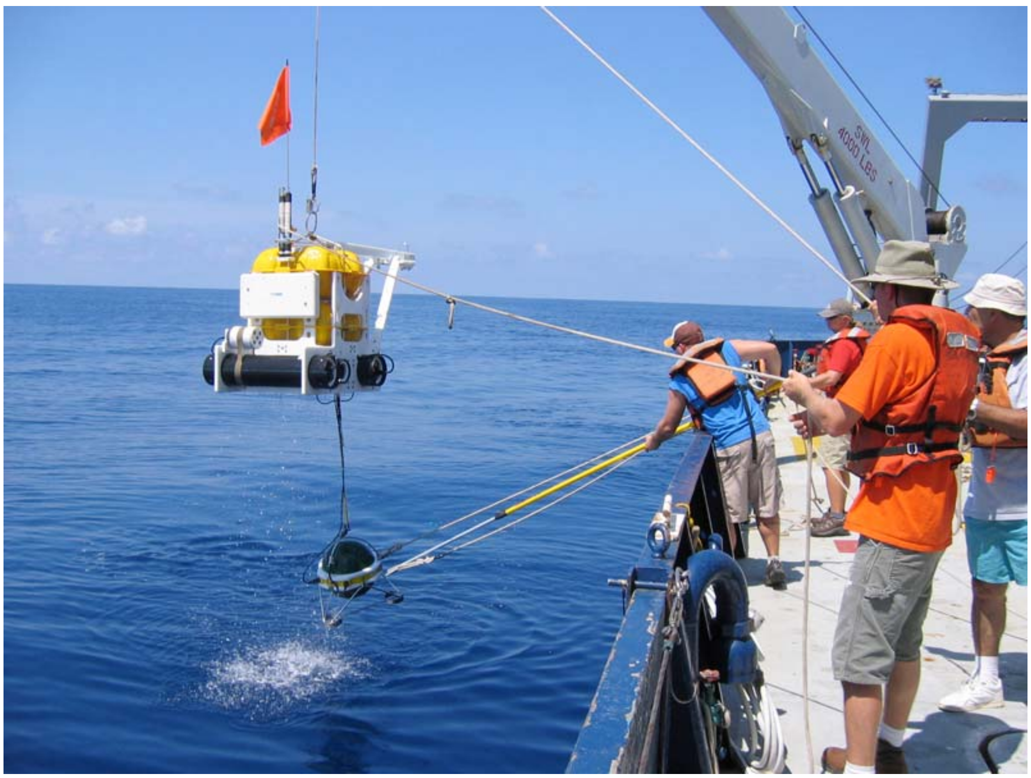
SCOOBA Sea of Cortez Ocean-Bottom Array Seismic Experiment

Cruise Report: SCOOBA II -- Recovery

R/V New Horizon, October 1 – October 17, 2006.



