OCEAN SEISMIC NETWORK PILOT EXPERIMENT

WHOI Ocean Bottom Seismograph Laboratory

OSN Objectives and Results

- The fundamental objective of the Ocean Seismic Network Pilot Experiment (OSNPE) – which was carried out at ODP Hole 843B (site OSN-1) 225 km southwest of Oahu from late January to early June 1998 - was to learn how to make sustained, high-quality, broadband seismic measurements in the deep oceans. The OSNPE results demonstrate that broadband data of quality comparable to quiet land stations can be acquired with seafloor seismographs, but that the location of the seismometer – whether it be on the seafloor, surficially buried within the seabed, or in a deep borehole – has a profound effect on data quality. At long-periods (< 0.1 Hz), data quality was highest for a seismometer buried just beneath the seafloor, while at short-periods (> 0.1 Hz), data quality was best for a seismometer deployed 242 m below the seafloor in a borehole.

- By burying the seismometer, tilt accelerations generated by seafloor currents pushing on the sensor are greatly reduced. In the short-period band, the location of the borehole seismometer at or just below the sediment-basement interface and well below the seafloor interface means that the amplitude of evanescent interface waves is reduced. Consequently, the short-period, teleseismic detection limit for station OSN1 is significantly less than for the seafloor and near-seafloor stations

