Acoustic Tools for Studying Marine Mammals

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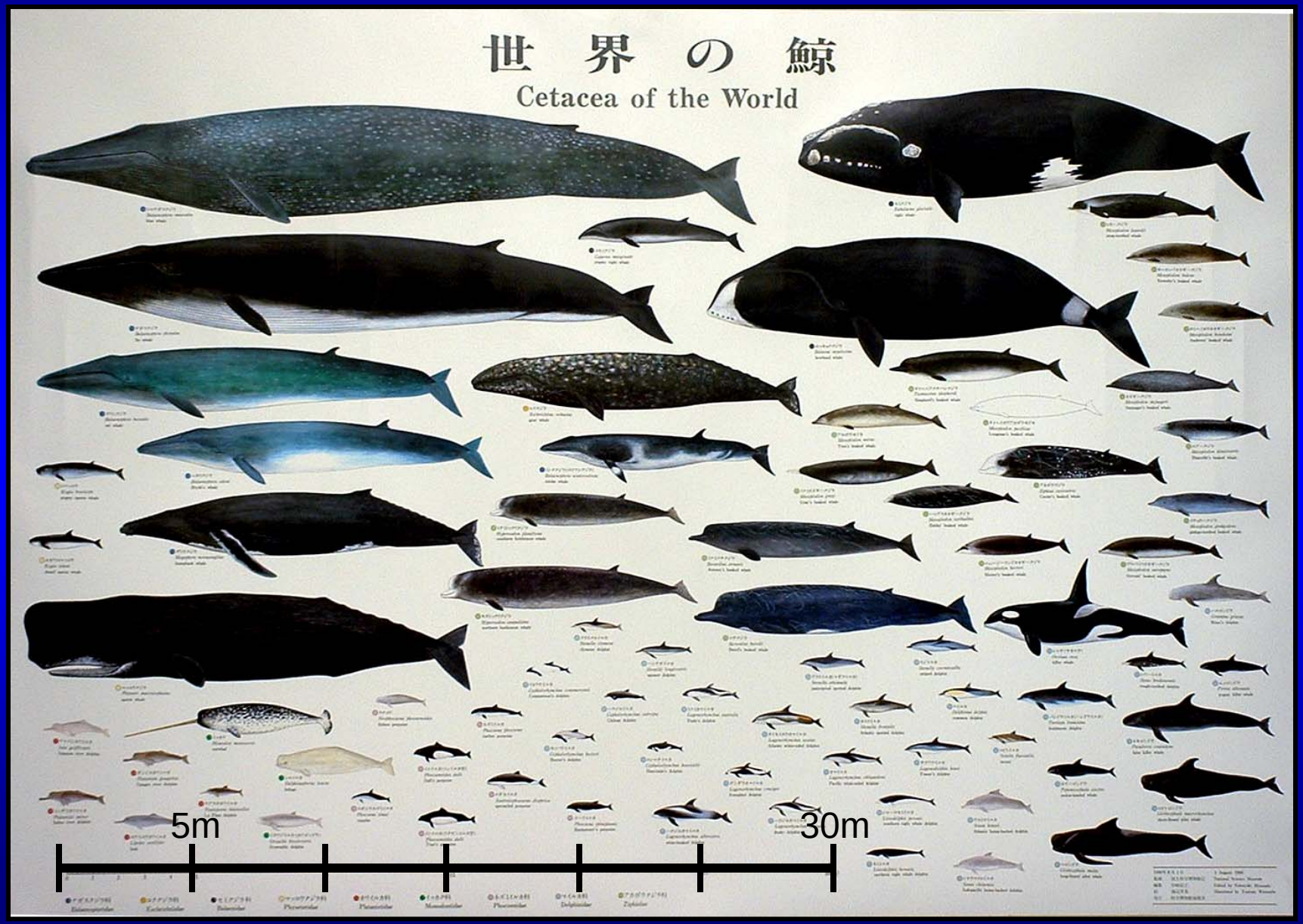
Whales and Dolphins of the World



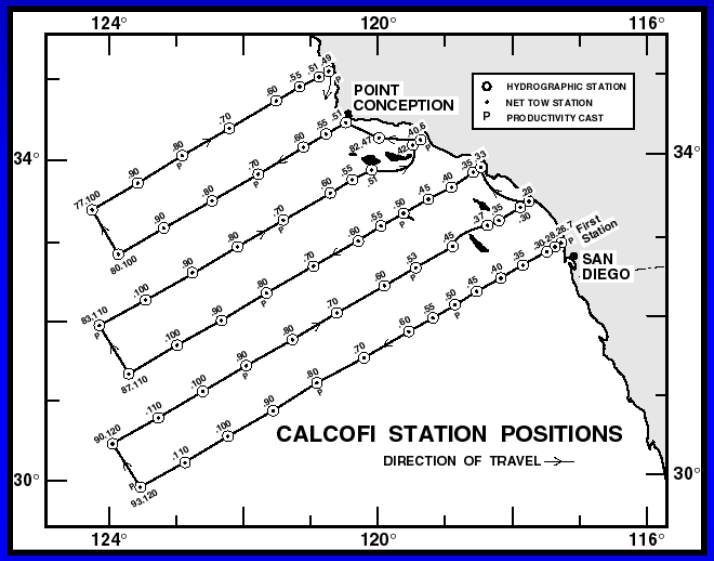
What do we need to know to conserve these animals?

- Geographical distributions
- Abundance
- Temporal patterns – Seasonal and Daily
- Behavior
- Response to anthropogenic influences

Traditional Methods for Studying Whales and Dolphins

Ship-based Visual Line Transect Surveys

- Count animals
- Note behaviors
- Photo-identification mark-recapture



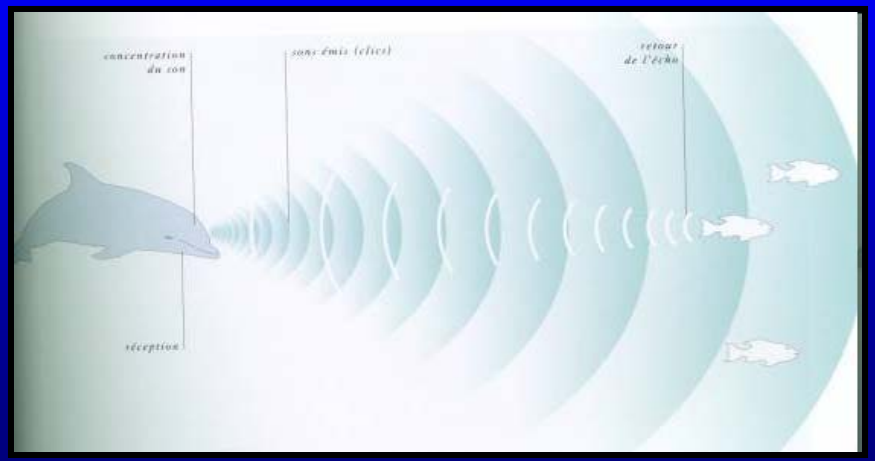
Limitations:

