Reference:
van Haren, H., 2010. Cruise report KM3NeT09: R/V Pelagia cruise 64PE316, 13-19 December 2009, NIOZ, 27 pp.

Cruise Report

KM3NeT09

R/V Pelagia cruise 64PE316

13 – 19 December 2009
Corfu (Greece) – Valetta (Malta)

Hans van Haren
(with contributions from participants)

Royal Netherlands Institute for Sea Research (NIOZ), P.O. Box 59, 1790 AB Den Burg, the Netherlands
hans.van.haren@nioz.nl

(Photos: J. Hogenbirk)

0. Contents

1. Summary of R/V Pelagia KM3NeT09 cruise

In December 2009 R/V Pelagia (Royal NIOZ, the Netherlands) sailed to the Ionian Sea (part of the Eastern basin of the Mediterranean Sea), mainly to perform several tests for the future cubic kilometer neutrino telescope KM3NeT. The research cruise was commissioned by Nikhef, the Dutch National Institute for Subatomic physics, Amsterdam. Nikhef is the main contributor to European Project KM3NeT in the Netherlands, with minor contributors NIOZ and KVI (University Groningen). The Dutch contribution to KM3NeT is funded via a large investment program in the realm of ESFRI by NWO, the Netherlands Organization for the advancement of scientific research.

The purpose of the KM3NeT09 cruise was to perform several test-deployments at two of the proposed sites, 'NEMO' east of Sicily Italy around 36.5°N, 15.8°E and 'NESTOR' west of Πελοπόννησος Greece around 36.5°N, 21.5°E. For better understanding of the internal wave field, optical, current and temperature variations over the period of a year, two long moorings are deployed. These consist of a top-buoy at around 900 m holding a 75 kHz Acoustic Doppler Current Profiler (ADCP) and 5 acoustic current meters distributed along the mooring line, with concentration in the deep part up to 700 m above the bottom. This 'near-bottom' layer is further investigated using between 60 and 100 NIOZ temperature sensors at 1 m distance and each mooring holds a glass sphere with two small Photo Multiplyer Tubes. For short-term investigations of near-bottom fauna a lander has been deployed and recovered at the NESTOR-site for the duration of about 16 hours. Every 1 minute photographs are taken of the environment around a fish-bait, showing abundance of life. Four Conductivity Temperature Depth (CTD)-profiles were obtained, distributed over the sites. Small Multibeam-bottom-mapping surveys are executed around the mooring sites. A newly designed compact mooring has been launched and tested for the first time. This 2.02 m diameter sphere holding 37 glass spheres of 17″-diameter unrolled a 700-m cable with 25 glass spheres in between and surfaced freely.

The cruise was quite successful, despite the unfavourable weather conditions. The constant sailing into force 6-7 winds caused a delay of more than 24 hours within this short 5-day cruise. Alas, the proposed lander deployment at the NEMO-site had to be cancelled because of shortage of time. An attempt to recover a German mooring at the NESTOR site was unsuccessful.

2. General research aim.

KM3NeT

KM3NeT, a European deep-sea research infrastructure, will host a neutrino telescope with a volume of at least one cubic kilometer at the bottom of the Mediterranean Sea that will open a new window on the Universe. The telescope will search for neutrinos from distant astrophysical sources like gamma ray bursters, supernovae or colliding stars and will be a powerful tool in the search for dark matter in the Universe. An array of thousands of optical sensors will detect the faint light in the deep sea from charged particles originating from collisions of the neutrinos and the Earth. The facility will also house instrumentation from Earth and marine sciences for long term and on-line monitoring of the deep sea environment and the sea bottom at depths of several kilometers. Presently, several MEuro EU-funding is granted to design and prepare the KM3NeT structure. Eventually, 150-250 MEuro is needed to actually build the telescope. Proposed sites are in the Northern Hemisphere, to compliment the IceCube-telescope in Antarctica, in the Mediterranean Sea where sufficiently deep waters are found within several tens of kilometers from coasts. Three sites are selected: ANTARES south of Toulon France, NEMO east of Sicily Italy, NESTOR west of Πελοπόννησος Greece.

KM3NeT-ESFRI

The NWO investment programme for large European Structures has granted Nikhef-Amsterdam, NIOZ-Texel and KVI-Groningen 8.8 MEuro to set-up the dutch part of KM3NeT. This financial support is the first national funding in hopefully many more to come within the KM3NeT-collaboration.

KM3NeT09 cruise

The purpose of the KM3NeT09 cruise in the Ionian Sea is to perform several test-deployments. For better understanding of the internal wave field, optical, current and temperature variations over the period of a year, long moorings are deployed at both NEMO and NESTOR sites. For short-term, near-bottom fauna investigations a lander has been deployed and recovered. Additionally, some Conductivity Temperature Depth (CTD)-yoyo and Multibeam-bottom-mapping surveys are executed for further hydrographic and topographic support-data, respectively. A newly designed compact mooring has been launched and tested.

3. KM3NeT09 overview.

The proposed KM3NeT sites in the Ionian Sea are approximately located at 36.5°N, about 100 km East of Capo Passero (NEMO) and 40-60 km West of Πύλος (NESTOR), see Fig. 1. The working areas of the R/V Pelagia during cruise 64PE316 are at and around these sites, with moorings deployed in about 3300 and 4400 m, respectively. The precise location of the moorings followed after some shipborne Multibeam mapping, searching for approximately flat surroundings, and avoided sites presently occupied by INFN, GKSS and NESTOR. In shallow water on the Greek site, between 800 and 1000 m, a newly designed mooring is tested.

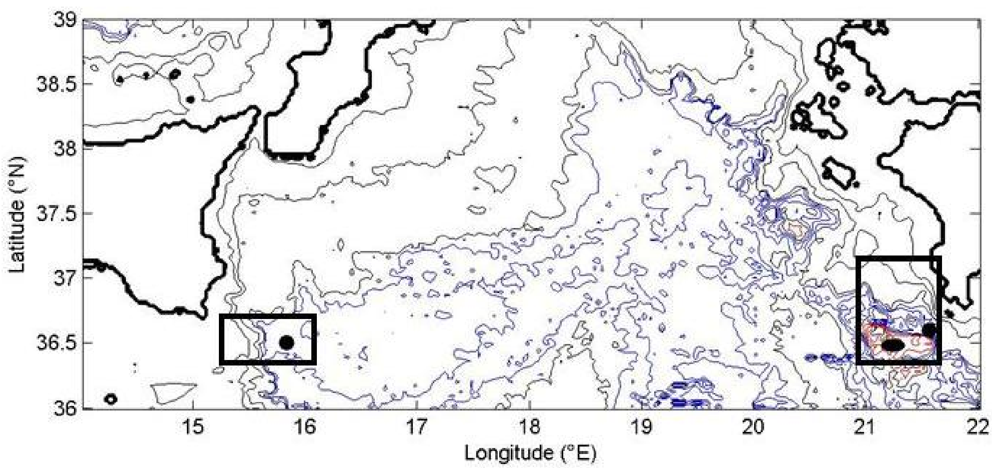


Fig. 1. Map of the Ionian Sea, with NEMO (~36.5N, 15.8E) and NESTOR (~36.5 N, 21.5E) sites. The dots indicate approximate proposed locations for KM3NeT, indeed two for NESTOR, and the rectangles indicate working areas of Pelagia.

Previously, over the past ten years or more, regular visits have been made to these sites. These visits were made to learn more about the general current regimes, local hydrography, light and suspended material variation with depth and from additional parameters like plankton abundance. The latter is important because life in the deep-sea, well below the range of sunlight penetration, depends largely on the capability of using light for predation: 'bioluminescence'. Large quantities of this light may obscure the weak light pulses caused by neutrino interactions.

The purpose of the present Pelagia cruise is to provide new information on specific oceanographic phenomena, and to test new equipment eventually to be used in and around the future telescope. One of these instruments is a small type of Photo Multiplier Tube (PMT), which is used here in a custom-made stand-alone fashion with local memory and power supply. It will measure in bursts every 10 minutes for a year. Another instrument is NIOZ-designed high-resolution temperature sensor that is planned to become mounted inside the telescope-array. It has been specifically designed to study the internal wave field, and KM3NeT provides the unique opportunity to study deep-ocean internal waves in a 3-D fashion, despite its rather course vertical resolution. Another means that may be further developed in the future is deep-ocean photography of fauna. During the present cruise this photography is used very near the bottom only, which is outside the range of the future neutrino telescope that has planned instrumentation between 100 and about 1000 m from the bottom. Presently the photography provides new information for specific marine biology studies.

For calibration and additional information some CTD stations are made, of which 2 in deep yoyo-fashion over a limited period of time (4-8 hours). Historic NESTOR data show a gradual increase in temperature with depth below 1200 m, and very weak vertical density stratification below 3500 m (Fig. 2). This limits the internal wave band to half a decade, but long-term moored observations should prove its stability, or variation with time. At the French ANTARES site, variations by a factor of 10 in stratification are not uncommon.

