Hikurangi Ocean Bottom Investigation of Tremor and Slow Slip (HOBITSS)

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International collaboration with scientists and students from the US, New Zealand, and Japan

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Photo credit Stuart Henrys

Fieldwork for SHIRE: Seismogenesis at Hikurangi Integrated Research Experiment

Image from NIWA
National Institute of Water and Atmospheric Research Ltd
Interseismic coupling and slow slip vary along the Hikurangi subduction margin

Perspective view of Hikurangi margin viewed from incoming plate
Stick-slip (red), aseismic slip (blue)
Green contours – slow slip

Region of Shallow Slow Slip
Repeat every one to two years
GPS evidence for slow slip

Gisborne, NZ cGPS station, East component 2003-2013

Deformation of a subduction zone recorded by GPS stations
Example from the Pacific Northwest

Ocean depth & plate deformation are exaggerated to show relative change
HOBITSS: Hikurangi Ocean Bottom Investigation of Tremor and Slow Slip

Seafloor geodesy using absolute pressure gauges to reveal vertical deformation
OBS for tremor, seismicity, and passive imaging of SSE source

OBS and APG Instruments from LDEO, UTIG, Univ. Tokyo, Tohoku Univ.

Deployed in May 2014 with NZ’s R/V Tangaroa, recovered using the R/V Revelle in June 2015

24 APGs, 15 OBS
HOBITSS – Seafloor instruments used

10 LDEO BB OBS, 7 WITH APG
5 LDEO BPRs
5 UTIG BPRs
4 Tohoku University BPRs
5 Univ. Tokyo SP OBS, 3 BPRs
3 JAMSTEC OBEM
HOBITSS – Seafloor instruments used

10 LDEO BB OBS, 7 WITH APG
5 LDEO BPRs

4 Tohoku University BPRs
5 Univ. Tokyo SP OBS, 3 BPRs
5 UTIG BPRs
Education and Outreach

- Ship tours in Napier, NZ
- Cruise blog
- Public Lecture at Napier Aquarium
- RESESS intern
- COSMOS high school program

Students go aboard

By CAROLYN VEEN

Spending two hours on board a research ship full of scientific instruments was a high light for Hawke’s Bay students last Thursday.

The budding young scientists were invited on a guided tour of the American research ship, Roger Revelle, which is in New Zealand studying earthquakes (especially slow-slip events) before it left Napier on Saturday to retrieve instruments from the seafloor of Poverty Bay.

“We laid 35 instruments a year ago to measure earthquake activity and movement of the seafloor where the Pacific Plate is being thrust beneath the eastern North Island,” USA scientist Laura Wallace, told the students.

“New Zealand is suitable for “silent earthquakes” known as slow-slip events, which are similar to earthquakes in that they involve more rapid than normal movement across a fault line and are a matter of seconds,” Dr Wallace said.

“Slow slip, which you can’t really feel or hear, are quite a new discovery and we still don’t know why they happen. Hawke’s Bay had some big ones in early 2013... it took days to happen... if it had been quick then you would have had a big magnitude 7 earthquake.”

Called ocean-bottom seismometers, the instruments range in size from that of a large suitcase to the size of a washing machine, and weigh between 130kg and 200kg each.

“Once these are back on board, we will download all the data, and it will likely take months to analyse the behaviours of the plate boundary off the Gisborne coast.”

The project constitutes the world’s largest ever deployment of seafloor instruments to study slow-slip events.

The 10-day voyage, which left Napier on Saturday, is funded by the United States National Science Foundation.

If the data recovery is successful, scientists anticipate some exciting results as a large slow-slip event occurred beneath Poverty Bay in late September early October of last year, directly beneath the seafloor network. The event was detected by onboard GPS instruments in the EQUS funded GeoNet network, which is operated by GNS Science.

“The only reason we know that slow-slip events occur in New Zealand is because of the large network of GPS instruments that are operated as part of the GeoNet project,” Dr Wallace said.

The students were impressed with what they learned.

