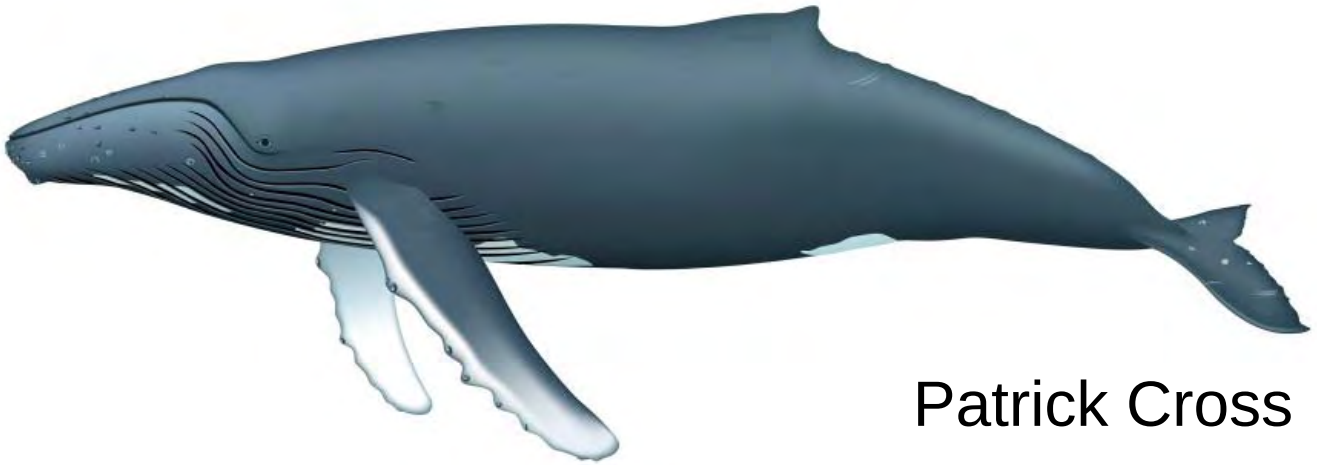
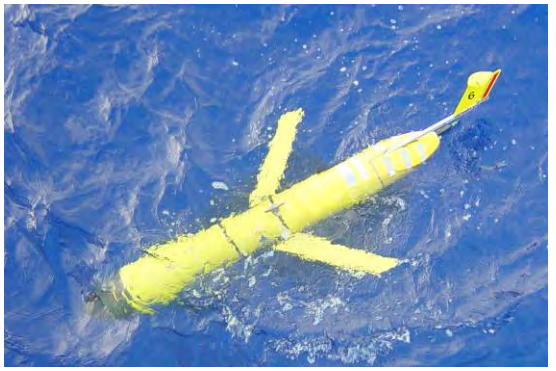
Using Ocean Gliders for Passive Acoustic Monitoring of Marine Mammals

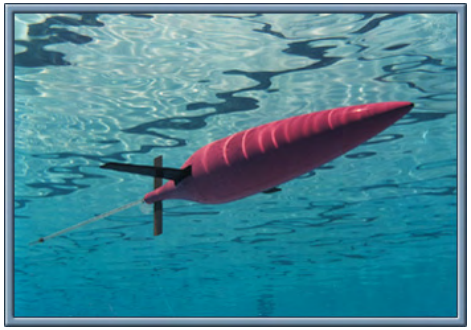




Patrick Cross

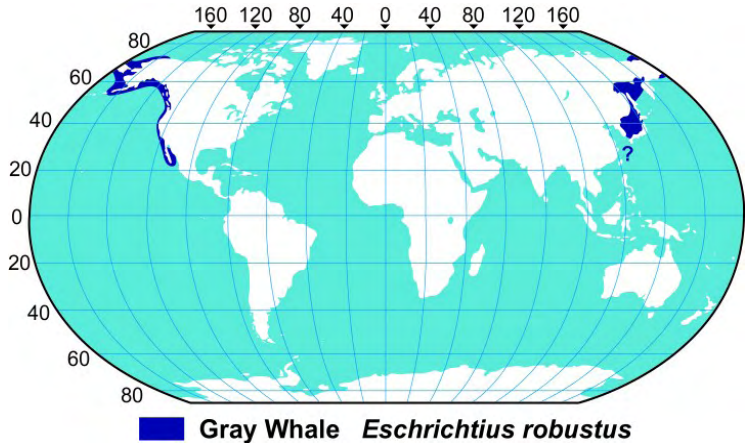
Senior Scientist, OASIS, Inc.

Sponsored by CEROS and ONR



Motivation

- Mammal monitoring relevant to:
  - Conduct of Navy exercises
  - Avoiding vessel/mammal collisions (Superferry, etc.)
  - MM distribution, migration
  - Relating MM presence/activity to oceanography, anthropogenic influences



Acoustic Monitoring

- Most mammals vocalize with some form of exploitable calls – songs, clicks, whistles
- Acoustic monitoring augments visual observation
  - Day/night
  - All weather/visibility

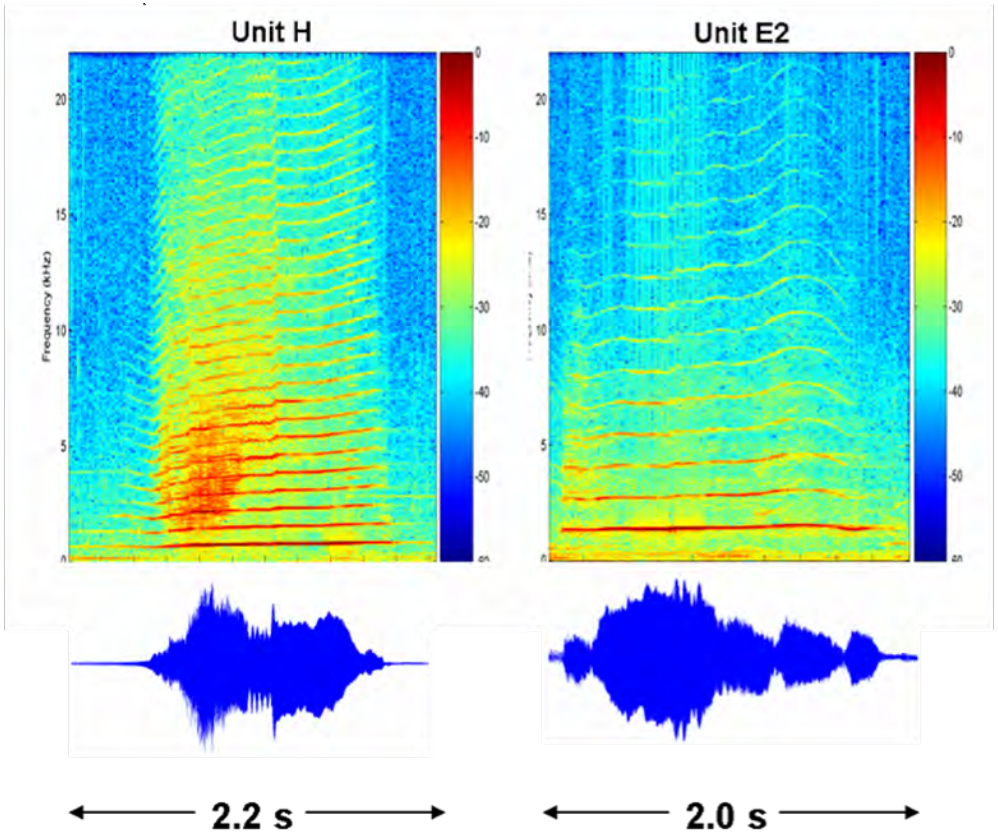
➢ Acoustic monitoring should be viewed as an essential component to a comprehensive marine mammal monitoring solution