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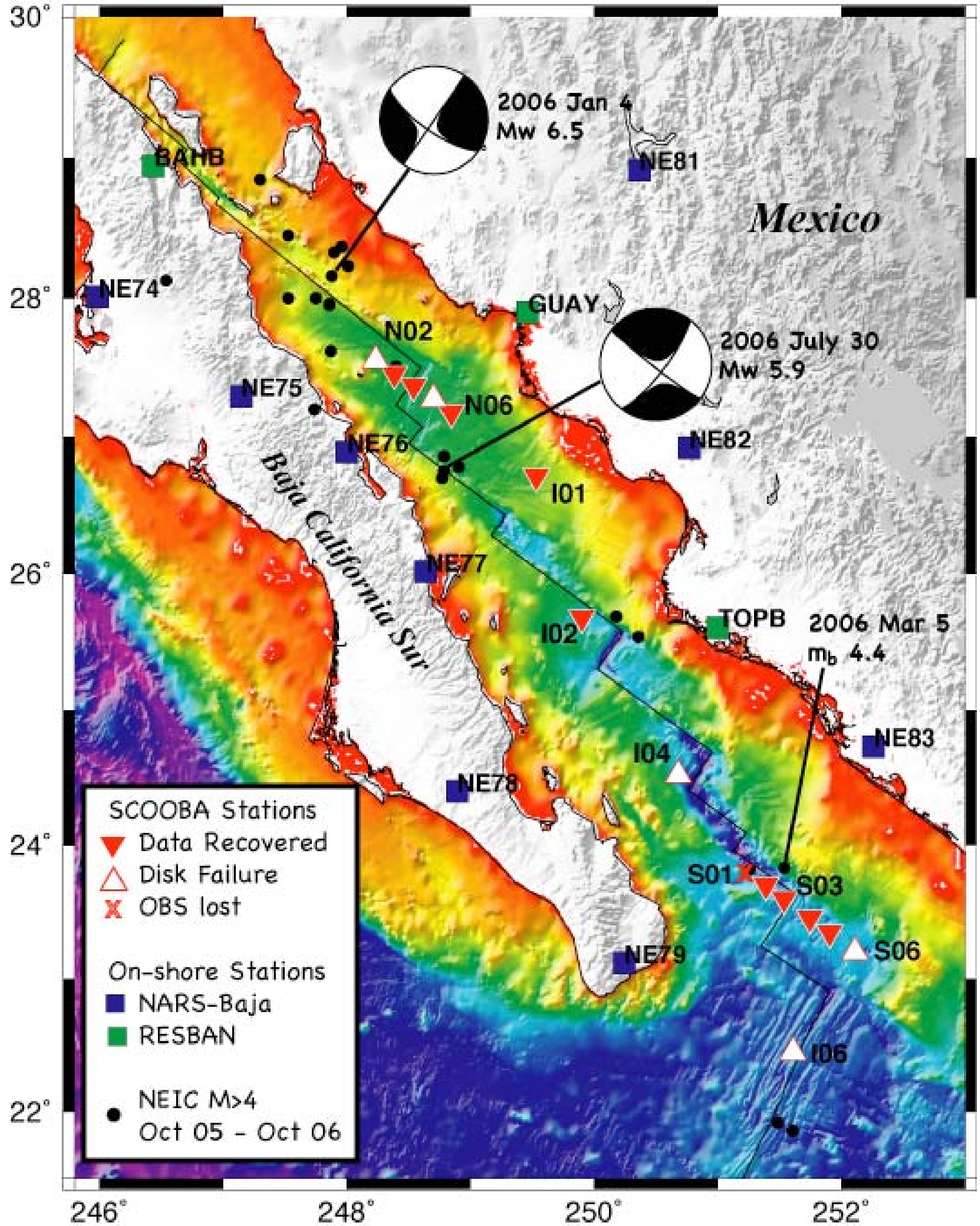
1) Experiment Objectives

The overall goal of the SCOOBA passive seismic experiment is to evaluate the degree to which mantle processes control lithospheric rupture and the initiation of seafloor spreading in the Gulf of California (GoC). In October 2005, we deployed 15 broadband ocean bottom seismographs (OBS) in the GoC for a duration of 12 months (Figure 1). The data from these stations, in conjunction with observations from the MARGINS-funded NARS-Baja experiment, will be used to image mantle structure beneath the Gulf and the surrounding region. We will specifically address two questions that are important for achieving the goals of the Rifting Continental Lithosphere science plan:

- **Is the upper-mantle directly underlying GoC extension anomalously hot?** This question is critical to understanding the magmatic budget of GoC extension, and the role of this magmatism on strain localization and partitioning. The GoC lies on a broad region of very low seismic velocities, implying that temperatures in the upper mantle are elevated. Volcanism associated with rifting, however, appears to be quite modest in the region compared to many rifted margins. The OBS deployment will allow us to image structure directly beneath the gulf and its margins, better constraining thermal processes in the region.
- **To what extent do North-South variations in extensional style correlate with upper-mantle velocity variations?** Addressing this question will allow us to evaluate the importance of mantle state in controlling or modulating rift extension. Despite nearly constant total extension all along the rift axis over the past 5 Ma, the style of extension changes dramatically from continental extension in the north, to sea-floor spreading in the south. Mantle thermal and rheological properties probably modulate this process. The OBS deployment will allow us to image along-axis variations in mantle structure, placing better constraints on the impact of this structure on rifting.

The deployment builds upon the NARS-Baja backbone array deployed on land on both the western and eastern sides of the GoC, placing 4 OBS at ~100-150 km spacing down the southern gulf axis. In addition, 5- and 6-station sub-arrays span the Guaymas and Alarcon spreading centers, providing the means to image the mantle beneath two of the crustal transects shot by the Lizarralde et al. active-source experiment conducted in the fall of 2001. We will measure Rayleigh-wave velocities, *P* and *S* delay times, and attenuation structure in order to provide estimates of mantle temperature variations. We will map mantle flow patterns by measuring the magnitude and orientation of azimuthal anisotropy using *SKS* and *SKKS* phases and inter-station Rayleigh wave dispersion. Azimuthal anisotropy will be further constrained by *Pn* and *Sn* travel times from regional events. We will use receiver functions to map the depth to both mantle transition zone and shallow mantle discontinuities, thereby providing additional constraints on thermal, compositional and mechanical structure. If useable Love waves are recorded, we will constrain radial anisotropy, which could place important constraints on local mantle buoyancy.