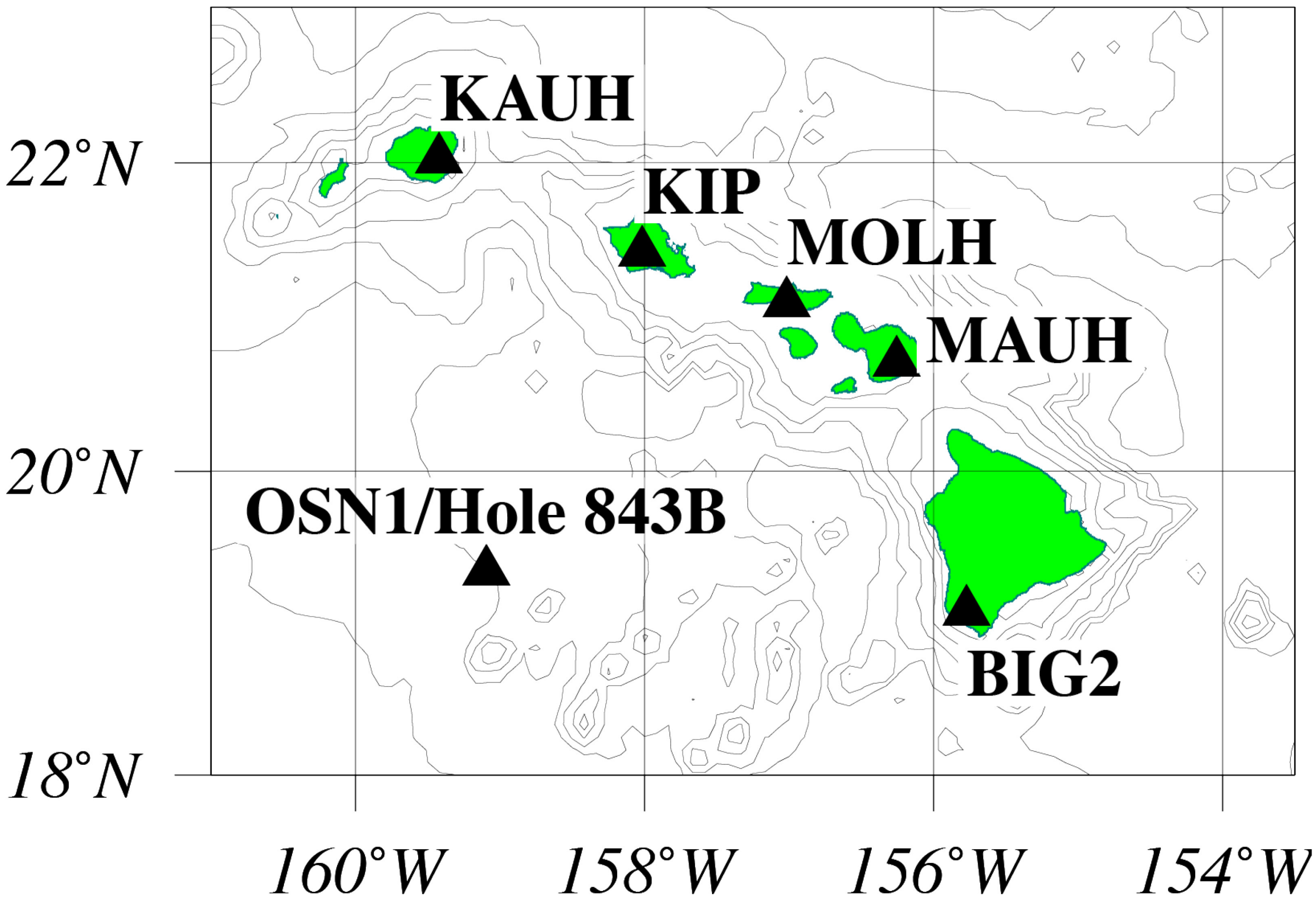
Experiment Design

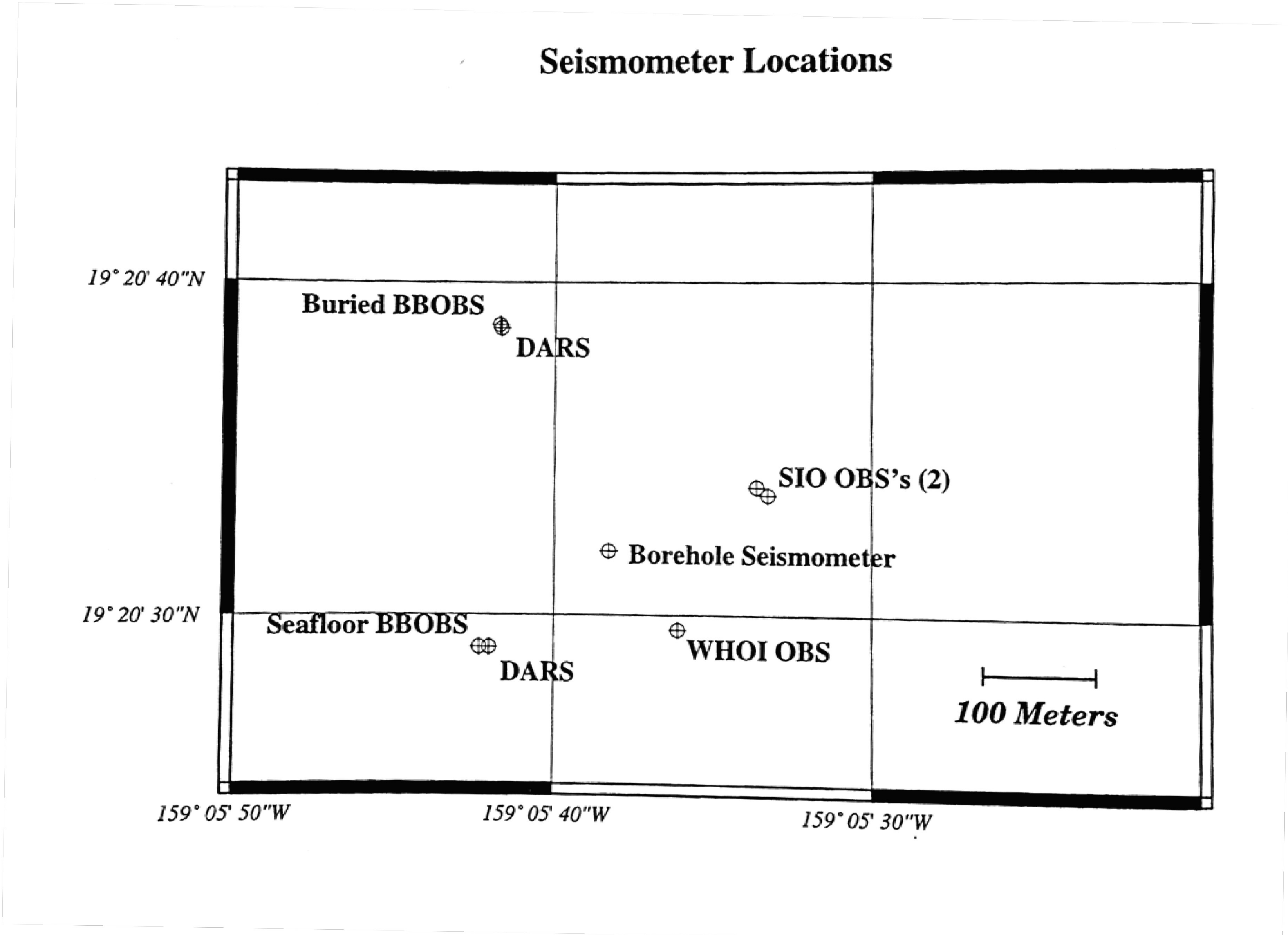
At the OSN-1 site, three broadband seismographs were deployed within 300 m of each other. The seismometers were: (i) a Teledyne GeoTech KS54000 deployed in a borehole 240 m beneath the seafloor; (ii) a Guralp CMG-3T deployed on the seafloor; and (iii) a Guralp CMG-3T buried just beneath the seafloor. We refer to the two seafloor seismographs as BBOBS (BroadBand Ocean Bottom Seismograph), and the borehole seismograph as B3S2 (BroadBand Borehole Seismograph System). Each BBOBS station also carried a Cox-Webb long-period, differential pressure gauge (DPG) that has a usable bandwidth from ~0.002 Hz to ~1 Hz. In addition to these three broadband stations, three short-period, Mark Products L4C-3D 1 Hz) seismometers were also deployed in the immediate vicinity. Meteorological and oceanographic data were also recorded continuously throughout the experiment. The magnitude and direction of seafloor currents were recorded at the experiment site. Four NOAA buoys in the vicinity of OSN -1 recorded wind speed, wave height and period, and directional wave spectrum.