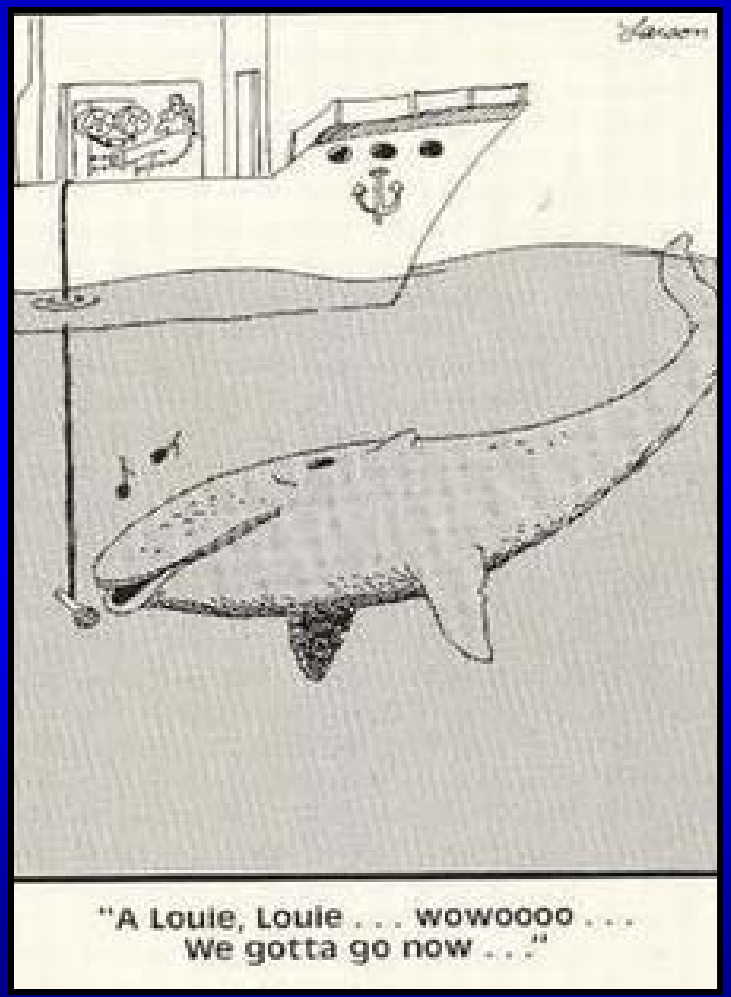
- Surveys are conducted only during daylight hours
- Weather affects visual detect ability
- Many species spend most of their time below the sea surface

Marine Mammal Sounds

Sounds used to:

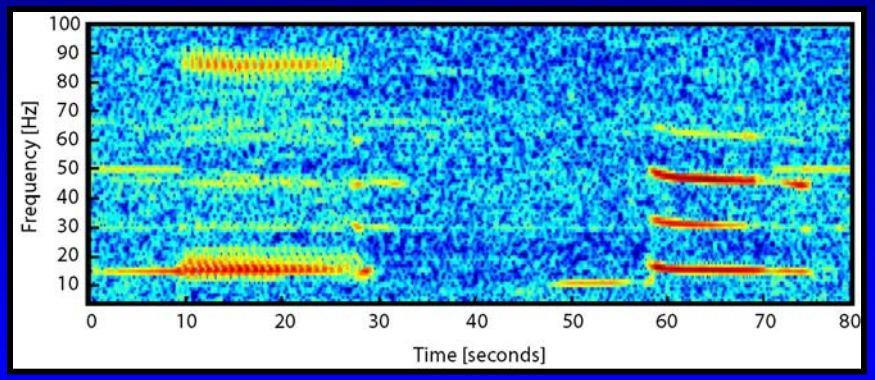
- Communicate
- Navigate
- Find food



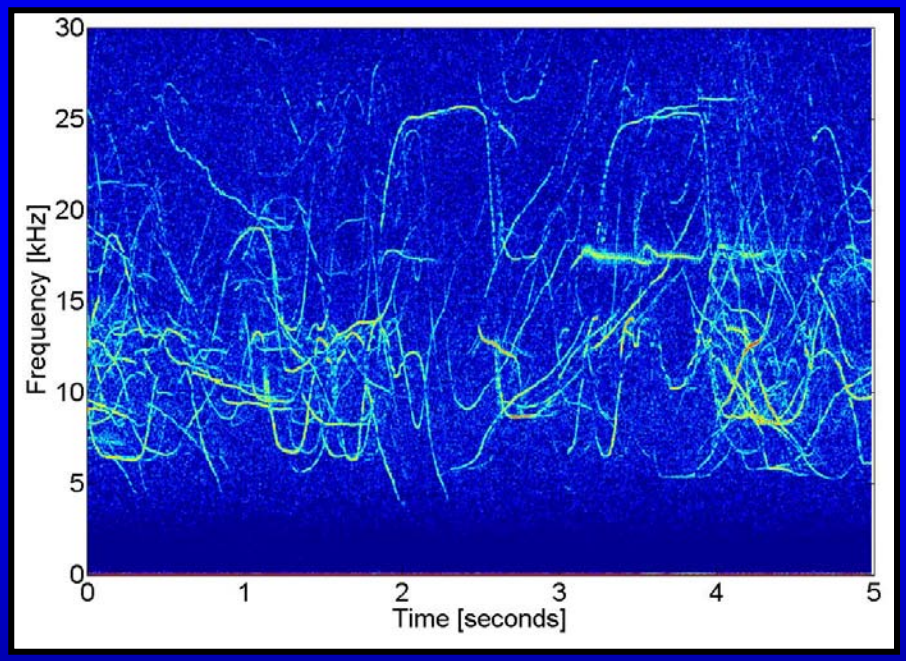


Sound Types

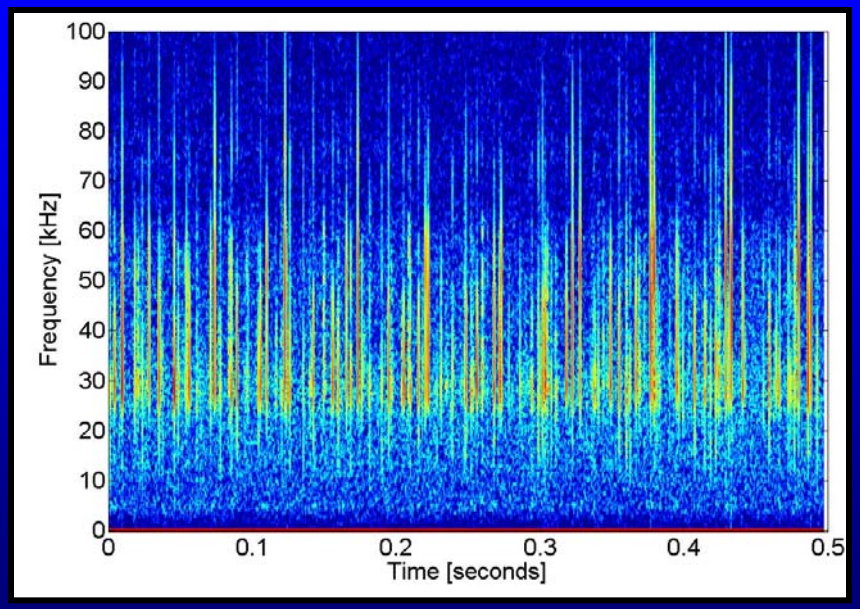
Blue Whale Low Frequency Tones



Dolphin “Narrow”-band Whistles
Omni-directional

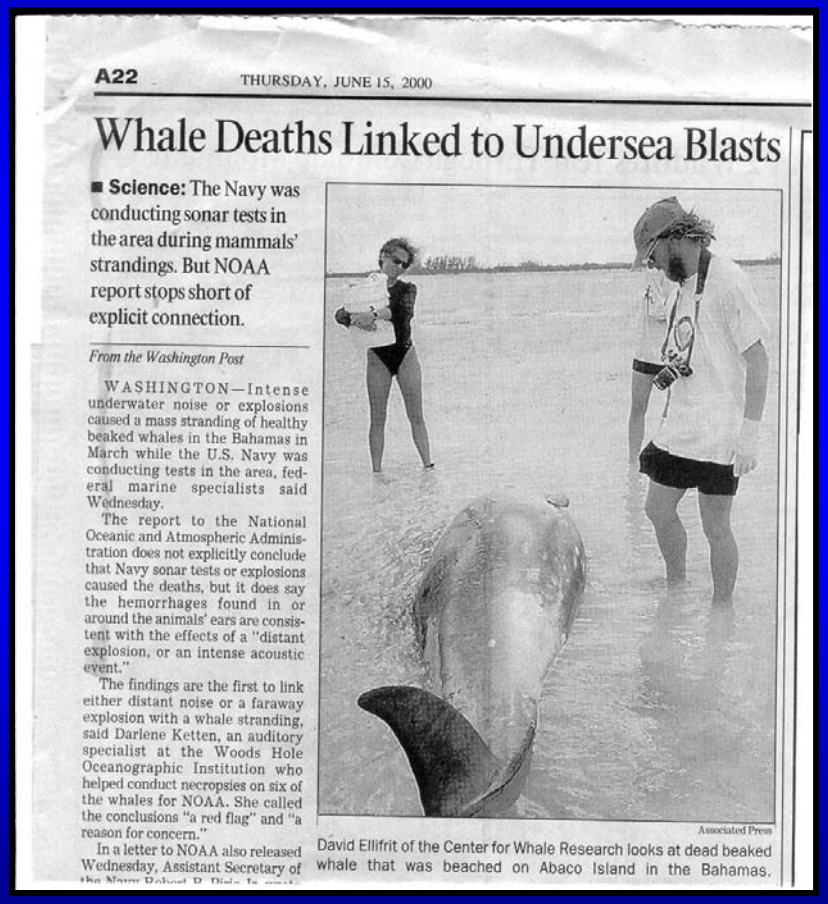


Dolphin Broad-band Clicks
Directional Beams



Man-made Sounds Affect Marine Mammals

Navy Sonar Causes Strandings



A22 THURSDAY, JUNE 15, 2000

Whale Deaths Linked to Undersea Blasts

■ **Science:** The Navy was conducting sonar tests in the area during mammals' strandings. But NOAA report stops short of explicit connection.

From the Washington Post

WASHINGTON—Intense underwater noise or explosions caused a mass stranding of healthy beaked whales in the Bahamas in March while the U.S. Navy was conducting tests in the area, federal marine specialists said Wednesday.

The report to the National Oceanic and Atmospheric Administration does not explicitly conclude that Navy sonar tests or explosions caused the deaths, but it does say the hemorrhages found in or around the animals' ears are consistent with the effects of a "distant explosion, or an intense acoustic event."

The findings are the first to link either distant noise or a faraway explosion with a whale stranding, said Darlene Ketten, an auditory specialist at the Woods Hole Oceanographic Institution who helped conduct necropsies on six of the whales for NOAA. She called the conclusions "a red flag" and "a reason for concern."

In a letter to NOAA also released Wednesday, Assistant Secretary of

Associated Press

David Ellifrit of the Center for Whale Research looks at dead beaked whale that was beached on Abaco Island in the Bahamas.

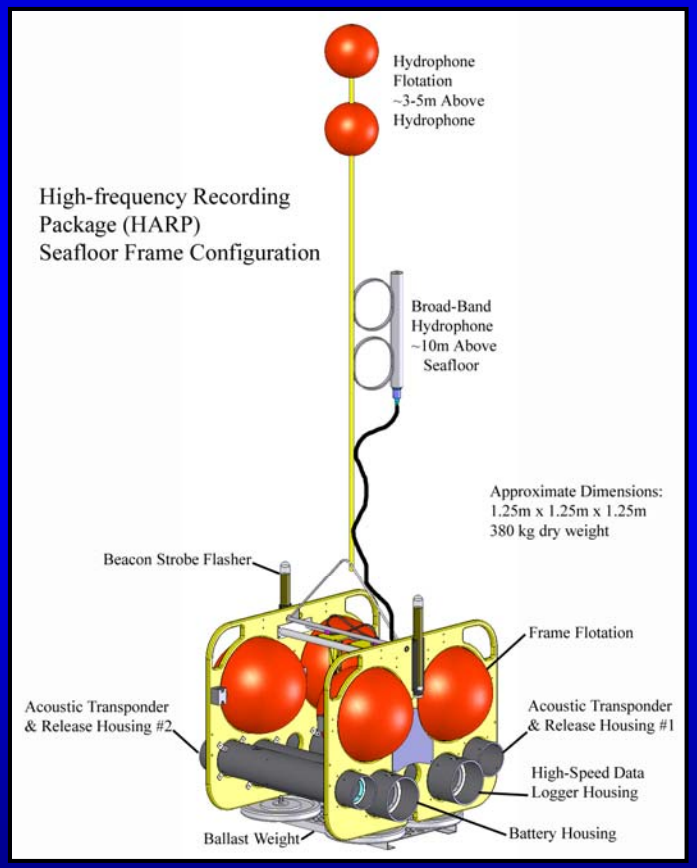
Beaked Whale Beached in the Bahamas
(LA Times 6/15/2000)

Propulsion Noise Masks Whale Calls

Blue Whale and Cargo Vessel
(photo: J. Calambokidis)

Two Methods for Studying Whale and Dolphin Sounds

Long-term Acoustic Recorder



~1.25m

Acoustic Recording Tag

~20cm

Tags

Barbed
Long-duration
GPS location only

(Andrews et al, 2008)

Suction Cup
Short-duration
Multi-sensor

DTAG

Woods Hole Oceanographic Institute
Dr. Mark Johnson

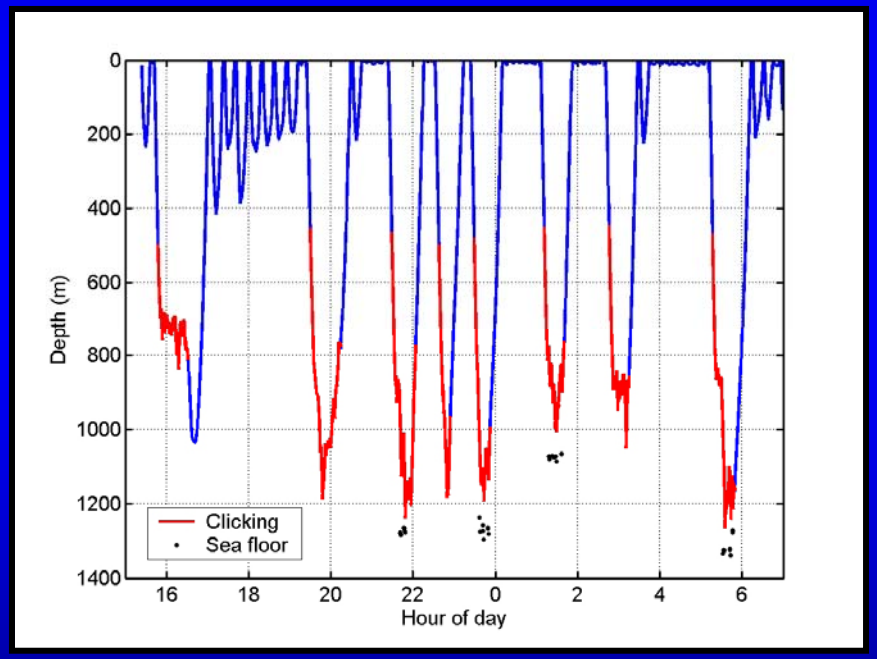
Audio:
192kHz sample rate
16 hrs with loss-less compression
10 GBytes solid state memory

Motion:
50Hz sample rate
Pitch, Roll, Heading, Depth

Misc:
Rechargeable battery
300g weight in air
Suction cup attachment
Infra-red data offload

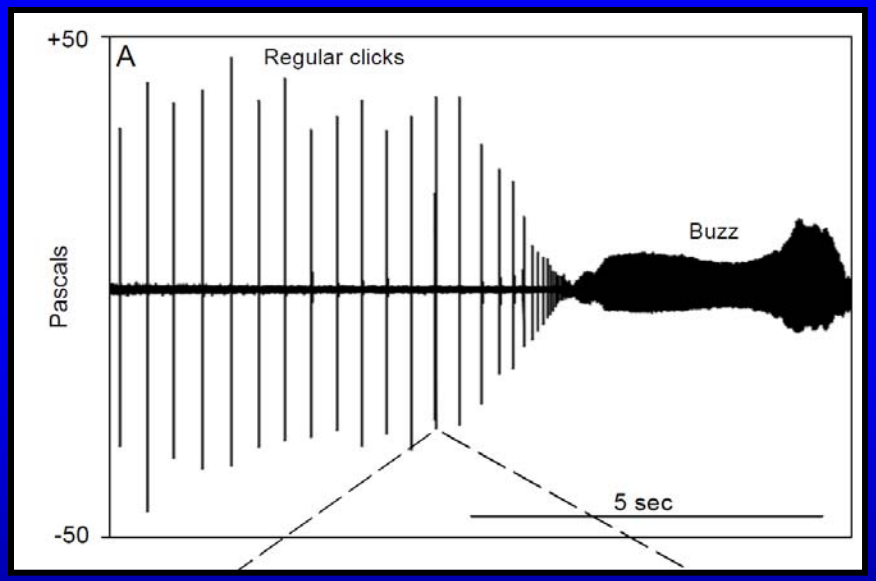
Beaked Whale Foraging

Dive profile and clicks



(Tyack & Johnson)