Challenge

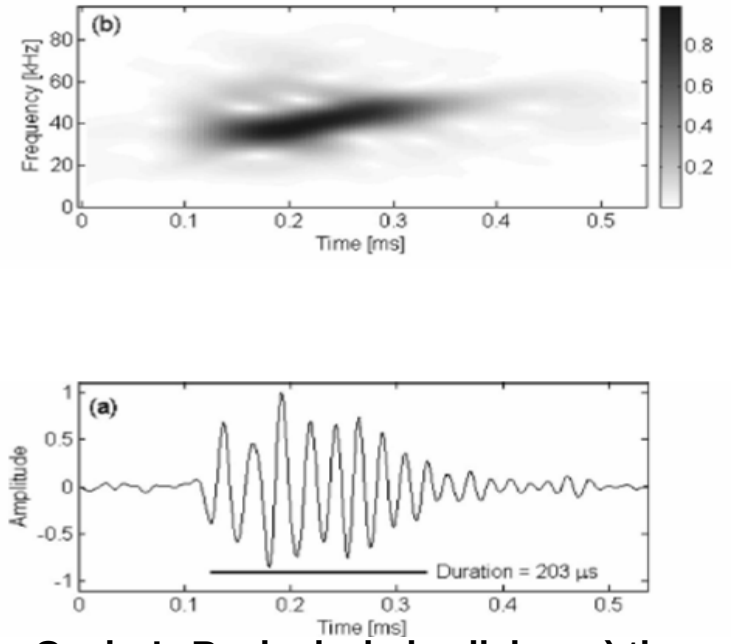
- Vocalizations are extremely varied in character
  - Blue whales – very low frequency (~20 Hz), long range detections
  - Humpback whales – many varied song components, wide frequency range (~100 Hz – several kHz)
  - Minke whales – distinctive “boing” and “star wars” sounds
  - Dolphins – very high frequency whistles and foraging clicks, some exceeding 100 kHz
  - Beaked whales – high frequency (10’s of kHz), very directed and narrow in beam width, vocalizations only when foraging deep (to > 1200m)
- Not much acoustic data available on some species

- Some features of OASIS monitoring approach
  - Autonomous detection and reporting of marine mammal vocalizations
  - Classification of species
  - Broad area coverage (multiple systems)
  - Persistent
  - Relocatable

Variety of Whale Sounds



Spectrograms of Humpback whale song units in Hawaii. From Au et al, 2006.

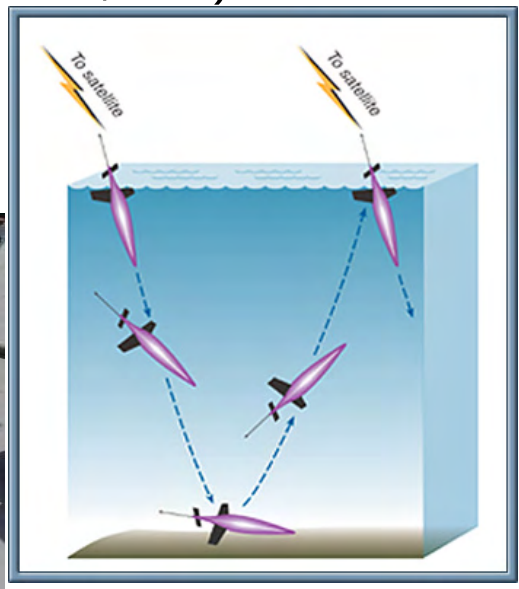


Cuvier's Beaked whale clicks: a) time series, b) spectrogram. From Tyack et al., 2006.

Key is to design classification algorithms that can reside in onboard signal processors and recognize these signals when received, allowing transmission of detection messages when glider surfaces.

Gliders

- No motorized propulsion (quiet)
- Driven by buoyancy changes
- Wings add horizontal component to motion
- About 6 ft, 120 lbs
- CTDs for long-term ocean monitoring
- Host various other sensors (optical, biological, chemical, etc.)
- Persist at sea for weeks/months
- Compared to ships, very cheap!



Seaglider

University of Washington

Displacement	52 liters
Dimensions	1.8 m long
	30 cm max diameter
Batteries	Lithium Primary
Communications	Iridium
Speed	~ 0.25 m/s
Endurance	6 months or more
Depth Range	~ 50 m to 1000 m

- Buoyancy controlled by inflation/deflation of oil bladder
- Pitch and roll controllable through movement of battery packs
- No rudder
- Communications/GPS in 1m tail/antenna

Slocum Glider

Webb Research, Inc.