“This ship’s got everything, I didn’t expect to see a hospital and lab on board,” said Elsayy Cunningham, 11, from Tauranga Girls’ High School.

Fellow student, Maui Tikitiki, also 11, said there was “a lot to be learned on the ship.”

“It was interesting finding out about the slow-slips and to learn that the hilly crust on the seabed... just offshore from here... may have been old volcanoes, and that they think these might have something to do with slow slips,” Maui said.

The tour of ship was organised by GNS, who were impressed with the “Geology Rocks” project for students, hosted in Napier last month by the National Aquarium of New Zealand.

Hastings Girls’ High School students were equally impressed with this follow-up programme – an extension of Geology Rocks.

“It is very interesting and fascinating, and we’ll be following the scientists’ blog to see what happens on their expedition when they pull up the instruments from the sea floor off the coast of Gisborne,” said Irini Hul, 14.

Want to learn more???

Follow us on our expedition!!

Hikurangi Ocean Bottom Investigation of Tremor and Slow Slip

http://ciresblogs.colorado.edu/hobitss2/

Check out our blog!
Figure from HOBITSS NSF proposal

GISB cGPS E component

Gambling on slow slip occurring during OBS deployment

Got it!

Hobitss deployment
A large slow slip event occurred beneath HOBITSS in Sept/Oct 2014

Horizontal displacement onshore >3 cm

Two SSE slip models were found to fit the GPS data well, with VERY different offshore predictions

Figure courtesy Laura Wallace
Sept/Oct SSE observed at all HOBITSS upper plate sites. 150-400 Pa pressure decrease (equivalent to 1-4 cm uplift)

Shaded green bar highlights the 20-day SSE

Incoming plate sites used as reference to remove noise  

Wallace et al., 2016
Summary of vertical (APG) and horizontal (cGPS) displacements in the Sept/Oct SSE

Absolute Pressure Gauge data revealed that slow slip occurs close to the trench—to within 2-3 km beneath the seafloor

Wallace et al., 2016
Example HOBITSS seismograms
Magnitude 3.1 earthquake, 20 km offshore

Collecting OBS data is not easy!

Clear P-wave arrivals on Pressure sensors
Examples of noise spectra from HOBITSS station LOBS8

From IRIS DMC MUSTANG
Abundant seismicity recorded by HOBITSS

Located using Antelope (dbgenloc) using HOBITSS OBS and APG data and GEONET land data

VELEST for two 1D velocity models

Relocate with BAYESLOC

2600 events

Jefferson Yarce
GEONET during HOBITSS period
Temporal Variation of Seismicity in Slow Slip Region from HOBITSS
Template matching to explore repeating earthquakes near plate interface

Heather Shaddox and Susan Schwartz poster at this meeting!
Repeating Earthquake Detection


(Shaddox and Schwartz)
Temporal Variation of Seismicity in Slow Slip Region from Template Matching

In area of subducting seamount updip of peak slow slip

Shaddox and Schwartz
Tectonic tremor also occurs predominantly after the slow slip event and updip of the area of highest SSE slip.
Additional HOBITSSS Studies underway

What are the conditions on and around the region that experiences slow slip? (e.g., stress, frictional properties, fluid pressure)
Do these conditions vary with time?
What is their spatial distribution?

Shear wave splitting – Zal and Savage
Ambient noise Green’s functions – Fry
Focal Mechanisms and Stress Inversions – Chon, Warren-Smith, Fry
Polarization – Iwasaki and Mochizuki
Source Parameters - Abercrombie
Tomography – Yarce, Nakai, Fry, Mochizuki
North Hikurangi is the subject of a number of upcoming studies (IODP drilling, seafloor deployments, seismic imaging)

2018: IODP drilling and observatories
Summary

• Seafloor Absolute Pressure Gauges capture a shallow slow slip event offshore Gisborne, New Zealand, with slip close to the trench

• Seismicity and tremor are not enhanced prior to or during the slow slip event, but are observed after, mostly updip.

• Gap in seismicity observed downdip of the slow slip region - possible locked zone

• Numerous studies ongoing – stay tuned!