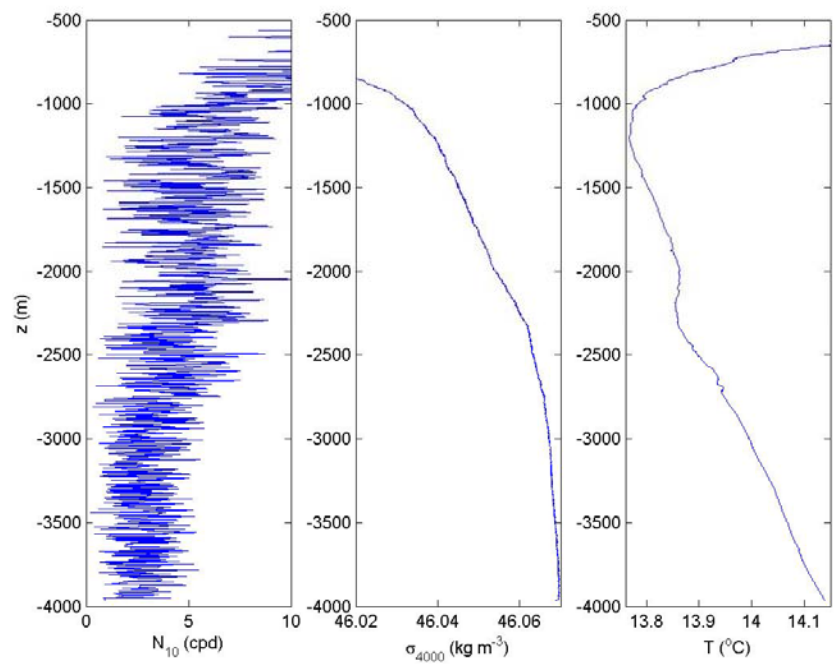


Fig. 2. Historic CTD-profiles with depth near NESTOR site. a. Buoyancy frequency, computed using 10 m vertical scale. b. Density anomaly referenced to 4000 m. c. In-situ temperature profile.

4. Participants.

Institute	***Name***
NIOZ-FYS	Hans van Haren (PI)
NIOZ-FYS	Theo Hillebrand
NIOZ-MEE	Margriet Hiehle
NIOZ-MTE	Martin Laan
NIOZ-MTI	Johan van Heerwaarden
NIOZ-MTI	Roel Bakker
NIOZ-MTM	Lorendz Boom
NIOZ-MTM	Yvo Witte
Smit Engineering	Andre Smit
Nikhef/UAmsterdam	Els de Wolf
Nikhef/UUtrecht	Paul Kooijman
Nikhef	Jelle Hogenbirk
Oceanlab Aberdeen UK	Thomas Linley
INFN Bologna I	Annarita Margiotta
Demokritos Athens Gr	Petros Rapidis

NIOZ departments

FYS	physical oceanography
MEE	marine ecology
MTE	electronics
MTI	fine mechanics instrumentation
MTM	sea technology

5. Data acquisition and instrumentation (see Appendix A for mooring diagrams).

a. KM3NeT09 long-term moorings

Both large NIOZ-moorings **(KM3NeT09_1** and **_2** at NESTOR and NEMO sites, respectively) have two ellipse-shaped buoyancy elements near the top, of which the upper one also holds an Iridium-satellite beacon. All instrumentation in the line is self-contained, with batteries and memory. An up- or downward looking 75 kHz ADCP is mounted in the top-buoy. The ADCP acoustically estimates currents every 10 m over a vertical range of about 600 m, between 100 and 700 m at NEMO (upward looking) and between 1100 and 1700m at NESTOR (downward looking). They sample once per 900 s (15 min). Deeper below, five current meters are mounted, all acoustic Nortek AquaDopp that also sample once per 900 s. In the depth range of future KM3NeT antennas 61 and 104 new NIOZ-4 accurate temperature sensors are mounted at 1 m intervals on a 65 and 104 m long cable, respectively. These sensors measure at 1 Hz. At each mooring, some 100-200 m below these sensors, a test Optical Module (OM) is mounted holding 2 small PMTs (Fig. 3). Each PMT has two measurement circuits. One circuit collects all events in a condensator. This condensator is read every 2160 s (36 min): a 'mean' value. The other circuit measures a 0.1 s burst, also every 2160 s: a 'peak' value. On the NESTOR mooring, a Nortek Vector is mounted for testing the capability of measuring turbulence at such deep sites. The Vector measures currents down to the cm-turbulence scales, sampling 16-Hz bursts every 600 s. At each mooring about 5 m above the steel weight (850 kg in water) two IXSea acoustic releases are mounted.

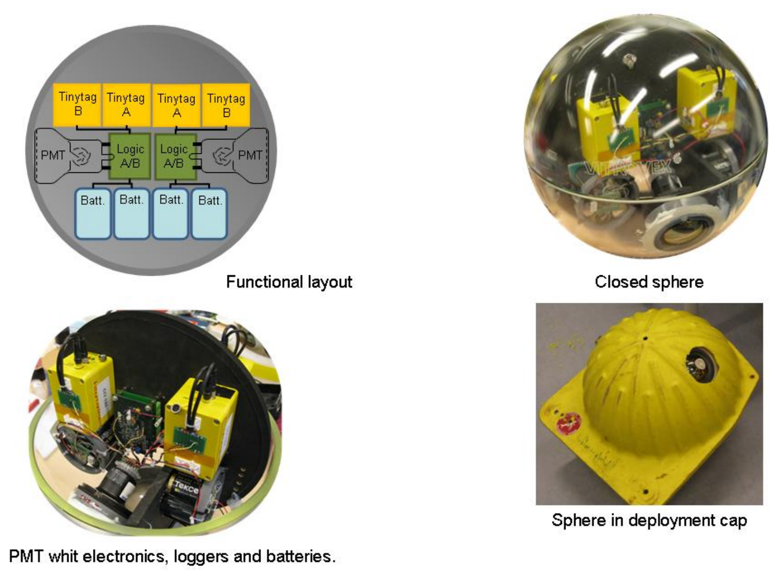


Fig. 3. Layout, electronics and mounting of in-situ sampling PMT (Nikhef).

Positioning of moorings is done following standard NIOZ-procedure for free-falling moorings: starting about 3-4 km from the intended position and sailing at a speed varying between about 0.5-1 knots (when instruments are attached and put overboard) and 2-3 knots (when line is paid out). First the top-buoy is put overboard, followed by line and instrumentation. Release of anchor is suspended by continuing to sail to the intended position. On average the final position of the anchor was about 300 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. 4). The drop speed of the weight reaches nearly 3 m s^{-1}, before slowing down to 1 m s^{-1} when the buoys are pulled under water, so that the bottom landing is fairly smooth.

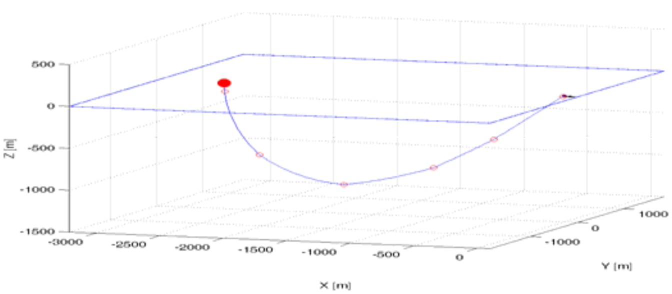


Fig.4.Simulation of deployment of a free-falling mooring just before anchor-weight is put overboard. Program by R. Dewey, UVic, Canada.

German institute GKSS Geesthacht near Hamburg requested attempt to recover a single mooring, approximately 1000 m in length at 4500 m, NESTOR site. The mooring consists of several glass spheres and biofouling panels. It has been under water for about 2 years now. The release responded a year ago, indicating the mooring is upright, but did not surface.

b. Lander short-term mooring

OceanLab moorings **OL09_1 and _2** (NESTOR and NEMO, respectively) is a free-falling bottomlander intended to become deployed and recovered after about 24 hours. The lander's main purpose is time-lapse photography of animals that are attracted to a whole ungutted mackerel bait. The camera (Kongsberg 5M pixel digital stills camera and flash unit) looks about 2 m down on a reference cross with bait at the centre. The camera is manually setup to best capture objects in this plane. An image is taken every minute with a single fire of flash.

The lander also has a SeaGuard recording platform with a Aanderaa Doppler current meter and SeaBird CTD. It takes readings every 300 s. The current data is used to estimate the dispersal of the scent of the bait and can be used to make estimates of local fish abundance.

