PLUME CRUISE 4/KM0706 CRUISE REPORT
ADDENDUM TO THE UNOLS REPORT FORM

Gabi Laske, Chief Scientist

Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics, Scripps Institution of Oceanography, UC San Diego

Cruise Date:	May 11 - June 06, 2007
Ship:	R/V Kilo Moana, U. Hawaii
Master:	Rick Meyer
Chief Scientist:	Gabi Laske
Marine Technicians:	Brad Issler and Dan Fitzgerald

PERSONNEL

Ship Crew

Name	Function
Rick Meyer	Master
Richard Wisner	Chief Mate
Brian Wehmeyer	2nd Mate
Mike Kinzie	3rd Mate
Brad Issler	Marine Technician
Dan Fitzgerald	Marine Technician
Mike Roth	AB
Warren Miller	AB
Dave Spurgin	AB
Roger Rios	AB
Quinton Perkins	AB
Debbie Gall	Chief Steward
Shari Hodge	Steward
Kim Gardber	Steward
Robert Tombari	Chief Engineer
Richard Webster	1st Engineer
Ted Kane	2nd Engineer
Paul Bingel	3rd Engineer
Rob McDonough	Oiler
Robert Aarts	Oiler
Willie Reyes	Oiler

Science Team

Name	Affiliation	Function
Gabi Laske	SIO	Chief Scientist
John Collins	WHOI	co-PI/WHOI OBS lab manager
Cris Hollinshead	SIO	OBS Development Engineer
Ernest Aaron	SIO	OBS Development Technician
Rob Handy	WHOI	OBS Technician
Jim Ryder	WHOI	OBS Technician
Ondrej Smarek	Yale Univ.	Watch Stander
Marine Denolle	visit. Yale Univ.	Watch Stander
Jared Warner	San Diego State Univ.	Watch Stander
Jillian Garber	UC San Diego graduate	Watch Stander
Susanne Lehndorfer	Univ. of Munich	Watch Stander
Jan Hautmann	Univ. of Munich	Watch Stander
Yu-Chin Huang	Univ. Taiwan	OBS Observer
Ching-Ren Lin	Univ. Taiwan	OBS Observer

Two co-PIs were on the science team, Gabi Laske and John Collins. John Collins is also the lab manager of the WHOI OBS pool. Six watch standers worked in 4h–shifts, each once a day. They were responsible for keeping a watch log and logs for instrument recoveries and other experiment related activity.

DESCRIPTION OF SCIENTIFIC OBJECTIVES AND ACHIEVEMENTS

Summary

The primary objective of this cruise was to recover the 38 ocean bottom seismometers (OBSs) that were deployed a year ago on the R/V Kilo Moana (KM hereafter) on cruise KM0612 (April 12 - May 11, 2006). An instrument was lost at site #16 during the recovery of the first array and was close to site #55 of our new array. We therefore planned to revisit the site, if time permitted.

We recovered only 28 of the 38 instruments. We lost 5 of 13 SIO OBSs and 5 of the 25 WHOI OBSs. In 8 of the 10 cases, we never established contact with the instrument despite deploying a rescue beacon. The latter can be programmed to send out release commands every several minutes. The beacon was lowered to the ocean floor on a CTD wire to come within a few 100m of the instrument's transducer. Unfortunately, the rescue attempt failed in all 8 cases. In the remaining 2 cases, we were able to communicate with the instrument (2 WHOI instruments) but it did not lift off the ocean floor, while we were on site.

We had anticipated that the chances for recovery were relatively low at two sites. At site number #42 we had deployed two instruments because we lost contact to the first one (WHOI) during the deployment survey a

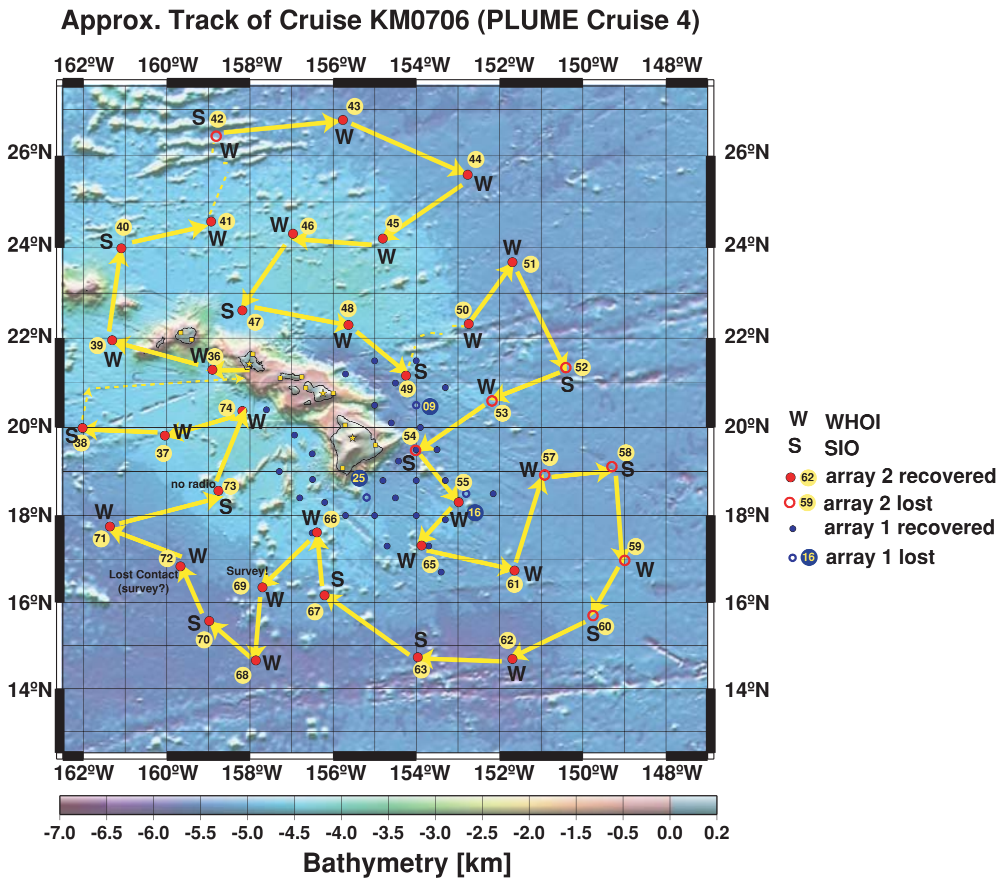

Figure 1. Location map of the two PLUME arrays. Blue dots mark the already recovered array (site numbers below 35) while the red dots mark the array that was to be recovered on this cruise (site numbers 36 and greater). Open blue circles mark the location of lost instruments of the first deployment. Yellow dashed lines mark anticipated transects for targeted multibeam survey.

year ago. Since this site is crucial for our data coverage, we then deployed a second instrument at the same location. We never established contact to either of these instruments during this recovery cruise. At site #72 we had encountered communication problems of a WHOI instrument during descent. Since this instrument was recovered successfully with the rescue beacon after having communication problems during the first deployment, the odds for a successful recovery were higher.

During the recovery of the first deployment last year, we lost 3 of 35 instruments (all SIO). The reason for the surprisingly large loss this time is currently unknown. All but 3 instruments were lost in a large area to the southeast of the island of Hawaii. This causes a serious gap in our data coverage which potentially will inhibit to address some key questions about mantle anomalies near the proposed location of the Hawaiian mantle plume.

* A secondary objective was to perform multibeam surveys on transits between stations to fill in crucial holes that still exist in publicly available bathymetry maps. Areas of special interest included, once again, the Maui Fracture Zone east of the islands, the southern Musician Seamount area, the Northern Arch Volcanic Field, the Molokai

Fracture Zone, the Clarion Fracture Zone, various seamounts, including the Swordfish and Cross seamounts and an apparently unnamed terminated fracture zone north of the Clarion FZ. We had mapped parts of the Maui and Molokai FZs on the first and second deployment cruises on the R/V Melville and the KM. We discovered significant gravity anomalies in some areas. This time, we also towed a magnetometer. The new dataset will significantly augment our current database. Near the end of the cruise, we had enough time to also map the Maui and Molokai FZs to the west of the islands where little is known about either of the two. While the Maui FZ has a clear signal in the Smith and Sandwell satellite altimetry map, the Molokai FZ is somewhat muted closer to the islands. We now have an excellent dataset for both sides of the FZ between 163 and 161.75 deg W. Unfortunately, our multibeam expert (Dayanthie Weeraratne) could not participate in the cruise so that the data editing will be done at home, during this summer.

* On April 18, three weeks before our cruise, U. Hawaii co-PI Cecily Wolfe received a request for a piggy-back experiment to measure seasalt particles in the atmosphere (PIs Tony Clarke and Steven Howell at U. Hawaii). The piggy-back experiment would not interfer with our recovery but the PIs had initially requested a bunk space. Due to berthing shortage, KM marine technician Brad Issler took over the minor tasks required keep operations running. The equipment which involved a few Zarges boxes (the largest being about 1m tall) was installed on level 02 on the port side, just if front of the pilot house.

* This was the first cruise on the KM to recover OBSIP passive seismic instruments. An issue raised before ship scheduling assigned our cruise was if a large-scale recovery would be feasible on the KM despite its unconventional double–hull design. An evaluation is attached.

* The loss of instruments compromises our proposed research. There are also some questions if OBSIP instruments could be improved to prevent such losses in future experiments. Since it is currently unknown why we lost so many instruments, it may be advisable to visit at least a few of our 13 sites with a submersible and try to get the instruments back that way.