Bathymetry map of the southern Sea of Cortez (Gulf of California) region. Cold colors represent deeper water, while hot colors represent shallow water. Solid black line indicates the Pacific-North America plate boundary. Triangles indicate SCOOBA OBS station locations, with colors representing current state of data recovery (see inset and status report). Squares show locations of onshore broadband stations of the RESBAN network operated by CICESE, as well as the temporary stations of the NARS-Baja experiment. Small black circles show locations of earthquakes with magnitude 4 and larger that occurred during the duration of the experiment. Large "beachballs" show the focal mechanisms of the two largest events.

2) Cruise Narrative

Saturday, September 30. Gaherty, Collins, Roland, and Huerta arrive in San Diego. Gaherty, Collins, and Roland meet with Jeff Babcock, manager SIO OBSIP, to discuss last minute logistical issues. SIO engineers had loaded necessary recovery equipment earlier in the week.

Sunday, October 1. Science party boards the New Horizon at the Scripps Nimitz Marine Facility at 0700. After slight paperwork delay, the NH departs at approximately 0900, steaming south at 10 knots in a modest swell from the Northwest.

Monday, October 2. At approximately 0500 LT, Captain Manion turns the ship to return to San Diego. A crewmember is extremely seasick, and SIO personnel decide that the best course of action is to evacuate her from the ship. The NH arrived in San Diego just before midnight, disembarks the ill crewmember, and then departs again.

Tues-Thurs, October 3-5. Proceeding at 10 knots. Settled on CS and watchstander rotations of 6 hours each.

Friday, October 6. Arrived at site **I06** at approximately 1000 LT (1700 UTC). OBS was enabled on the first try, and released on the first burn. Came to the surface with a rise rate of approximately 30 m/min (~84 min total between "double ping" and visual sighting). Bridge received no radio signal, strobe appeared to be working. Clock check was good, measured drift of ~-3.6 s. Since there was a leap second on Jan 1, 2006, all drifts have and additional -1 s added to them. Data recovery from the IDE drive in this instrument failed; last block # is 1347223552, which appears to be the total disk size. **Download failed** immediately. Disk was removed and bagged for recovery at SIO. Total time on station was just over two hours.

At site **S06** at approximate 1715 LT (Oct 7 0015 UTC). Enabled and released on first try. Rise rate was surprisingly fast, ~37 m/min. Flashers and radio worked fine, on board at 0150 UTC, total time at station <2 hours. Drift was again reasonable (-1.5 s). Same problem occurred with disk. **Download failed**. Disk was removed and bagged for recovery at SIO.

Arrived at site **S05** at approximately 2030 LT (Oct 7 0330 UTC). Enabled and released on first try. Off bottom at 0342, radio received at 0459, rise rate of 33 m/min. On board and underway in less than 2 hours. Drift ~-3s. In an effort to avoid disk problems, SIO team opts not to do a RAM dump prior to downloading data. Disk mounts fine, and approximately **11 Gb of data** are downloaded at a rate of approximately 1 Gb/min to two LaCie disks. IDE disk was left in the OBS. A quick view of a few earthquakes indicates that the instrument recorded 4 channels throughout the time period.

After downloading data, SIO team tried a test to determine if the RAM dump is responsible for the disk failures. They executed the RAM dump, and then remounted the disk. It appeared to be fine, suggesting that the dump may not be the source of the trouble. However, since this dump only recovers a small % of the total data, it was decided that the dump would be skipped pending further investigation of the failure.

Arrived at site **S04** at approximately 2330 LT (Oct 7 0630 UTC). Recovered without incident in less than 2 hours, **11 Gb data** downloaded and backed up.

Saturday, October 7. Arrived at site **S03** at 0300 LT (1000 UTC). Recovered without difficulty in 2 hours, **11 Gb** data downloaded and backed up. Clock drift was –0.6 s, despite observation during deployment that OBS02 had a high drift rate.

Arrived at **S02** at approximately 0620 LT (1320 UTC). Recovered without difficulty in less than 2 hours. An error was encountered reading the IDE disk. Header looked fine, and last block (23097688) suggests that ~**11 Gb of data** were recorded. However, offload terminated with a **read error** after about **35%** had been transferred. The transferred file looked fine as far as it goes, so it was archived and backed up. The IDE disk was removed from the OBS for evaluation in the lab. Again, clock drift appears to be very reasonable (-1.7 s), despite warnings of apparent high drift rate during deployment checkout.