Displacement	52 liters
Dimensions	1.8 m long 21 cm diameter
Batteries	Alkaline
Communications	Iridium or RF
Speed	~ 0.25 m/s
Endurance	28 to 50 days
Depth Range	4 to 200 m

- Buoyancy controlled by movement of water in/out of glider's nose
- Pitch controllable through movement of battery packs
- Has rudder for greater navigability in shallow water
- Communications/GPS in tail/antenna

Ocean Gliders – RIMPAC 06

- 6 gliders in support of ASW
  - 4 Seagliders (1000m)
  - 2 Slocum gliders (200m)
- Deployed 25 June – 29 July
- ONR – Sponsor, provided gliders
  - APL-UW, UHawaii, SPAWAR, OASIS, NAVOCEANO

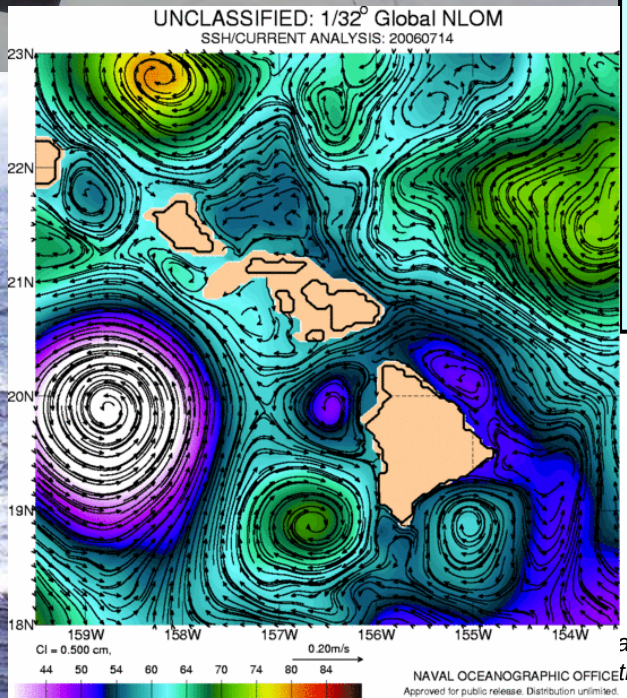
<u>Challenges</u>

- Deconflicting with foreign subs
- Strong currents
- Loss of 1 Slocum

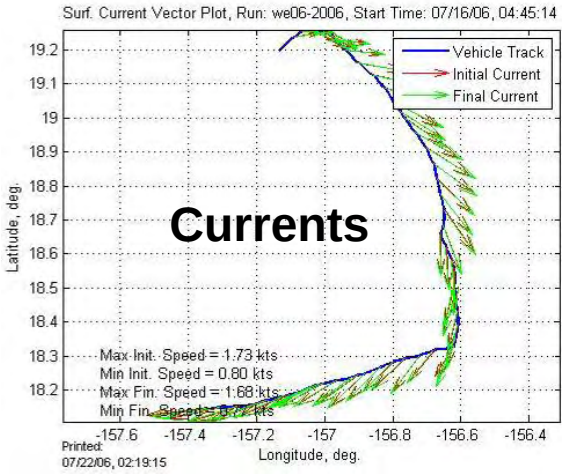
<u>So What</u>

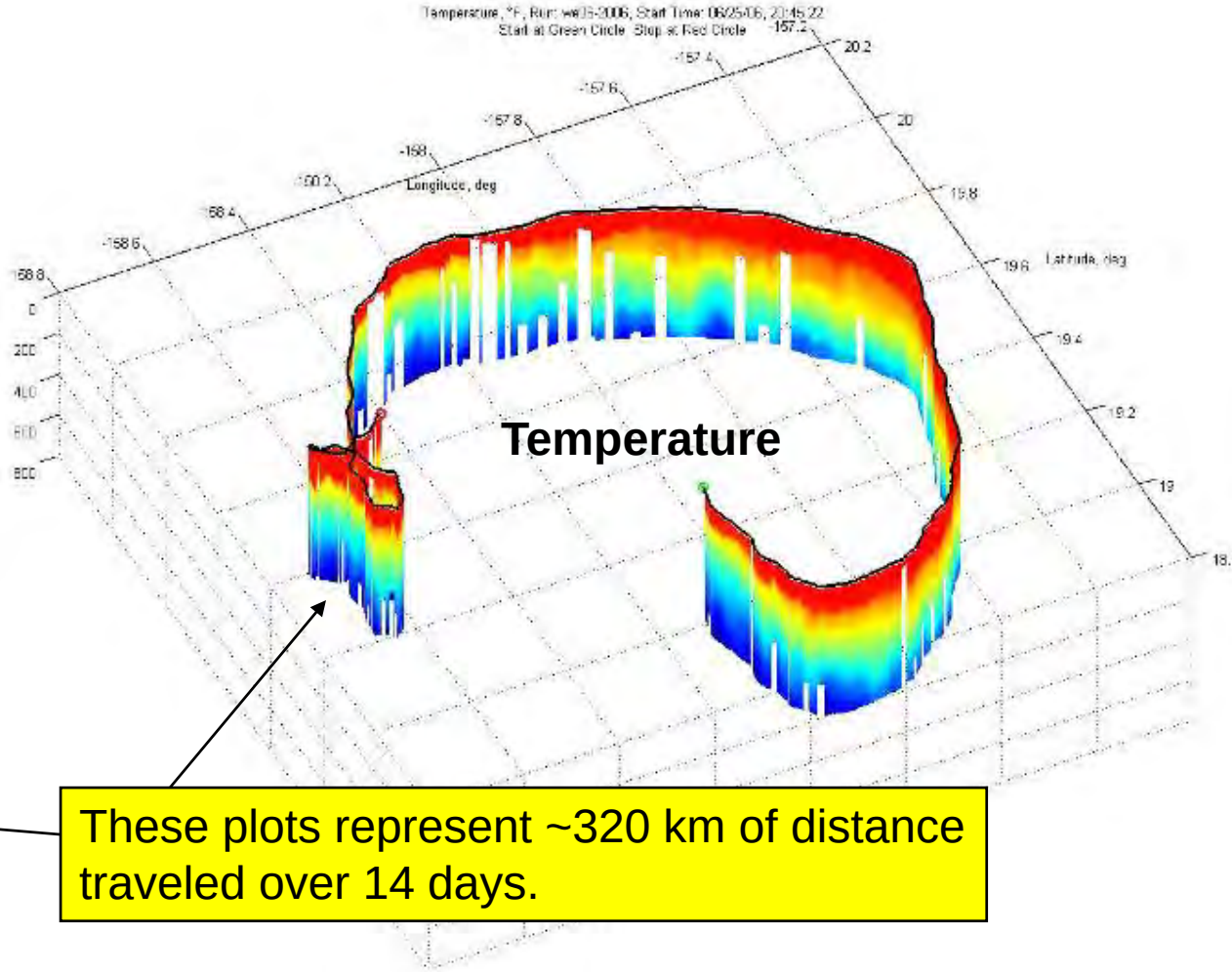
- Improvement in eddy characterization
- Cost savings (versus P-3/ship)