The Recovery of the Second PLUME Array

The primary objective of this cruise was to recover the 38 OBSs (ocean bottom seismometers) of the second PLUME array on the Hawaiian Swell (red dots in Figure 1). This array was deployed on R/V Kilo Moana cruise KM0612 (Apr 12 - May 11, 2006) and recorded earthquakes for 13 months. Our primary interest focuses on teleseismic events to image the crust, upper mantle and transition zone beneath the swell. The array's large aperture of over 1000 km will allow us to conduct a thorough surface wave analysis to study the lithosphere/asthenosphere system of the swell and explore possible geodynamical causes for the swell relief. It will also allow us to perform deep–reaching body wave tomography and a comprehensive receiver function study that will explore the depth extent and a possible lower–mantle origin of the Hawaiian plume. We were fortunate enough to also record the large October 15, 2006 local earthquake. The observation of core-reflected phases from this event will give us unprecedented insight into structure near the core-mantle boundary and elucidate the question whether the Hawaiian plume reaches all the way to the CMB.

We recovered 28 of the 38 instruments deployed: 8 of 13 SIO instruments and 20 of 25 WHOI instruments. Operations went smoothly at the sites where we did recover the instruments. Contact to the instruments was established quickly and, on average, the first release command could be sent within 18min upon reaching the site. Releasing WHOI instruments usually take longer than releasing SIO instruments because their Güralp seismometer has to be locked before releasing it from the ocean floor. Several WHOI instruments required several burn commands (up to 4) before the instrument released. The reason for this is not entirely understood but a low voltage on the burn wire may be a reason. A relationship to water depth was not established. After lift-off, the instruments rose at speeds of 50–60 m/min in case of the WHOI instruments and 35–40m/min in case of the SIO instruments which have higher sink speeds than the WHOI instruments. The SIO instruments had achieved rise rates of only 30 m/min during the recovery of the first array, whereupon the SIO OBS team equipped their instruments with a syntactic foam pad for additional floation. One of the instruments had two pads and reached a rise rate of nearly 45 m/min. Recovery times (time between first sight of the instrument and "instrument on deck") were 21 min on average and compatible with recovery times on other ships (see section "OBS recovery on the KM").

Upon recovery, the internal clock time of the instrument was compared to GPS, as was done just prior to recovery. These two data points allow us to correct for drifts of the internal clock. With only two data points available, we assume a linear, mostly temperature-driven drift. Since temperature variations in the deep ocean are thought to be insignificant, there is no reason to assume more complicated drifts. An unpublished study of the time–dependence of ambient noise recorded during the 97/98 SWELL pilot experiment appears to confirm this in general though some instruments exhibited more complicated drifts. An initial data backup was made on board. At the end of the cruise, the chief scientist received a backup disk for 6 of the 8 recovered SIO instruments. The data were in MINISEED format though without the DATALESS SEED volume of the instrument responses that is required to read the data with program RDSEED provided by the IRIS (Incorporated Research Institutions in Seismology) data management center. Two instruments produced faulty headers and which requires post processing in the lab. The WHOI data will be distributed to PIs after time corrections have been applied.

Failed OBS Rescue Attempts

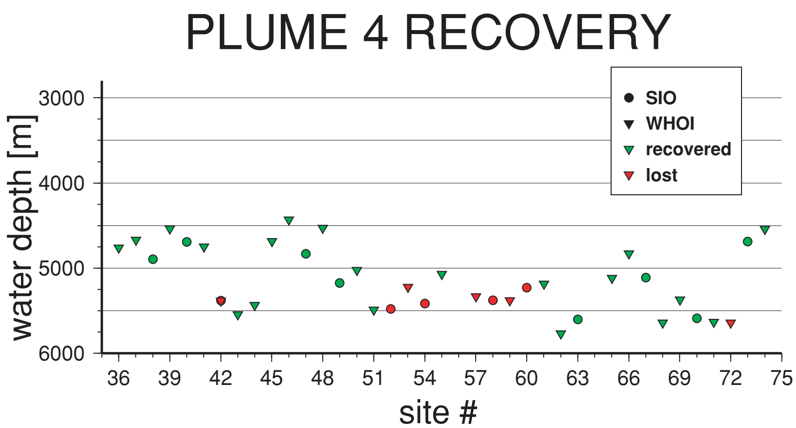

Figure 2. Successful and failed recoveries as function of local water depth, broken down by instrument type (SIO or WHOI). Both a WHOI and an SIO instrument were lost at site #42.

We had originally budgeted for at least one *rescue operation* in which a beacon is lowered on a winch wire to within a few 100 m of the instrument. The beacon can be programmed to send release commands for a specific instrument, every few minutes. A rescue operation is attempted when communication to an instrument cannot be established using the standard Edgetech deck unit. The failure to establish contact can have several causes and the rescue operation described here promises success only for the following cases:

1) the Edgetech deck unit fails, cannot send or receive commands reliably. It may send out a signal that is too weak or is unable to 'hear' the instrument's replies. Since the rescue attempt is time consuming, a first trouble shooting step is to swap the Edgetech unit. Intermittent and inconsistent problems with the units had occurred in earlier cruises where a swap sometimes led to success. On this cruise, we started out with an SIO unit and no swapping was deemed necessary. A swap with a battery–operated, possibly weaker unit occurred only once for an SIO instrument, but did not improve communication.

2) the ship–side transducer fails or has directivity issues. The WHOI tow–fish may not lie horizontal in the water, so that the transducer does not point downward but sideways. In this case the instrument receives the signal at a reduced strength. The deployment of a "dunk–ducer" (transducer on a simple cable) was sometimes performed to rule out sub–optimal source conditions.

3) the instrument's acoustics electronics board and/or transducer are weak and require a stronger signal than the Edgetech deck unit provides. The SIO group found at least one unit in the lab that had a diode mounted backwards, causing a reduction in sensitivity. This unit failed the acoustics rosette test on last year's deployment cruise when we found that communication failed beyond a certain water depth. Rather than risking the loss of an instrument, we had not deployed this unit. No other units failed the rosette test though the benefit of this test was contested on the deployment cruise and the configuration altered.

4) the SIO instruments have known issues with the directivity of the signal received and sent. Since the transducer is mounted horizontally near the bottom to one side of the instrument package, there apparently exists a shadow zone within which the instrument communicates

poorly. Lowering the beacon should increase the change to get the release signal outside of this zone.

5) ambient noise levels are too high. Noise could be generated on the ship or in the water. Various pumps and other components were shut off during recoveries. The improvement of communication was intermittent and inconsistent but switching off the starboard steering pump appears to have helped (see section ”OBS recovery on the KM”).

There are several unknowns to a rescue attempt with the beacon. We currently have no way to monitor the operation of the rescue beacon while it is in the water, as the Edgetech box does not pick up the signal of the beacon. We therefore do not know the distance of the beacon to the ship nor that it actually operates in the water. The only information we have is that we hear it on deck and the first few meters in the water. We also know how much wire is given out by the winch in order to estimate how far down the beacon is. We can not communicate with the instrument while the beacon sends out release commands and while the instrument is disabled. After a release command is sent, the instrument is in the burn phase in which it cannot receive other commands though it sends out a ping every 15 s, if the instrument is enabled. The latter requires a successful receipt of an enable command which we could not confirm on any instrument that required the rescue beacon approach. During the rescue phase, we therefore cannot range to the instrument, i.e. send a signal and wait for a reply. All we can monitor is an ordinary ping bouncing off the rising instrument which could also be a ping reflected from somewhere else.

Of 4 rescue attempts on the first PLUME recovery cruise in January 2006, we were successful in only one case which involved a WHOI instrument. The other three attempts failed (all SIO instruments). The WHOI instrument was examined after the rescue in the lab but it worked flawlessly then and the cause for the failure to communicate in the field was not established. This instrument was then deployed at site #72 where we lost contact about 3/4 down. A rescue attempt with the beacon on this cruise failed.

At site #42, we had successfully deployed a WHOI instrument but then lost contact during the site survey. An immediate rescue attempt with the beacon failed and we concluded that the instrument either experienced a catasptrophic glass floatation failure or the acoustic system stopped working. Since the site is a key location at the northern end of our array, we deployed an SIO instrument where this deployment proceeded flawlessly. Upon arrival to the site on this cruise, we planned to attempt another rescue of the WHOI instrument, after the recovery of the SIO instrument. However, we never established contact to the SIO instrument and rescue attempts of both instruments were unsucessful. Losing two instruments at the same site due to instrument–related failure is somewhat unlikely and we suspect site–specific circumstances. The water depth of nearly 5400 m should not be an issue as we successfully recovered deeper instruments. The instruments were placed in a valley between two ridges that rise about 2 km above the seafloor, at the southern end of the Musician Seamounts (see Figures 2,3). The valley is likely filled with sediments. It is possible that the instruments sink into the sediments but the should then still be able to communicate (Steve Constable, personal communication). A comparison of multibeam data from the deployment and recovery cruises does not reveal a major change in bathymetry, speaking against the occurrence of a major slide though detailed images covering the exact same area before and after the deployment are not available. However, a composite map reveals that the instruments may sit within 2km of a slump from the northern ridge. Sidescan sonar images obtained after we left the site toward the north show stronger reflectivity than to the south where the surface is smoother (likely covered by undisturbed sediments). The images and data will undergo further analysis. If the slump occured *before* the deployment, the instruments may have landed on small blocks and toppled over during the deployment or later.

After successfully recovering a WHOI instrument at site # 55 we tried, for the forth time, to establish contact with the SIO instrument at site #16. A rescue attempt with the beacon was not tried. This instrument is located 13.8 km to the northeast of site # 55, with a similar morphology (flat seafloor over several km). The site was abandoned after trying unsuccessfully for 15 min.

Instruments lost to the East of the Island of Hawaii

The other 7 instruments were lost at 7 sites in an area to the east and south of the island of Hawaii. At sites # 57 and 59, we established clear communication with two WHOI instruments and release commands were ackowledge by the instruments. However, the instruments remained on the ocean floor after at least 15 release commands had been sent. The instruments were disabled to conserve power and the sites were abandoned after 5 h 45 min and 4 h 30 min. The group discussed several scenarios why the instrument would be able to communicate but get stuck on the ocean floor:

1) the sensor ball could release early and the package could land on the ball, pinning the ballast weight between the sensor and the package. In this case, the sensor ball would hold the package down after a release.