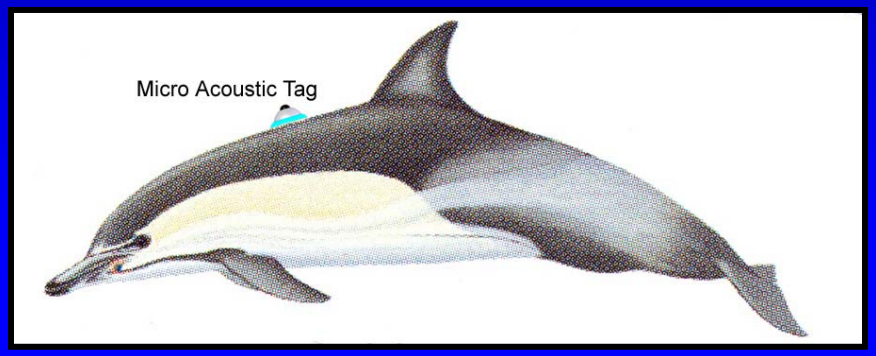
Echolocation clicks and buzz

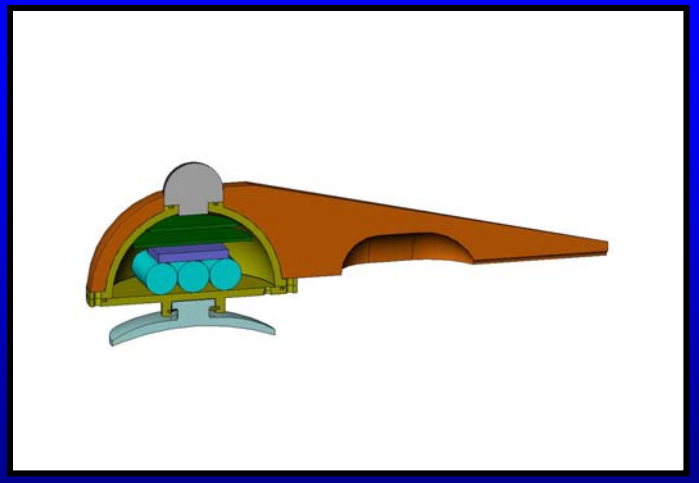


(Madsen et al, 2005)

Next Generation Tag

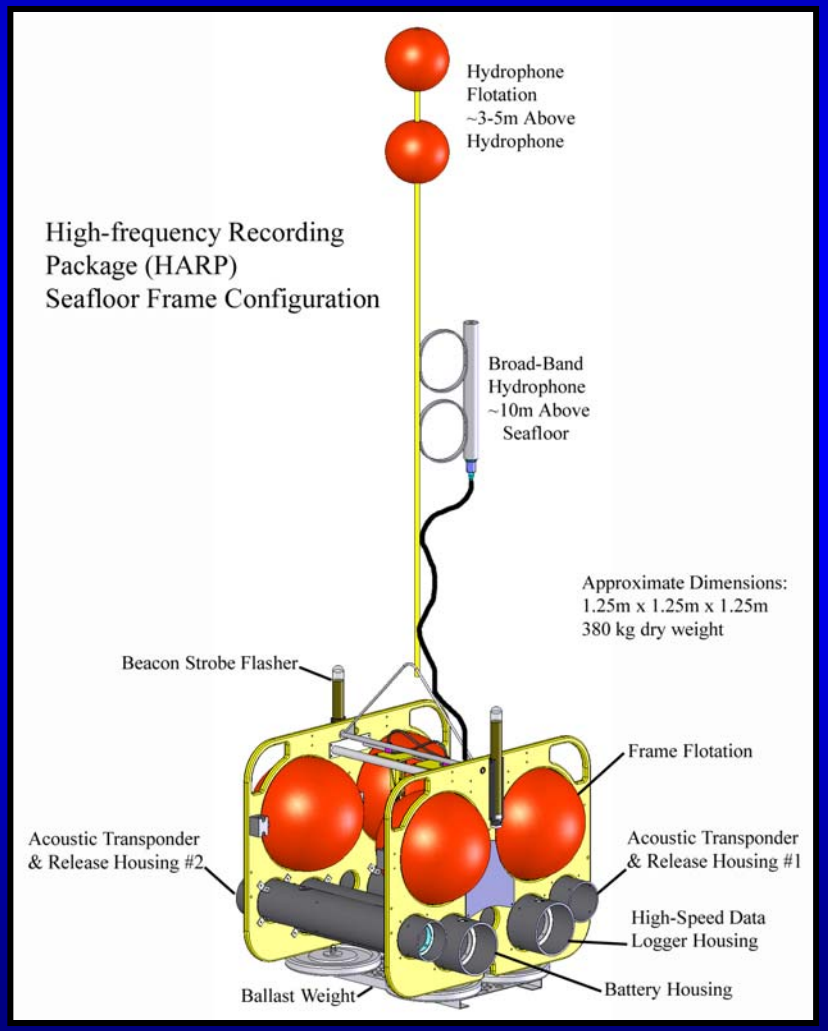
Further miniaturize electronics & packaging for small dolphins





High-frequency Acoustic Recording Package (HARP)

- Recording durations: months
- Deployed in remote locations
- Low operational costs
- Monitor over large areas
- Configurable into tracking arrays



