UTC first CTD/LADCP.

*(Photo: M. van Duijn)*

**Friday 19 May**

ENE4. 08 UTC Successful deployment mooring LOCO12/3. In the afternoon followed by successful recovery LOCO12/2. ARGO float (KNMI) deployed near 30N, 24W. 20 UTC calibration thermistorstrings. Of each string about 10% of the sensors fail (90% good).

**Saturday 20 May**

NE4-3. 19 UTC. Start CTD/LADCP transect up the eastern slope of GMS (along 30N). At the third station FLY winch shows problems.

**Sunday 21 May**

NNE3. 08.45 UTC. Deployment of DOC06-2, followed at the end of the morning by deployment of DOC06-1. 16 UTC Test Towed-ADCP. 18.05 UTC start 50h transect Towed ADCP in direction 213° from the top of GMS above the SSW slope.

**Monday 22 May**

N3. Continuation Towed-ADCP. At ~19 UTC the vehicle is lowered to 800 m depth.

**Tuesday 23 May**

ENE3. ~20 UTC. End of Towed-ADCP, 12 M (22 km) from the starting point. Set course to mooring location 14.

*(Photo: C. Tsimitri)*

**Wednesday 24 May**

ENE6. 14 UTC. CTD/LADCP and FLY. Continue steaming to mooring site. Around 29N, 27W a Red-billed Tropicbird, presumably from Cape Verde (according to Kees Camphuysen, NIOZ), stays with us a couple of hours during the afternoon.

**Thursday 25 May**

ENE5. 08 UTC. Deployment mooring LOCO14/3. By 17 UTC first attempt to contact acoustic releases mooring LOCO14/2. At a distance of about 7 km it seems contact is established and release commands are given. An hour later we know that false echos were heard. An extensive area of some 30 km across is searched visually and, foremost, acoustically until midnight, in vain. Set course to mooring LOCO13/2.

**Friday 26 May**

ENE4. 04 UTC. Argo float (KNMI) put overboard 28N, 23W. 07 UTC recovery of mooring LOCO13/2. 16 UTC deployment of mooring LOCO13/3. Return to position of mooring LOCO14/2.

**Saturday 27 May**

NE2-4. Entire day spent attempting to dredge the mooring LOCO14/2. By 22 UTC attempts are stopped. Negative result. We consider the mooring as lost, although we are uncertain of its existence.

**Sunday 28 May**

Var2. 15 UTC. Argo float (KNMI) put overboard 26N, 24.5W. 18 UTC deployment of mooring LOCO15/3.

**Monday 29 May**

N2, springtide. 09 UTC. Argo float (KNMI) put overboard 24N, 26W, sequence of 3 CTD/LADCP and 1 FLY for some open ocean eddy diffusivity estimates statistics.

**Tuesday 30 May**

Var1. 08 UTC deployment of mooring LOCO16/3, CTD/LADCP. Two more sightings of Red-billed Tropicbird, regular sightings of flying-fish (their favorite catch).

**Wednesday 31 May**

ENE4. 07 UTC deployment of mooring LOCO17/3, CTD/LADCP. Group of three Red-billed Tropicbird around the ship.

**Thursday 01 June**

ENE3, partly cloudy, humid. Reach southernmost position during cruise. 17 UTC deployment of mooring LOCO18/3, CTD/LADCP. Kees launches his ‘flessenpost’ as promised during the 2005 National Science Contest. We head back to Great Meteor Seamount.

**Friday 02 June**

NNE5. 18 UTC CTD/LADCP underway (17° 30'N).

**Saturday 03 June**

NE5. 21 UTC shortage noticed in CTD-winch cable. As resistance measurements show that it is at the far end, it us decided to wheel out the entire 6300 m via de stern, whilst steaming ~ 4 knots. A 50 kg weight is attached to the cable. Spooling is slow between 1500-3500 m.

**Sunday 04 June.**

NNE1-2. 02:15 UTC CTD-cable on board again, 25 m cut, shortage appeared in the very last turn. 08 UTC CTD/LADCP resumed.

**Monday 05 June**

N3. 19 UTC CTD/LADCP (27° 30'N).

**Tuesday 06 June**

NNW4. 10:30 UTC Multibeam mapping across mooring DOC06/2. 12 UTC start CTD/LADCP and FLY transect on SSE side of GMS (6 stations along towed-ADCP track).

*(Photo: C. Tsimitri)*

**Wednesday 07 June**

*Var2.* 01:30 UTC again shortage in CTD-winch cable. Same procedure as before, except that the first half hour we head for deeper water at full speed. During cable cut and repair now also possible sharp edges on the inside of the drum are smoothed. 08 UTC CTD-cable back on deck. 08:40 UTC start 25-hours yoyo-CTD/LADCP station above 2000 m, in the centre of the towed-ADCP track.

**Thursday 08 June**

NNE3. 09:15 UTC end of yoyo-CTD/LADCP. 10 UTC recovery mooring DOC06/2. 13 UTC recovery mooring DOC06/1. 17 UTC recovery mooring LOCO11/2. All, without any problems. For recovery of moorings including a thermistor string a new drum is constructed (photo previous page).

**Friday 09 June**

NW2. 13 UTC CTD/LADCP (31° 30’N).

**Saturday 10 June**

NW3. 07:30 UTC CTD/LADCP (33° 00’N). 11 UTC deployment LOCO11/3. For the first time both buoys are seen at the surface after the weight is dropped. Second buoy dives down quickly.

**Sunday 11 June**

16 UTC (17 LT). Arrival Funchal, Madeira.

*(Photo: E. Exarchou)*

## 7. Scientific summary and preliminary results

*a. Long-term mooring recoveries.*

All recoveries were done by approaching the buoy from the starboard side, with a line from the stern-winch laid out on the starboard side to the side-winch. From the side-winch deck a small dredge was thrown to catch the line between a small float and the surface buoy. This 20 m line was sufficient and easy to catch. The detachment of the large elliptical buoys from the mooring line was fairly easy due to the ~1 m chain below the upper buoy and on both sides of the inline buoy.

*a.1. Moorings LOCO11/2-13/2*

Three out of four moorings deployed during LOCO-IW04 were successfully recovered. The instrumental performance of these three moorings **LOCO11/2-13/2** was excellent (see Table 2). No bio-fouling was found, only one ARGOS-satellite beacon flooded and just minor corrosion was observed at IXSea (Oceano) acoustic releases.

One ADCP worked the entire intended period. The other stopped after 14 months, because the instrument was programmed ‘sharply’ and one battery pack turned out bad. Both instruments covered all of their range at fairly high signal-noise ratio as scatterers amounts were still fairly abundant between 800-1300 m.

The RCM-11 and the one RCM8 (from **LOCO11/2**) all worked as expected, providing good data over the entire period of 19 months, except for one T-sensor of an RCM-11 that was set in the wrong temperature range.

All 6 organic contaminant samplers (Fig. 7; details in van Haren, 2004) were successfully retrieved from moorings **LOCO12/2** and **LOCO13/2**. They were stored deep-frozen.

The mooring design will not be changed, as the present taught-wire design is very successful: we learned from the tilt- and pressure sensors 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.

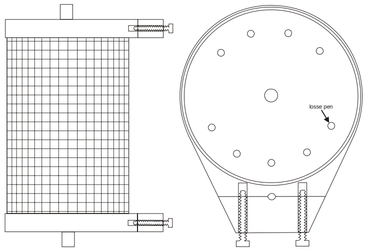


***Fig. 7.*** *Contaminant Sampler cage: sideview (left) and view from above/below (right).*

***Table 2. Data return of IW04 moorings. CM-abbreviations: A=Aanderaa; R=RDI; Sensors, A:C,R,T; R: C,R,T,p,tilt. (C=speed, R=direction, T=temperature, p=pressure).***

*Moorings deployed between 20-24 October 2004, recovered during LOCO-IW06*

| Mooring | Instrument | Serial# | depth [m] | sampl. int. [s] | remarks |
|---|---|---|---|---|---|
| *LOCO11/2* | R 75 kHz ADCP | 3174 | 1345 | 1800 | TML 28m; 14 mon. |
| | A RCM11 | 187 | 1460 | 900 | T low |
| | A RCM8 | 11826 | 2260 | 1800 | T low |
| | A RCM11 | 188 | 3015 | 900 | T arctic |
| | A RCM11 | 189 | 3760 | 900 | T arctic |
| | A RCM11 | 190 | 4355 | 900 | T arctic |
| *LOCO12/2* | R 75 kHz ADCP | 3175 | 1455 | 3600 | TML 40m |
| | LPDE/SPMD | 20 | 1456 | | contam. meter |
| | A RCM11 | 416 | 1550 | 1800 | T low |
| | A RCM11 | 414 | 2350 | 1800 | T arctic |
| | A RCM11 | 405 | 3100 | 1800 | T arctic |
| | LPDE/SPMD | 21 | 3102 | | contam. meter |
| | A RCM11 | 415 | 3850 | 1800 | no T |
| | A RCM11 | 406 | 4455 | 1800 | T arctic |
| | LPDE/SPMD | 22 | 3102 | | contam. meter |
| *LOCO13/2* | | | | | ARGOS beacon flooded |
| | LPDE/SPMD | 23 | 1345 | | contam. meter |
| | A RCM11 | 417 | 1435 | 900 | T low |
| | A RCM11 | 404 | 2035 | 900 | T arctic |
| | A RCM11 | 408 | 2785 | 900 | T arctic |
| | LPDE/SPMD | 24 | 2795 | | contam. meter |
| | A RCM11 | 192 | 3535 | 900 | T arctic |
| | A RCM11 | 193 | 4455 | 900 | T arctic |
| | LPDE/SPMD | 25 | 4965 | | contam. meter |

The perfect positioning of the moorings, so that positions are 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 falls well within the spectral resolution. This is verified using the major semidiurnal tidal constituent $M_2$. Near GMS, sample spectra show common internal wave kinetic energy spectra with familiar large peaks at tidal, inertial and higher harmonic frequencies (Fig. 8a). With increasing depth, stratification decreases and so does the kinetic energy across the entire spectrum (down to the white noise level). This is accompanied by a shift in inertial peak frequency. In general the known internal wave polarization was well-measured (Fig. 8b), the shift near the inertial frequency is unlikely due to barotropic diurnal tidal currents and is presently investigated. Peculiar is the large change in semidiurnal tidal polarization between the two depths that is probably related to topography.