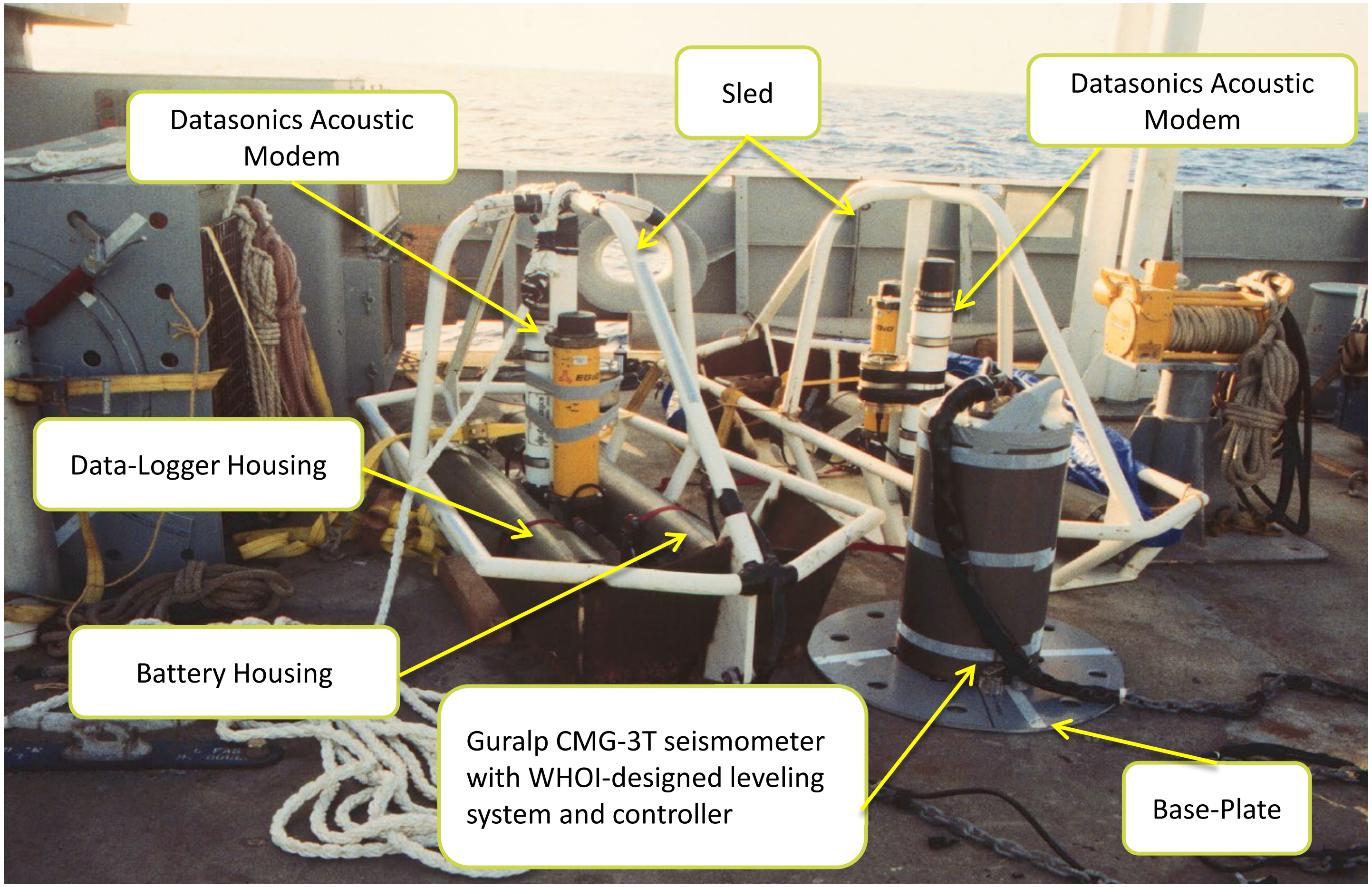
All of the seismographs deployed at OSN-1 acquired data continuously for at least 115 days. Over fifty teleseismic earthquakes were observed on the three broadband seismographs, ranging in size from a 4.5 Mb event at 44˚ epicentral distance to the 7.9 Mw Balleny Island earthquake at 91˚ epicentral distance. The most distant event identified to date is an 5.2 mb event on the mid-Indian Ridge at an epicentral distance of 135˚. The combined data sets provide the raw material to help address the usefulness of broadband seismology in the oceans.