At approximately 0930 LT (1630 UTC), we arrived at the deployment site for S01. As described in the SCOOBA Deployment cruise report, the S01 deployment was unsuccessful, as the instrument was lost from acoustic contact prior to reaching the seafloor. However, there remained the possibility that the problem was limited to a weak acoustic transponder, for either sending and/or receiving commands. Therefore, we made a significant attempt to recover this instrument, under the hope that it was still alive on the seafloor. We first sent four "Enable" commands from the deck unit, with send power set to the maximum and receive threshold set low, with no reply. We then rigged and lowered the downwire rescue beacon, encoded with release code to send at 1-minute intervals. A single burn command was sent from the deck unit, leaving it in "receive" mode awaiting confirmation of the burn throughout the operation. Beacon was in the water at 1730 UTC and lowered at 40 m/min while the ship drifted into the drop location. Unit was stopped at 2600 m (~200 m from bottom) and held for 15 min. Beacon was raised to 2400 m and held for 15 min. Unit was recovered at 50 m/min, and was on deck at 1948 UTC. No communication was received from the OBS throughout the operation. We then waited on site for a full 90 min (rise time of the instrument) to ensure that it was not released during the last stage of communication, regularly sending enable and ranging commands, with no response. At 2120 UTC S02 was declared lost. RIP SIO81.

Sunday, October 8. Arrived at site **I04** at 0030 LT (0730 UTC). Recovered without incident. Header was corrupt, same as I05 and S06. **Download failed**. Clearly the RAM dump is not at fault.

Arrived at site **I02** at 1010 LT (1710 UTC). Recovered without incident, rise rate 37 m/min. **11 Gb data** downloaded and backed up.

Arrived at site **I01** at 1820 LT (Oct 9 0120 UTC). This was our shallowest instrument, recovered in just over an hour without incident. OBS had several passengers – large red spine-covered crabs, dead presumably because of pressure. **11 Gb data** downloaded and backed up.

SIO OBS personnel began converting raw data to Antelope mseed database.

Monday, October 9. Weather conditions remained hot with little breeze. Given the high daytime temperatures on deck, it was decided to set up the N-array recovery to be overnight. Slow steam to site N02 to accommodate this schedule. However, after receiving word of the approach of tropical storm Norman, we increased to 10 knots to advance the schedule.

Arrived at site **N02** at 1355 LT (2055 UTC). Recovered without incident. Two octopi perished on the OBS on the ride to the surface. Corrupt data header, **download failed**.

Arrive at site **N03** at 1645 LT (2345 UTC). Recovered without incident, **11 Gb** data downloaded and backed up.

Arrive at site **N04** at 1911 LT (Oct 10, 0211 UTC). Recovered without incident, **11 Gb** data downloaded and backed up.

Arrive at site **N05** at 2154 LT (Oct 10, 0454 UTC). Recovered without incident, corrupt data header, **dowload failed**.

Tuesday, Oct 10. Arrive at site **N06** at 0023 LT (0723 UTC). Recovered without incident, **11 Gb** data downloaded and backed up. High-fives all around.

3) Data

The primary data to be collected during the experiment is the passive-source seismic data from the OBS; these will be processed over the next several months, and submitted by SIO OBSIP to the IRIS data management center (www.iris.edu). It will be available to the community on or before October, 2008. In addition, data from the 12.5 kHz Knudsen echosounder is available for much of this area from the deployment cruise. These data are available through the MARGINS database at the Marine Geoscience Data center (www.marine-geo.org). To date, data from 9 of the 15 deployed instruments have been recovered (Figure 1 and Table 1).

4) Feedback for Future Operations

Crew, *R/V New Horizon*. Overall performance of the New Horizon crew was excellent. The New Horizon is a very good platform for OBS deployments, at least in locales where high-resolution (multibeam) bathymetry is previously available. The computer system is significant improved from SCOOBA1, with the addition of HiSeasNet internet service and full-time email. It would have been helpful to have access to a color printer, for realtime production of maps, etc. In addition, there are a number of “comfort” issues that will be addressed in the post-cruise report to SIO.