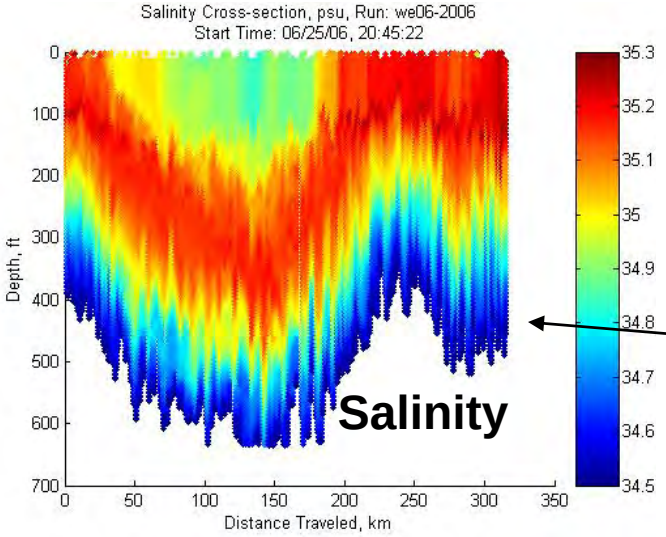
From: GlobalSecurity.org



RIMPAC 06 Glider Data

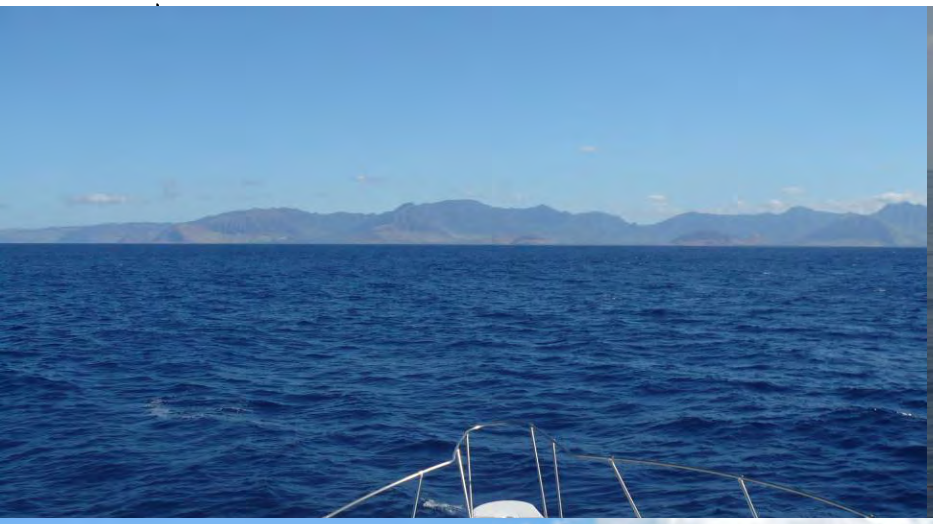


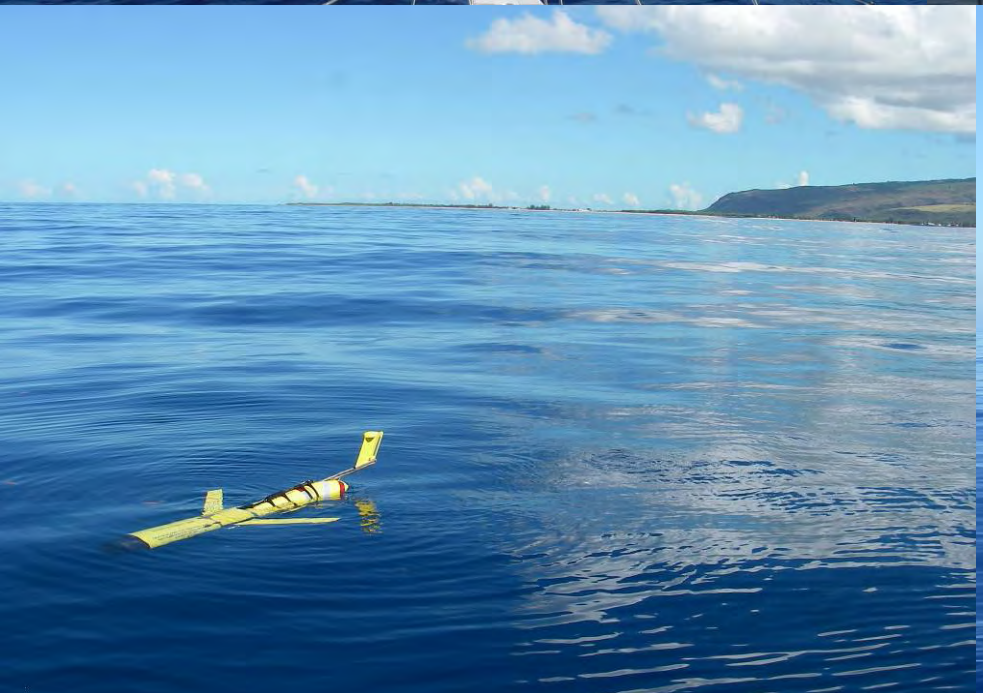