The OSNPE a collaborative effort between WHOI (*Stephen and Collins*) and SIO (*Orcutt, Vernon, Spiess*). For the BBOBS systems, WHOI (*Collins*) took the lead in designing and constructing the seafloor and buried seismometers and the the seismometer burial system, and SIO (*Vernon and Orcutt*) was responsible for the 24-bit data acquisition system. For the borehole seismograph, SIO were responsible for the seismometer and hole-locks, while WHOI (*Stephen*) was responsible for the data acquisition system. Seismometer deployment and recovery, including borehole re-entry. was done by the Spiess group.

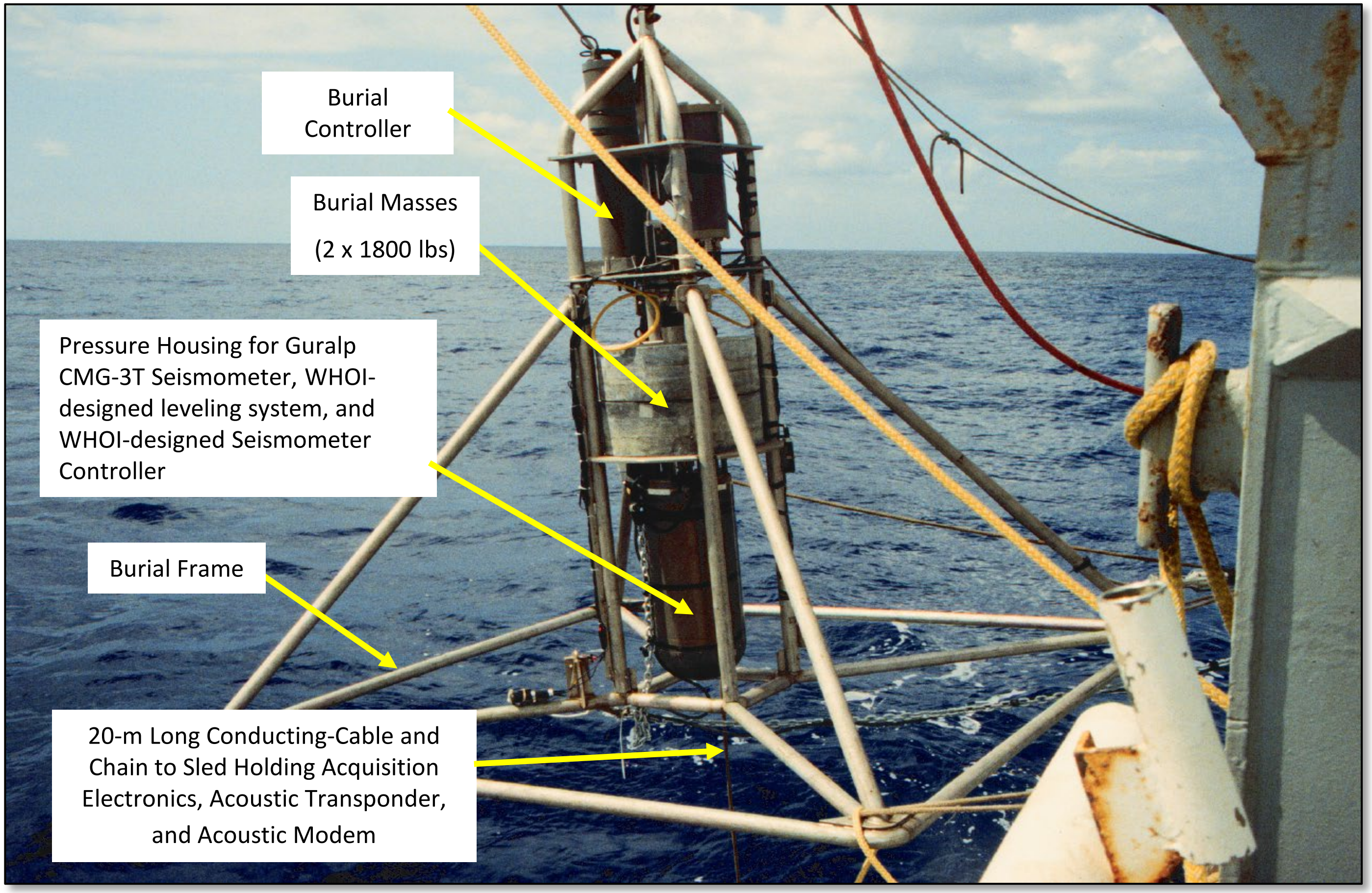
The Ocean Seismic Network Pilot Experiment