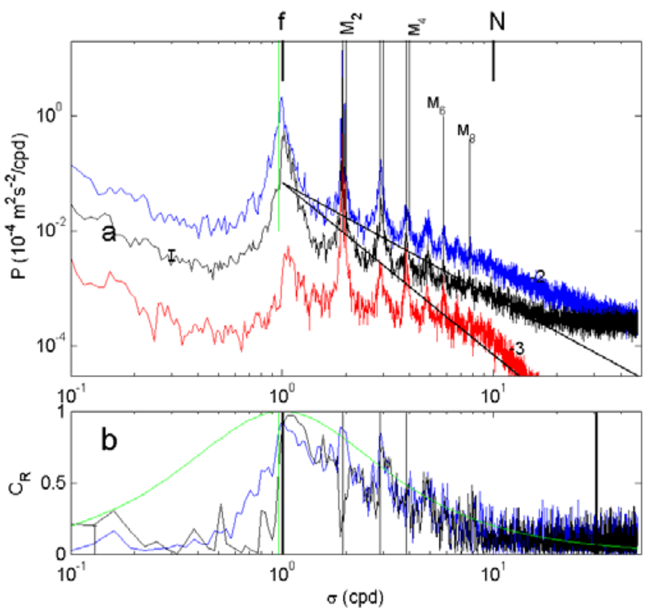



*Fig. 8. a. Kinetic energy spectra of current meters near 1400 m (blue) and 3000 m (black) in mooring LOCO11/2. In red temperature from 3000 m. b. Smoothed rotational spectrum of currents in a. In green the symmetric theory for symmetrically forced waves, in the internal wave band for frequencies larger than f (van Haren, 2003 for definitions).*

*a.2. Deep-dredging LOCO14/2*

During LOCO-IW06 no contact could be made with the acoustic releases of **LOCO14/2**. It was decided to dredge for it (at depths greater than 5000 m) using a weight with 3 dredge anchors on one end, 800 m steel cable, a second weight, which led 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 location. This was successfully done twice, in slightly different manners, but the mooring was not (partially) retrieved. It may not have been at position… No further attempts were undertaken.

*b. Short-term mooring deployment and retrieval*

Bottom lander **DOC06-1** was moored for 18 days near the top of the eastern slope of Great Meteor Seamount (Table 3). All instruments worked nearly flawlessly. The NIOZ-3 thermistor string (101 sensors at 0.5 m intervals) returned 90% good data during the entire period (Fig. 9). The CM, the ADCP (80 depth levels 1 m intervals) and the pressure sensor provided the full suite of data.

In contrast, nearly all instruments on mooring **DOC06-2** failed, as NIOZ-2 only gave 14 h of data due to renewed recorder problems, whilst the two Valeport CM were programmed sampling too fast for their like.

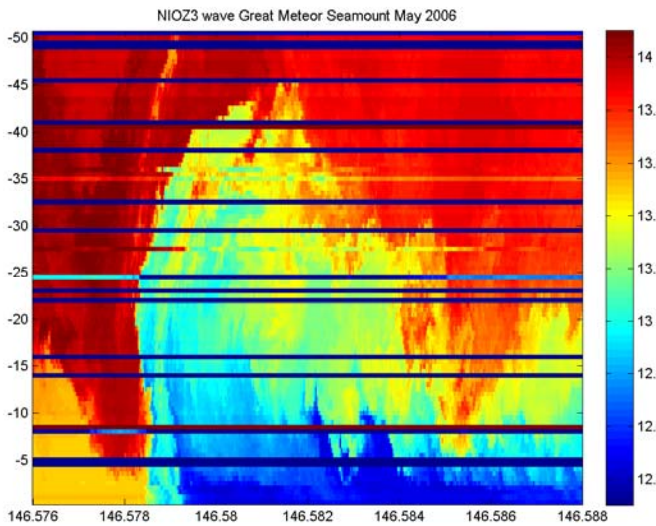



*Fig. 9. Nearly 17 minutes of NIOZ-3 data in 50 m above the bottom, showing passage of large overturning wave in. The horizontal lines are partially bad sensors and partially poor calibration (that needs further treatment using a second calibration).*

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

*LOCO-IW04 mooring between* **21/05/06 - 08/06/06 at** 30°00.052'N 028°18.802'W 549 m

| Mooring | Instrument | Serial# | depth [m] | sampl. int. [s] | remarks |
|---|---|---|---|---|---|
| *DOC06-1* | N AquaDopp | 4/02 | 400 | 5 | |
| | FT-string | NIOZ-3 | 548.5(lows.) | 1 | 5% sens. fail; 5% need recal. |
| | 300 kHz ADCP | 6227 | 544.5(fb) | 2 | TM2.6 m |
| | N AquaDopp | 1/02 | 547.25 | 5 | |
| | SBE53 BPR | 97179 | 547.25 | 3 | modified version |

*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.

*c.1. Moorings LOCO11/3-18/3*

Eight long (~3.7 km) moorings were deployed between 15-33ºN roughly along 28ºW (Fig. 6; Table 4). Positioning of moorings is done as during LOCO-IW04: 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. 10). The final position was always well within ±100 m north/south of the sailed latitude.

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

***Table 4. Mooring positions LOCO-IW06, ARGOS and local inertial frequencies f (with harmonic diurnal tidal names between brackets). Depths are echo sounder estimates.***

| *Mooring* | *Latitude* | *Longitude* | *depth* | *f* | *ARGOS* |
|---|---|---|---|---|---|
| LOCO11/3 | 33°00.010’N | 022°24.406’W | 5274 m | 1.092260 cpd | 22686 |
| LOCO12/3 | 29°59.948’N | 023°04.841’W | 5139 m | 1.002711 cpd ($K_1$) | 22621 |
| LOCO13/3 | 27°36.737’N | 024°29.802’W | 5146 m | 0.929510 cpd ($O_1$) | 22312 |
| LOCO14/3 | 28°47.992’N | 023°59.620’W | 5110 m | 0.966142 cpd ($M_1$) | 23007 |
| LOCO15/3 | 25°29.958’N | 024°52.696’W | 5158 m | 0.863367 cpd | 22580 |
| LOCO16/3 | 22°29.615’N | 027°18.965’W | 5396 m | 0.767255 cpd | 21467 |
| LOCO17/3 | 19°59.977’N | 028°48.383’W | 4908 m | 0.685900 cpd | 20378 |
| LOCO18/3 | 14°59.870’N | 030°00.304’W | 5390 m | 0.518981 cpd | 23004 |

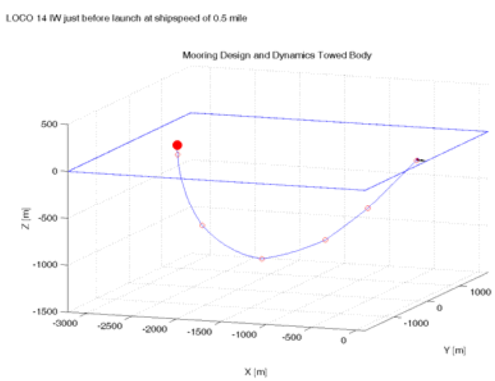



*Fig. 10. Estimated mooring line at moment of release of anchor (computed by T. Hillebrand using program by R. Dewey,Uvic Canada).*

*(Photo: P. van Breevoort). Preparation of CM.*

***Table 6. Long-term mooring details IW06*** ***(A=Aanderaa; R=RDI; N = Nortek; V=Valeport).***
*Moorings deployed between* **19 May – 10 June 2006**