2) the package could get stuck in the mud. The instrument package may have sunk into the surface sediments. Since the transducer is installed near the top of the package, it would still be able to communicate but a partially buried package would not have enough floatation to pull itself out of the mud. The danger in this case would be that the released package could slowly inch its way out of the mud after we abandoned the site.

3) the voltage on the burn wires could be too low, causing not enough corrosion for a release in a timely fasion. Weaker batteries could lower the target voltage from 10.4 V to nearly 10 V though we have no evidence that this really occurred. There was a suggestion that the release process could depend on water depth/pressure though this needs further investigation. The danger in

this case is that the instrument now sits on the ocean floor with a partially corroded burn wire so that the instrument could release before a return visit.

After completing the visit at site #60, the chief scientist suggested to go back to site #59 to check on the instrument though this would have meant that less time be available for further rescue attempts which typically add 4 h to the time on site. The OBS personnel argued that little could be learnt from such a visit and voted against it.

At the five other sites, site numbers #52 (SIO), #53 (WHOI), #54 (SIO), #58 (SIO) and #60 (SIO), communication to the instrument was never established and the rescue beacon was deployed. None of the rescue attempts were successful. The time spent on site was typically 6 h 30 min but some recovery attempts lasted up to 8 h. The winch broke during one such attempt and required repair. The group discussed several scenarios for the failed rescue attempts:

1) site–specific issues. We tried to find a common factor in morphology, sediment cover or other site–specific parameters. Instruments deployed in valleys or large plains are more likely located on sediments. The instruments lost were found on both, valleys as well as along slopes or even on ridge-like abyssal hills. A common factor has not been established (see below).

2) a massive turbulence flow that covered the instruments. We have no evidence for such an event. Instruments that a moderately buried in sediments (e.g. a few meters) should still be able to communicate (Steve Constable, personal communication), much like the 12 kHz Knudsen echosounder can penetrate several meters into the sediments.

3) an event that triggered liquefaction and subsequent burial of the instruments. The only known earthquake that could cause large–scale liquefaction was the magnitude 6.7 October 15, earthquake on the island of Hawaii. The closest site, #54, was 210 km away. It is somewhat unlikely that liquefaction could occur at such distance though the highly water saturated sediments on the ocean floor may increase the likelihood. All other stations were likely too far away.

3) failure of the glass floatation. The sites of the lost instruments were some of the deepest (Figure 2). Instruments that did not communicate could have suffered from a catastrophic failure of the glass floation that would also knock out communication. This would be especially the case for the WHOI instruments, whose electronics is housed in Zeiss–Jena glass balls. SIO instruments can also be affected even though the anodized aluminum pressure case housing the acoustics electronics is about 1 m below the McLane glass balls. Many discussions appear to indicate that this distance is not sufficient to protect the pressure cases of the SIO instruments. It is unknown to the chief scientist that such an imploded instrument was ever recovered from the deep ocean.

4) dead batteries in the acoustic system of the instrument. The instrument's acoustic system is powered by off–the–shelve C or D cell batteries. The SIO team recently discovered that newly purchased batteries carried less charge or were empty where the manufacturers do not QC (quality control) their batteries before shipment. It was also discovered that sometimes the leads connecting the batteries in a custom–made pack could be damaged along sharp edges. Though such a pack would be functional on board, contraction during descent could damage some of the leads and cause premature discharge. If partially discharged batteries upon deployment were an

issue, it would be hard to understand why the loss of our instruments clustered in one area.

5) premature release of the instrument. Some instruments can release prematurely when the burn wire corrodes faster than anticipated. While this is a possibility at individual sites, it is somewhat unlikely that 8 instruments that are deployed over an area of over 300,000 km^2 would suffer such a failure simultaneously. Unlike other ecperiments, e.g. deployments in the Gulf of Mexico or even in the deeper ocean off Venezuela, we have not observed any major corrosion issues on the recovered instruments.

6) premature release by an accidental acoustic command or random noise. Each instrument releases on an individually coded command that, according to Edgetech, involves the combination of a set of frequencies. We do not know the exact composition of this signal. We also don't know how likely a release is when random acoustic signals are emitted. A possibility could also be that other acoustic sources interfere while we try to release our instruments. An enquiry by U. Hawaii ship operations confirmed that there were no NAVY operations ongoing during our recovery attempts. The area around Hawaii hosted RIMPAC operations in July 2006, a multi–national war–game training exercise involving 40 ships and 6 submarines. It is currently unknown if this specific area was visited during this time. News articles point toward the northwest of the islands that was declared a Marine National Monument by President Bush only a few weeks earlier. Navigational charts mark some of the area involving our sites as areas for NAVY training exercises though it is unknown if acoustic communication has occurred.

7) a massive differential pressure event. There were several tsunami generating earthquakes during the deployment, the most serious being the magnitude 8.1 April 1, 2007 Solomon Islands event. It is not clear if a tsunami could destroy our instruments in a specific area but leave all the others unharmed. A massive explosion in the military training area may be a possible cause though this is highly speculative.

The unsuccessful recovery attempts to the east and south of the island of Hawaii caused a devastating loss of data. The bathymetry across the Hawaiian swell is strongly asymmetric. Data from both sides of the islands are crucial for the surface wave study to investigate the geometry of the lithosphere–asthenosphere system beneath the swell. Stations near the rim of the array are located on presumably unaffected 90 Mio year old lithosphere and data from the lost instruments are crucial to benchmark 90 Mio year old lithosphere. This step is crucial to evaluate the anomalies caused through the interaction with a presumed mantle plume. The loss of data coverage will likely not allow us to investigate structure in the deeper transition zone and uppermost lower mantle through body wave tomography and receiver functions. The lost instruments are in line with earthquakes in Japan, one of the richest and most valuable sources of distant seismicity. The question whether the Hawaiian plume originates in the lower mantle may therefore be elusive to the PLUME project.

Morphology and Surface Character near the 7 Failed Rescue Sites

A possible site–specific scenario for losing instruments could be massive landslides. Comparison of multibeam data before and after deployment provided no evidence for such an event. The lateral resolution of multibeam data is probably no better than 100 m. The compatibility of multibeam depths between different surveys also depends strongly on the velocity profile applied in the data processing. On both cruises, profiles were calibrated through daily XBT profiles so the baseline shift between before and after images should be better than 20m. Hence, we cannot exclude the possibility of small-scale changes such as slides of less than a few 100 m and changes in bathymetry of less than 20 m.

A composite map of the greater area around site #42 indicates that the instruments may sit within 2 km of the foot of a slump originating from a ridge to the north (Figure 3). The top of the ridge that raises at least 2000 m above the ocean floor is more than 20 km away. Sidescan sonar images show stronger reflectivity to the north of the site than to the south, indicating the the northern part is rougher than the southern part that is likely covered by undisturbed sediments. It is conceivable that the instruments may have landed on small boulders and toppled over. The composite image, that includes the area north of the site, was not available to us prior to deployment. The images and data will undergo further analysis. There is no such evidence at any of the other sites.

We find no common factor in morphology that could indicate why we lost the instruments for site–specific reasons. Recoveries were unsucessful on both the perhaps rougher ridge–like abyssal hills as well as the smoother valley floors in between (Figure 3). In fact, any of the shown morphology can also be found at sites of sucessful recoveries. On the deployment cruise, we used the multibeam images to avoid locations on steep slopes or with otherwise rough topography whenever avoidable. It is unclear whether a completely flat area in a valley is to be preferred over the top of a ridge or not. The flat areas in valleys could provide stable platforms but could also host sediments where an instrument could sink in. On the other hand, the deep ocean away from Hawaii experiences extremely low sedimentation rates of only a few cm per thousand years, or less. Sediments are likely to be compact and not of the 'sticky type' (Jerry Winterer, personal communication). We tried to avoid topographic highs as these are exposed areas and currents are likely stronger, providing noisy environments. Sometimes, we compromised on gentle slopes, away from topographic highs and vallye floors. "Gentle slopes" in this context are areas with slopes less than 1 m over a 10 m distance.

A certain type of sediment may increase the likelihood of loss of instruments in the deep ocean though it is not entirely clear what this would be. No experience has been gathered so far for long–term OBS deployments in ocean depths much greater than 3 km. According to U. Hawaii's OTG director, Bruce Applegate, off–swell sediments in the deep ocean are predominantly fine clays with extremely low sedimentation rates (cm per thousand years). Setting site #54 aside, the area of the 6 other lost instruments seems too far from the islands to produce significant biogenic sediments or sediments from run-off down the island margins. The "Surface–sediment composition of the northeastern Pacific" map of DNAG volume N (Northeastern Pacific and Hawaii) shows a mix of sediments