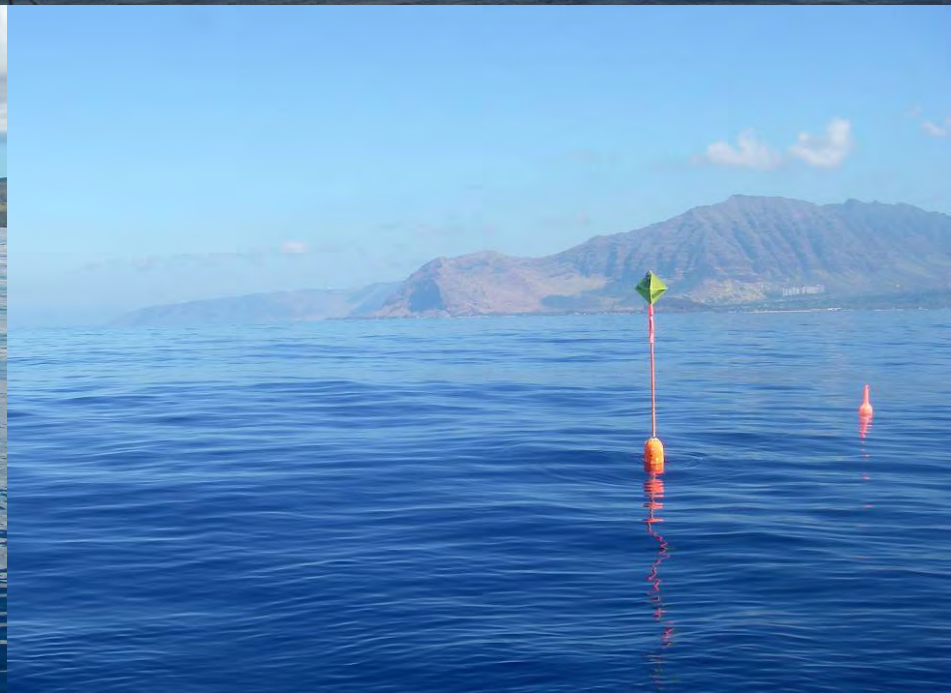


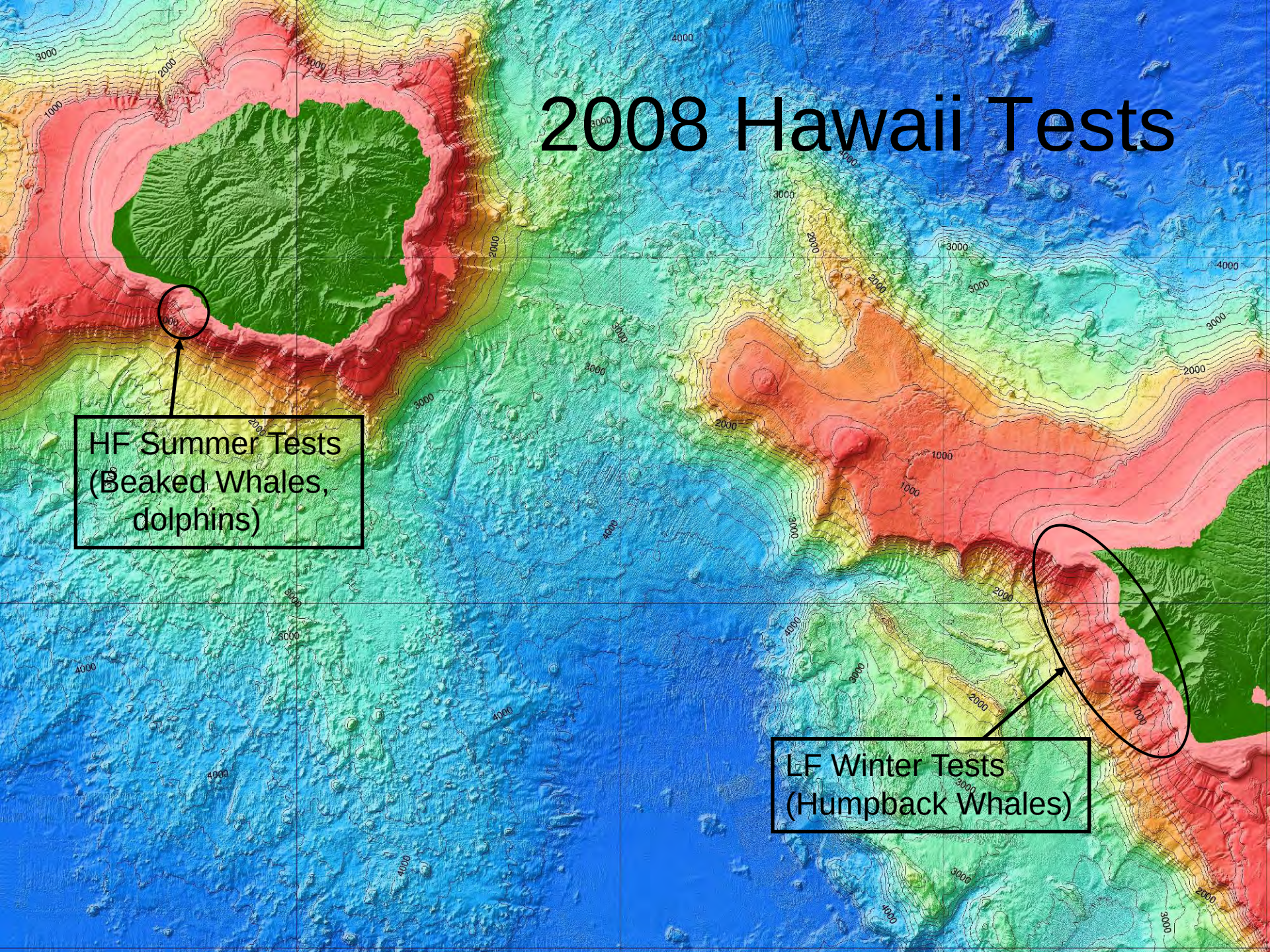
These plots represent ~320 km of distance traveled over 14 days.