Seismometer Locations
19° 20' 40"N
19° 20' 30"N
Buried BBOBS
DARS
SIO OBS's (2)
Borehole Seismometer
Seafloor BBOBS
DARS
WHOI OBS
100 Meters
159° 05' 50"W
159° 05' 40"W
159° 05' 30"W

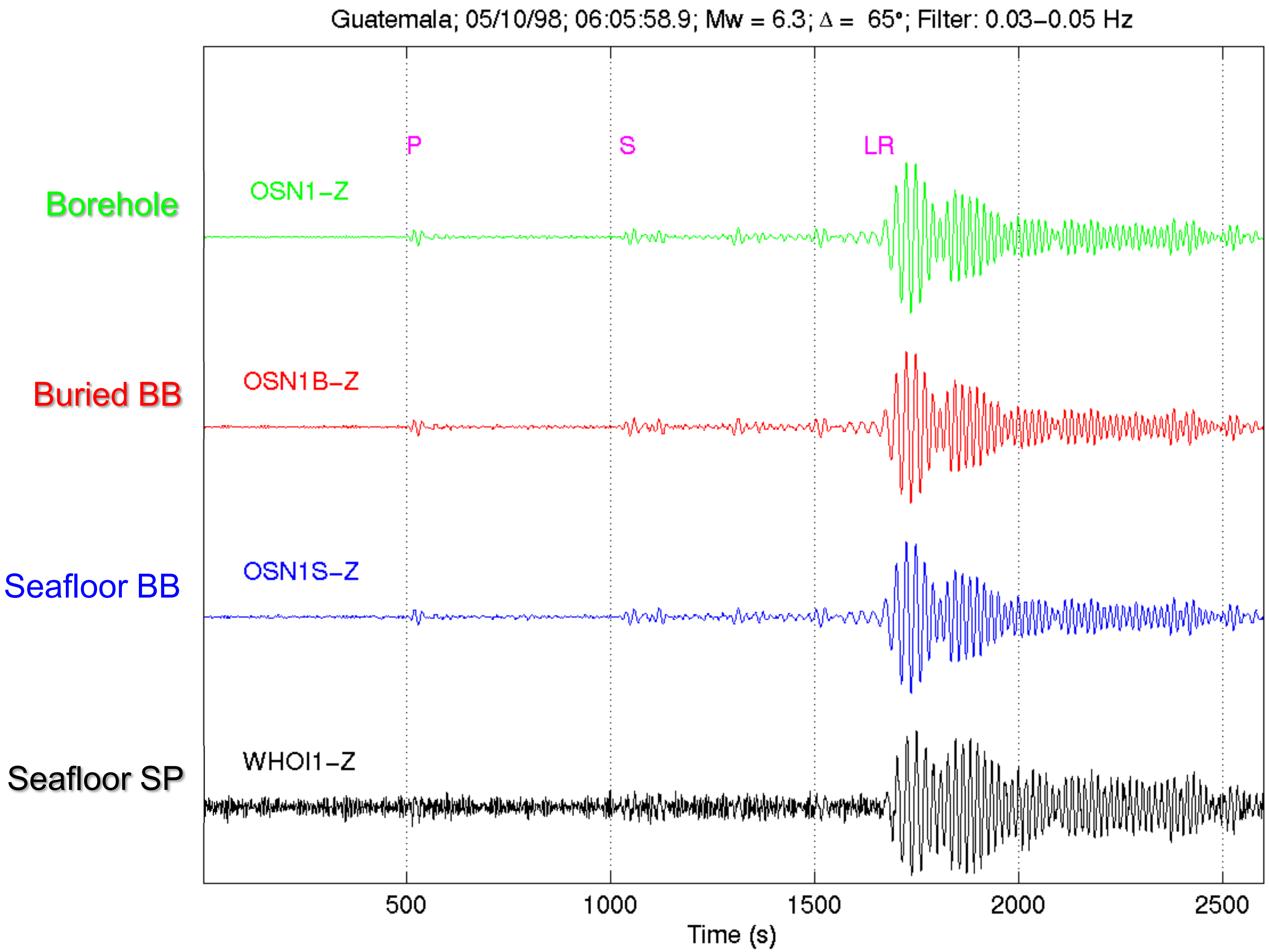


Broadband Ocean Bottom Seismograph (BBOBS) sitting on the main-deck of the R.V. *Thomas G. Thompson* in February, 1998. This was one of two BBOBS deployed as part of the Ocean Seismic Network Pilot Experiment (OSNPE) to compare the performance of a seismometer sitting on the seafloor to that of a seismometer buried in the sea-bed. The sleds for both systems are shown. This is the seafloor system; the base-plate ensured that the seismometer did not sink into the sea-bed over the course of the 4 month long deployment. The sled and seismometer are lowered on the ship's trawl wire and deployed on the seafloor with up to 20 m lateral separation.