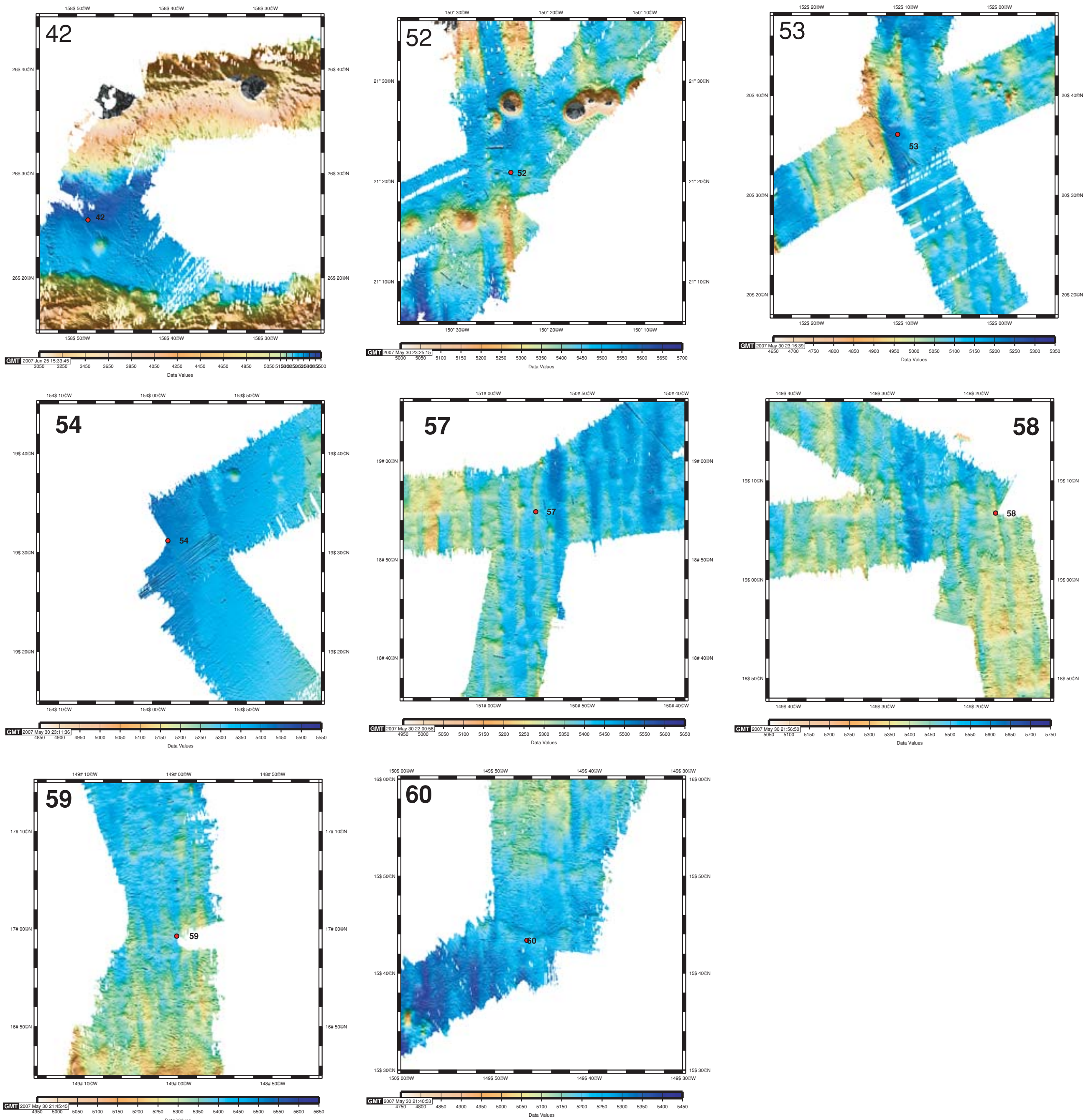

Figure 3. Maps of the seabeam survey near 8 of the 9 sites of lost instruments (site #72 is not shown). The "streaks" in many maps are mid–ocean ridge–parallel abyssal hills that are ubiquitous in the deep Pacific Ocean, off the Hawaiian Swell. The color scale changes in 50 m increments, except at site #42 where the 50 m increment is applied below 5100 m but in 200 m increments above. We find no particular morphology that could explain the loss of the instruments as similar morphology can be found at sites with sucessful recoveries.

of unknown and terrigeneous lithology. Some references cite "soupy sediments" in the area where a significant amount of particles remain suspended tens of meters above the seafloor. Clear communication at two of the 7 sites to the east and south of the island of Hawaii also argues against such sediments. Our Knudsen records also show clear reflectors, arguing against such sediments at our sites. “Soupy sediments” would likely hamper communication to the instrument but it is not clear how they would hold an instrument on the ocean floor. Muddy sediments, with fine particles, may exhibit a clear reflector but could be soft enough for an instrument to sink in and get stuck though communication should remain clear (Steve Constable, personal communication). At many sites, the bottom of the recovered WHOI seismometers were covered with light ochre to reddish sienna colored sticky mud of extremely fine particles. The about 1 in high feet of the seismometer frames of the SIO instruments were also covered, sometimes to the rim. No mud was found higher up on the frame though the frame could have lost the mud upon ascent. Some WHOI instruments required several burns to leave the ocean floor. While a weak burn could be one cause, another possibility is that it takes some time for the WHOI instruments to pull out of such sediments. These instruments are mounted on a 1 in thick plastic grid that has a relatively large foot print. While mud was found only on the seismometers, the grid may have lost the mud during ascent. Table 3 summarizes site–specific parameters for the lost instruments.

Table 3: Failed Rescue Attempts

Site #	Instrument	Rescue Status	Water Depth	Local Morphology	Surface Character (Knudsen)
52	SIO	no commun.	5478	rough; lower level less than 100m topo over 2km	diffuse reflector (2m) over 5m layer 2nd reflector over 20m layer clear 3rd reflector
53	WHOI	no comm.	5221	bottom of ca. 2km wide valley 500m escarpment 1km to the W	?? [4]
54[3]	SIO	no comm.	5414	flat over many km	?? [4]
57	WHOI	no release	5333	top of ridge ca. 500m wide; 50m high	sharp reflector over poss. 20m completely transparent layer overlying diffuse reflections
58	SIO	no comm.	5377	rough; top of ridge ca. 650m wide; 50m high	?? [4]
59	WHOI	no release	5379	rough; near valley floor ca. 850m wide; 50-100m deep	sharp reflector over 7m transparent layer; sharp reflector over 30m transparent, then diffuse
60	SIO	no comm.	5228	rough; near top of ridge ca. 1500m wide; 50m topo	sharp reflector over diffuse layer 10m more transparent layer possible noisy Knudsen
42	WHOI	no comm.[1]	5382	flat 20km wide valley between ridges 2km higher within 2km of a slump?	sharp reflector over 20m completely transparent layer 20m diffuse layer below
42	SIO	no comm.	5382	”	”
72	WHOI	no comm.[2]	5642	deep ocean, flat	at least 3 reflectors within 10m over diffuse (>10m) reflections

[1] Lost contact after 3/4 of survey. Deployment and recovery on first array flawless.
[2] Lost contact on way down. Instrument recovered with rescue beacon on first deployment.
[3] Successful recovery of a nearby instrument the year before.
[4] data require postprocessing

Future Rescue Attempts Using a Submersible

The loss of instruments seriously compromises our proposed research in nearly all aspects of seismic applications. The great loss at the southeastern perimeter of our array is particularly troubling. After coming back from the recovery cruise with such bad news, there are now some questions if OBSIP instruments are ready for long–term deployment in the deep ocean. Clearly, there needs to be some improvement to prevent such losses in future experiments. It is currently unknown why we lost so many instruments. Geological factors are unlikely responsible as we recovered instruments successfully on the first deployment, where we now lost them. We also find no common factor in morphology and surface character. Water depth and ambient pressure may be an issue but this is uncertain as we successfully recovered our deepest instruments. We have a long list of technical issues

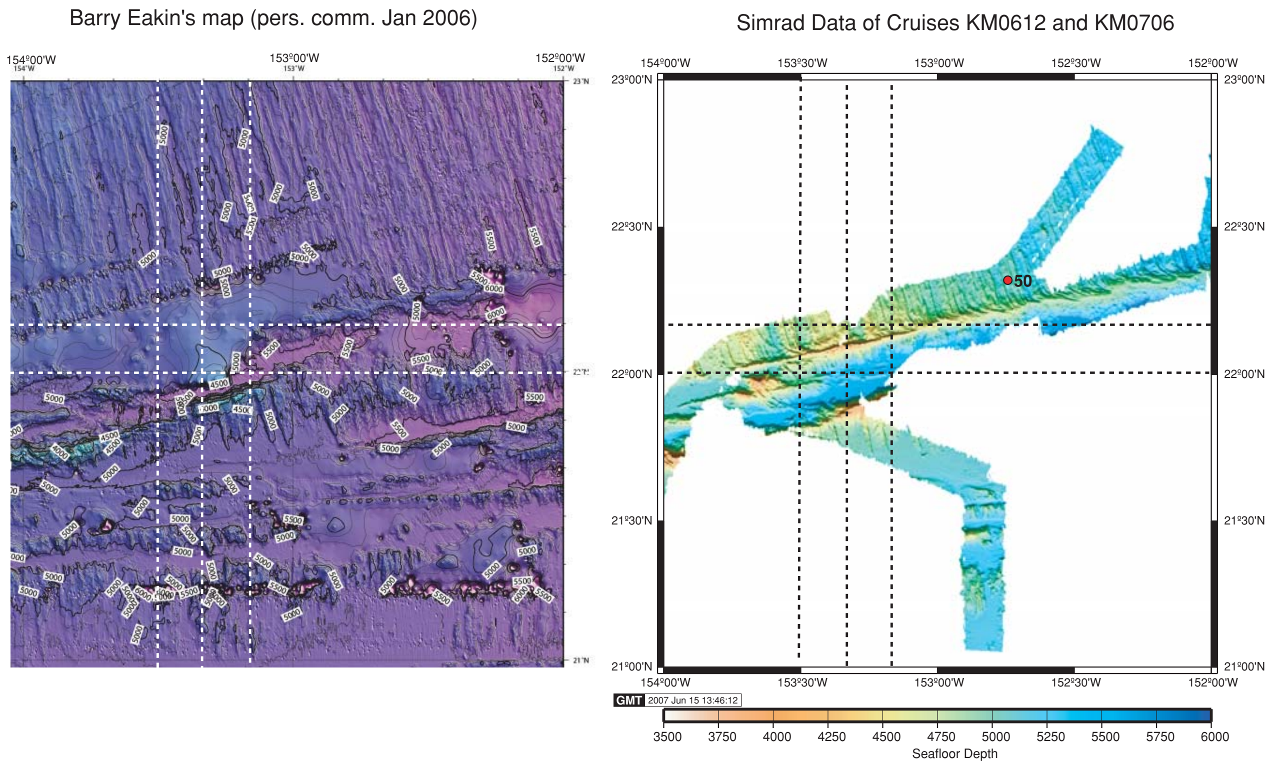

Figure 4. Map of the seafloor along the Molokai Fracture Zone (FZ) as known before and after the PLUME cruises on R/V Kilo Moana, KM0612 and KM0706, on the same scale. Left: Barry Eakin's unpublished map that includes classified and otherwise publicly not available data. Right: Simrad multibeam swaths collected during KM0612 and KM0706. The red dot marks PLUME site #50. In the area marked by the dashed lines the pre–PLUME cruise bathymetry was known through satellite altimetry data only (the "Smith and Sandwell" map). Large discrepansies are obvious.