SIO OBSIP Team. The onboard performance of the OBS technicians was excellent. The team was clear on their needs regarding scheduling and assistance, and they were very responsive to all requests and needs of the science party. The recovery of the instruments went remarkably smoothly, the proverbial well-oiled machine. The data download and archiving process went somewhat less smoothly. The onboard personnel are capable of doing the data download from OBS to a computer if everything goes smoothly. However, in the case where things do not go smoothly, there are no tools available to try to solve the problem immediately. Instead, the disk is put aside to be worked on by the software engineer in the lab. This approach has the obvious flaw that there is no back-up copy of this data available. In addition, the on-ship personnel are not very familiar with the secondary processing software (i.e. clock corrections, seed conversion, etc.). These codes are not trivial, and this is primarily matter of experience and training; the on-board team is competent and will grow to better understand and implement these codes. However, it also appeared to be at least in part due to an evolving processing scheme. Standardizing this scheme as quickly as possible will greatly improve the on-board data processing flow.

As of this writing, the source and extent of the IDE disk drive problem is unknown. These drives are now widely distributed in the SIO OBS fleet, and it should be a top priority of SIO OBSIF to determine the cause of failure, evaluate data recovery prospects, and fix the problem.

5) Personnel

Science Party
Jim Gaherty, Chief Scientist
John Collins, Co-chief Scientist
Carlos Huerta, watchstander
Emily Roland, watchstander
Mark Gibaud, SIO OBS Technician
Martin Rapa, SIO OBS Technician
Ernie Aaron, SIO OBS Technician
Lucian Parry, NH Science Tech

New Horizon Crew
John Manion, Captain
Roger Price, 1st Mate
Elizabeth Jackson, 2nd Mate
George Kennedy, A/B
Steve Lewis, A/B
Jim Potts, Chief Engineer
Laddie Rayala, 1st Engineer
Eddie Bautista, Oiler
Peter Solis, Wiper
Eddie Lograsso, Cook
Richard Buck, Cook

Additional onshore support for logistics and permitting were provided by Elizabeth Brenner and Rose Dufour of the SIO Ship Scheduling Office, and Angelica Narvaez of the US State Department in Mexico City.

Sea of COrtez Ocean-Bottom Array (SCOOBA) Recovery Operations

Recovery waypoints, in order, all times PST.   Version 3, 11 Oct 2006

	SN		lat	long	depth	Start Time	End Time	Transit (hrs)	Rise Time (min)	Data (Gb)
1)	I06	OB	22.4487	-108.3924	2591	10/6/06 10:00	10/6/06 12:30	4.8	86	0
2)	S06	OB	23.2033	-107.8891	2456	10/6/06 17:18	10/6/06 19:18	1.5	82	0
3)	S05	OB	23.3487	-108.0960	2560	10/6/06 20:48	10/6/06 22:48	1.1	85	11
4)	S04	OB	23.4567	-108.2531	2505	10/6/06 23:52	10/7/06 1:52	1.1	84	11
5)	S03	OB	23.5997	-108.4616	2421	10/7/06 2:57	10/7/06 4:57	1.1	81	11
6)	S02	OB	23.7046	-108.6127	2853	10/7/06 6:02	10/7/06 8:02	1.0	95	4
7)	S01	None	23.8151	-108.7768	2788	10/7/06 9:00	10/7/06 14:30	9.5	**	NA
8)	I04	OB	24.5191	-109.3191	3228	10/8/06 0:00	10/8/06 2:00	8.1	108	0
9)	I02	OB	25.6798	-110.0987	3248	10/8/06 10:06	10/8/06 12:06	6.5	108	11
10)	I01	OB	26.7136	-110.4671	1327	10/8/06 18:34	10/8/06 20:34	17.3	44	11
15)	N02	OB	27.5521	-111.7669	1636	10/9/06 13:54	10/9/06 15:42	1.0	55	0
14)	N03	OB	27.4579	-111.6149	1775	10/9/06 16:43	10/9/06 18:13	1.0	59	11
13)	N04	OB	27.3668	-111.4595	2042	10/9/06 19:15	10/9/06 20:51	1.0	68	11*
12)	N05	OB	27.2712	-111.2988	1886	10/9/06 21:52	10/9/06 23:22	1.0	63	0
11)	N06	OB	27.1749	-111.1535	1784	10/10/06 0:23	10/10/06 1:53	20.0	59	11

At each location, We recoverd ocean bottom seismometers (OBS) that were deployed in October, 2005. OBS were recovered by transitting a low power 11-13 kHz acoustic signal; upon receiving this signal the OBS returns to the surface and is manually hoisted on-board.

Locations given are actual seafloor instrument locations, as determined by acoustic ranging.

*Data was downloaded from datalogger, but subsequent conversion to mseed failed. No data delivered to PI to date.
**5.5 hours for downwire operations