| Mooring | Instrument | Serial# | depth [m] | sampl. int. [s] | remarks |
|---|---|---|---|---|---|
| *LOCO11/3* | R 75 kHz ADCP | 3174 | 1350 | 1800 | 60 10m bins; DOWN look. |
| | FT-string | NIOZ3 | 1490(ls) | 1 | 54 sensors at 2.5 m intervals |
| | A RCM11 | 188 | 1600 | 900 | T-LOW |
| | N AquaDopp | 4/02 | 2300 | 900 | 30 sam diag/day |
| | A RCM11 | 189 | 3050 | 900 | T-arctic |
| | A RCM11 | 190 | 3800 | 900 | T-arctic |
| | N AquaDopp | 1/02 | 4550 | 900 | 30 sam diag/day |
| *LOCO12/3* | R 75 kHz ADCP | 5945 | 1250 | 1800 | 50 10m bins; UP look. |
| | A RCM11 | 200 | 1350 | 1200 | T-LOW |
| | A RCM11 | 48 | 2150 | 1200 | T-arctic |
| | A RCM11 | 240 | 2900 | 1200 | T-arctic; 1800? |
| | A RCM11 | 123 | 3650 | 1200 | T-arctic |
| | A RCM11 | 36 | 4250 | 1200 | T-arctic |
| *LOCO13/3* | V BFM-308 | 20643 | 1150 | 300 | 12x5 s. |
| | V BFM-308 | 20636 | 1650 | 300 | 12x5 s. |
| | N AquaDopp | 2/04 | 2350 | 900 | 30 sam diag/day |
| | A RCM11 | 406 | 3100 | 900 | T-arctic |
| | A RCM11 | 415 | 3850 | 900 | T-arctic |
| | N AquaDopp | 2/02 | 4450 | 900 | 30 sam diag/day |
| *LOCO14/3* | R 75 kHz ADCP | 3175 | 1650 | 1800 | 60 10m bins; UP look. |
| | V BFM-308 | 23121 | 1750 | 300 | 12x5 s. |
| | N AquaDopp | 1/04 | 2450 | 900 | 30 sam diag/day |
| | A RCM11 | 416 | 3200 | 900 | T-arctic |
| | A RCM11 | 414 | 3950 | 900 | T-arctic |
| | N AquaDopp | 3/02 | 4550 | 900 | 30 sam diag/day |
| *LOCO15/3* | V BFM-308 | 23120 | 1497.5 | 300 | 12x5 s. |
| | V BFM-308 | 20637 | 1500 | 300 | 12x5 s. |
| | N AquaDopp | 8/02 | 2200 | 900 | 30 sam diag/day |
| | A RCM11 | 202 | 2950 | 1200 | T-arctic |
| | A RCM11 | 132 | 3700 | 1200 | T-arctic |
| | N AquaDopp | 7/02 | 4450 | 900 | 30 sam diag/day |
| *LOCO16/3* | R 75 kHz ADCP | 3550 | 1500 | 1800 | 60 10m bins; UP look. |
| | A RCM9 | 341 | 1600 | 1200 | T-LOW |
| | N AquaDopp | 20126-3 | 2300 | 900 | 30 sam diag/day |
| | A RCM11 | 404 | 3050 | 900 | T-arctic |
| | A RCM11 | 405 | 3800 | 900 | T-arctic |
| | N AquaDopp | 6/02 | 4600 | 900 | 30 sam diag/day |
| *LOCO17/3* | V BFM-308 | 20641 | 1550 | 300 | 12x5 s. |
| | N AquaDopp | 20126-4 | 2250 | 900 | 30 sam diag/day |
| | A RCM11 | 408 | 3750 | 900 | T-arctic |
| | A RCM11 | 417 | 4350 | 900 | T-arctic |
| *LOCO18/3* | R 75 kHz ADCP | 6778 | 1400 | 1800 | 60 10m bins; UP look. |
| | A RCM11 | 44 | 1500 | 1200 | T-LOW; leak. in MZC |
| | N AquaDopp | 20126-1 | 2200 | 900 | 30 sam diag/day |
| | A RCM11 | 192 | 2950 | 900 | T-arctic |
| | A RCM11 | 193 | 3800 | 900 | T-arctic |
| | N AquaDopp | 20126-2 | 4600 | 900 | 30 sam diag/day |

*d. CTD sampling*

The CTD operations were 'normal'. The instrument, deck unit and the winch generally worked very fine. However, due to the great depths we were working at (>5500 m, with occasionally 5800 m cable out) and the relatively short CTD-cable (~6300 m) we experienced shortage in the cable twice. This happened when the last layer of turns on the drum was visible. Shortage occurred at the turn just before the cable went through the side of the drum. Due to swift action of crew and technicians the entire cable was paid out to sea via the stern whilst steaming. Entire operation of repair was done within 6 hours.

The density-depth profiles were quite simple as before, with a main pycnocline between 100-1100 m and weak stratification below 1500 m (Fig. 4). 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 and IW04. Extremely weak stratification ($N \sim f$; $\sim 0.7\ 10^{-4}\ s^{-1}$) was only found very near the bottom. Details of variation in N and steppiness across the critical diurnal latitude require further investigation.

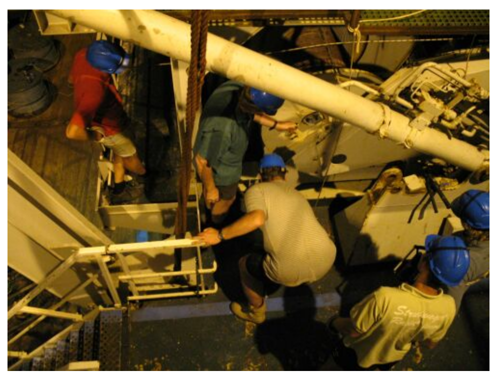


*Photo (P. van Breevoort): CTD-cable repair.*

*e. LADCP (by C. Veth)*

The LADCP-system has been applied during all regular CTD-casts. The two ADCP's are positioned in a "Janus configuration", which means that one is looking downward and the other upward from the CTD-frame. With this system water velocity profiles were measured from surface to bottom for depth intervals of 20m (or minimally 8 m). In the beginning of the cruise some technical problems were encountered that have been solved after replacement of the communication cables between the two ADCP's and the battery pack. Probably a technical fault in one of these cables caused a serious voltage drop of the power necessary for the instruments to function.

Spatial shear spectra derived from the LADCP velocity profiles will be used to estimate the vertical turbulent diffusivity Kz. Although this method is rather crude, relative comparison can be made for profiles at different latitudes and bottom topography circumstances. The figure shows the series of velocity profiles at the 24-hours yo-yo-station at the GMS flank.

*f. Yoyo-CTD/LADCP (by T. Gerkema)*

Over a period of 24 hours, in the centre of the towed-ADCP track above GMS (see Section 7.h) the ship was kept at a fixed position whilst repeatedly yoyo-ing the CTD-LADCP system. The purpose was to establish internal wave fluxes from these complete surface-bottom high-detailed profiles near an important internal tidal wave source. The computed semidiurnal tidal flux-estimates from these data amount 2.5±0.1 kW/m and compare very well (to within 10%) with flux estimates from a numerical model. The contoured CTD-data (Fig. 11) surprisingly showed a layering in dominant semidiurnal tidal motions (upper 600 m), above less-well discernible dominant diurnal tidal motions (600-1200 m) and dominant fourth diurnal motions (1200-2000 m).

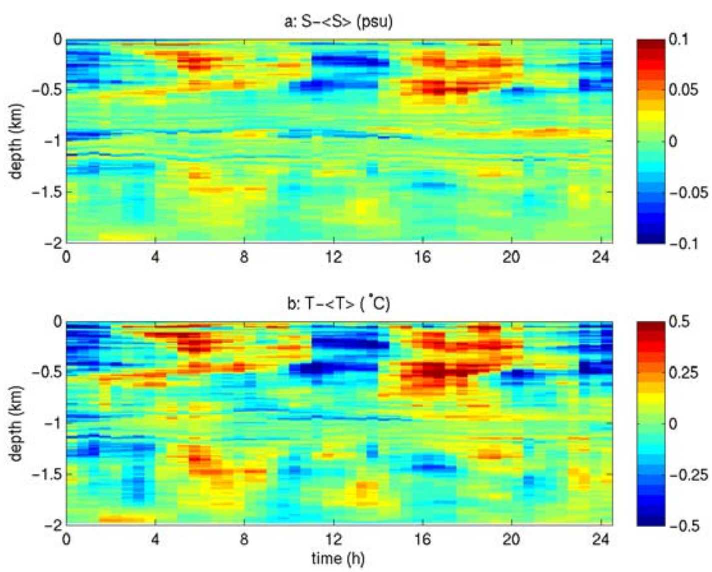



*Fig. 11. Yoyo-CTD variation data: 20 profiles in 24 hours. a. Salinity. b. Temperature.*

*g. FLY microstructure profiler (C. Veth & M. Laan)*

At a number of selected stations microstructure measurements were done with the completely modified FLY-II. The older version of the instrument was limited by the instrumental noise, probably vibrations, but acceleration detectors have added to the system to determine the instrumental motions during a drop. Software to apply these acceleration data to subtract instrumental vibrations from the turbulence signal is under construction.

With the microstructure data from the FLY the rate of dissipation of turbulent kinetic energy $\varepsilon$ can be calculated. This quantity, combined with data from the CTD-system and the LADCP-velocity profiles will give insight in the turbulent structure of the water column at the station. For that reason Fly drops have always been performed in combination with a CTD/LADCP-cast.

In a technical/operational sense the FLY worked well. It was necessary to replace the shear sensors, but this was an expected replacement, because the shear sensors have a limited lifetime. The handling of the winch system with line-puller worked without serious problems. Due to rescaling of the pressure sensor, it was possible to go to deeper depths than before. The new depth record with the FLY is now over 1900 m. The sensors did not show pressure damage from dropping to this depth.

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.

*(Photo P. van Breevoort: launching FLY)*

*h. Deep-towed ADCP's above GMS*

A sequence of the deep towed-ADCP was performed for a consecutive period of 24 hours (4 semidiurnal, or 2 diurnal, tidal periods) above the steep south-western 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 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 entire procedure of sailing a towed body is rather complex, and the manual resulting from previous tests is strictly followed here (van Sebille, Loeve and Huisman, 2004). Tow speed was 3 knots and two sections of ~12 km length were sampled 11 times each. The towing depths were 200 and 800 m. Due to the steepness of the slope, the tow transects overlapped by about 2 km. The direction of the transect was 213°TN (return: 33°TN), with starting point at 29°41.12´N, 28°23.34´W (water depth 292 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. Instrumental tilt was never more than 5° ensuring the good data quality and sufficient depth range. During the towing with the frame at a depth of 200 m the online depth variations were generally within reasonable limits. However, although previous tests showed exactly the tolerance of ship' speed translated in depth variations of the instrument package and sailing speed was generally kept constant within the preferred tolerance of ±0.1knots, vertical variations sometimes were as large as ±40 m when the towed body was at 800 m. Presumably, deep currents were substantial ~0.4 knots, thus off-setting the towed body. This stressed that in future tows on-line depth knowledge is necessary for commanding ship speed variations. Such information was not available here despite the electric cable in the Kevlar, due to electrical connections problems. Likewise, the vessel mounted ADCP (capable of surveying between 0-600 m) was not available due to poor installation.

Nonetheless, already in the raw towed-ADCP data a banding of enhanced and weakened currents can be seen, but it is too early to conclude observational evidence of internal tidal beams.