for troubleshooting where a replacement of some of the components may be very costly. Since we lost most instruments in moderately deep water (around 5500 km), the #1 candidate for failure are failing glass floation balls. Replacing those in the SIO instruments with syntactic foam is expensive, while the WHOI group would need to completely redesign their instruments (all parts are now housed in glass balls). On the other hand, it could turn out that the instruments were lost due to failing acoustic systems. Or the culprit may simply be bad batteries though this could not easily explain why we lost so may instruments in one area. Replacing the wrong component can turn out to be a very costly and potentially devastating to the image of the fleet. It seems therefore extremely beneficial for both the PLUME project as well as OBSIP to try and recover at least some of the lost OBSs with a submersible such as WHOI's Jason or SIO's deep-tow. Such a mission was extremely successful in another project called PLUME near the Society Islands conducted by a group of French and Japanese scientists. The group lost almost all of the Japanese OBSs but then recovered them successfully with a submersible.

Collection of Seafloor Mapping Data

A secondary objective was to perform multibeam surveys on transits between stations to fill in crucial holes

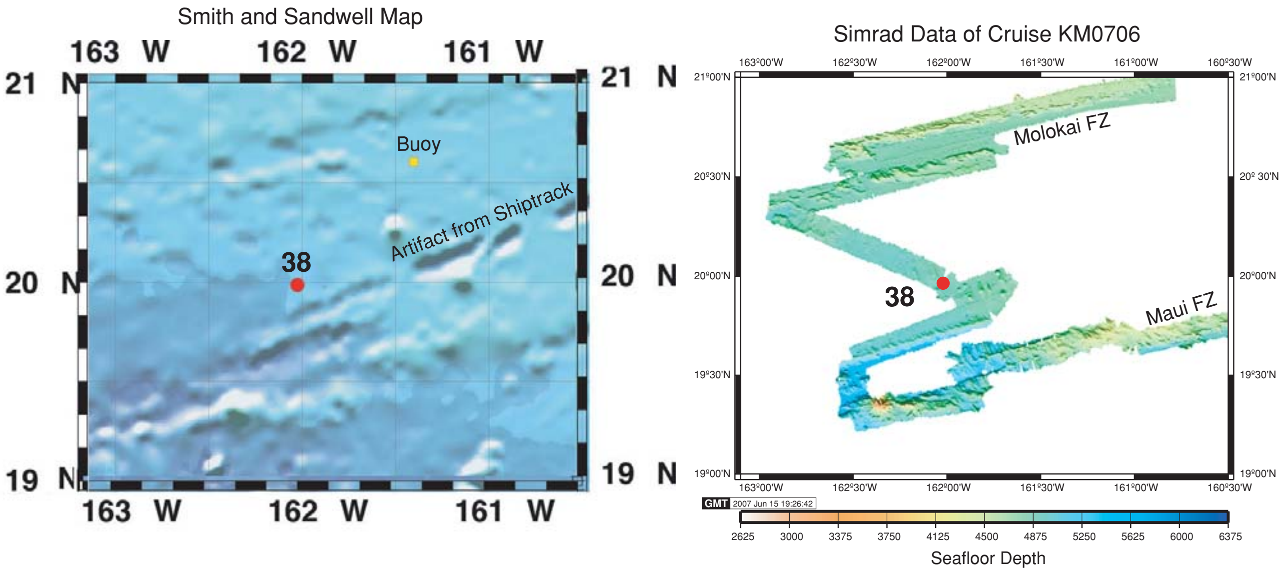

Figure 5. Map of the seafloor as known before and after PLUME cruise KM0706, on the same scale. Left: Smith and Sandwell map that is derived from satellite altimetry and shiptrack data. Right: Simrad multibeam swaths collected during KM0706. The red dot marks PLUME site #38. The published USGS map by Eakins et al. has one swath across the Maui FZ, east of 161° W, while the Molokai FZ had not been mapped.

that still exist in publicly available bathymetry maps and/or databases. This was not proposed in the original proposal to NSF. However, during cruise preparations it became evident that detailed seafloor data are not readily available for our study area, especially not in the area of this second, far-reaching deployment. Prior to the first deployment cruise somewhat more than a year ago, the chief scientist was handed a detailed version of the USGS map by Barry Eakins. We have no access to the data nor an electronic version of this map. The USGS web site then said that the data of the original map would be released within a year. This announcement has now disappeared. In the meantime (Jan 2006), Eakins provided a pdf file of an updated map though the plotted area jure barely covers the first PLUME deployment. We have no access to the data as the database allegedly contains classified and otherwise restricted data. The best easily accessible dataset to–date is the data provided at the NGDC. To within roughly 1 degree of the islands, detailed bathymetry data are available (on a scale of a few arc seconds), but outside of this the only data available are 2min data derived from the Smith and Sandwell satellite altimetry/shiptrack map. GEBCO sells maps on a 1 minute scale but inspection of samples of this map, and comparison with the Sandwell map, discouraged us from purchase. After many increasingly frustrating discussions with Sandwell, we now realize that the assumption Sandwell used (crust is isostatically compensated everywhere) to derive bathymetry, is invalid in many places around Hawaii, but this does not appear to be public knowledge. Also, erroneous combination of satellite altimetry and ship track data created artifacts in the map.

For example, significant parallel streaks exist to the southeast of the Hawaiian islands (see Figure 1). These streaks are roughly parallel to the plate motion direction and cover a part of the ocean around Hawaii where the swell is missing. It is very tempting to search for a geodynamical model to explain these streaks in conjunction with the missing swell. Only after talking to Sandwell did we learn that these streaks are artifacts. There is no mention of this on the NGDC website, nor on his own web site. We realize that the Hawaiian mapping group has an extensive database but this dataset, to our knowledge, also is not publicly available and does not cover our second deployment. Since seafloor data collected on UNOLS vessels eventually become public, our data will be available to other researchers and this secondary objective of ours meets NSF's broader impact policy of funded reserach.

Areas of interest included the Maui and Molokai Fracture Zones (FZ). In the cruise report for PLUME cruise 3 (KM0612) we showed the first detailed image of the Maui FZ east of the islands that no one really believed existed east of the islands. On last year's cruise, we also mapped a part of the Molokai FZ that has not been mapped previously but showed a unique residual bathymetric high in Eakin's unpublished map that may have resulted from merging multibeam data with the satellite altimeter data. We had mapped this region but then found that we missed some escarpments because we were misled by this map. This year, we filled these gaps and we now have moderately good coverage on a previously unmapped area (Figure 4). We also collected gravity and magnetic data to evaluate a possible anomaly such as buried core complexes that have been found in fracture zone segments in the Atlantic Ocean (Donna Blackman, personal comm.). Since the recovery of the last third of our deployment occurred relatively timely, we had enough time left over, to also map these fracture zones to the west of the islands (Figure 5). To our knowledge, only an incomplete survey exists of the Maui FZ east of 161° W. The Maui FZ appears to be quite complicated and, in fact the imaged segment reminds us of the segment of the Molokai FZ that we visited in the east. The Molokai FZ has no remarkable signature in the Smith&Sandwell map but the multibeam data attest the typical en–echelon features on both sides of the fracture zone that are also found elsewhere.

Other targets developed during this cruise and were mapped as time for detours became available: we mapped targets in the Musician Seamount area, the Northern Arch Volcanic Field, the Clarion Fracture Zone, an apparently unnamed terminated fracture zone north of the Clarion that we began to map on last year's cruise, and various seamounts including the Cross and Swordfish seamounts that are part of the southern Arch volcanoes. We also identified several intriguing "seamounts" near site #66 that show up in the Sandwell map. The seafloor turns out to be flat which may indicate features buried by sediments. A detailed analysis of the ship gravity and magnetic data is underway.

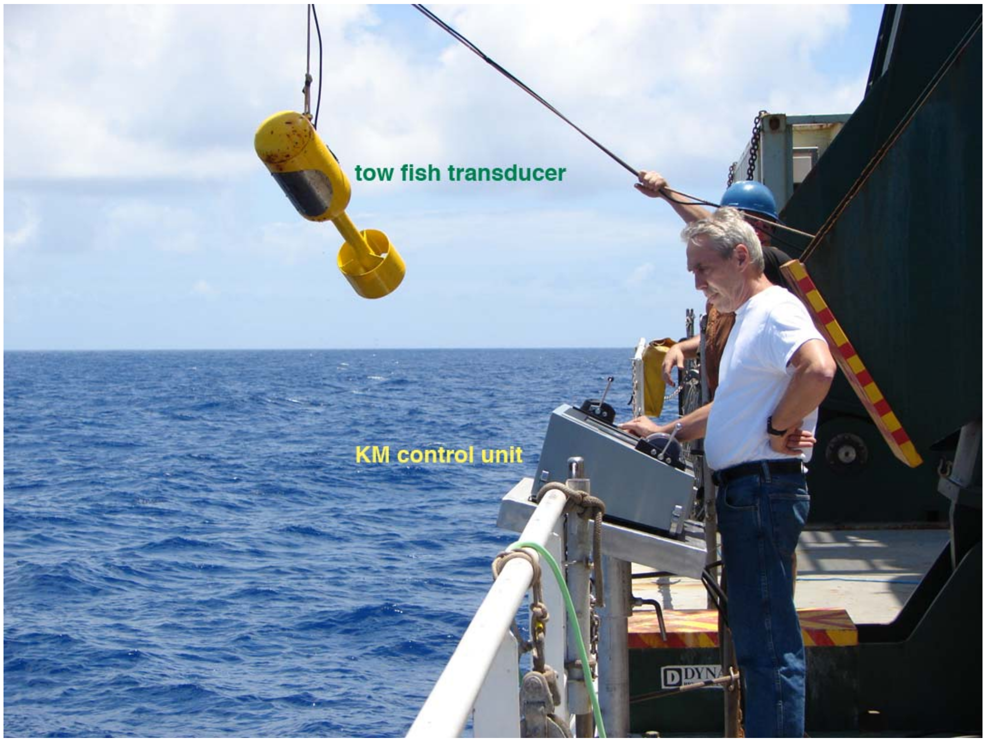

Figure 6. Control unit mounted on the stern. The captain steers the ship from here during recoveries. Background: the WHOI tow fish transducer is recovered after the instrument has surfaced.