HARP Data Logger

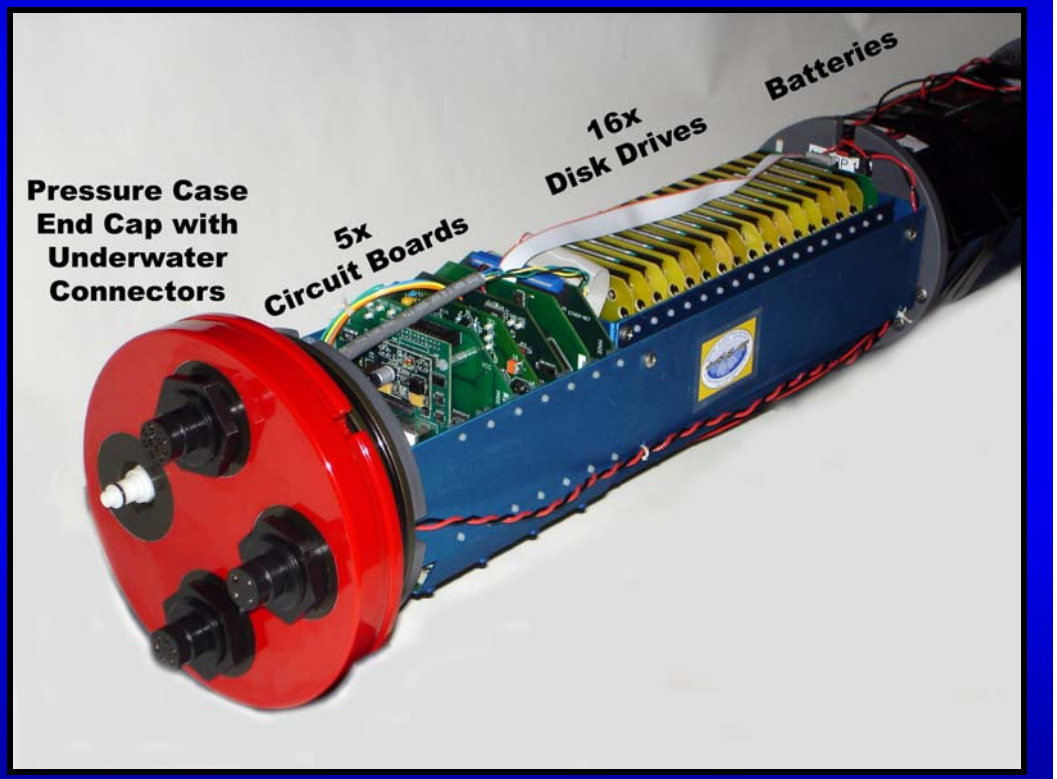
Sample rate: up to 200 kHz

Data capacity: ~2 TB on 16 low-power laptop disk drives

Persistence: ~55 days @ 200 kHz cont. or up to 1 yr @ slower rate or scheduled

Interchangeable circuit boards for modifications and enhancements

Low drift (~10^{-8}) clock for array surveys

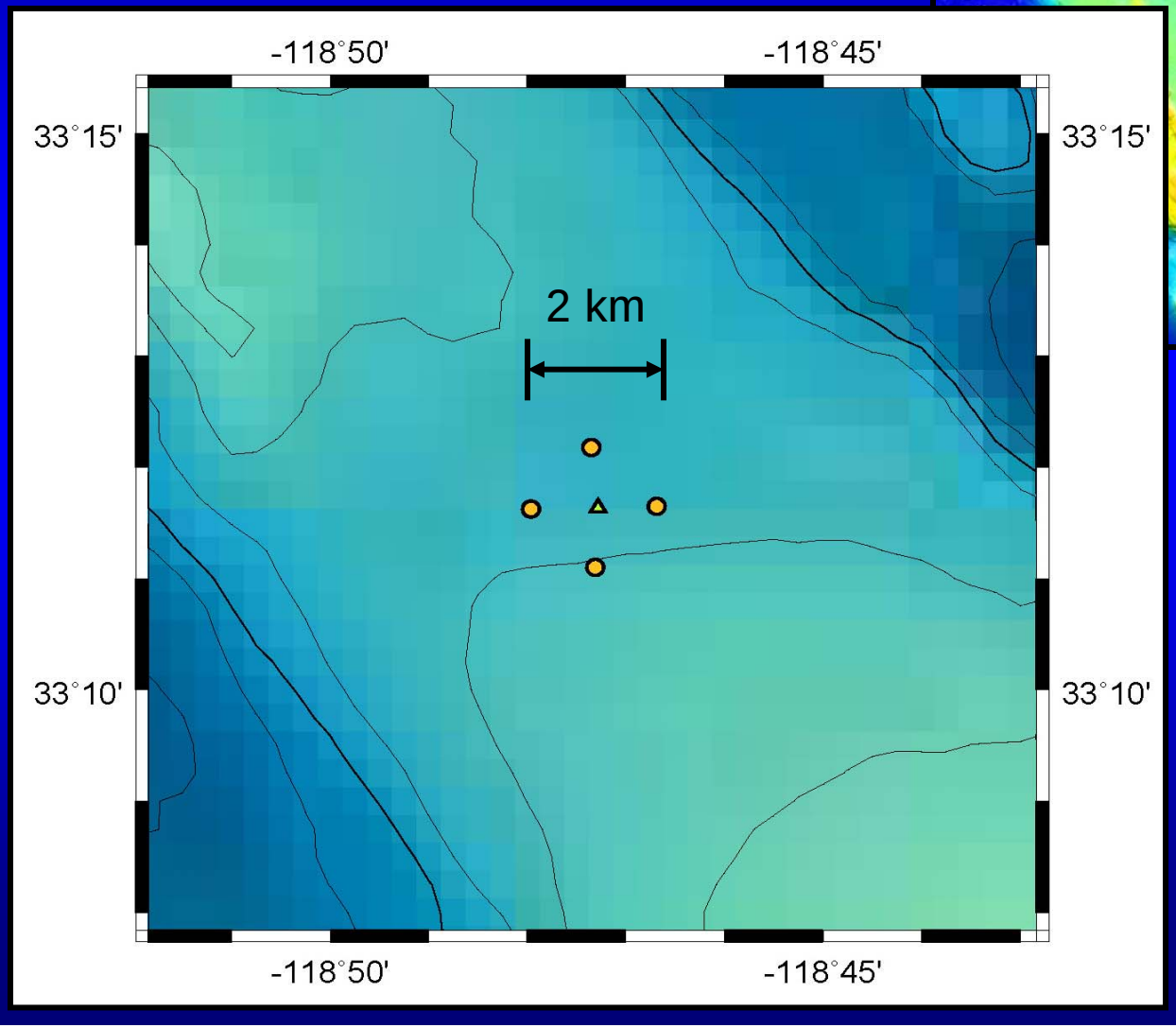


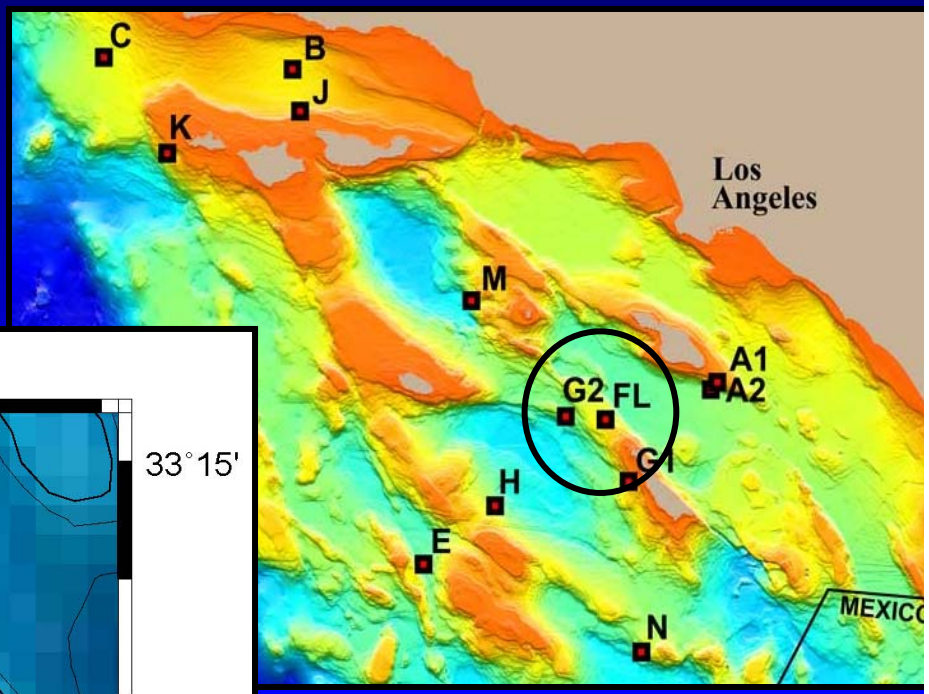
HARP Enhancements

Goal: Longer deployments
= lower costs

- Lossless data compression
- Replace hard disks with flash memory for lower power and higher capacity data storage