Deployment is a swift operation, although descent to 4000 m takes some time due to its relatively slow sinking speed of about 0.5 m s^{-1}. Its recovery is slightly faster, mainly because its ascent-speed of nearly 1 m s^{-1} and its radio beacon and flag for quick visibility once at the surface.

c. Launcher Optical Module (LOM) new compact mooring test

NIOZ built a new concept mooring for compacting a single string holding glass spheres, which eventually is designed to be launched with 10-15 strings attached to a single sea-floor cable. The entire design is to minimize the number of underwater-connectors, quick deployment of multiple mooring-strings and minimal drag. A single string has two 4-mm lines for support and one 6 mm tube holding all electric cabling. Thirty-one small PMTs will eventually be held in one, presently 17″, glass-sphere, the OM. A string will hold twenty OMs that are presently separated by approximately 30 m. The OMs will be mounted ‘naked’ in between the two lines without further supporting or protecting materials. For compact mooring deployment, the entire nearly 700 m long string and five empty glass spheres for top-buoyancy are mounted in a 2.02 m diameter aluminum sphere, the Launcher of OMs (LOM), see Fig. 5. This LOM is mounted directly above a 820 kg weight (weight under water) to which a video system is mounted. Upon release it unrolls its lines and instrument-spheres due to its positive buoyancy of some 5000N. After releasing the top-buoys it detaches itself and surfaces freely.

For the KM3NeT09 cruise a test-string has been developed, following the above dimensions, without PMTs but with monitoring test-sensors and concrete dummy-weights of the same value as future PMT-weight. This mooring (**KM3NeT_LOM**) is deployed for the first time. As this test-mooring has to be recovered to read the stand-alone test-sensors, it is deployed in a U-fashion, with a ground-line to a second weight and extra line with separate surface marker. The test-sensors in each of the 20 instrument-glass-spheres measure tilt and compass at 2 Hz. The LOM itself holds 2 of such sensors, which also measure temperature, and a single pressure sensor running at 0.25 Hz. For redundancy another 3 NIOZ4 temperature sensors are mounted inside the LOM.

For additional information, the separate surface marker holds a down-looking 75 kHz ADCP, to monitor currents over about 600 m, a substantial part of the water column. After deployment CTD-data are collected for reference temperature profile across the water column.

Deployment started at the stern, separate surface marker going out first, but after spooling out the 14 mm ground cable it was taken over to the side-winch A-frame from where the LOM package was lowered all the way to the bottom. This package includes the separate acoustic release in a beacon above the LOM and another acoustic release for detaching the winch-cable once bottom is hit (Fig. 6). To move this cable away from the LOM two glass spheres are attached to it, some 20 m above the release.

Recovery requires assistance of the MOB-boat. This is because two items float separately, the LOM-release buoy and the LOM itself, but also because the unprotected glass-spheres easily bump into each other at the surface: the line needs to be stretched as soon as it surfaces. Lifting the LOM-weight from the bottom is not easy as it requires the ship simultaneously moving forward with continued rapid hauling.

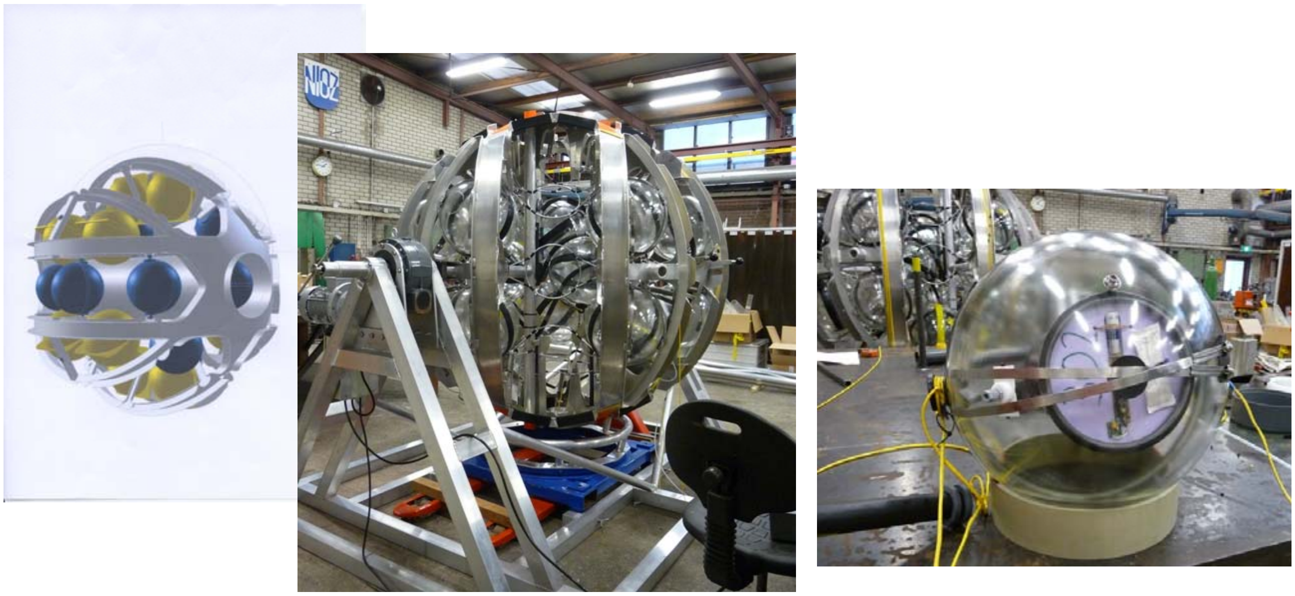


Fig. 5. Launcher of Optical Modules (LOM), its design (left), being built with own buoyancy (middle) and showing test-instruments and cable (right).

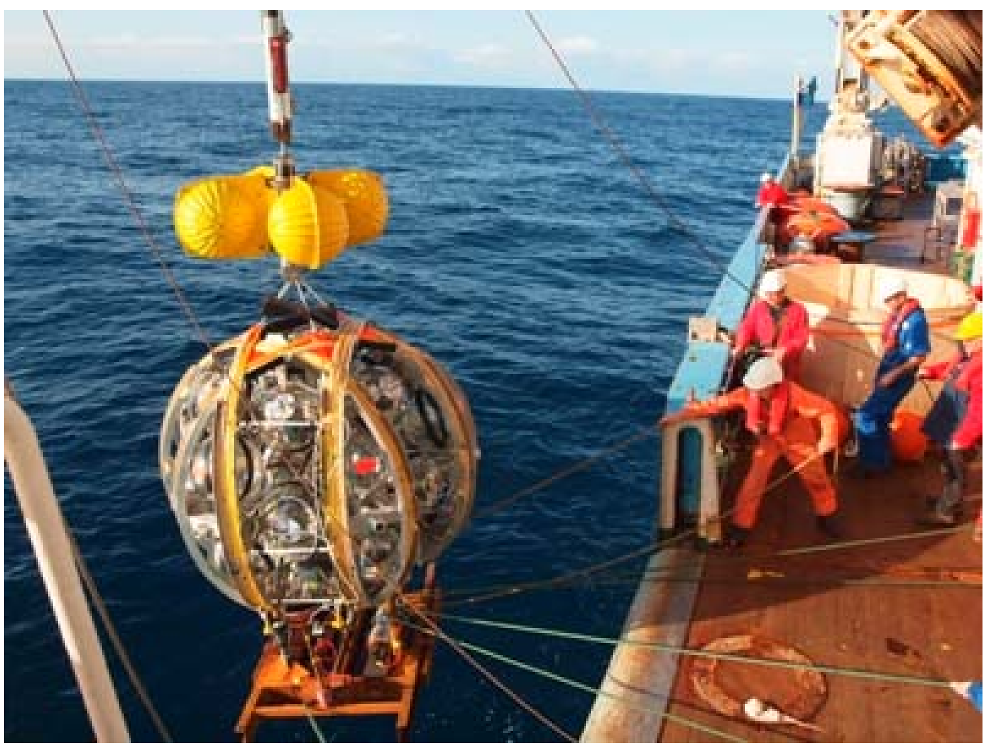


Fig. 6. Fully equipped LOM just before being put in the water. Below the LOM the bottom weight and video camera are visible. Above it, its own acoustic release is visible in between four plastic-capped glass spheres and a second acoustic release for detaching the winch cable.

d. Shipborne sampling

The Pelagia CTD/Rosette system contains a Seabird 911 Conductivity Temperature Depth sensor, with a Seapoint STM Optical BackScatterer (OBS). The CTD samples at a rate of 24 Hz. It is used to calibrate the NIOZ-temperature sensors and to perform several hydrographic stations, mainly in yoyo fashion of about 4 hours at the NEMO and NESTOR sites, and near the LOM-testsite.