OBS Recovery on the R/V Kilo Moana

Our cruise last year (KM0612) had shown that the KM is an ideal platform to deploy instruments. There are significant advantages to use this vessel for a research cruise in general. This ship provides a very stable platform, event in moderate sea state, and probably has the best seafloor mapping capabilities in the UNOLS fleet. It has less deck space than other global–class UNOLS vessels but ample lab space that is spread over several labs. Since OBSIP personnel now bring their own transducers and GPS antennas, they no longer depend on compatibility with ship equipment. This had been an issue on other vessels as well but came up, again, on last year's cruise. However, a point of concern between OBSIP personnel remained how feasible it is to use the KM for OBS recoveries, due to its unique double–hull design. A mock–recovery on the KM on our cruise KM0612 was regarded a success by the chief scientist and the ship crew. But OBSIP remained concerned that the ship could pass over the instrument, especially in high sea state. The instrument could then be damaged when it is pinned and slammed against the ship. There is also the perception that recoveries on the KM last longer than on 'regular' ships because the backing down on instruments takes longer than an along–side approach.

There are three principal issues regarding OBS recoveries on the KM:

1) The Freeboard Issue: The approx. 16-18 ft freeboard of the KM is significantly higher than on other vessels. KM's freeboard can vary significantly because changing the ballast in the hulls can lower the stern. At 25 ft, the ship crew provides significantly longer fishing poles than the OBS groups use to hook up their instruments. Some OBS personnel feel that the longer poles are more cumbersome to handle.

2) Along-side versus Stern Recoveries: On a "regular" vessel the instrument is approached from the starboard side and at least 3 people need enough room on deck to maneuver with fishing poles for the hook–up of the instrument. Along-side recovery is not possible on the KM because the stern is too short. Recovery is therefore done over the stern where the ship backs down on the instrument and the retrieval is done through the A-frame. Backing down on the instrument is potentially hazardous when swell flushes it beneath the stern and pins it against the ship. During our 28 successful recoveries on the KM, this never happened. Though sea state was higher on the KOK recovery cruise, we did have one incident on the KOK where the ship ran over the instrument, thereby clipping off the flag.

3) During both deployment and recovery, the life lines have to be removed to move the instruments off and on deck. Apart from experienced OBS personnel, only ship crew members handle tag lines and fishing poles.

While the OBS groups have plenty of experience using this technique, we had incidences on the PLUME recovery cruise on the KOK last year were the instrument swayed too much and it or the sensor banged into the hull. Swaying of an instrument occurs when the ship rolls and/or taglines are not applied securely. This is potentially catastrophic for the seismometer (e.g. if the WHOI sensor failed to lock). The handles on the WHOI OBSs turned out to be too small for an easy hook–up and were redesigned. The SIO OBS group is aware that handles near the bottom of the instrument package would significantly reduce the risk of swaying and potential damage but they have not yet found the time to add these handles. The chance that the instrument could bang against the hull while it is swaying during recovery on the KM is nearly zero though SIO instruments tended sway somewhat.

Ship personnel have made significant improvements since last year's mock recovery to cut down on recovery times and to make recoveries safer:

1) a control unit was mounted on the stern, directly by the railing (see Figure 6). The captain can operate the ship from this control unit much like from similar units that are mounted on the two wings near the bridge when the ship docks or passes a narrow canal (e.g. the Panama Canal). He sees the instrument at all times and can react to unexpected movements much better than if standing either on level 02 (as done during the mock recovery last year) or on the bridge.

2) the ship purchased new 25 ft carbon poles that are lighter than the aluminum poles used during last year's mock recovery.

3) the ship purchased new rope for the retrieval. The relatively expensive rope is made of a synthetic fiber that does not absorb water. It therefore does not get heavier when wet. The rope is mounted on a winch near the staging bay on the stern. Once the instrument is hooked and the seismometer

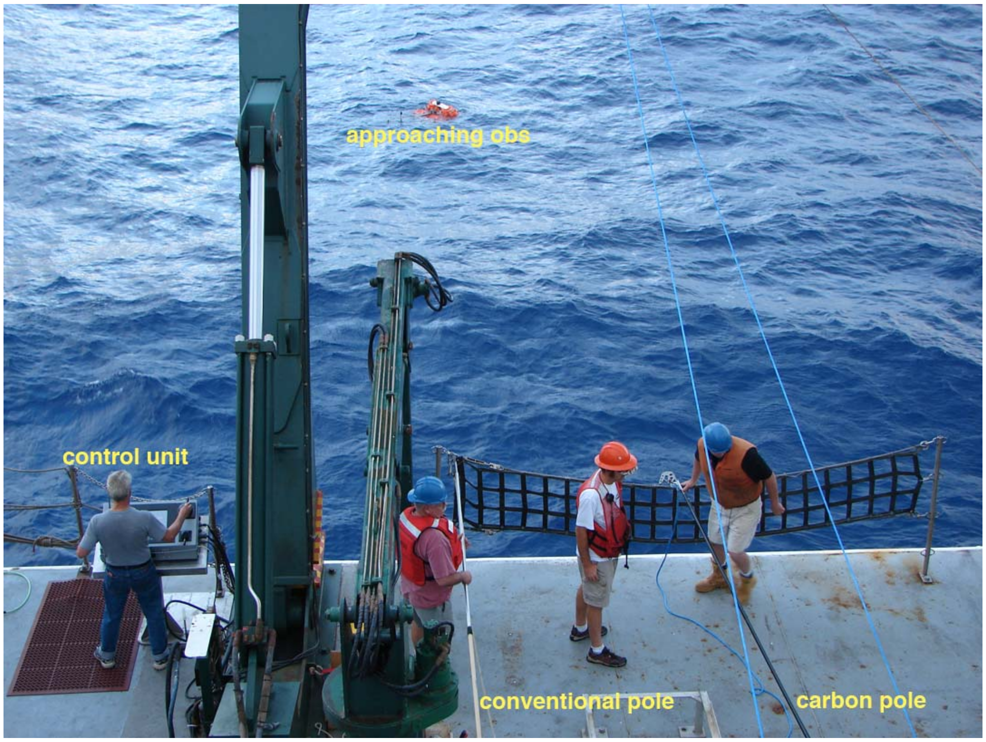

Figure 7. Approach of a WHOI OBS. At this point, the ship is operated from the stern using a control unit that is mounted near the railing. In calm weather, the ship is turned into the wind and the stern backs down on the instrument. In rougher sea state, the stern is turned into the wind and the ship has to chase the instrument.

secured by tag lines, it is pulled by the winch on the rope through the A-frame.

The recovery procedure is then as follows (see Figures 7,8,9,10): after an instrument has surfaced, the bridge turns the ship into the wind and lets the instrument float past the stern. The wind then helps to push to ship toward the instrument. At this point, the captain on the stern takes over. The stern turns toward the instrument and slowly backs down on it. OBSIP personnel waits with tagline poles and hook onto the bail on top of the instrument. The instrument is then lifted approximately to the level of the stern so that more tag lines can be attached to the instruments (to reduce swaying) and to the seismometer chain to secure the sensor ball. The lifelines on the stern are then removed to allow a speady haul of the instrument on deck. To some, the fishing from a higher stern (the KM has a higher freeboard than other ships) may be a point of concern. Fishing for instruments using a longer pole may take a little longer and/or requires more trials than on conventional recoveries. It was also felt that the carbon poles bend more than the aluminum poles. The chief scientist knows of only one complaint in this respect and this was not really a big issue on this cruise.