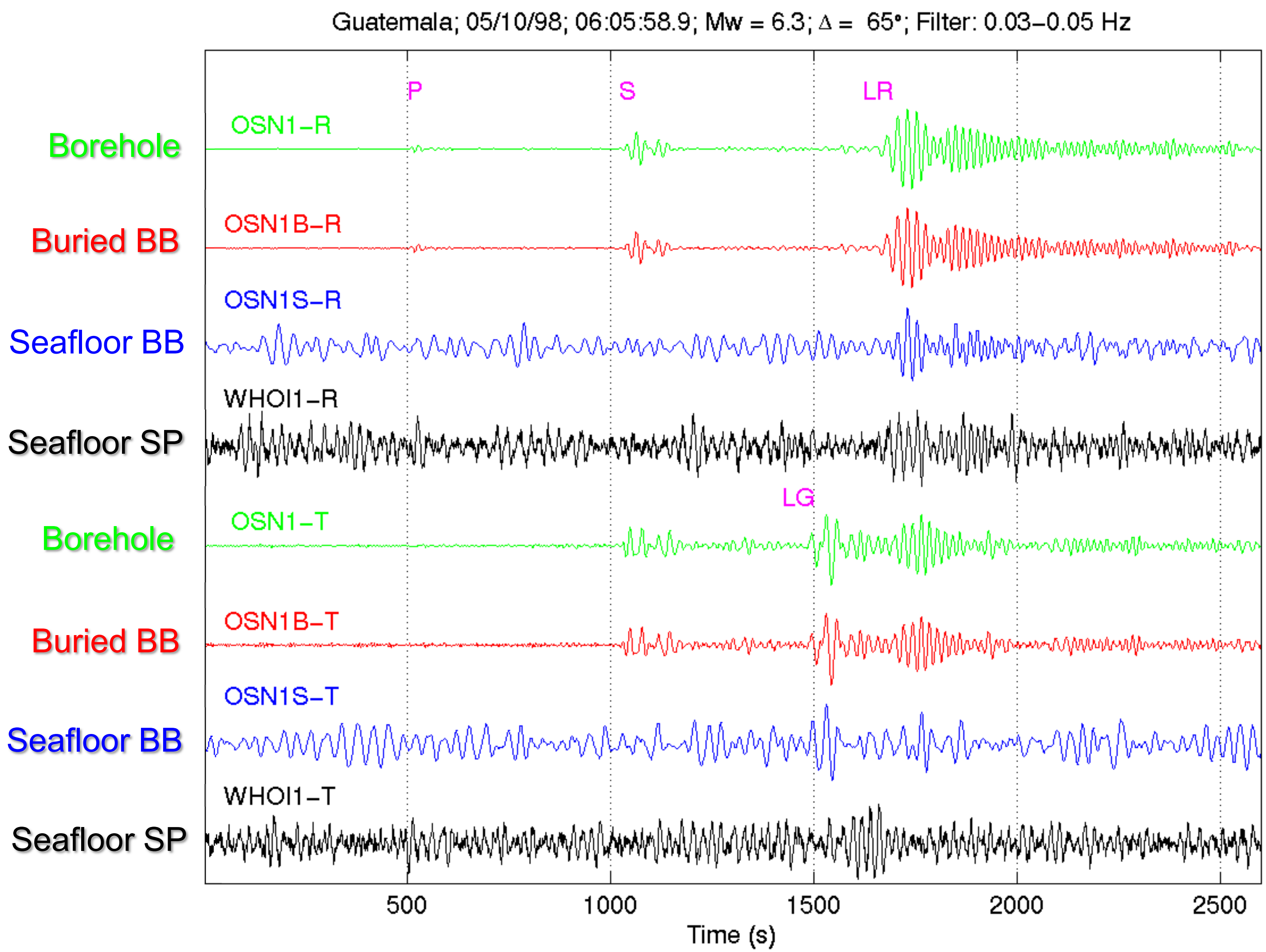
Broadband Ocean Bottom Seismograph (BBOBS) mounted in the WHOI-designed seismometer burial system in the process of being deployed over the stern of the R.V. *Thomas G. Thompson* in February, 1998. This was one of two BBOBS deployed deployed as part of the Ocean Seismic Network Pilot Experiment (OSNPE) to compare the performance of a seismometer sitting on the seafloor to that of a seismometer buried in the sea-bed. This is the buriable system. The burial masses each weigh 1,800 lb. The sled and burial frame are lowered on the ship's 0.68" coaxial cable and deployed on the seafloor with up to 20 m lateral separation. A sequence of releases are then fired, the burial masses push the seismometer into the seabed, and the sled and seismometer are detached from the burial frame.