6. Daily summary of KM3NeT09.

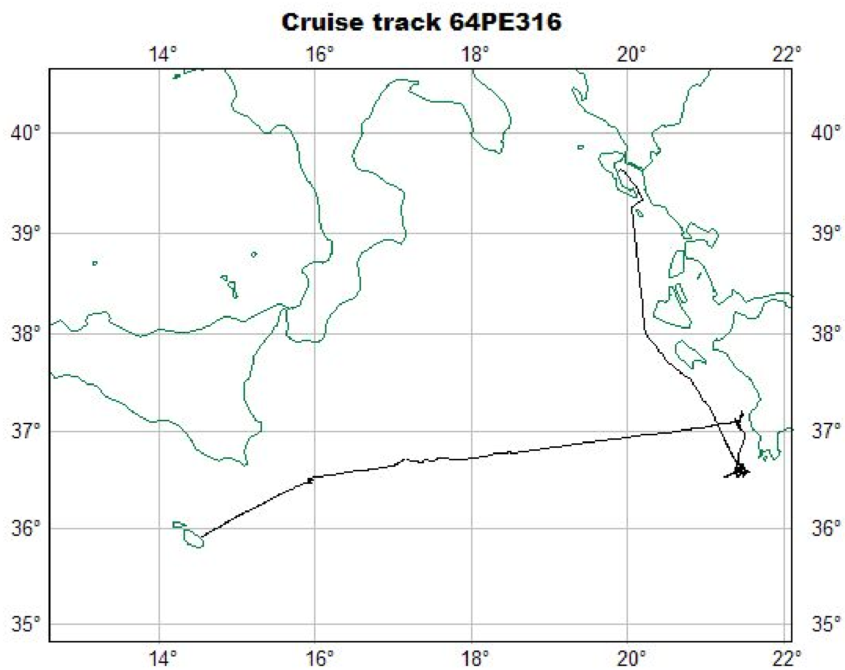


Fig. 5. KM3NeT09 cruise track (M. Hiehle).

Sunday 13 December

16:30 LT (14:30 UTC). Departure from Corfu, Greece. S4, initially calm weather.

Monday 14 December

SE7-8, rough. Try to steam straight into wind along Greek coast to NESTOR-site, just off the west coast of the Πελοπόννησος. Program has to be changed twice due to rough weather and slow progress. Limited work done. 08 UTC first CTD+calibration thermistors and bottle test. In the evening a remarkably smooth deployment of lander OL09_1, still under Bf7 winds and high seas. During night Multibeam survey.

Tuesday 15 December

SE6-2. Start with attempt to recover GKSS mooring, which was left behind 14 months ago. We can hear the acoustic release, but some 10 release attempts have no success. The mooring stays in the deep and does not surface. 10 UTC small CTD-yoyo. 14 UTC successful lander OL09_1 recovery. In the evening long mooring deployment KM3NeT09_1.

Wednesday 16 December

Var2-W7. Night: Multibeam survey of shallow (800 m) location for test-deployment new compact mooring. 05 UTC Start with deployment U-shaped mooring KM3NeT_LOM. Operations very smooth, until moment of release of the LOM: the release is stuck to one cable leading to bottomweight. After two hours and lift/pulling of bottom cable spontaneous release followed by unrolling and surfacing of LOM. 14 UTC successful recovery of mooring KM3NeT_LOM. 15 UTC end of CTD and transit to NEMO-site, East of Sicily.

Thursday 17 December

WSW7. Transit, slow progress due to sailing directly into wind.

Friday 18 December

W7. Lander deployment OL09_2 has to be cancelled, unfortunately. 12 UTC short yoyo-CTD. 16:30 UTC deployment long-term mooring KM3NeT09_2.

Saturday 19 December

S5. 07 UTC. Arrival Valetta.

7. Scientific summary and preliminary results

Table 1. Mooring positions KM3NeT09. The first two are moored for a year, the others have been recovered during the cruise. Depths are Multibeam estimates.

Mooring	*Latitude*	*Longitude*	*depth*	*Iridium*
KM3NeT09_1	36°37.657′N	021°24.907′E	4450 m	BC44363
KM3NeT09_2	36°29.555′N	015°54.826′E	3320 m	BC44387
OL09_1	36°37.139′N	021°29.002′E	4250 m	--
KM3NeT09_LOM	37°05.719′N	021°25.506′E	800 m	--

a. Long-term mooring deployments KM3NeT09_1,_2 (Appendix A for mooring diagrams)

The mooring deployment from the stern worked fine due to proper preparation and despite rather adverse weather conditions, with winds up to Bf7.

Two about 3 km long moorings were deployed near 36.5ºN at about 16 and 21.5ºE for the duration of a year (Fig. 6; Table 1). Deploying of moorings caused no trouble and went generally very smoothly. Table 2 gives an overview of the instruments, their sampling rates and their positions in the moorings.

Table 2. Long-term mooring details KM3NeT09 (R=TeleDyne-RDI; N = Nortek). *Moorings deployed on* **15 and 18 December 2009**

Mooring	**Instrument**	**BC**	**depth [m]**	**sampl. int. [s]**	**remarks**
KM3NeT09/1	R 75 kHz ADCP	1953	1125	900	60 10m bins. DO look
	N AquaDopp	2031	2475	900	100 sam diag/day
	N AquaDopp	13208	3225	900	100 sam diag/day
	N AquaDopp	12850	3975	900	100 sam diag/day
	N Vector	33589	3976	600	152 sam/burst 16Hz
	NIOZ-4 T-str	12980	3977	1	103 sensors@1m
	N AquaDopp	2295	4275	900	100 sam diag/day
	NikhefmoorPMT	*33251*	4280	2160	mean and 0.1s burst
	N AquaDopp	2325	4375	900	100 sam diag/day
KM3NeT09/1	R 75 kHz ADCP	1854	720	900	60 10m bins. UP look
	N AquaDopp	2271	1420	900	100 sam diag/day
	N AquaDopp	11488	2170	900	100 sam diag/day
	N AquaDopp	2264	2920	900	100 sam diag/day
	NIOZ-4 T-str	13130	2921	1	61 sensors@1m
	N AquaDopp	2288	3170	900	100 sam diag/day
	NikhefmoorPMT	*33268*	3172	2160	mean and 0.1s burst
	N AquaDopp	11471	3220	900	100 sam diag/day

The location of the long-term mooring at the NESTOR-site (Fig. 7) is just north of NESTOR4.5, which was relatively full with (remains of) some 9 moorings, and east of NESTOR5.2. The free-falling mooring was manoeuvred into a small basin. The long-term mooring just to the north of the NEMO-area is dropped in a relatively flat area.

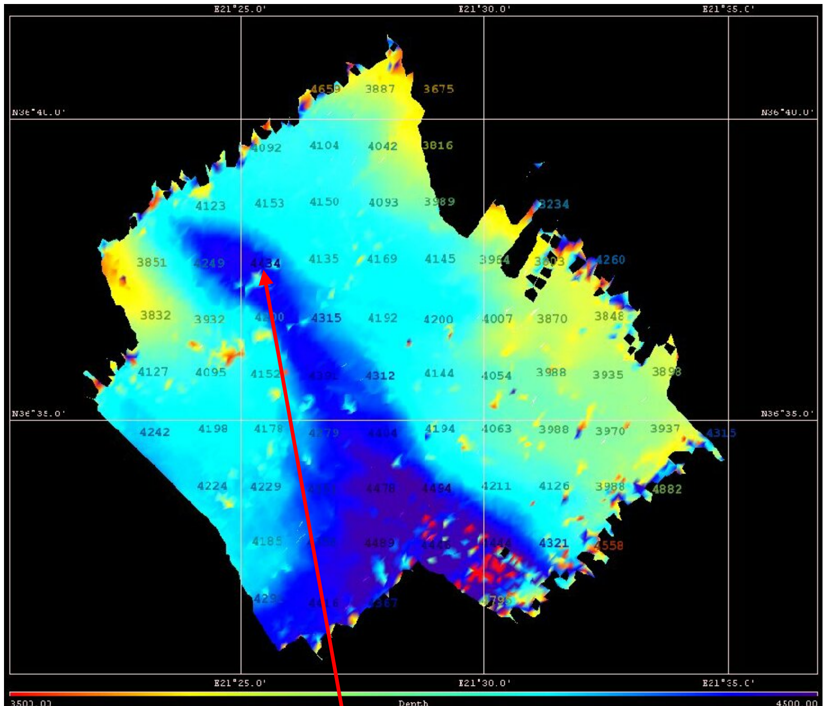


Fig. 7. Location of mooring KM3NeT09_1 in a small subbasin to the north of site Nestor4.5. Nearly raw shipborne Multibeam image, with calibrated sound velocity using local CTD-data.