### More References

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*(Photo: E. Exarchou)*

## 8. Achnowledgments

On behalf of the participants, I would like to thank captain Kees de Graaff and the crew of R.V. Pelagia for the very pleasant cooperation. Funding by the Netherlands Organization for the advancement of Scientific Research and BSIK is gratefully acknowledged.

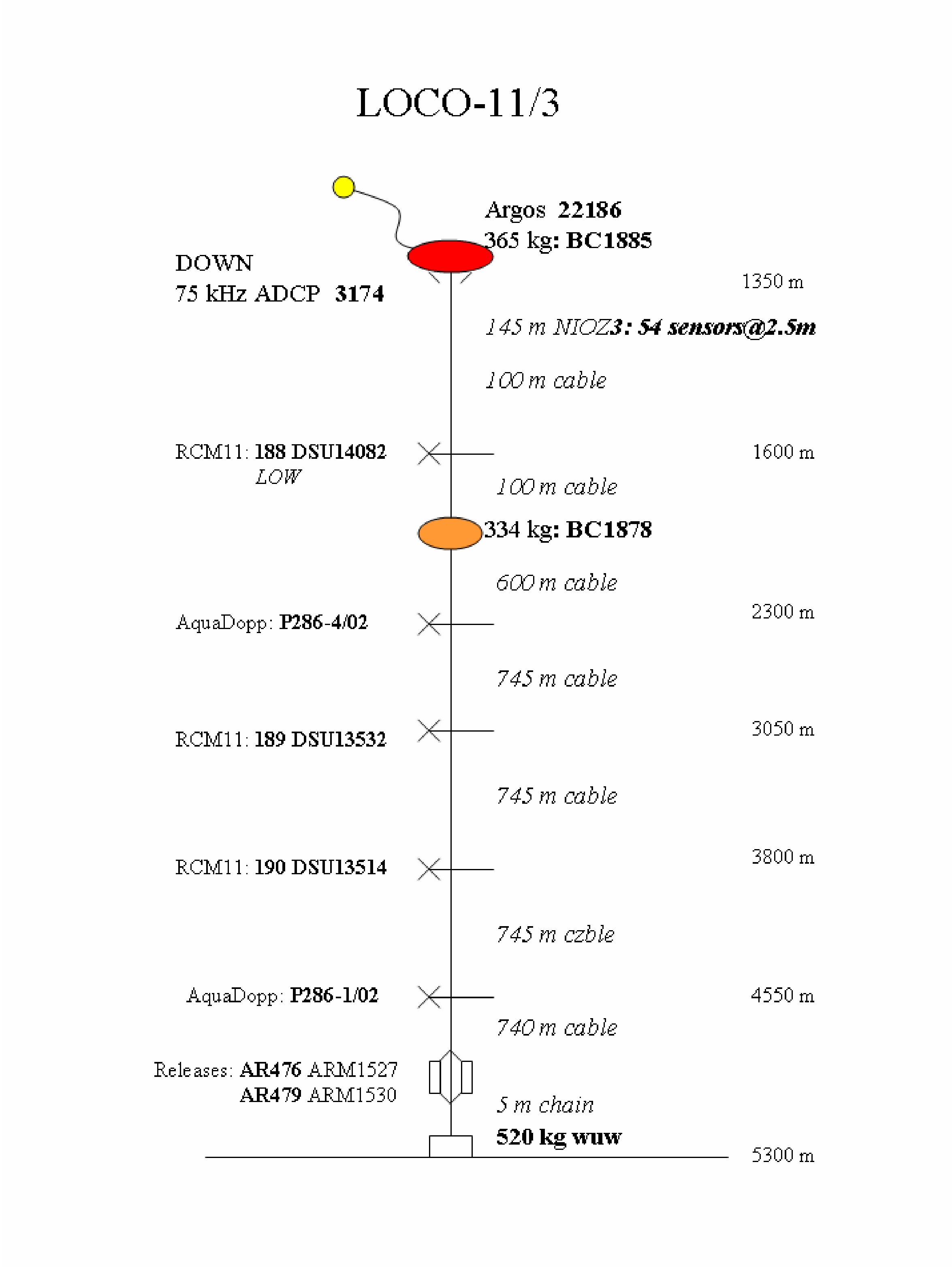
July 2006,

Hans van Haren

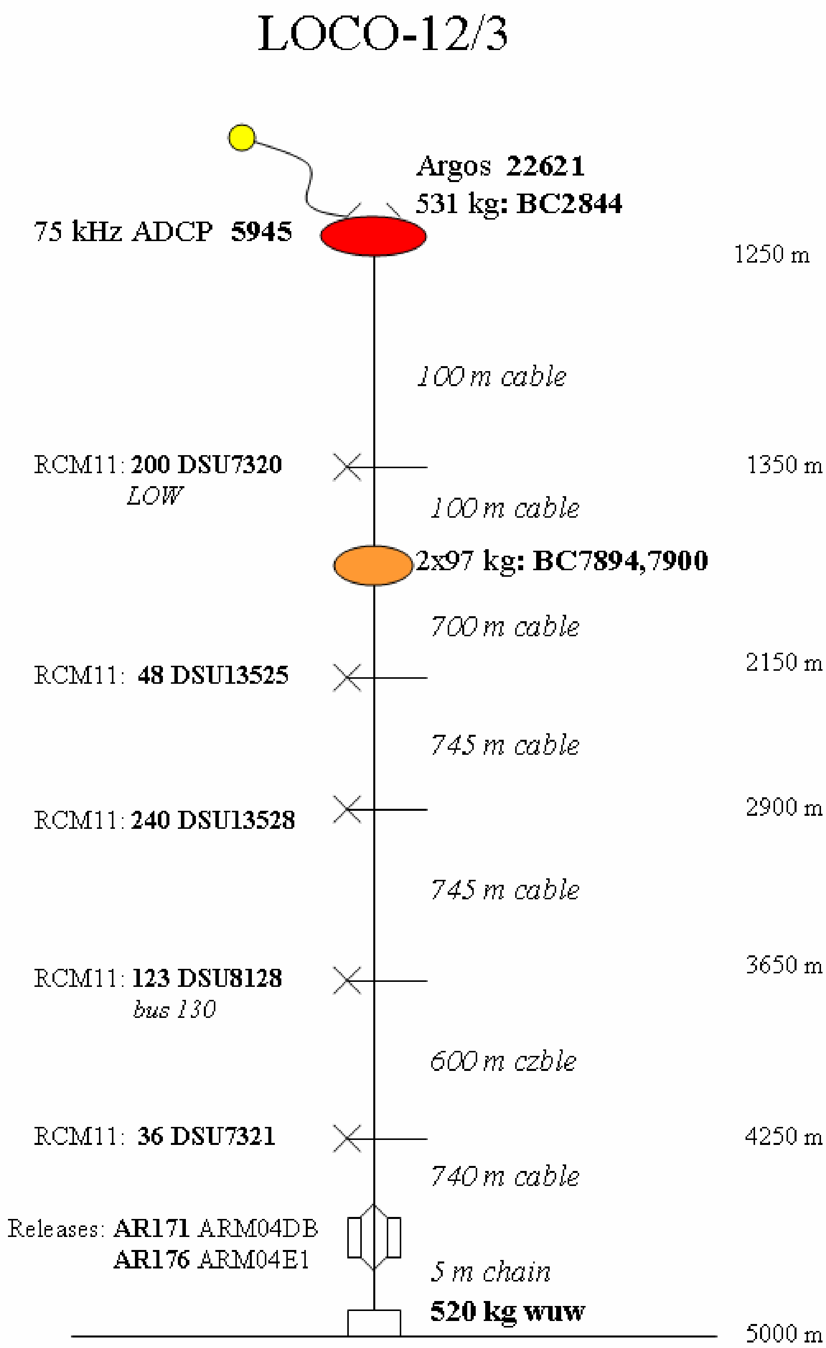
*(Photo: Y. Witte)*

**Appendix A Mooring diagrams LOCO-IW06 (*by Dept. MTM & T. Hillebrand*)**

***LOCO11/3***



***LOCO12/3***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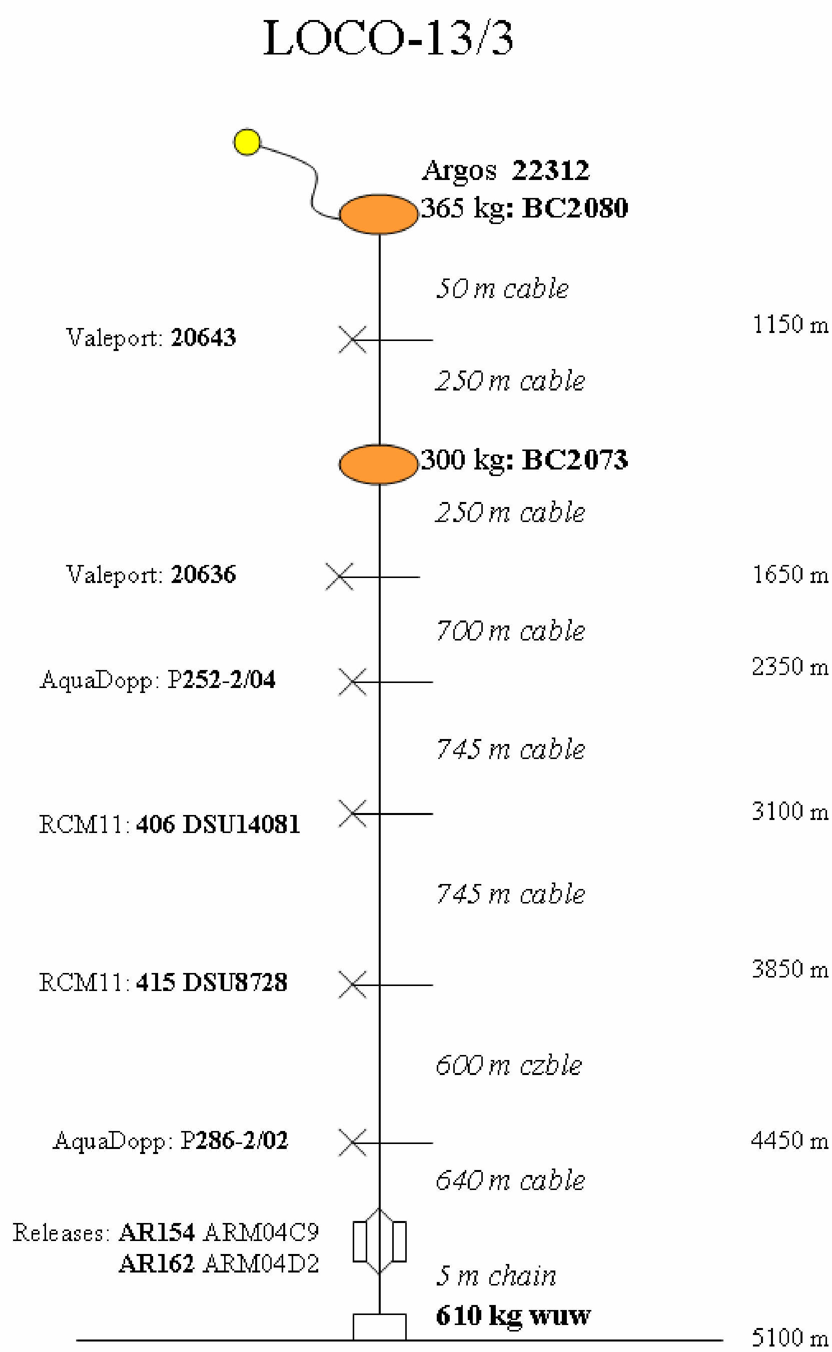
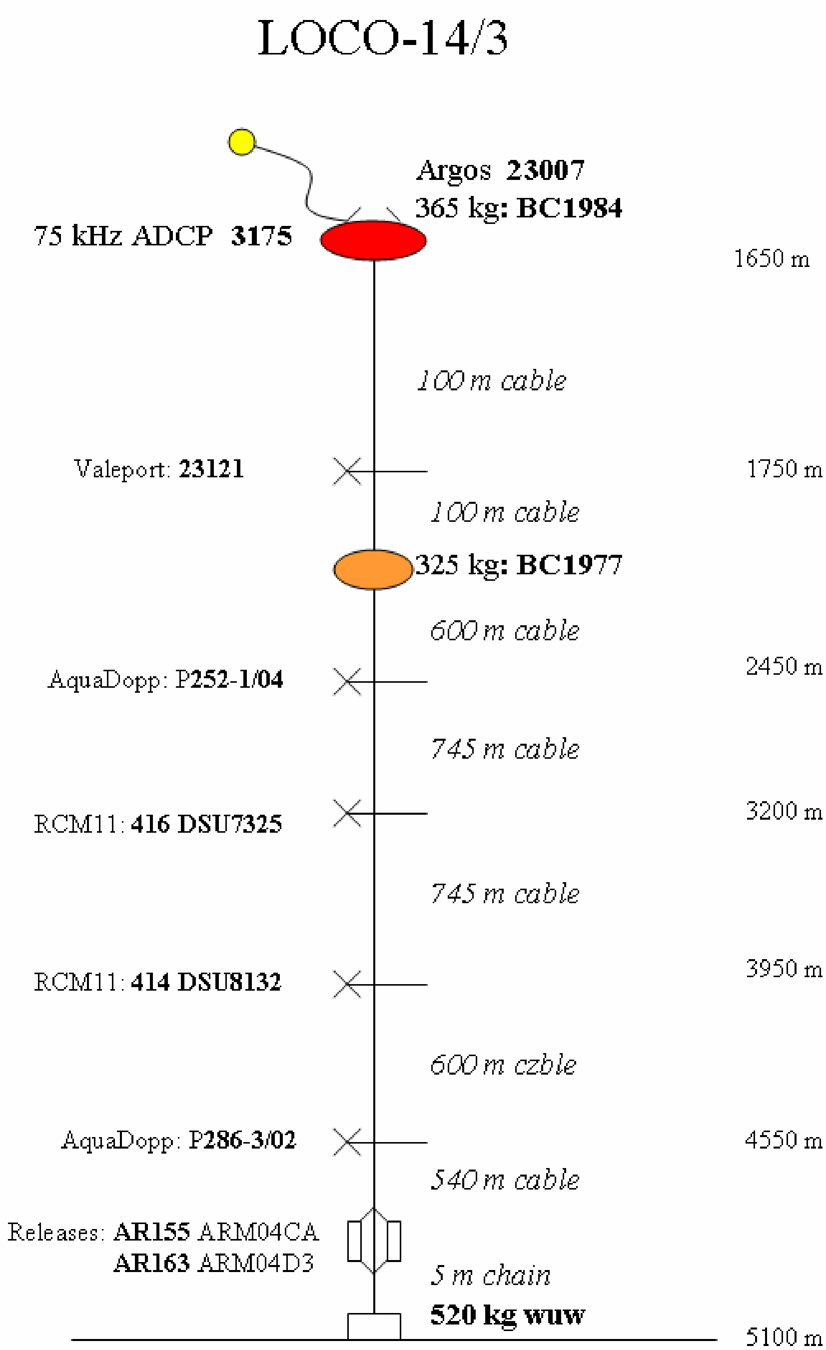
Argos 22621