The frame is then recovered. The dimensions of the frame are ~10' x 10' (base) and 10' high.



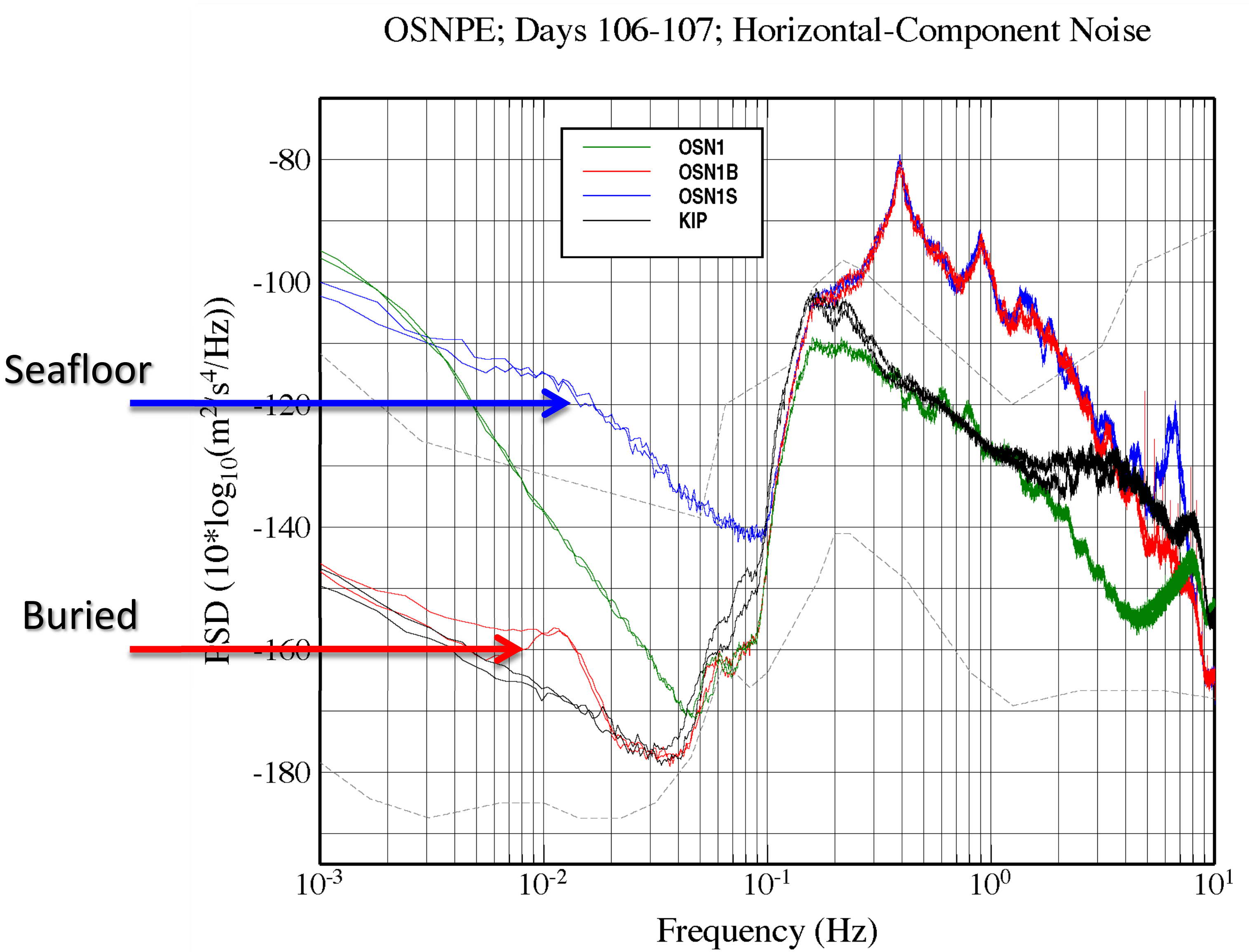
Guatemala; 05/10/98; 06:05:58.9; Mw = 6.3; Δ = 65°; Filter: 0.03–0.05 Hz
Borehole
Buried BB
Seafloor BB
Seafloor SP
P
S
LR
OSN1–Z
OSN1B–Z
OSN1S–Z
WHOI1–Z
500
1000
1500
2000
2500
Time (s)