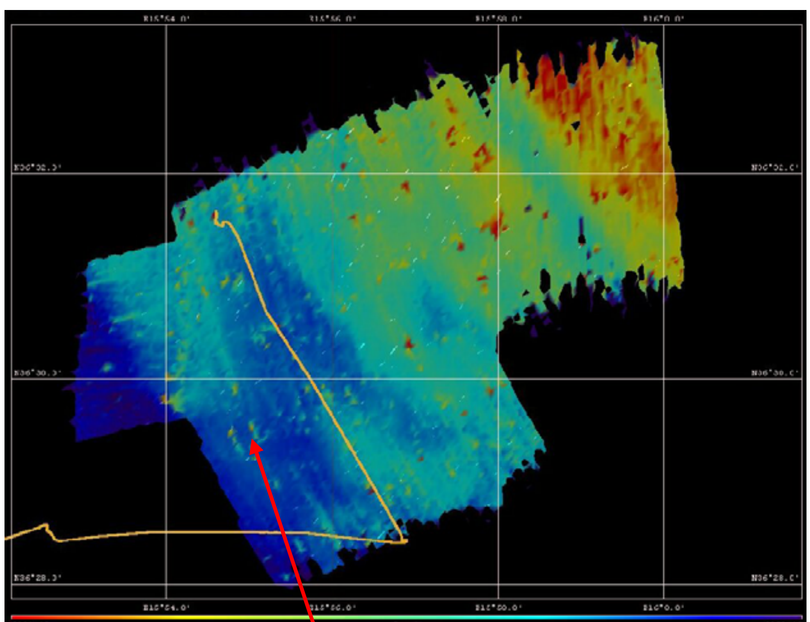


Fig. 8. As Fig. 7 but for mooring KM3NeT09_2 slightly to the north of the NEMO area. Note the different color scale compared to Fig. 7.

b. Short-term mooring deployment and retrieval (by T. Linley)

Of the two planned, only one lander deployment **OL09_1** near NESTOR at 4100 m could be completed, due to adverse weather conditions throughout the cruise. This was due to adverse weather conditions Previous lander deployments in this area focused on the shallower sites and revealed a very clean silt/sand seabed with little visible infauna or detritivours; supporting the assessment that this was a highly oligotrophic area. Opportunistic scavengers were seen to be mainly cat sharks and the large red pennaid shrimp. The present observations show the same sediment, but which is beyond the range of shark species. The shrimp persist in high numbers but also a large number of rat tails are observed, often exceeding 4/image. At least two species were observed but complete identification is not possible until compared with reference material.

The most striking feature that emerged during review of the images is the low variation in fish size. This will have to be quantified during analysis however it appears that all fish photographed are of a very similar size (approximately 10cm) (see Fig. 9), potentially indicating an optimum size for surviving in this low energy environment.

Further study at different depths in this area may indicate if this represents the fish's adult size or if a depth migration occurs during their ontogeny.

Fig. 9: Two images representative of this site showing high abundance of shrimp and rat-tails.

Future analysis of the data will consist of:

a) image analysis; simple time series counts, length frequency determination, bait visitation by individuals, local abundance estimation calculation for the numerically dominant species, confirmation of species identification, behavioural observations.

b) Collation and interpretation of ADCP data in relation to the scavenging fauna observed.

c. LOM test mooring

Test-mooring **KM3NeT_LOM** was deployed in about 800 m on a smooth slope just north of NESTOR sites, during the only calm day of the cruise. The bottom texture turned out perfect, a clean silty bottom without large rocks, as is interpreted from video camera observations and residue at the bottom-weights after recovery. The overboard operation of the U-shaped mooring was smoothly handled. The 2000 m long ground-line was long enough for the ship to move gently away from the surface marker/ADCP and allow ample time to transfer this cable from the stern to the side-frame where the LOM was sitting prior to deployment. The LOM itself was lowered using a Kevlar winch cable, which was easily released and brought back to the surface. During the lowering the underwater weight of some 300 kg was only just about enough in the calm seas. In the future, the LOM weight is better increased by 100 or 200 kg, for quicker lowering.

The test of this first LOM-deployment was successful. The main process of unwinding went rapid and smooth, no glass spheres were damaged. Several shortcomings were noticed. The LOM-release remained initially stuck at one of the 3 cables through the central LOM-pipes. Future release should be integrated in LOM or cables should be entering the release hook under a less acute angle. After some pulling at the ground cable, spontaneous release and LOM-unwinding followed. The present LOM-speed during ascent is too high, reaching 1.55 m s^{-1} (Fig. 10), resulting in rather abrupt release of OM-spheres. Although none of the spheres was damaged, the shock in the cable is undesirable. Also, the quick ascent caused the LOM to bump into the release-beacon, which was initially ascending at a slower speed.

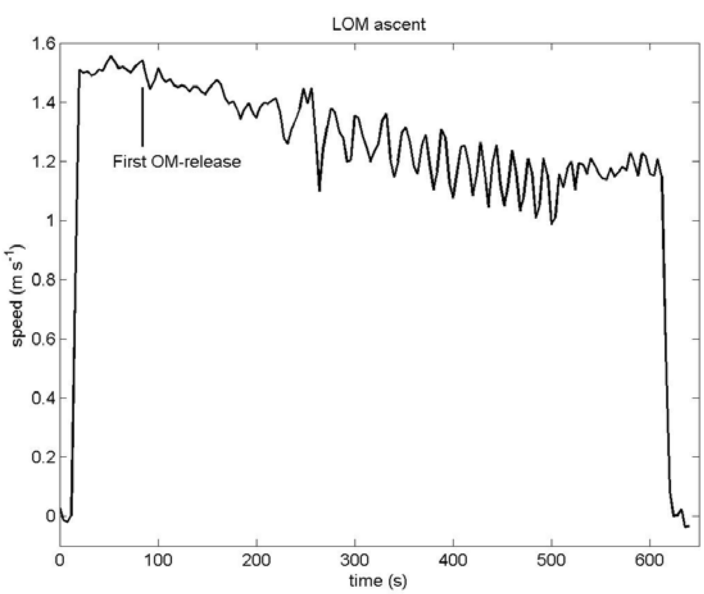


Fig. 10. Ascent speed LOM inferred by first-differencing pressure sensor signal.

After release, the mooring remained at the bottom for 1.5 hours before retrieval and worsening weather conditions. Relative current speeds were measured up to about 0.15 m s^{-1} over the ADCP-range, excluding the near-surface layer down to 60 m (Fig. 11). However, it is noted that interpretation in terms of absolute speeds is difficult, because the ADCP moved about due to wind motions and large slack in its 1200 m long mooring cable during the entire period. As a result, Figure 11 displays the same data in two different reference styles. It is also noted that the ADCP-data do not cover the period when the OM-string was unwinded, because the ADCP was already recovered before the LOM unwinded the string after pulling the ground cable.

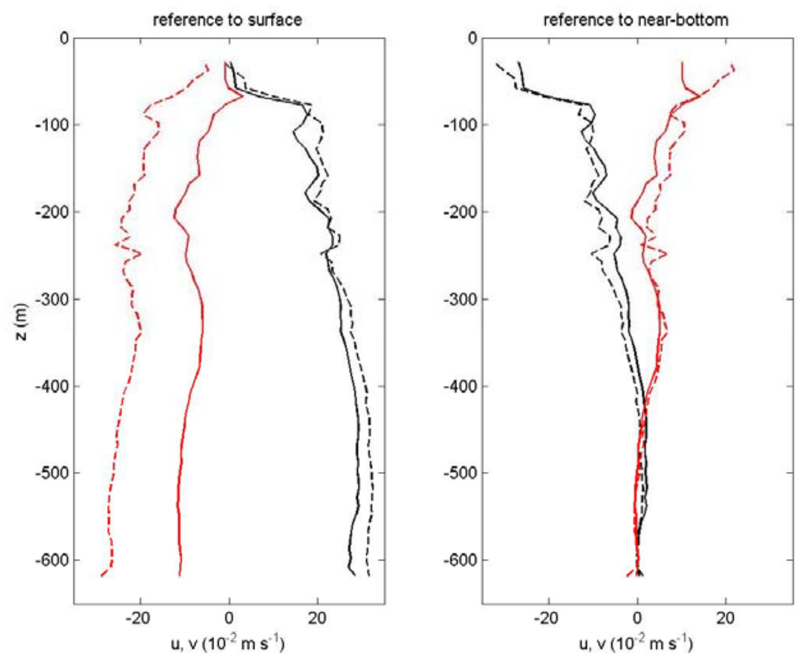


Fig. 11. ADCP-data of East-West (black) and North-South (red) current components averaged over the entire mooring period of 4 hours (solid) and the last 20 minutes (dashed). The graphs in the left panel are original data and basically referenced to the surface, which appears to stand still, with respect to the wind-blown near-surface layer. In the right panel data are referenced to the average of data observed between 570 and 590 m.

d. CTD sampling

The CTD operations were 'normal'. The instrument, deck unit and the winch worked very fine. The data collected near NESTOR-site compare well with historic data (Fig. 2). Of some interest here are near-bottom details of stratification and its possible rapid variation with time, to be inferred from short-term yoyo. In contrast with the historic observations it is seen that only below 4050 m the water column is truly homogeneous (Fig. 12). Above that depth stratification is weak, buoyancy frequency N ~ 2f, f the inertial frequency, and more or less continuous with depth. As a result, very low-frequency internal waves are expected. As for potential effects in interior mixing, the yoyo-profiles do not give much evidence: some small-scale variations are seen, e.g. near 3920 and 4100 m. Around the present transition, between 4000 and 4100 m, the NIOZ4 high resolution temperature sensors are moored.