531 kg: BC2844
75 kHz ADCP 5945
1250 m
100 m cable
RCM11: 200 DSU7320
LOW
1350 m
100 m cable
2x97 kg: BC7894,7900
700 m cable
RCM11: 48 DSU13525
2150 m
745 m cable
RCM11: 240 DSU13528
2900 m
745 m cable
RCM11: 123 DSU8128
bus 130
3650 m
600 m czble
RCM11: 36 DSU7321
4250 m
740 m cable
Releases: AR171 ARM04DB
AR176 ARM04E1
5 m chain
520 kg wuw
5000 m

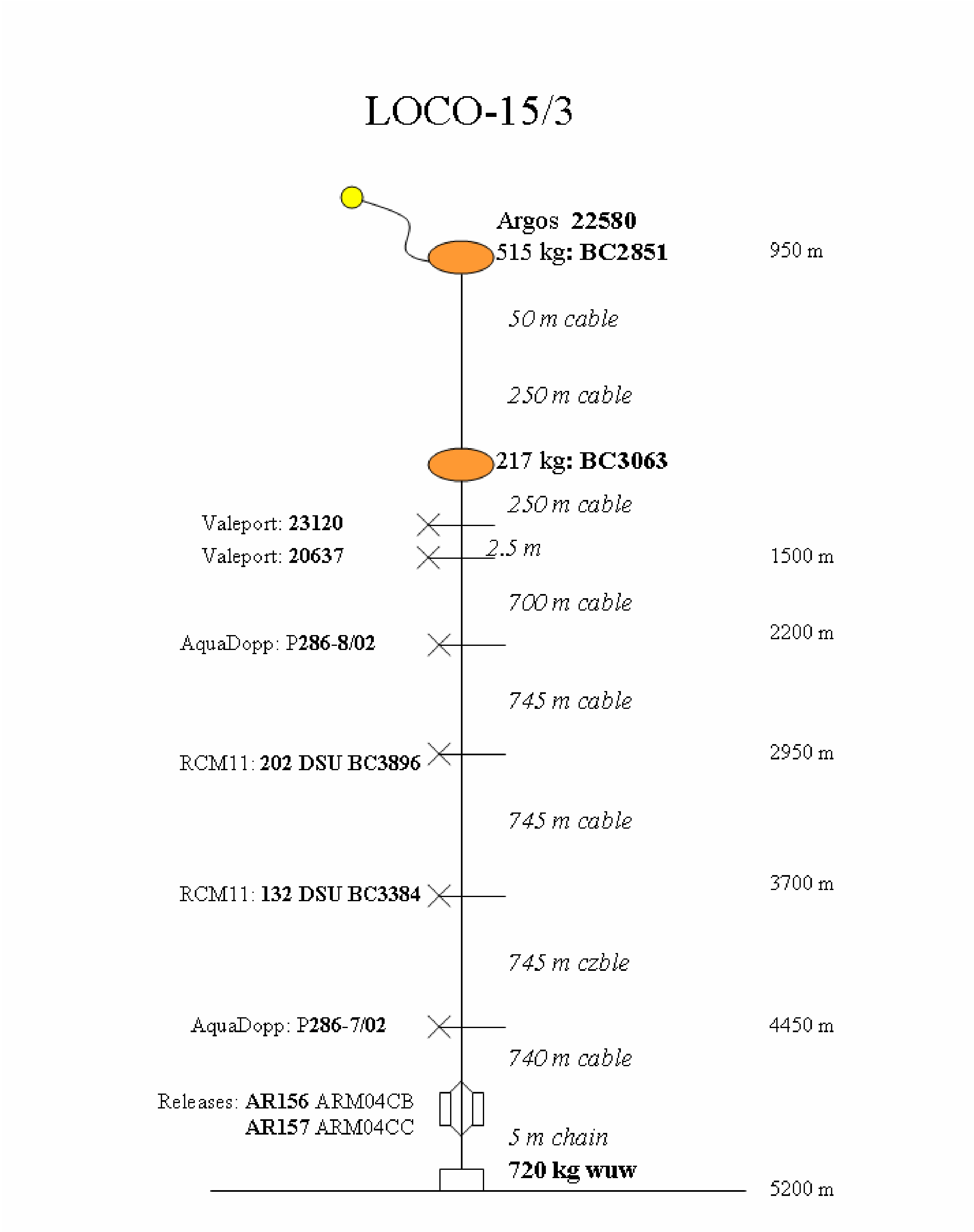
*LOCO13/3*


LOCO-13/3
Argos 22312
365 kg: BC2080
50 m cable
Valeport: 20643
1150 m
250 m cable
300 kg: BC2073
250 m cable
Valeport: 20636
1650 m
700 m cable
AquaDopp: P252-2/04
2350 m
745 m cable
RCM11: 406 DSU14081
3100 m
745 m cable
RCM11: 415 DSU8728
3850 m
600 m czble
AquaDopp: P286-2/02
4450 m
640 m cable
Releases: AR154 ARM04C9
AR162 ARM04D2
5 m chain
610 kg wuw
5100 m