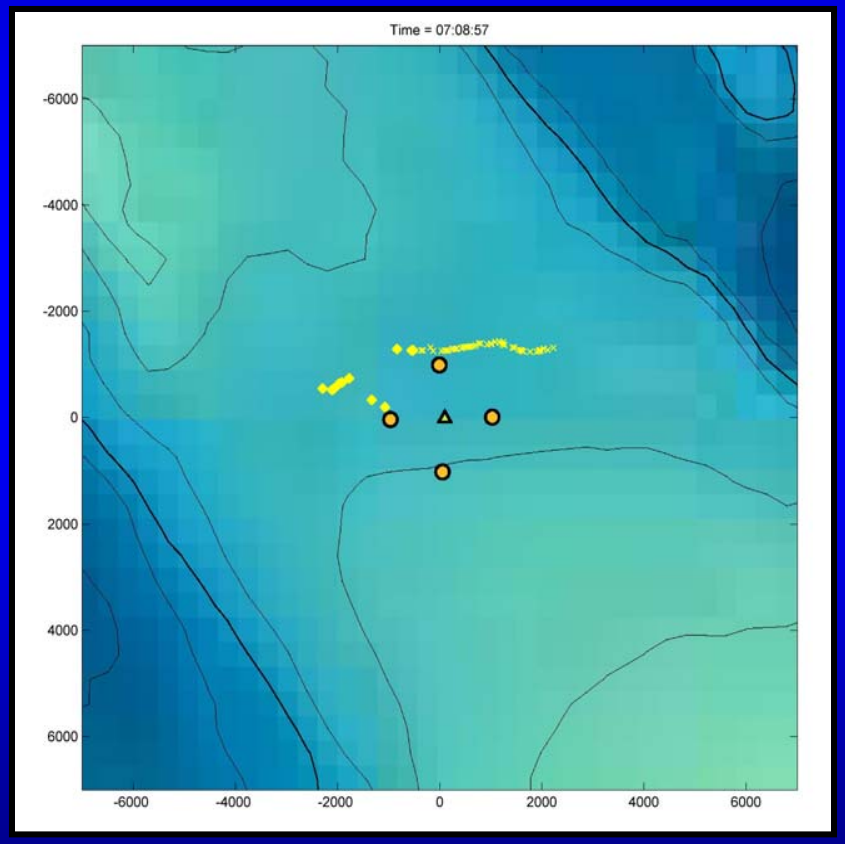
4 Seafloor HARPs in 2km Array



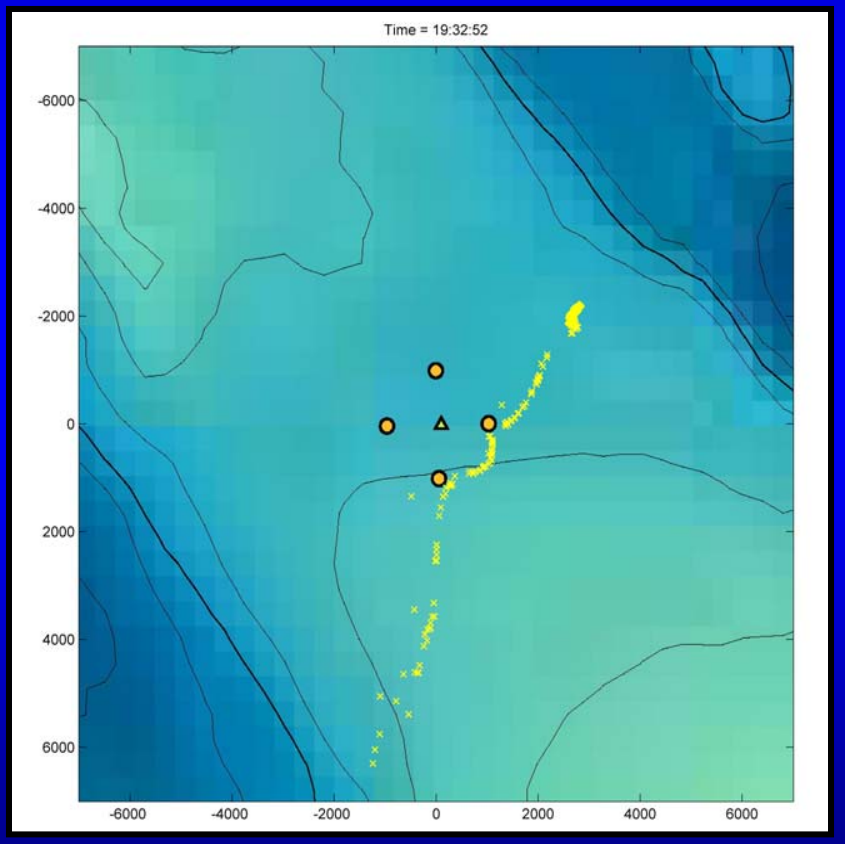


Offshore Southern California
Near San Clemente Island

Common Dolphin Tracks from Whistles

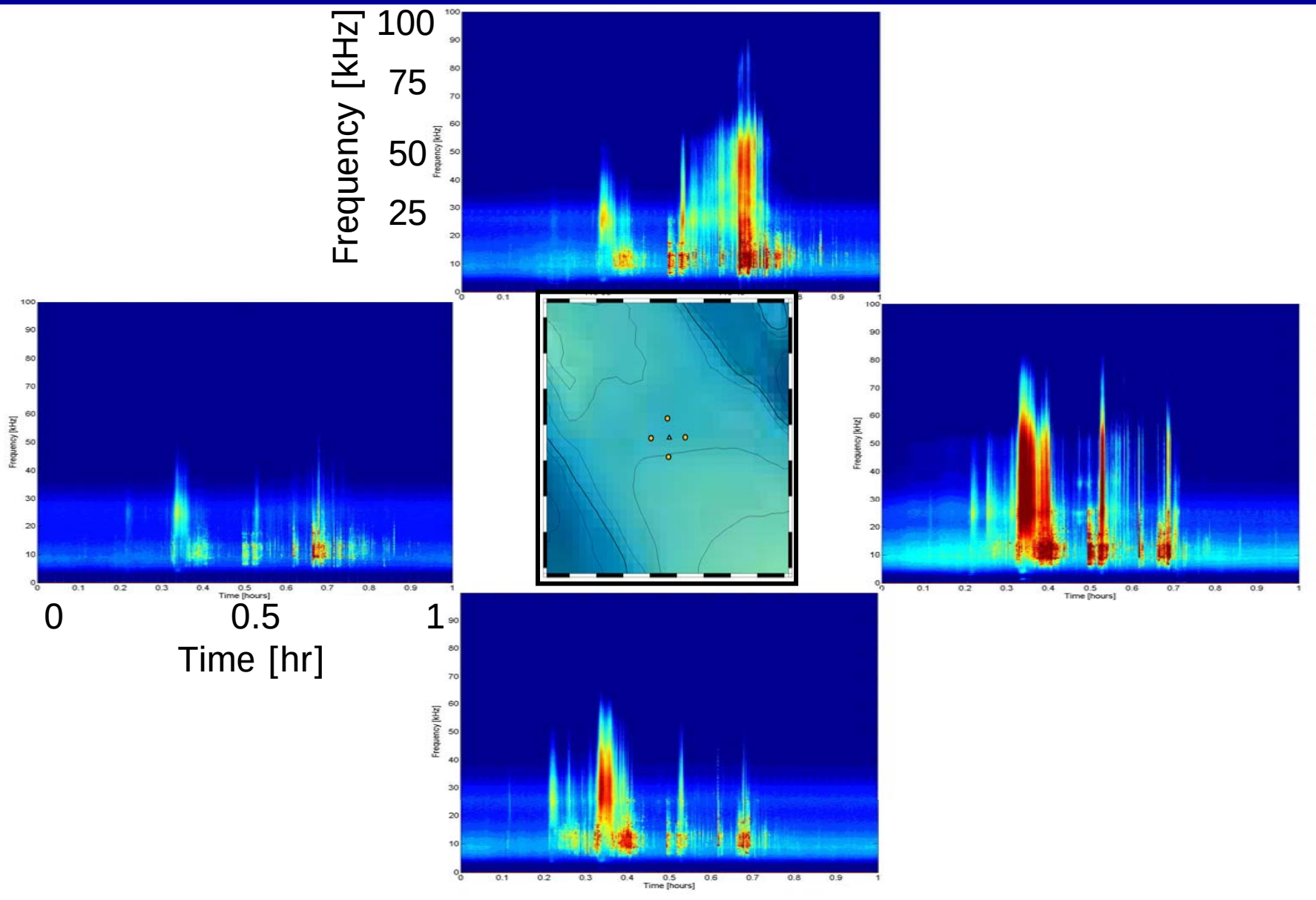


Traveling E-W in early evening

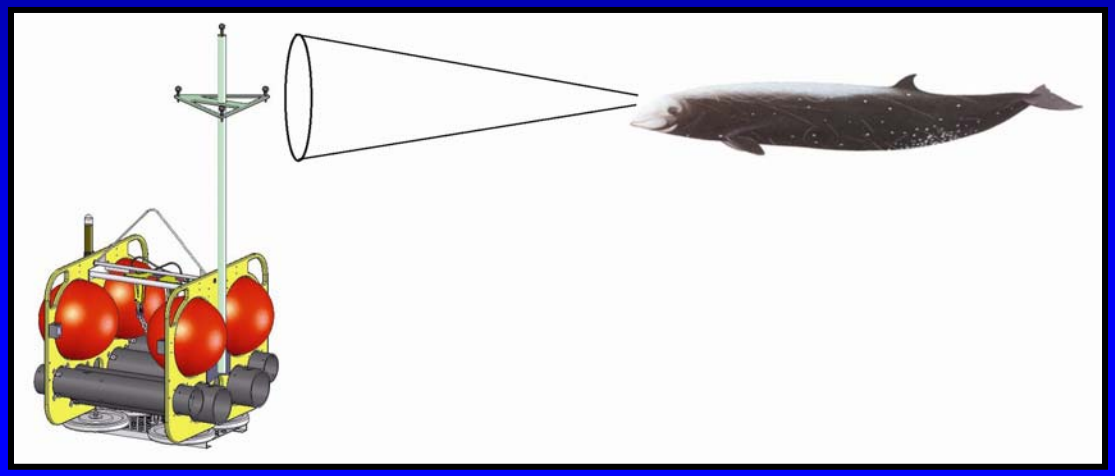


Traveling SW - NE in late evening

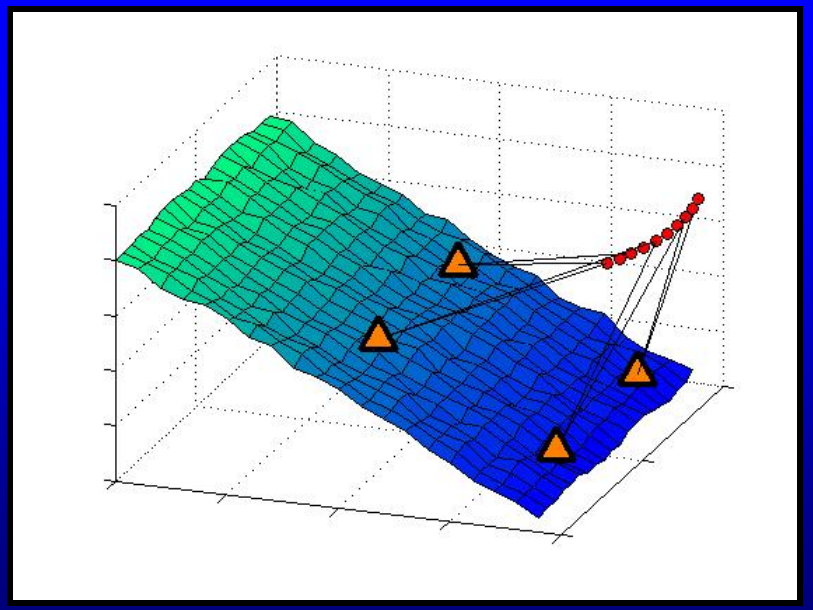
Common Dolphins on HARP Array



Tracking HARP