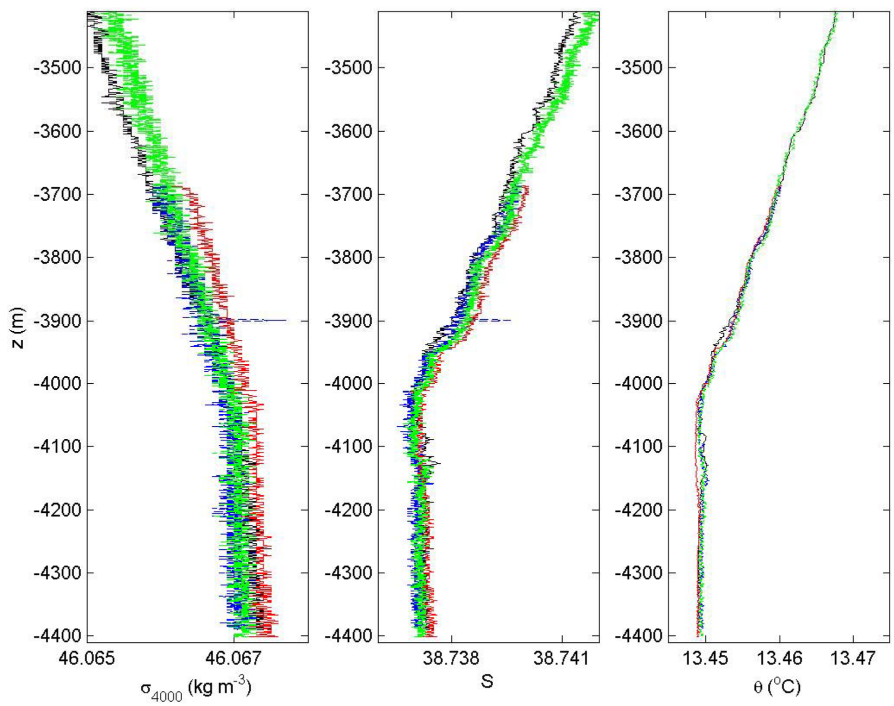


Fig. 12. Detail of lower 1000 m of some parameters of CTD-profiles near NESTOR-site of mooring KM3NeT09_1. The lower 700 m above the bottom was once repeated in yoyo. a. Potential density referenced to 4000 m. b. Salinity. c. Potential temperature.

The profiles near NEMO (Fig. 13) show equally few small-scale variations (note however the different scales), and more large-scale variations. The density stratification is about 4 times larger than at NESTOR, so the internal wave band is about twice as large in frequency. The homogeneous layer stands just over 100 m above the bottom.

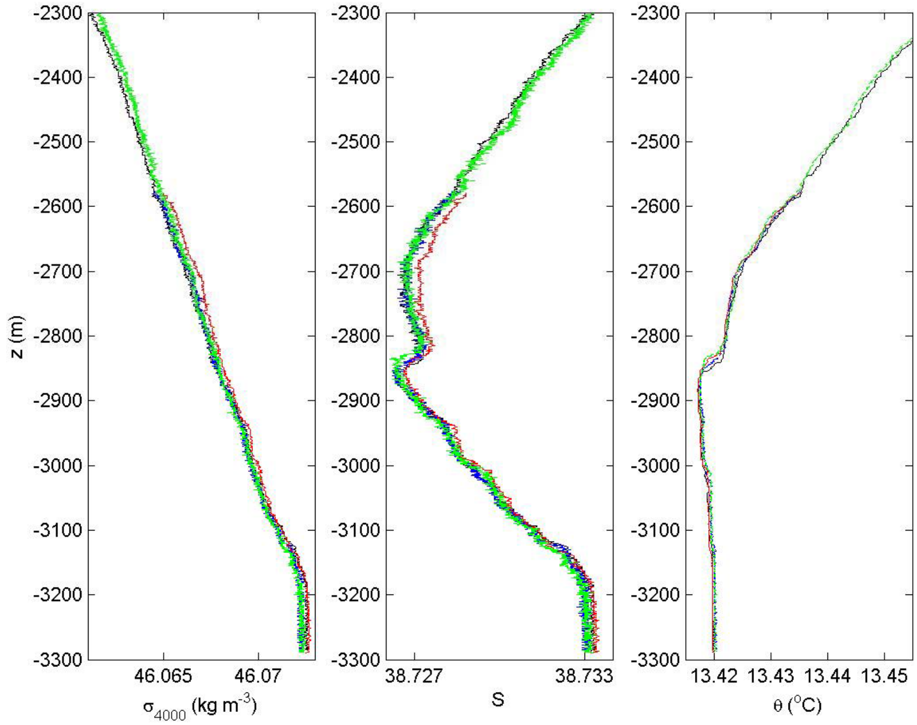


Fig. 13. As Fig. 12, but for NEMO-site of mooring KM3NeT09_2 and with different horizontal scales.

8. Achnowledgments

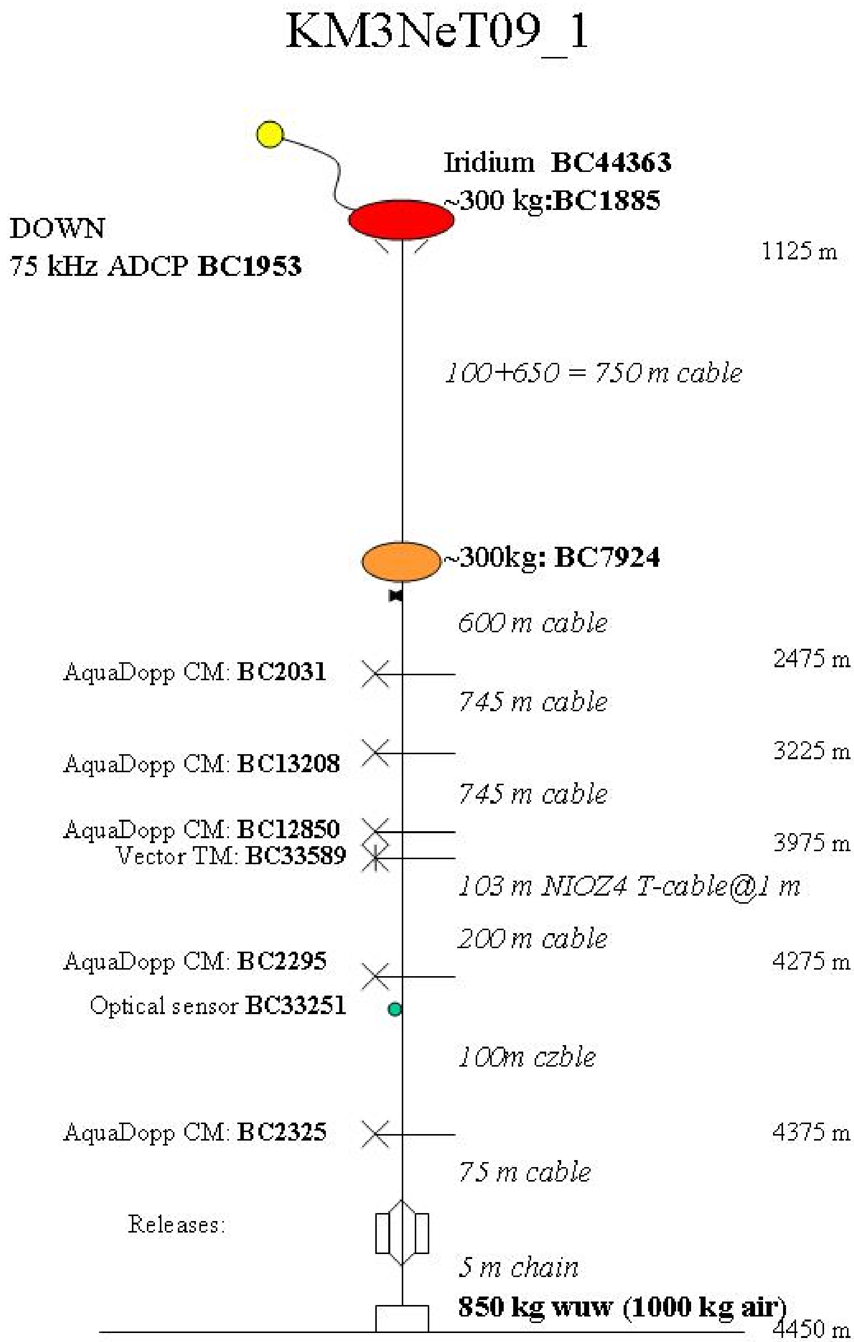
On behalf of all participants, I would like to thank captain Kees de Graaff and the crew of R/V Pelagia for the very pleasant cooperation. Funding by the Netherlands Organization for the advancement of Scientific Research is gratefully acknowledged.