Recent Tests in Hawaii





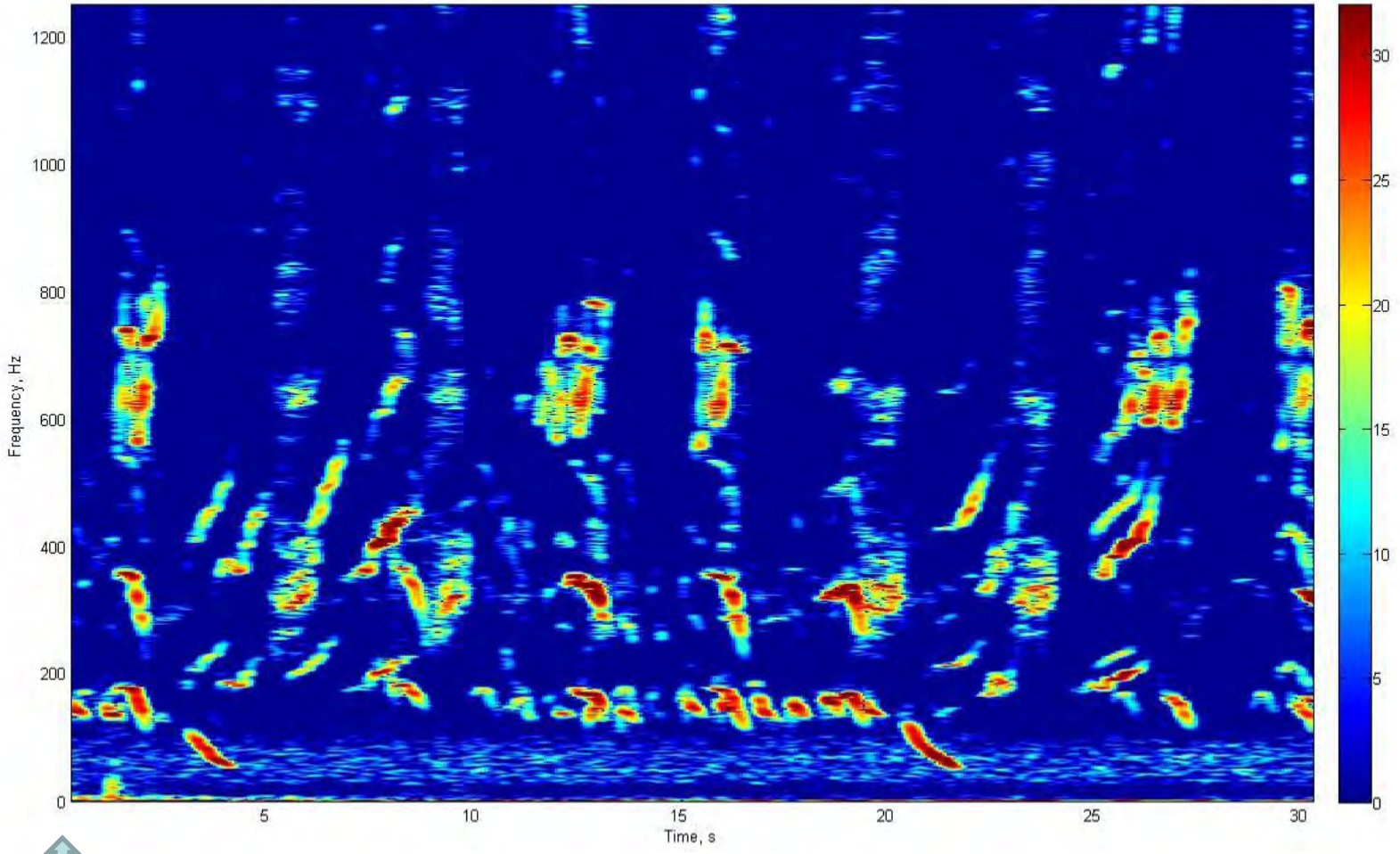



2008 Hawaii Tests
HF Summer Tests
(Beaked Whales,
dolphins)
LF Winter Tests
(Humpback Whales)

Hawaii Tests

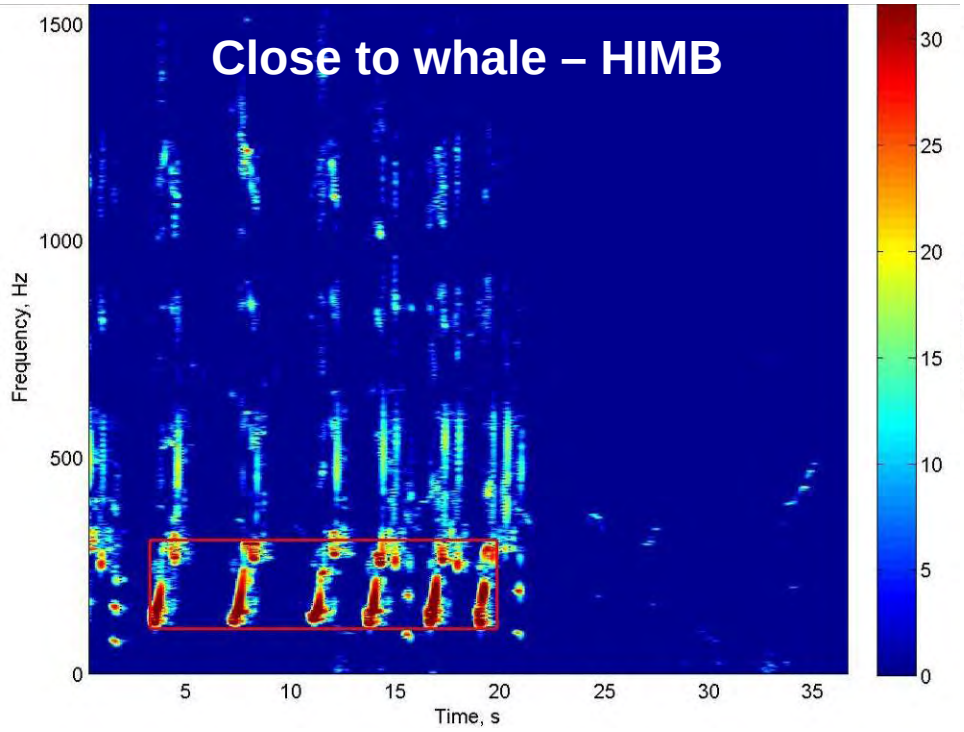
- Low-frequency (<100 Hz to 1 kHz)
  - February 2008
  - Focused on humpback whales, off leeward Oahu
  - Recorded abundant humpback songs onboard glider
  - Coordinated with HIMB singer localization
  - Autonomous reporting of mammal detections
- High-frequency (tens of kHz)
  - July/August 2008
  - Focused on beaked whales, off leeward Kauai
  - Recorded 94 hours of HF data