For the safety of the instrument, the most critical point during the recovery is the moment when the instrument gets very close to the ship. If the personnel fail to hook the instrument, the ship has to back away and try a

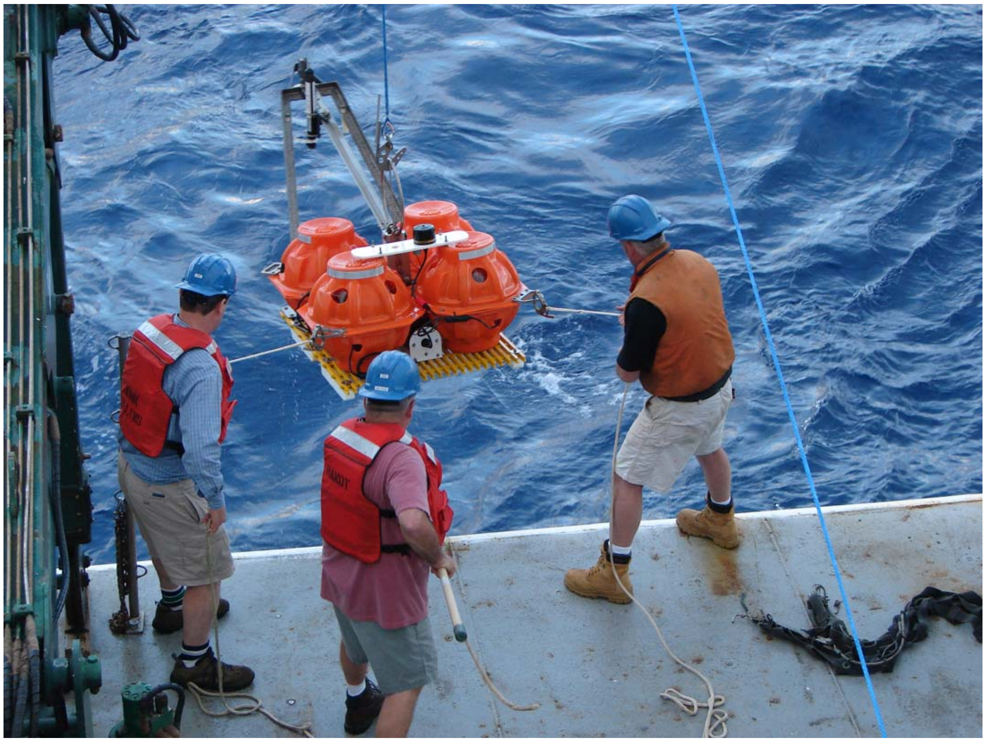

Figure 8. Retrieval of a WHOI OBS. Three or four taglines are deployed. One hooks into the top bail and is used to hook into the A-frame rope for lifting. One or two taglines are then deployed in one of the lower loops in the instrument frame to stabilize the instrument during lifting. A forth tagline secures the sensor ball.

new approach. This takes a few extra minutes and happened only a few times (less than 5 times) on our cruise. Once the first tagline is attached to the bail, the time it takes to get the instrument on deck is probably less than a minute. The retrieval onto the ship seems trivial and safer than on other ships. As the A-frame is extended, the instrument is pushed away from the ship and then raised and pulled in. During this step, SIO instruments tended to sway somewhat while WHOI instruments appeared stable. The reason for this is probably because loops near the bottom of the frame on the WHOI instruments allowed the deployment of an additional tag lines below the center of mass of the instruments. WHOI personnel also had one more person than SIO personnel. At no point however, was an instrument close to bumping into anything on the ship, as had occured on the KOK last year. Regarding personnel safety, the most critical point during the recovery is the operation through the A-frame when the lifelines are removed. On some recoveries (perhaps the first few), the lifelines were removed before the last tagline was attached. To some, this may appear dangerous (NB: untrained personnel such as the watch standers were not allowed to participate in operation). A recovery without lifelines is not an issue on mono–hull ships that approach the instrument along–side. On the other hand, removing lifelines is standard procedure when hauling dreges on board. The recoveries on our cruise KM0706 can therefore be considered safe and 100% successful.

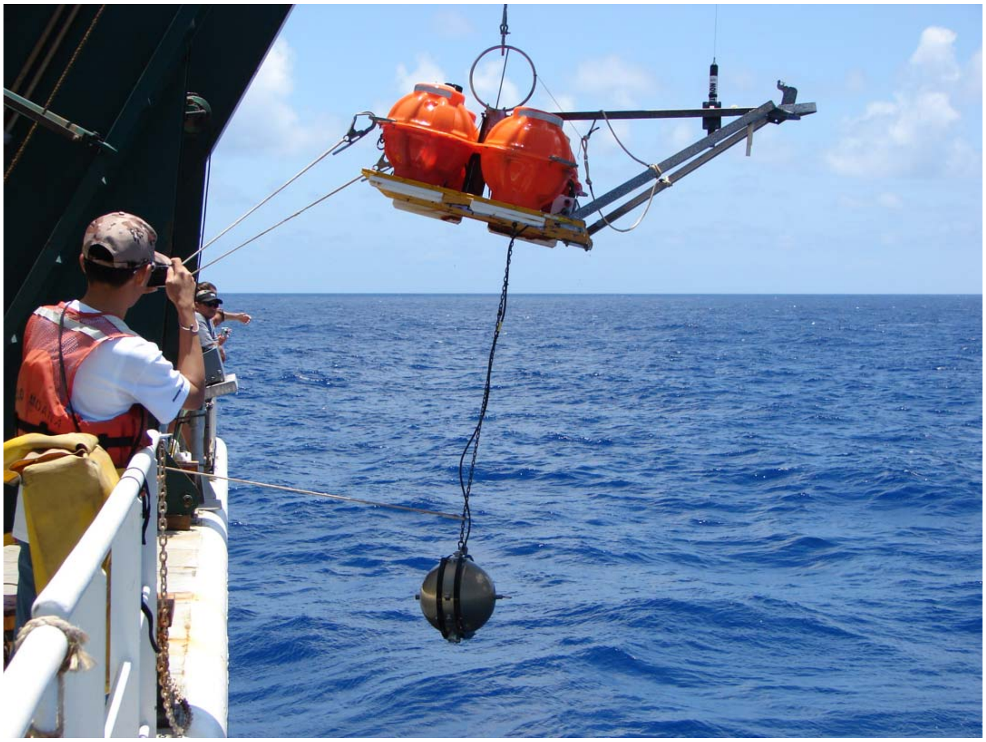

Figure 9. View from the stern, portside. Securing the WHOI sensor ball prior to the retrieval of the instrument.

Figure 10. Retrieval of a WHOI OBS. The instrument is pulled through the A-frame and hauled on deck.

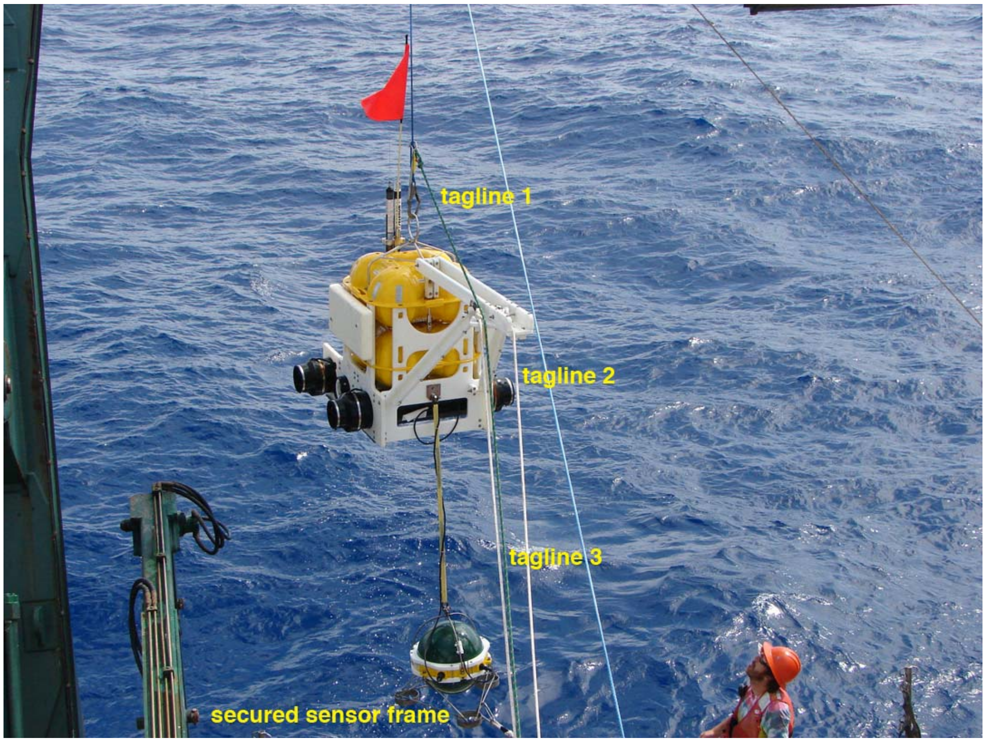

Figure 11. Tagging of a SIO OBS. These instruments have four tagline, including the one the hauls the instrument through the A-frame, plus a line securing the sensor frame near the bottom.

The winds and sea state were unusually calm during our cruise, with wind speeds rarely more than 20 knts and swell rarely more than 9 ft. The chief scientist enquired about the scenario with higher sea state. In this case, the ship would not head into the wind but with it. The ship's approach to the instrument then may take longer but the ship is then less likely to drift over the instrument. OBS personnel were impressed that the recoveries ran significantly smoother than the 'mock recovery' a year ago that lasted 25 min. The "recovery time" here is that time between the surfacing of the instrument and the instrument sitting on deck. We have three tools to determine whether an instrument is on the surface: 1) the acoustic communication to the instrument degrades significantly for the WHOI instrument because the transducer sticks out of the water. The radio signal from the instrument can be heard on the ship's RDF (radio direction finder) and we have visual contact. A flag on the SIO instruments helps to sight the instrument during day time and strobe lights help to find the instruments at night. Indeed, most of the recovery times on this cruise were significantly shorter than 25 min, with the mean being 21 min. Recovery times on the KOK last year varied between 5 and 44 min, with an average of 21 min though the sea state was typically rougher. Recovery times on the KM are therefore comparable to those on other vessels.

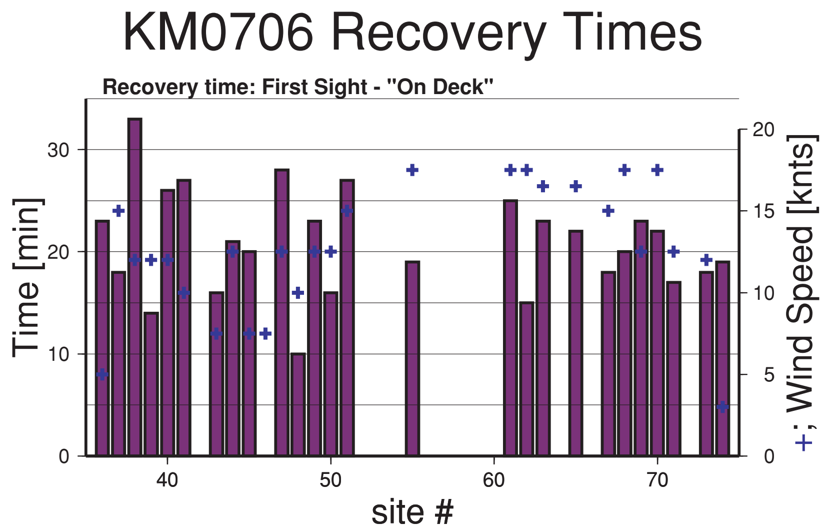

Figure 6. Recovery times on the KM. Left axis and bars show the recovery times. Right axis and blue crosses mark prevailing wind speeds. Higher wind speeds may be indicative of rougher sea state. The average recovery time was 21 min.