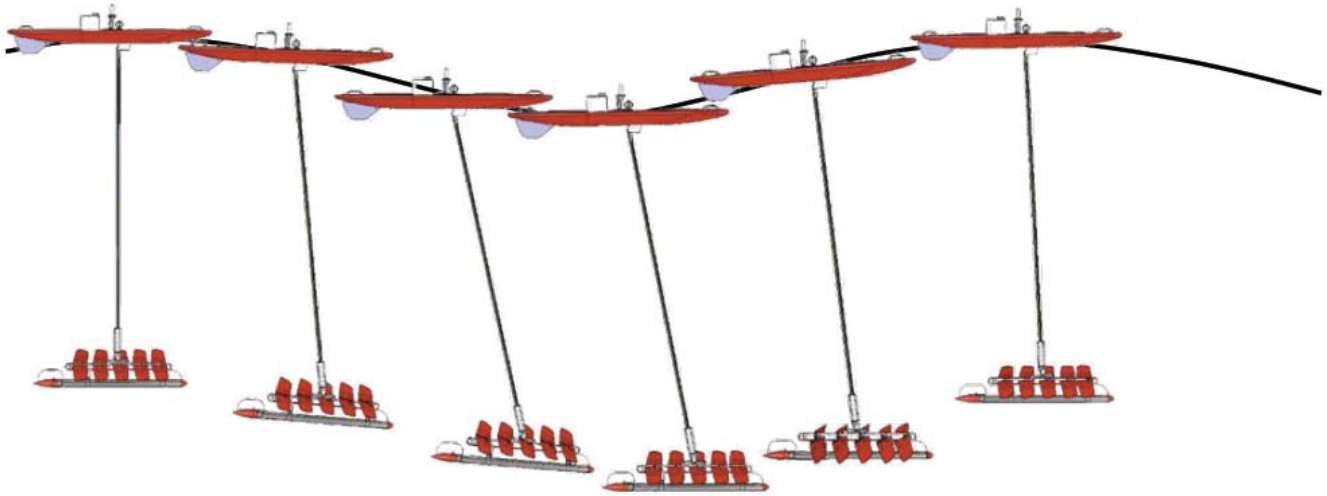


- 4 hydrophones = 3D bearings
- Multiple instruments = tracking
- Completely non-invasive
- Long-duration = many dives/animals



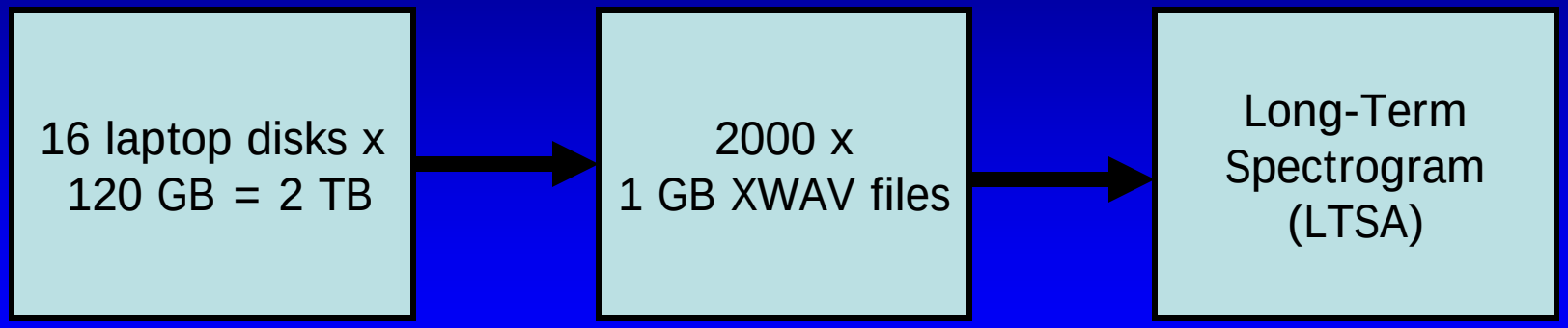
Wave Glider HARP

Wave Glider Motion Phases



- The Glider is “pumped” up and down by the surface float
- The foils’ angle of attack changes with the rising and sinking of the glider
- A thrust component of up to 100 lbs is developed on each up and down stroke.