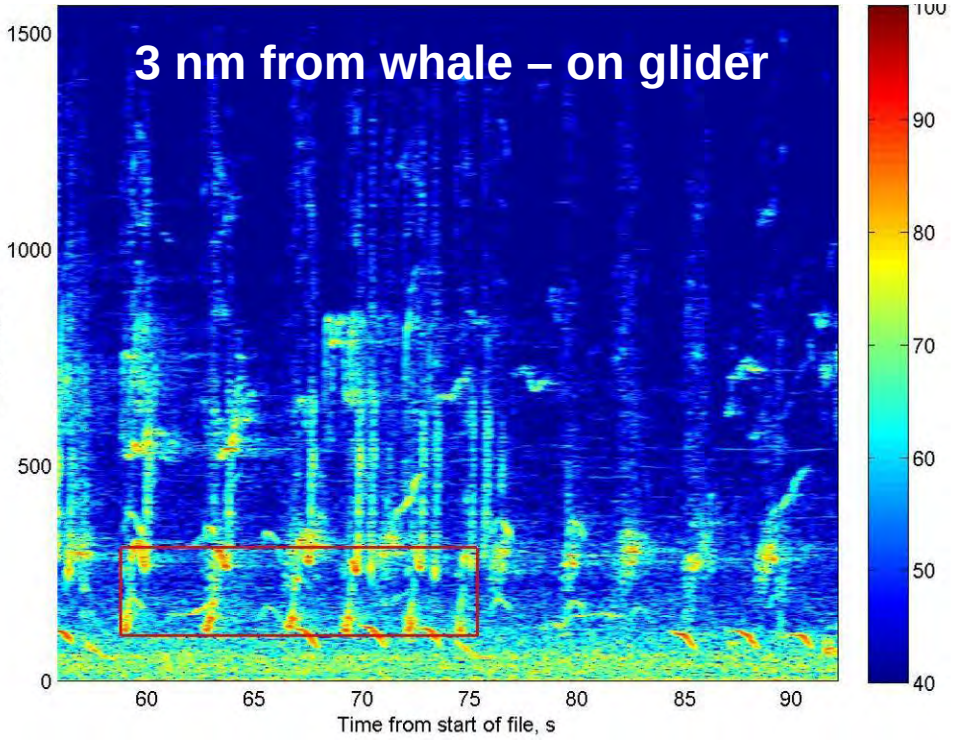
LF (Humpback) Signals Detected



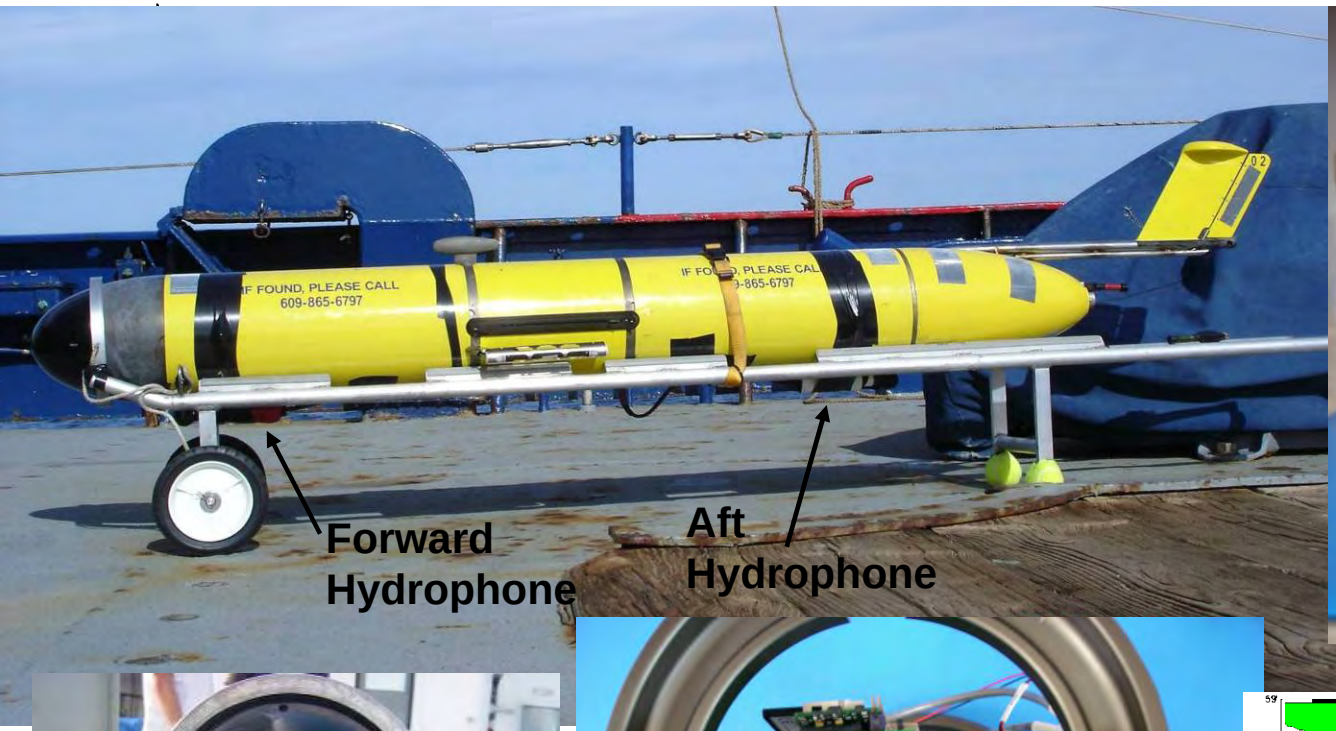
Role of HIMB

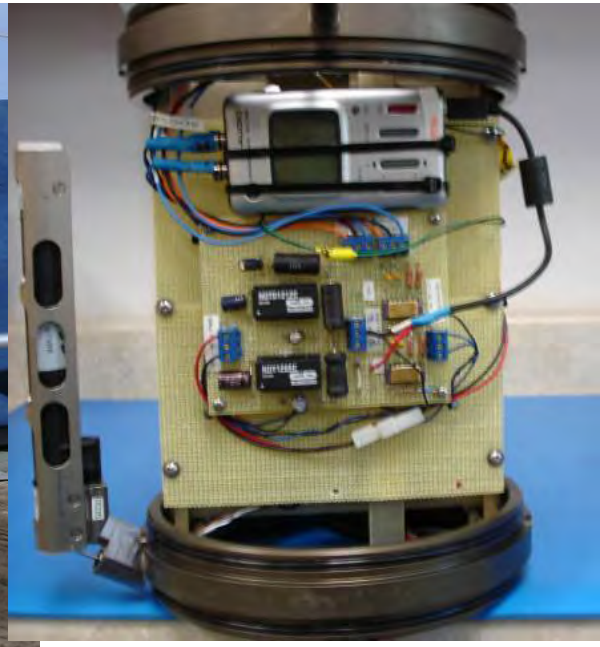
- Marine mammal consultants
- Field test design (where and when to test)
- Received signals analysis (LF and HF)
- Design of 3-EAR (Ecological Acoustic Recorder) system for glider
- Measuring near-field humpback songs during LF tests