***LOCO14/3***

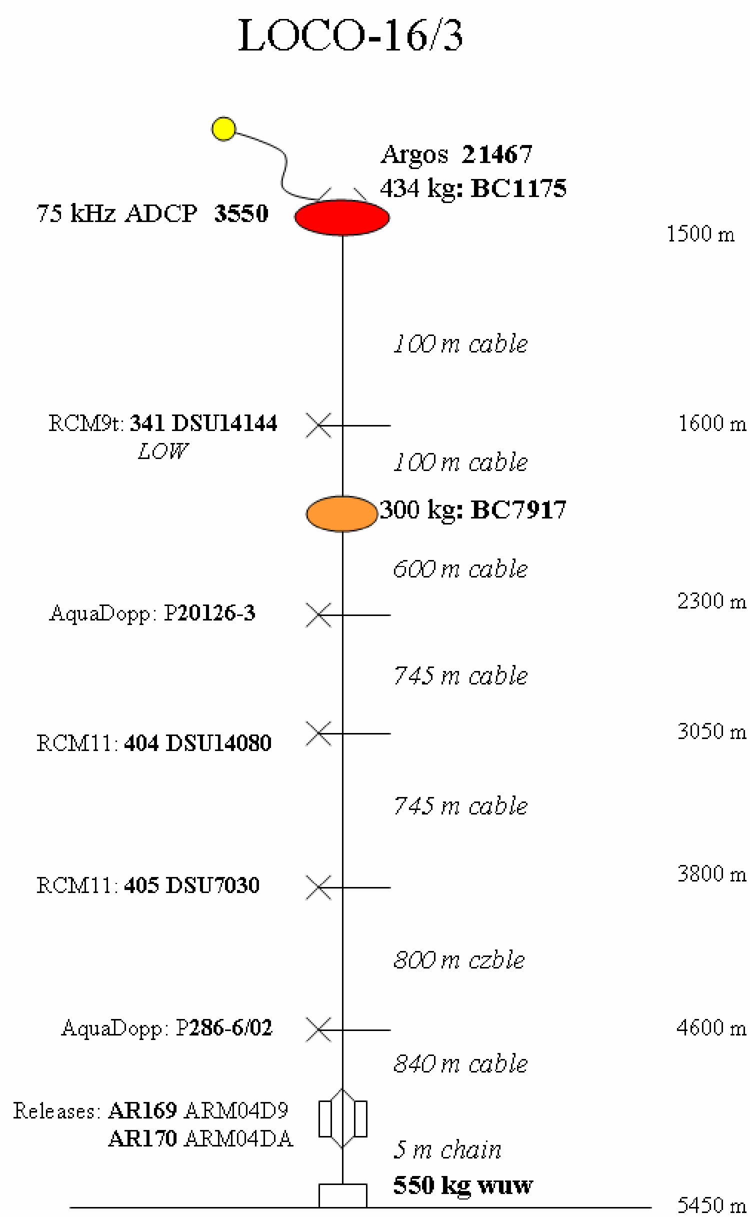

LOCO-14/3
Argos 23007
365 kg: BC1984
75 kHz ADCP 3175
1650 m
100 m cable
Valeport: 23121
1750 m
100 m cable
325 kg: BC1977
600 m cable
AquaDopp: P252-1/04
2450 m
745 m cable
RCM11: 416 DSU7325
3200 m
745 m cable
RCM11: 414 DSU8132
3950 m
600 m czble
AquaDopp: P286-3/02
4550 m
540 m cable
Releases: AR155 ARM04CA
AR163 ARM04D3
5 m chain
520 kg wuw
5100 m

***LOCO15/3***

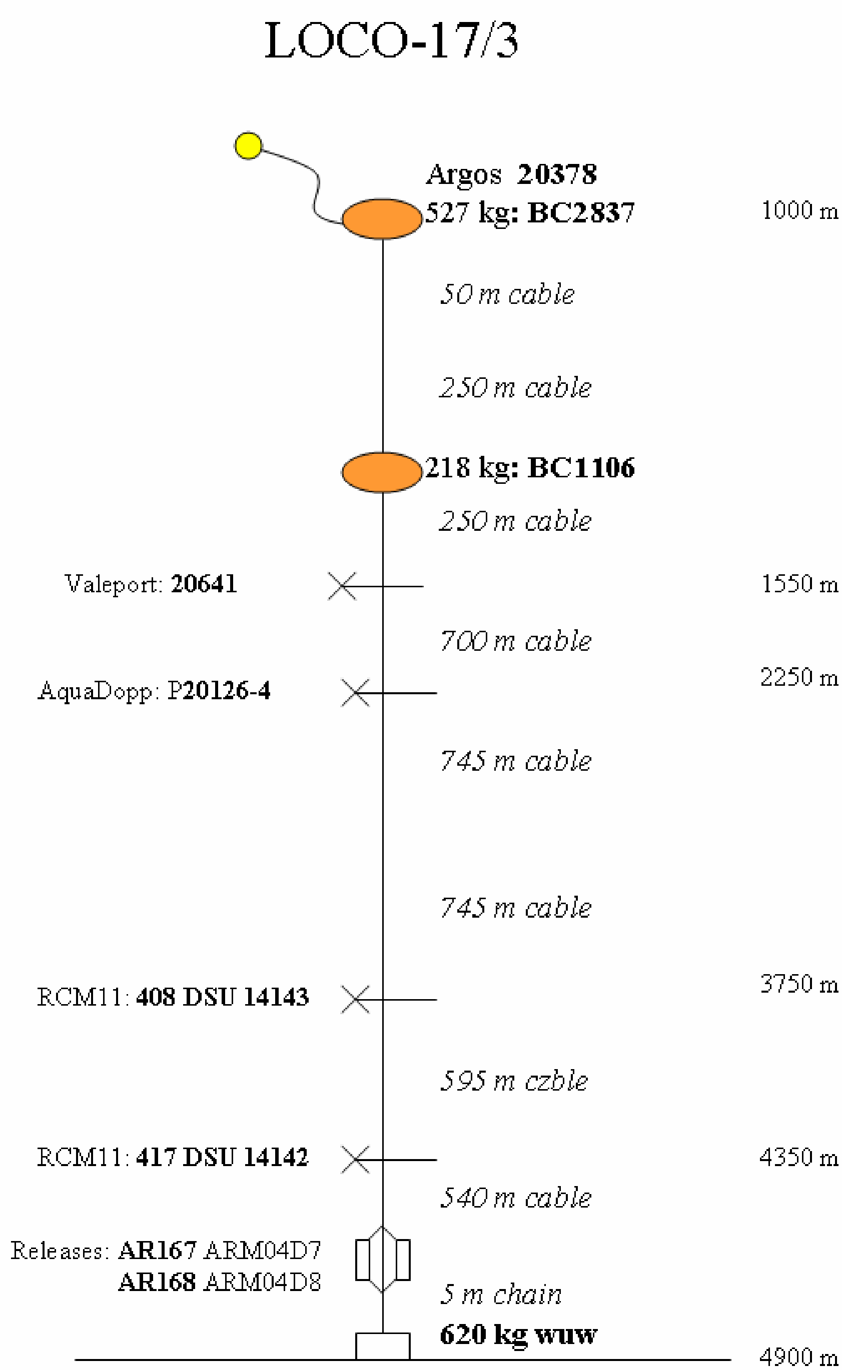


LOCO-15/3
Argos 22580
515 kg: BC2851
950 m
50 m cable
250 m cable
217 kg: BC3063
250 m cable
Valeport: 23120
Valeport: 20637
2.5 m
1500 m
700 m cable
AquaDopp: P286-8/02
2200 m
745 m cable
RCM11: 202 DSU BC3896
2950 m
745 m cable
RCM11: 132 DSU BC3384
3700 m
745 m czble
AquaDopp: P286-7/02
4450 m
740 m cable
Releases: AR156 ARM04CB
AR157 ARM04CC
5 m chain
720 kg wuw
5200 m