Coupling: Buried seismometer improves S/N

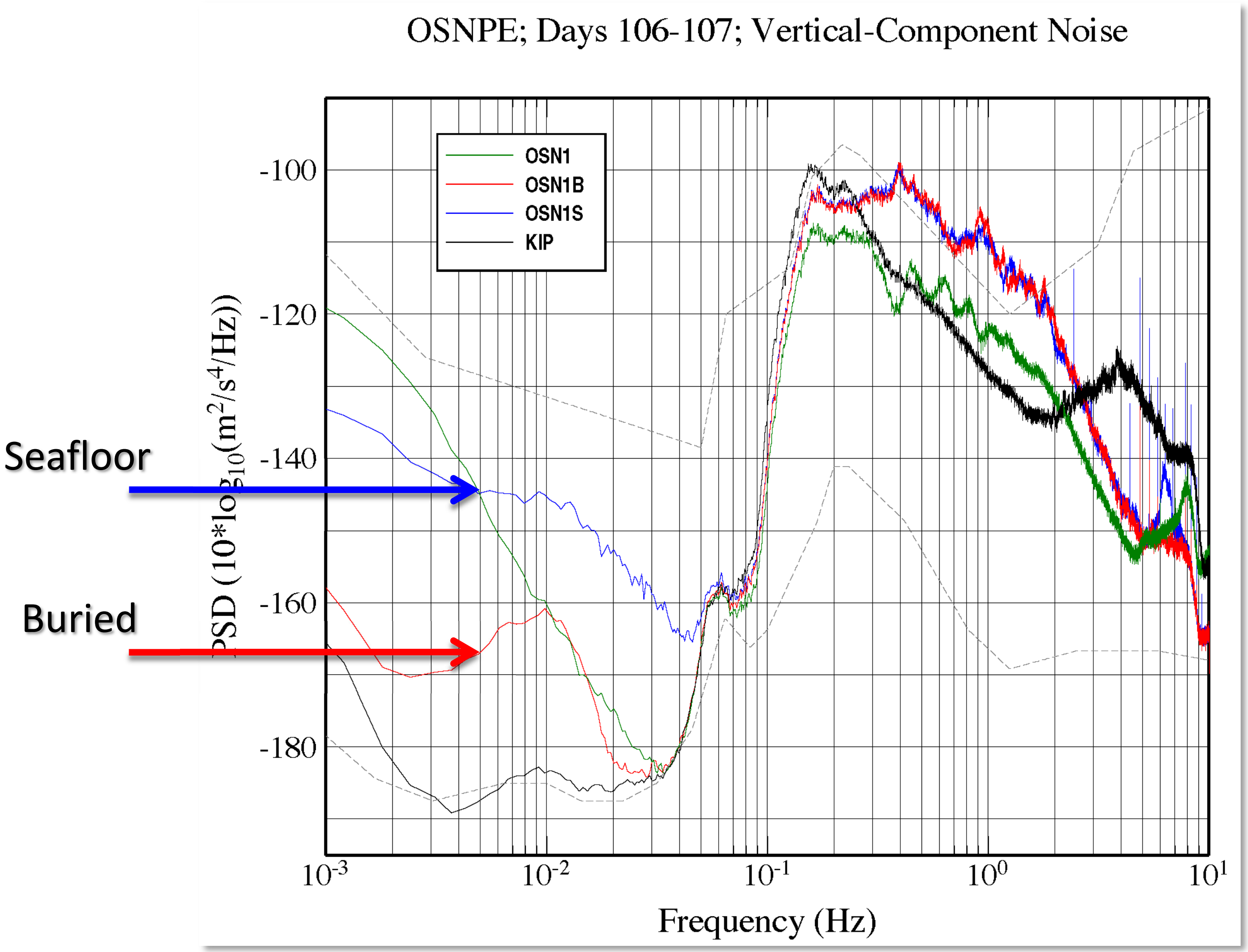


Woods Hole Oceanographic Institution

Coupling: Buried seismometer improves S/N



Coupling: Buried seismometer improves S/N



Publications

Sutherland, F.H., F.L. Vernon, J.A. Orcutt, J.A. Collins, and R.A. Stephen (2004), Results from OSNPE: Low Detection Threshold Magnitudes for Ocean-Bottom Recording, *Bull. Seismo. Soc. America*, *94*, 5, 1868–1878.

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