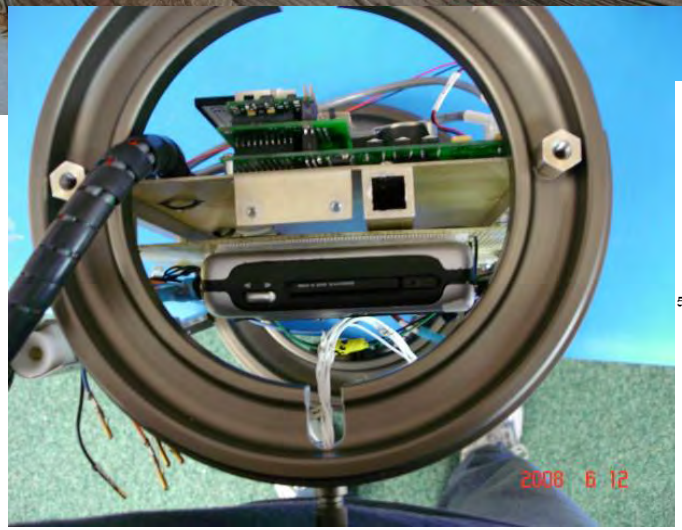


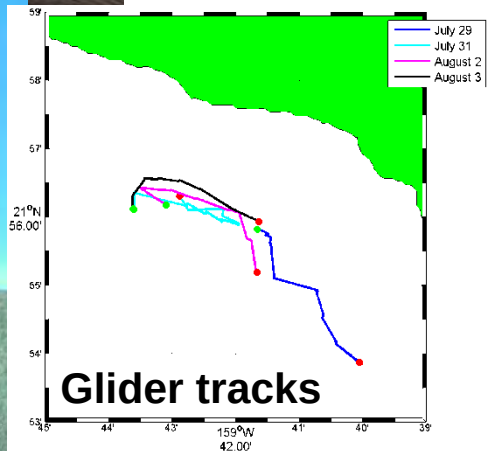


OASIS HF Glider

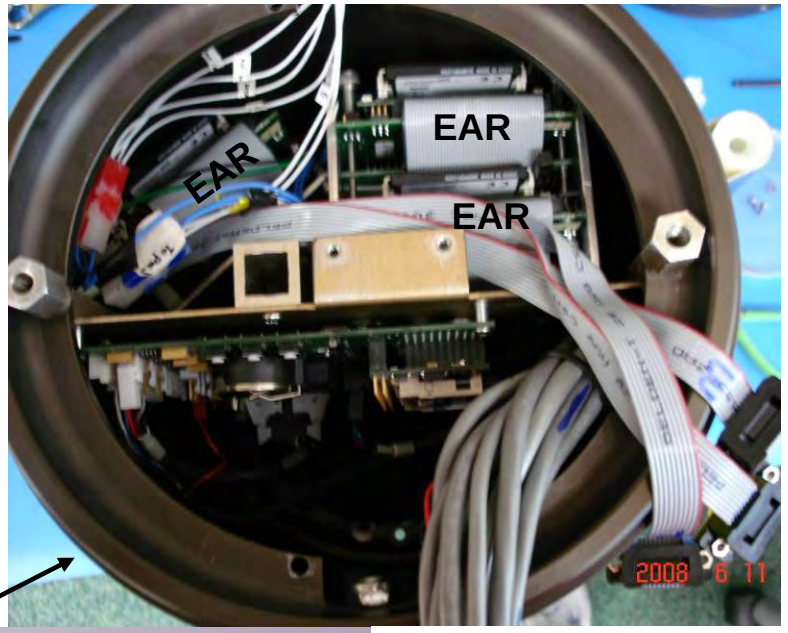






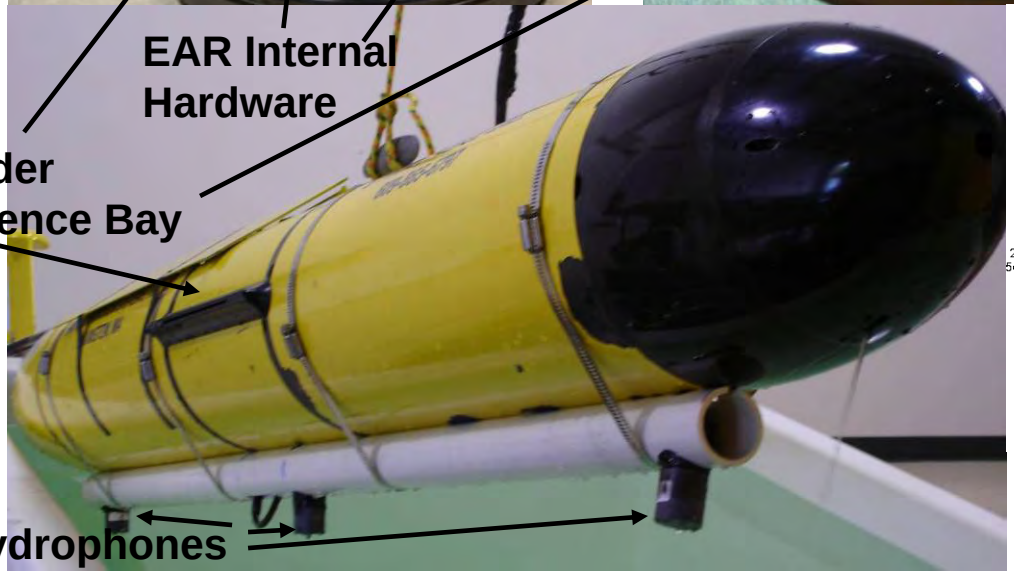


HIMB HF Glider

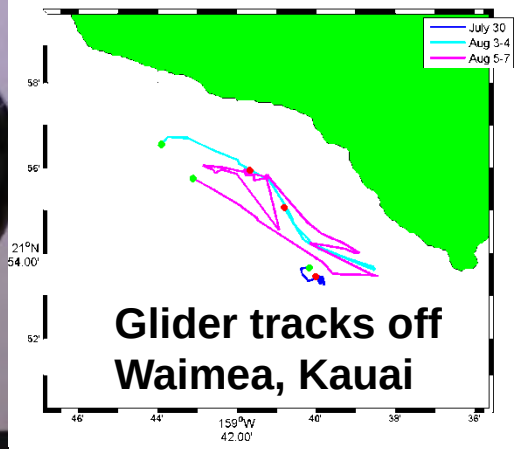


EAR Internal Hardware

Glider Science Bay



EAR Hydrophones



Summary

- Marine mammal monitoring is an important issue for the Navy, academia, commercial interests
- Most mammals vocalize with some regularity, allowing an opportunity for passive acoustic monitoring
- Gliders are a proven oceanographic sensor platform that can be outfitted with acoustic sensors
- Promise exists for species classification
- Successful tests of quiet, non-intrusive glider-based monitoring conducted
- Next phase of tests off Oahu in Feb/Mar 2009

Questions?