***LOCO16/3***

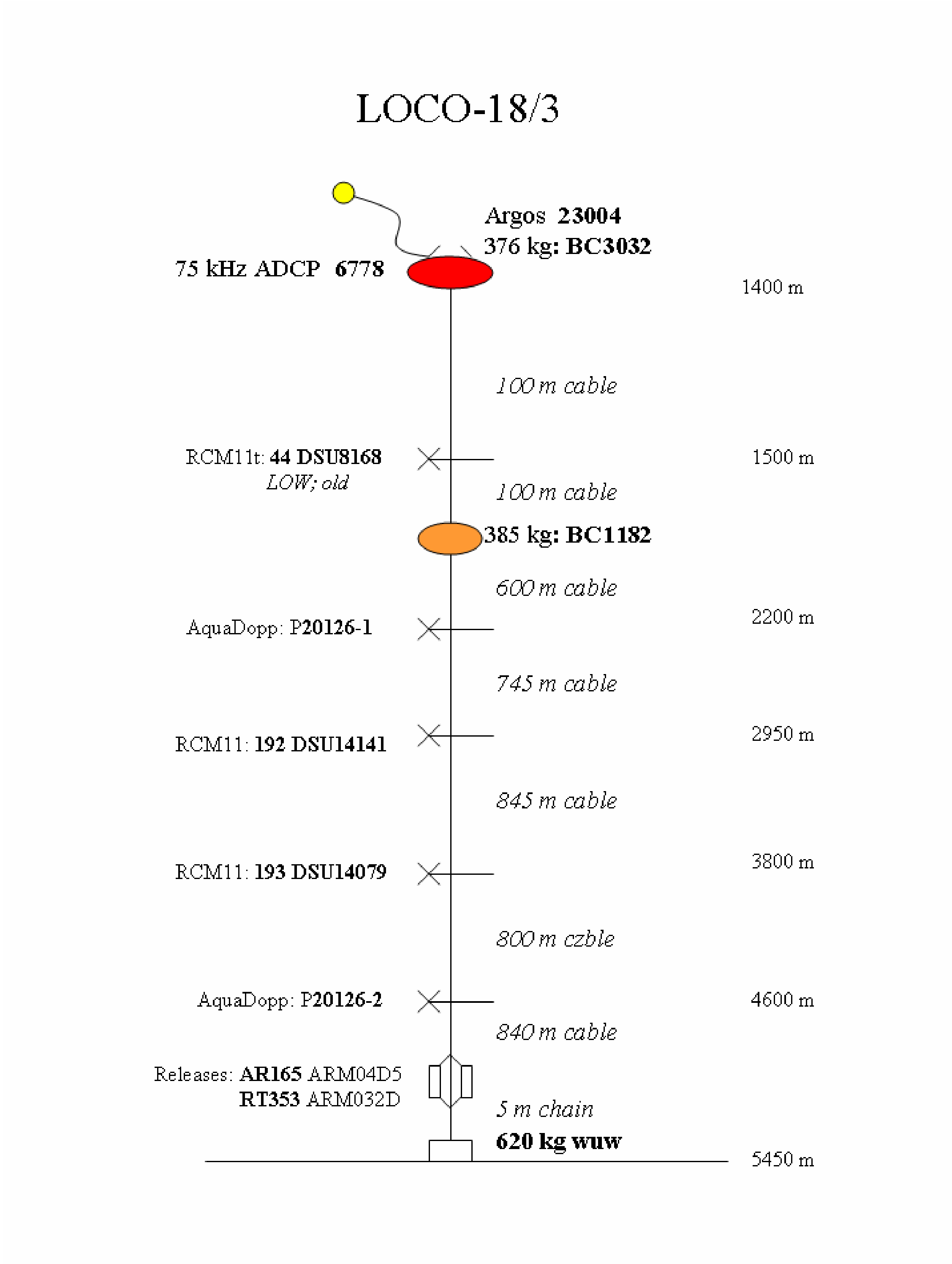

LOCO-16/3
Argos 21467
434 kg: BC1175
75 kHz ADCP 3550
1500 m
100 m cable
RCM9t: 341 DSU14144
LOW
1600 m
100 m cable
300 kg: BC7917
600 m cable
AquaDopp: P20126-3
2300 m
745 m cable
RCM11: 404 DSU14080
3050 m
745 m cable
RCM11: 405 DSU7030
3800 m
800 m czble
AquaDopp: P286-6/02
4600 m
840 m cable
Releases: AR169 ARM04D9
AR170 ARM04DA
5 m chain
550 kg wuw
5450 m

***LOCO17/3***



LOCO-17/3
Argos 20378
527 kg: BC2837
1000 m
50 m cable
250 m cable
218 kg: BC1106
250 m cable
Valeport: 20641
1550 m
700 m cable
2250 m
AquaDopp: P20126-4
745 m cable
745 m cable
RCM11: 408 DSU 14143
3750 m
595 m czble
RCM11: 417 DSU 14142
4350 m
540 m cable
Releases: AR167 ARM04D7
AR168 ARM04D8
5 m chain
620 kg wuw
4900 m

***LOCO18/3***



LOCO-18/3
Argos 23004
376 kg: BC3032
75 kHz ADCP 6778
1400 m
100 m cable
RCM11t: 44 DSU8168
LOW; old
1500 m
100 m cable
385 kg: BC1182
600 m cable
AquaDopp: P20126-1
2200 m
745 m cable
RCM11: 192 DSU14141
2950 m
845 m cable
RCM11: 193 DSU14079
3800 m
800 m czble
AquaDopp: P20126-2
4600 m
840 m cable
Releases: AR165 ARM04D5
RT353 ARM032D
5 m chain
620 kg wuw
5450 m

***Appendix B Cruise summary of stations (activities) of LOCO-IW06* (M. Hiehle*)***

| Station | Cast | Type | Event | date 2006 | time | Latitude | Longitude | Depth m | name mooring |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | CTD | Begin | May 18 | 16:11:02 | 29.50770 | -20.51732 | 4707 | |
| 2 | 1 | Mooring deployment | ground | May 19 | 11:50:14 | 29.99745 | -23.09137 | 5140 | LOCO 12/3 |
| 3 | 1 | Mooring recovery | released | May 19 | 13:21:34 | 29.99982 | -23.13892 | 5140 | LOCO 12/2 |
| 4 | 1 | CTD_Thermistor | Begin | May 19 | 20:36:01 | 30.00422 | -23.97502 | 5292 | |
| 4 | 2 | ARGO float | Begin | May 19 | 21:52:13 | 29.99893 | -23.98573 | 5292 | |
| 4 | 3 | CTD | Begin | May 19 | 22:02:36 | 29.99948 | -23.98708 | 5292 | |
| 5 | 1 | CTD | Begin | May 20 | 18:49:52 | 30.00030 | -28.00038 | 3963 | |
| 5 | 2 | FLY | Begin | May 20 | 21:17:48 | 29.99997 | -28.00240 | 3963 | |
| 6 | 1 | CTD | Begin | May 20 | 23:14:58 | 29.99998 | -28.15075 | 2993 | |
| 6 | 2 | FLY | Begin | May 21 | 01:09:06 | 30.00052 | -28.15147 | 2981 | |
| 7 | 1 | CTD | Begin | May 21 | 02:41:06 | 29.99998 | -28.24998 | 2530 | |
| 7 | 2 | FLY | Begin | May 21 | 03:47:25 | 29.99993 | -28.25007 | 2530 | |
| 8 | 1 | CTD | Begin | May 21 | 04:59:53 | 29.99965 | -28.29987 | 575 | |
| 8 | 2 | FLY | CANCEL | May 21 | 05:23:25 | 29.99968 | -28.30148 | 581 | |
| 9 | 1 | CTD | Begin | May 21 | 05:51:05 | 29.99988 | -28.34945 | 430 | |
| 10 | 1 | CTD | Begin | May 21 | 06:31:42 | 29.99998 | -28.39948 | 332 | |
| 11 | 1 | Lander deployment | ground | May 21 | 09:12:16 | 30.00183 | -28.31418 | 547 | DOC 6/1 |
| 12 | 1 | Mooring deployment | ground | May 21 | 12:00:16 | 29.68388 | -28.36428 | 419 | DOC 6/2 |
| 13 | 1 | Towed_ADCP | SOL 1 | May 21 | 18:05:23 | 29.68300 | -28.38962 | 297 | |
| 13 | 1 | Towed_ADCP | SOL 2 | May 21 | 20:30:10 | 29.59227 | -28.46057 | | |
| 13 | 1 | Towed_ADCP | SOL 3 | May 21 | 22:52:26 | 29.68300 | -28.38945 | 302 | |
| 13 | 1 | Towed_ADCP | SOL 4 | May 22 | 01:14:41 | 29.59222 | -28.46052 | 2390 | |
| 13 | 1 | Towed_ADCP | SOL 5 | May 22 | 03:36:48 | 29.68307 | -28.38928 | 293 | |
| 13 | 1 | Towed_ADCP | SOL 6 | May 22 | 05:59:16 | 29.59212 | -28.46042 | 2355 | |
| 13 | 1 | Towed_ADCP | SOL 7 | May 22 | 08:23:52 | 29.68297 | -28.38933 | 293 | |
| 13 | 1 | Towed_ADCP | SOL 8 | May 22 | 10:45:09 | 29.59222 | -28.46063 | 2395 | |
| 13 | 1 | Towed_ADCP | SOL 9 | May 22 | 13:06:30 | 29.68313 | -28.38987 | 293 | |
| 13 | 1 | Towed_ADCP | SOL 10 | May 22 | 15:29:37 | 29.59215 | -28.46093 | 2385 | |
| 13 | 1 | Towed_ADCP | SOL 11 | May 22 | 17:53:00 | 29.68305 | -28.38972 | 293 | |
| 13 | 1 | Towed_ADCP | SOL 12 | May 22 | 20:01:01 | 29.59248 | -28.45797 | 2329 | |
| 13 | 1 | Towed_ADCP | SOL 13 | May 22 | 22:24:14 | 29.52875 | -28.52382 | 2696 | |
| 13 | 1 | Towed_ADCP | SOL 14 | May 23 | 00:57:09 | 29.59255 | -28.45792 | 2317 | |
| 13 | 1 | Towed_ADCP | SOL 15 | May 23 | 03:19:55 | 29.52865 | -28.52410 | 3371 | |
| 13 | 1 | Towed_ADCP | SOL 16 | May 23 | 05:48:22 | 29.59247 | -28.45797 | 2323 | |
| 13 | 1 | Towed_ADCP | SOL 17 | May 23 | 08:09:30 | 29.52867 | -28.52382 | 3365 | |
| 13 | 1 | Towed_ADCP | SOL 18 | May 23 | 10:40:44 | 29.59253 | -28.45803 | 2390 | |
| 13 | 1 | Towed_ADCP | SOL 19 | May 23 | 13:03:10 | 29.52875 | -28.52412 | 3365 | |
| 13 | 1 | Towed_ADCP | SOL 20 | May 23 | 15:36:09 | 29.59257 | -28.45803 | 2323 | |
| 13 | 1 | Towed_ADCP | SOL 21 | May 23 | 17:58:32 | 29.52908 | -28.52533 | 3365 | |
| 13 | 1 | Towed_ADCP | SOL 22 | May 23 | 20:36:42 | 29.59245 | -28.45812 | 2310 | |
| 14 | 1 | CTD | Begin | May 24 | 14:08:44 | 29.11673 | -26.08725 | 5042 | |
| 14 | 2 | FLY | Begin | May 24 | 17:29:57 | 29.11880 | -26.08847 | 4926 | |
| 15 | 1 | Mooring deployment | Begin | May 25 | 08:32:38 | 28.79827 | -24.00917 | 5109 | LOCO 14/3 |
| 15 | 1 | Mooring deployment | ground | May 25 | 11:02:51 | 28.80048 | -23.99297 | 5109 | LOCO 14/3 |
| 16 | 1 | CTD | Begin | May 25 | 20:44:12 | 28.80395 | -23.17502 | 4908 | |
| 17 | 1 | ARGO float | Begin | May 26 | 04:09:55 | 28.00182 | -23.13405 | 4951 | |
| 18 | 1 | Mooring recovery | released | May 26 | 07:19:50 | 27.61307 | -23.12930 | 4932 | LOCO 13/2 |