SHIP AND SHIP CREW

Space Issues

The ship is commonly compared to global class UNOLS vessels and most significant numbers compare with those of the Melville (e.g. fuel capacity, range, endurance, fuel comsuption, berthing, lab space). Space issues had been discussed in the last cruise report. Kilo Moana's stern is shorter but wider, which requires some rearrangement and adjustment of procedures. Aft deck space is significantly smaller than on the R/V Melville (2200 sq ft vs. 4050 sq ft). Though initially thought to be of concern, we had plenty of space to store the partially disassembled WHOI instruments and the SIO instruments. We would have had no problem storing the additional 10 lost instruments. On the Melville, the WHOI instruments did not have to be partially disassembled because more space was available. Initial plans to store the instruments on level 01 on the KM deployment cruise were refuted by the captain who would not authorize associated crane operations in heavy sea state. On the other hand, disassembling the instruments on transit reduces off–loading times. The WHOI OBS frames were stacked, without the aluminum seismometer arms, on the main deck on the port side of the staging bay. SIO instruments were placed on the starboard side of the staging bay and on the starboard side of the stern. The staging bay has a pulley system mounted to the ceiling that was quite useful in moving the heavy boxes. The center of the main deck, in front of the winch operating the recovery line through the A-frame, remained completely free to allow easy operations with a pallet jack. Part of the 370–sq ft staging bay was used to store SIO's seismometer boxes.

There is more space inside in the science storage room that we did not use, except to store one or two seismometer boxes. In addition to the instruments, we had a fully equipped 20 ft lab container on the stern (portside) as well as an 20 ft empty ragtop container on level 01 (port side). There is space for another such container on the starboard side. The lab van required AC power which the ship could provide.

An advantage of using the KM as a ship for the PLUME cruises is that cruises start and end in Honolulu. This makes the PLUME cruises dedicated stand–alone cruises and not part of longer transects that require sharing space with other projects. Though the ship may have less space than other ships it may turn out that more space is available for our cruises.

The KM has about the same amount of lab space (2550 sq ft + conference room + library) as the Melville (2630 sq ft + library) but the layout is quite different. Most of the space on the Melville is dedicated to a main lab on the main deck. There is no central main lab on the KM, which we had initially thought of as a bad idea. Ideally, we would like a central lab from which all the functions relevant to our project can be overseen and/or controlled. However, on last year's cruise on the KM, we had grown accustomed to spreading out through various labs (Labs 1 and 2, wet lab, hydro lab, chem lab). This multi–lab arrangement is clearly preferable over the central main lab design of the Melville, especially on long cruises. Having several smaller labs gives people the chance to work with less distractions/disturbances, set air conditioning levels (which is a major point of contention!) and get out of each others' space.

Noise Issues

As on any other cruise, we encountered times of poor acoustic communication with the instruments. While this can have various reasons ranging from failing equipment to the ”noisy ocean”, ships can be sources of acoustic noise. During our recovery attempts, we tried to identify source of ship noise but we have found a systematic reduction in noise only rarely. Taking the ship out of DP (dynamic positioning) appeared to have helped but shutting down a combination of the 4 engines did not bring significant effects. The starboard steering pump appeared to have caused some noise and so was switched off during recoveries. At some point, it was suspected that the starboard evaporator pump caused significant noise but this was never conclusively established. Later in the cruise, we noticed that the starboard fuel purifier feed pump, that was switched on twice daily for an hour, interfered with the 3.5 kHz Knudsen system. We verified that it also interfered with our communication and the use of the pump was scheduled accordingly. In none of the unsucessful recoveries did this pump play a role. We conclude that the ship is as good as any ship, or quieter, for acoustic communication with the instruments.

Computers, Networking and Seafloor Mapping

The computer lab on the 01 level is also the ship's seafloor mapping lab. The lab is equipped with an impressive modern video multi–screen system which can show everything from SIMRAD data, over nav data and video cameras to the movie that is currently played in the lounge. Such screens also exist in all the labs and staterooms, where the screen could serve as computer monitor. Every stateroom also had access to the ship's LAN. There appears to be a wireless network but the reach is not great. All science party members had a ship user account and email was sent and received every 15min. Unlike last year, where some email appeared to have been lost, we know of no such incident on this cruise. There was a PC with public (science and crew) internet access in the computer lab, a PC and a Mac in the library and a PC in the hydro lab.

Public computing facilities on the KM are limited but may reflect current trends that PIs bring their own computers on board, which we did. The science team had access to three IP addresses with internet capabilities. The chief scientist held one, the co-PI from WHOI held the other. The third was dedicated to the public PC in the hydro lab. The IP addresses were restricted to not receive popmail in fear that spam email downloads would clog the ship's limited access.

The KM is equipped with a SIMRAD EM120 system for the deep ocean and a EM1002 for shallow seafloor mapping. The ship is also equipped with several sub–bottom echo sounder systems. On this cruise, we used the 3.5 kHz Knudsen system during the whole cruise. Watch standing personnel was trained to adujst parameters for optimal data collection. Post-cruise analysis is underway.

The SIMRAD multibeam system provided spectacular bathymetry and sidescan data which require almost no editing. Especially the edges of the swaths are usually very noisy but are clean on the KM records. The ship operators explain that the superior data quality is not lastly due to the ship's unique hull design where the bow thruster is on the starboard hull but the multibeam transducer is very low in the water beneath the portside hull. Also, the ship usually slices through the water without creating significant bow waves, even in moderate swell. This creates less bubbles that could be cause for noise in the multibeam records on other ships. As far as seafloor mapping capabilities are concerned, this ship probably provides the best, or at least some of the best, data in the UNOLS fleet. The web site advertizes a beam width of up to 22km in the deep ocean that we only rarely achieved. At a depth of 5000m, we usually achieved a beam width of 17-19km but it could be as low as 14km. This may result from different sediment cover on the seafloor (e.g. mud vs. exposed lava flows).

Ship Crew

The ship crew was outstanding. Several crew member sailed with us before, on last year's cruise. From the very beginning, the science party felt very welcome. The two marine technicians were very knowledgable and professional but also great pals. The crew members were very forthcoming to the science party and also functioned as a great coherent team, from the bridge personnel to the oilers.

The ship has an excellent internal web site that explains almost everything from berthing assignment to how to access the ship data. It also has a table with mug shots of the crew members. The PI was inspired by this and posted similar mugshots of the science team in the mess hall. This was greatly appreciated by the ship crew and help breaking the ice.

Various social events such as a tour to the engine room, dedicated movie sessions, star gazing, game tournaments and BBQs on level 02 provided ample opportunity to initiate and hone lasting friendships. There were quite a few newcomers among the ship crew but the crew readily integrated them. Interaction while on duty as well as off duty was a real pleasure. This is not necessarily the case for crews on other ships. On the professional side, the crew did more than expected provided more support than on other ships. This was most certainly the best and safest option for the instruments and the project but some students complained that they did not get enough 'hands-on' experience.

SCIENCE TEAM

The science crew consisted of a number of individuals tied directly to the project (Laske, Collins), OBS personnels (Collins, Ryder, Handy, Hollinshead, Aaron) and personnel responsible for watch standing (Smarek, Warner, Denolle, Garber, Hautmann, Lehndorfer) in 4h–shifts. Smarek and Denolle were sent by the Yale co-PI Dave Bercovici. Warner was recommended by former office mate Rob Mellors who now teaches at San Diego State University. Garber has recently graduated from UC San Diego and took the PI's undergraduate classes in Earth Sciences. Hautmann and Lehndorfer visited a colleague at IGPP (Frank Vernon) earlier this year. They were introduced to the PI because they came from Germany. We discussed a possible cruise participation and both were very enthusiastic about this. The PI could not find any SIO graduate students who were willing to come along. Students argued that the cruise would be too long. The chief scientist is not sure how a month–long cruise could be made more attractive to SIO graduate students (most of the people who came along were actually graduate students). Adequate computer resources could be an issue. Some students depend on large machines to do their research, many require hardly more than a laptop computer. For example, Smarek and Denolle brought their laptops computers and continued their work or studies.

This group was most likely the best science team of all four PLUME cruises. Interaction between science team members and with ship crew was excellent. The watch standing operations ran smoothly. Morale was great, even during the trying times of instrument losses. The chief scientist is unaware of any problems such as fights or breaking rules as it happened on last year's cruise.

Education and Outreach

The watch standing team on this cruise consisted exclusively of undergraduate and graduate students. One student came from San Diego State University. The co-PI from Yale University sent two students where one was a French visiting student just starting her masters thesis. Two students from the University of Munich, Germany who had visited SIO half a year before and expressed interest to come along. One student took the PI's undergraduate courses and was invited to come along. During the cruise, we had a weekly journal club seminar to discuss project–related research papers. Students were encouraged to make us of the well–equipped ship library. In fact, the chief scientist found quite a few useful project-related books. She also donated a few introductory books on Natural Disasters, Earth Sciences and Global Climate Change. We also had a tutorial, with homeworks, on GMT and how to plot and interpret the ship data we gathered on this cruise. The PI brought poster material along that explained the project in laymen's terms. The posters sparked great interest among the ship crew.