December 2009, Febraury 2010,

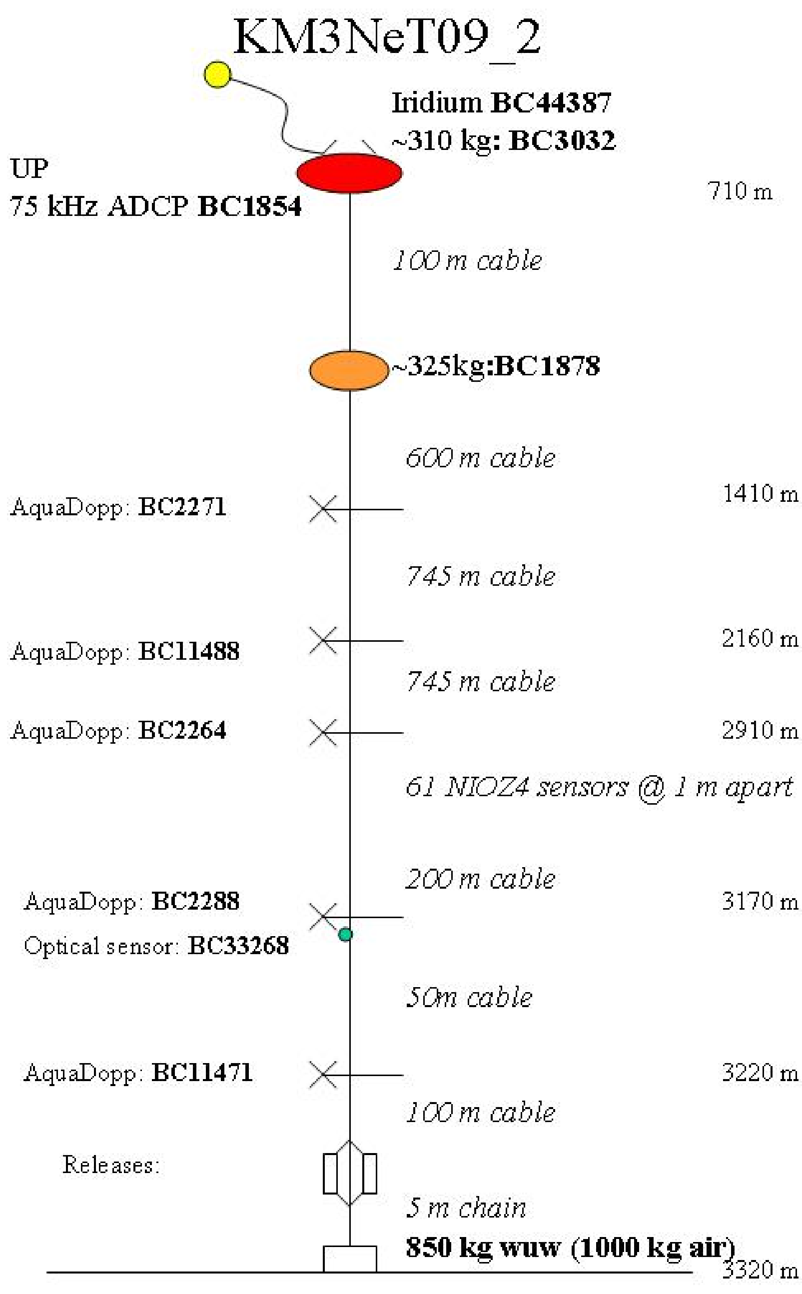
Hans van Haren

Appendix A Mooring diagrams KM3NeT09 (*by T. Hillebrand, T. Linley & Dept. MTM*)