| Station | Cast | Type | Event | date 2006 | time | Latitude | Longitude | Depth m | name mooring |
|---|---|---|---|---|---|---|---|---|---|
| 19 | 1 | Mooring deployment | ground | May 26 | 19:31:07 | 27.61257 | -24.49505 | 5146 | LOCO 13/3 |
| 20 | 1 | Mooring recovery | dredging | May 27 | 09:01:43 | 28.80123 | -23.11803 | 4993 | LOCO 14/2 |
| 20 | 2 | Mooring recovery | dredging | May 27 | 15:59:12 | 28.79732 | -23.12162 | 4993 | LOCO 14/2 |
| 21 | 1 | ARGO float | Begin | May 28 | 14:30:19 | 25.99903 | -24.60223 | 5091 | |
| 22 | 2 | CTD | Begin | May 28 | 19:37:00 | 25.50337 | -24.87583 | 5152 | |
| 22 | 1 | Mooring deployment | ground | May 28 | 20:13:33 | 25.50320 | -24.87613 | 5152 | LOCO 15/3 |
| 23 | 1 | ARGO float | Begin | May 29 | 09:01:18 | 24.02792 | -25.98028 | 3006 | |
| 24 | 1 | CTD | Begin | May 29 | 09:24:12 | 24.00002 | -25.99933 | 5310 | |
| 24 | 2 | CTD | Begin | May 29 | 12:26:00 | 23.99962 | -26.00003 | 5310 | |
| 24 | 3 | CTD | Begin | May 29 | 15:32:26 | 24.00007 | -25.99978 | 5310 | |
| 25 | 1 | FLY | Begin | May 29 | 18:40:05 | 23.99597 | -26.00252 | 5310 | |
| 26 | 1 | Mooring deployment | ground | May 30 | 10:30:50 | 22.51213 | -27.28558 | 5402 | LOCO16/3 |
| 26 | 2 | CTD | Begin | May 30 | 10:32:57 | 22.51190 | -27.28590 | 5402 | |
| 27 | 1 | Mooring deployment | ground | May 31 | 09:28:14 | 20.01810 | -28.77352 | 4810 | LOCO 17/3 |
| 27 | 2 | CTD | Begin | May 31 | 10:24:46 | 19.96798 | -28.80742 | 4768 | |
| 28 | 1 | Mooring deployment | ground | Jun 01 | 19:26:28 | 14.96617 | -30.00407 | 5408 | LOCO 18/3 |
| 28 | 2 | CTD | Begin | Jun 01 | 20:34:09 | 15.01567 | -29.97790 | 5378 | |
| 29 | 1 | CTD | Begin | Jun 02 | 18:27:03 | 17.50015 | -29.73243 | 4756 | |
| 30 | 1 | CTD | Begin | Jun 04 | 08:11:00 | 22.70917 | -29.17975 | 5585 | |
| 31 | 1 | CTD | Begin | Jun 05 | 18:51:25 | 27.50007 | -28.65963 | 5170 | |
| 32 | 1 | CTD | Begin | Jun 06 | 12:14:38 | 29.64473 | -28.41817 | 310 | |
| 32 | 2 | FLY | Begin | Jun 06 | 12:31:56 | 29.64452 | -28.41878 | 310 | |
| 33 | 1 | CTD | Begin | Jun 06 | 12:54:42 | 29.63960 | -28.42220 | 382 | |
| 33 | 2 | FLY | Begin | Jun 06 | 13:14:04 | 29.63915 | -28.42327 | 404 | |
| 34 | 1 | CTD | Begin | Jun 06 | 13:41:11 | 29.62813 | -28.43110 | 1080 | |
| 34 | 2 | FLY | Begin | Jun 06 | 14:20:12 | 29.62837 | -28.43045 | 1038 | |
| 35 | 1 | CTD | Begin | Jun 06 | 15:04:17 | 29.61485 | -28.44105 | 1744 | |
| 35 | 2 | FLY | Begin | Jun 06 | 16:08:31 | 29.61397 | -28.44243 | 1744 | |
| 36 | 1 | CTD | Begin | Jun 06 | 17:23:14 | 29.57415 | -28.47147 | 2718 | |
| 36 | 2 | FLY | Begin | Jun 06 | 18:56:41 | 29.56928 | -28.47490 | 2815 | |
| 37 | 1 | CTD | Begin | Jun 06 | 20:14:27 | 29.52275 | -28.51027 | 3325 | |
| 37 | 2 | FLY | Failed | Jun 06 | 22:04:13 | 29.52153 | -28.51095 | 3335 | |
| 37 | 3 | FLY | Begin | Jun 06 | 23:05:21 | 29.52083 | -28.50945 | 3351 | |
| 38 | 1 | CTD YoYo | Begin | Jun 07 | 08:42:53 | 29.61030 | -28.44547 | 1884 | |
| 38 | 2 | CTD | Begin | Jun 07 | 09:53:38 | 29.61002 | -28.44603 | 1902 | |
| 38 | 3 | CTD | Begin | Jun 07 | 11:05:03 | 29.60998 | -28.44615 | 1896 | |
| 38 | 4 | CTD | Begin | Jun 07 | 12:13:35 | 29.61012 | -28.44598 | 1902 | |
| 38 | 5 | CTD | Begin | Jun 07 | 13:22:33 | 29.61037 | -28.44572 | 1890 | |
| 38 | 6 | CTD | Begin | Jun 07 | 15:09:59 | 29.61003 | -28.44597 | 1902 | |
| 38 | 7 | CTD | Begin | Jun 07 | 16:26:19 | 29.60890 | -28.44673 | 1939 | |
| 38 | 8 | CTD | Begin | Jun 07 | 17:38:26 | 29.60698 | -28.44715 | 1987 | |
| 38 | 9 | CTD | Begin | Jun 07 | 18:51:18 | 29.60848 | -28.44652 | 1951 | |
| 38 | 10 | CTD | Begin | Jun 07 | 20:01:10 | 29.60958 | -28.44578 | 1908 | |
| 38 | 11 | CTD | Begin | Jun 07 | 21:11:08 | 29.60982 | -28.44580 | 1902 | |
| 38 | 12 | CTD | Begin | Jun 07 | 22:20:58 | 29.60937 | -28.44647 | 1926 | |
| 38 | 13 | CTD | Begin | Jun 07 | 23:31:01 | 29.60897 | -28.44565 | 1914 | |
| 38 | 14 | CTD | Begin | Jun 08 | 00:46:21 | 29.60932 | -28.44668 | 1932 | |
| 38 | 15 | CTD | Begin | Jun 08 | 02:00:45 | 29.60983 | -28.44670 | 1920 | |
| 38 | 16 | CTD | Begin | Jun 08 | 03:10:49 | 29.61018 | -28.44625 | 1902 | |

| Station | Cast | Type | Event | date 2006 | time | Latitude | Longitude | Depth m | name mooring |
|---|---|---|---|---|---|---|---|---|---|
| 38 | 17 | CTD | Begin | Jun 08 | 04:22:29 | 29.60983 | -28.44663 | 1920 | |
| 38 | 18 | CTD | Begin | Jun 08 | 05:32:59 | 29.60890 | -28.44613 | 1926 | |
| 38 | 19 | CTD | Begin | Jun 08 | 06:44:53 | 29.61055 | -28.44560 | 1878 | |
| 38 | 20 | CTD YoYo last | Begin | Jun 08 | 07:58:08 | 29.61008 | -28.44597 | 1902 | |
| 39 | 1 | Mooring recovery | released | Jun 08 | 09:50:51 | 29.68420 | -28.36503 | 500 | DOC 06/2 |
| 40 | 1 | Lander recovery | released | Jun 08 | 12:43:58 | 30.00348 | -28.31367 | 500 | DOC 06/1 |
| 41 | 1 | Mooring recovery | released | Jun 08 | 17:03:20 | 29.99812 | -27.80638 | 4560 | LOCO 11/2 |
| 41 | 2 | CTD_Thermistor | Begin | Jun 08 | 19:09:15 | 29.97320 | -27.81213 | 4481 | |
| 42 | 1 | CTD | Begin | Jun 09 | 13:11:27 | 31.50007 | -25.12692 | 5097 | |
| 43 | 1 | CTD | Begin | Jun 10 | 07:37:21 | 32.99967 | -22.40088 | 5274 | |
| 43 | 2 | Mooring deployment | ground | Jun 10 | 13:09:49 | 32.97248 | -22.42592 | 5268 | LOCO 11/3 |