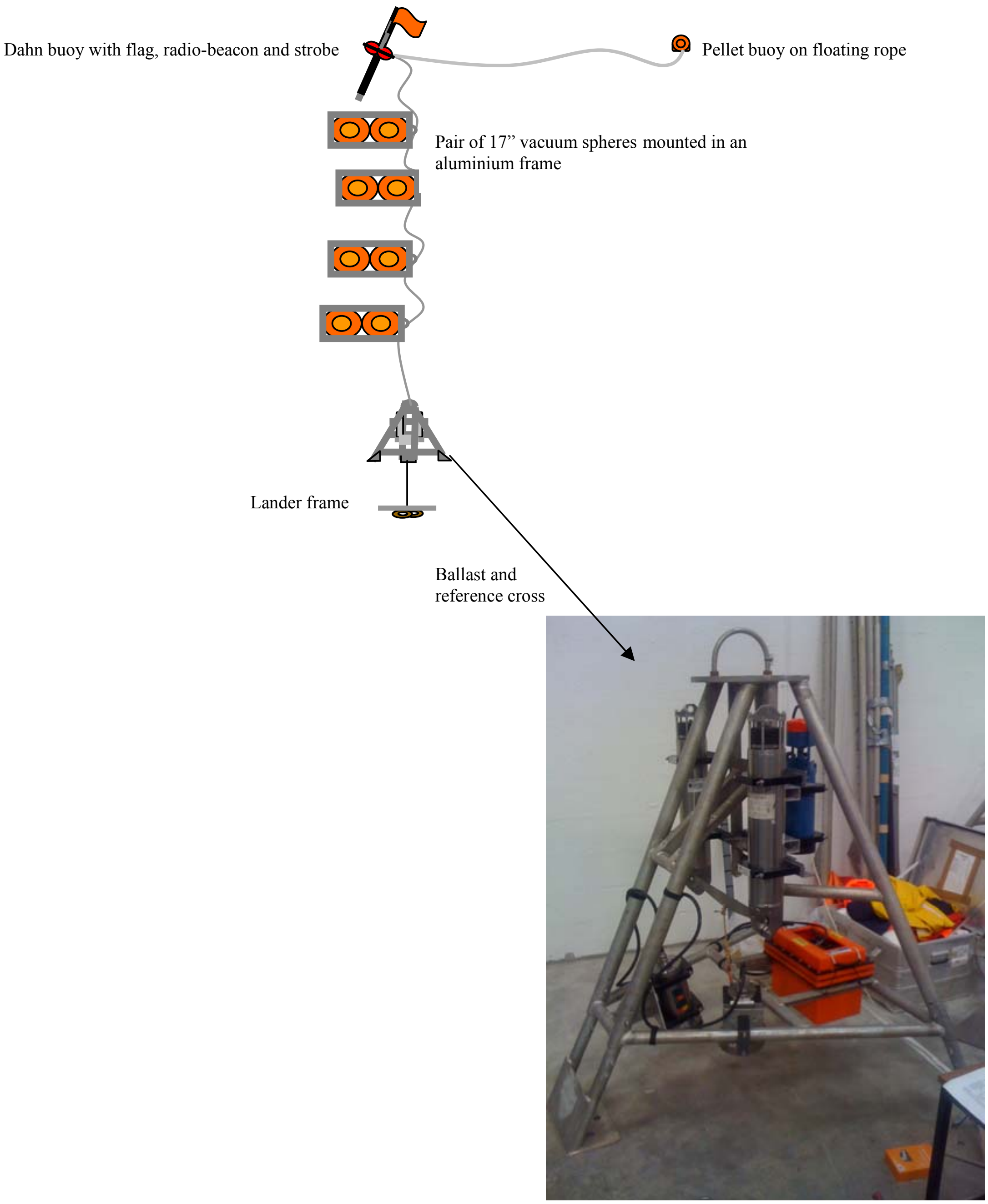
Long-term mooring KM3NeT09_1



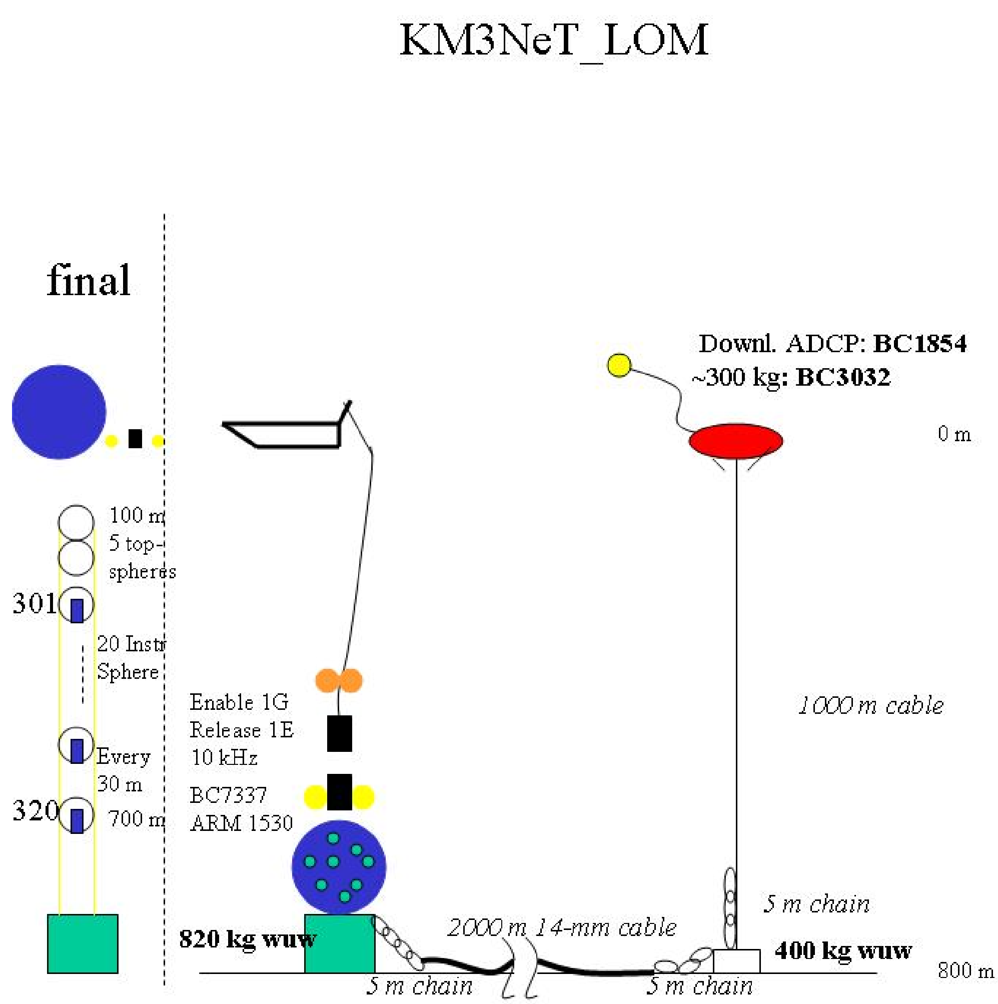
Long-term mooring KM3NeT09_2



Bottom lander mooring OL09_1



LOM mooring



KM3NeT_LOM
final
100 m
5 top-spheres
301
20 Instr Sphere
Every 30 m
320
700 m
Enable 1G
Release 1E
10 kHz
BC7337
ARM 1530
820 kg wuw
5 m chain
2000 m 14-mm cable
5 m chain
Downl. ADCP: BC1854
~300 kg: BC3032
0 m
1000 m cable
5 m chain
400 kg wuw
800 m

Appendix B Cruise summary of stations (activities) of KM3NeT09 (M. Hiehle)

Station	Type	Event	Date time (UTC)	Lat. (decimal)	Lon (decimal)	Depth uncor.(m)	Remark
1	CTD-thermistor	Begin	Dec 14 2009 07:40:36	37.35980	20.93600	1184	
1	CTD-thermistor	Bottom	Dec 14 2009 08:00:02	37.35978	20.93610	1184	
1	CTD-thermistor	End	Dec 14 2009 08:44:57	37.36012	20.93553	1190	
2	Lander deployment	Begin	Dec 14 2009 17:42:09	36.61695	21.48050	2097	OL09_1
2	Lander deployment	End	Dec 14 2009 18:01:34	36.61738	21.48482	4079	Dropped
3	MultiBeam begin	End	Dec 14 2009 19:09:55	36.58502	21.55697	3798	line 0 bad data steady crse
4	MultiBeam end	End	Dec 14 2009 19:58:27	36.62672	21.48410	4865	line 1 perpendicular line 0
5	MultiBeam begin	Begin	Dec 14 2009 21:53:18	36.60708	21.38047	3859	Line cnt. 0002(31)
6	MultiBeam end	End	Dec 14 2009 23:20:00	36.66305	21.47825	3274	Line cnt. 0005(30)
7	MultiBeam begin	Begin	Dec 14 2009 23:51:49	36.63257	21.49953	2798	Line cnt. 0005(30)
8	MultiBeam end	End	Dec 15 2009 01:28:44	36.57122	21.38688	4146	Line cnt. 0008(24)
9	MultiBeam begin	Begin	Dec 15 2009 01:54:20	36.53953	21.41692	4128	Line cnt. 0009(30)
10	MultiBeam end	End	Dec 15 2009 03:21:48	36.60940	21.51993	3786	line ctr.0012(30)
11	MultiBeam begin	Begin	Dec 15 2009 03:44:31	36.59467	21.55260	4115	line ctr. 0012(30)
12	MultiBeam end	End	Dec 15 2009 04:55:00	36.54145	21.47958	4371	line ctr. 0014(20)
13	CTD-yoyo	Begin	Dec 15 2009 09:56:22	36.61698	21.43328	5006	
13	CTD-yoyo	End	Dec 15 2009 12:56:53	36.61658	21.43167	4225	
14	Lander recovery	released	Dec 15 2009 13:04:30	36.61798	21.43138	4225	
14	Lander recovery	Begin	Dec 15 2009 14:30:43	36.61983	21.48357	4018	
14	Lander recovery	End	Dec 15 2009 14:52:43	36.62332	21.48208	4024	
15	Mooring deployment	Begin	Dec 15 2009 16:16:55	36.56858	21.46782	4378	KM3NeT09_1
15	Mooring deployment	End	Dec 15 2009 19:18:37	36.62850	21.41317	4250	Dropped
16	MultiBeam begin	Begin	Dec 15 2009 23:05:44	36.99080	21.49955	771	line ctr. 0015(30)
17	MultiBeam end	End	Dec 16 2009 01:44:41	37.20102	21.47718	796	line ctr. 0020(21)
18	MultiBeam begin	Begin	Dec 16 2009 01:54:58	37.20705	21.46732	832	line ctr. 0021(30)
19	MultiBeam end	End	Dec 16 2009 04:04:05	37.03203	21.43360	875	Line ctr. 0025(22)
20	MultiBeam begin	Begin	Dec 16 2009 04:27:54	37.07835	21.43400	723	Line cnt. 0026(0)
21	MultiBeam end	End	Dec 16 2009 04:46:46	37.10885	21.44107	796	Line ctr. 0026(12)
22	LOM deployment	Begin	Dec 16 2009 05:21:07	37.07503	21.41798	808	
22	LOM deployment	End	Dec 16 2009 06:32:18	37.07808	21.41942	808	Bottom First Weight
22	LOM deployment	ground	Dec 16 2009 08:22:09	37.09267	21.42438	796	cable winch relse; LOM bott
23	LOM deployment	Release	Dec 16 2009 08:46:39	37.09532	21.42510	796	LOM released from bracket
24	LOM recovery	Begin	Dec 16 2009 09:33:12	37.08048	21.41098	406	Smarty
24	LOM recovery	End	Dec 16 2009 14:08:07	37.12978	21.38807	1052	
25	CTD	Begin	Dec 16 2009 14:45:02	37.09952	21.42433	814	
25	CTD	Bottom	Dec 16 2009 15:00:07	37.09947	21.42417	814	
25	CTD	End	Dec 16 2009 15:15:16	37.09925	21.42408	814	
26	MultiBeam begin	Begin	Dec 18 2009 09:51:16	36.53558	16.00185	3164	lin cnt 0027 (0)
27	MultiBeam end	End	Dec 18 2009 11:01:43	36.50767	15.90822	3237	lin cnt 0029 (20)
28	MultiBeam begin	Begin	Dec 18 2009 11:16:20	36.4831	15.91082	3256	lin cnt 0030 (30)
29	MultiBeam end	End	Dec 18 2009 11:47:55	36.50543	15.96557	3231	lin cnt 0031 (29)
30	CTD-yoyo	Begin	Dec 18 2009 11:55:38	36.50688	15.96905	2713	
30	CTD-yoyo	End	Dec 18 2009 14:14:34	36.50698	15.96915	3207	
	MultiBeam begin	Begin	Dec 18 2009 14:40:00	36.5009	15.9667		line 32
	MultiBeam end	End	Dec 18 2009 16:29:00	36.4917	15.9127		line 35
31	Mooring deployment	Begin	Dec 18 2009 14:37:23	36.50068	15.96753	3225	KM3NeT09_2
31	Mooring deployment	End	Dec 18 2009 16:34:18	36.49128	15.91013	3243	Dropped
32	MultiBeam begin	Begin	Dec 18 2009 16:40:40	36.49438	15.90788	3243	Line ctr. 0036 (30)
33	MultiBeam end	End	Dec 18 2009 17:19:16	36.52518	15.9099	3237	Line ctr. 0036(18)