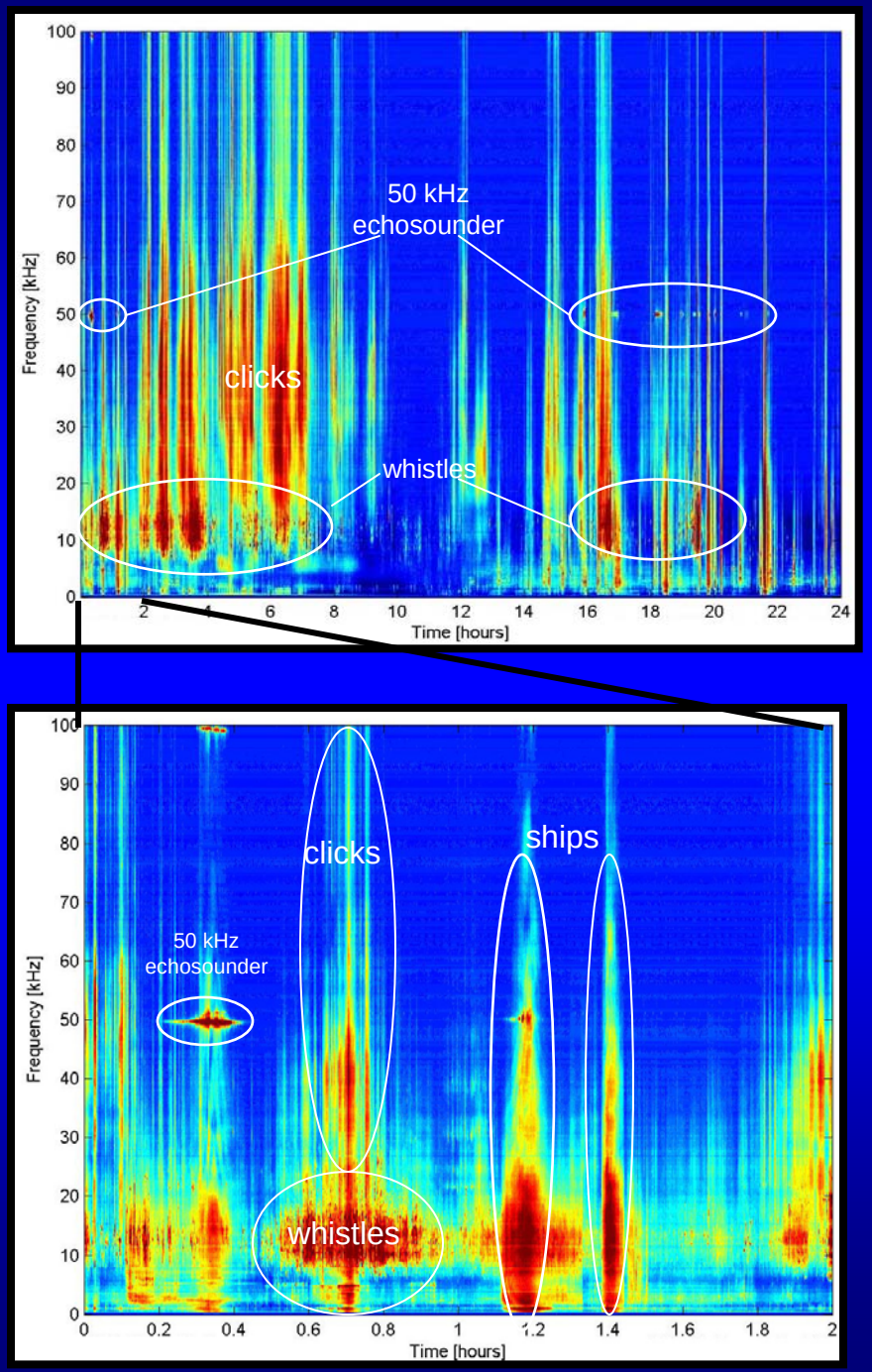
Processing 2 TB of HARP Data



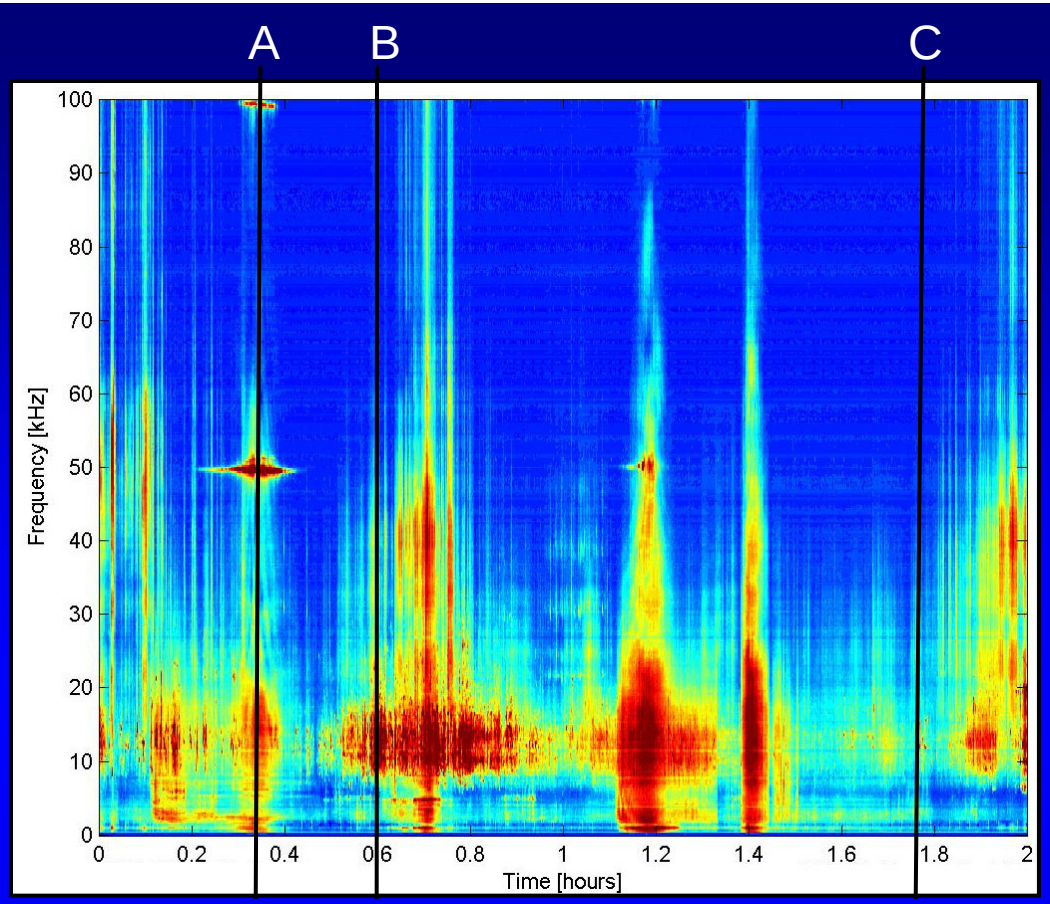
- XWAV files are similar to WAV files with additional information in file header
- XWAV files can be played/viewed with WAV file capable software
- Too much data to analyze manually and unknown sounds limit the use of automatic detectors
- Long-Term Spectral Averages (LTSA) provide a quick but powerful visual overview of the data set

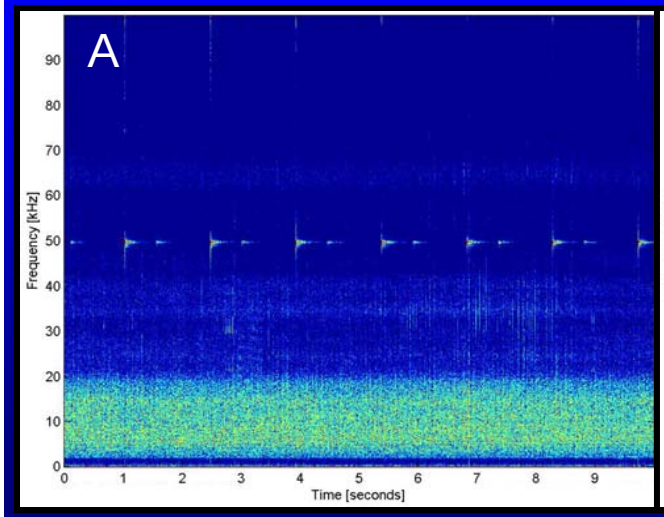
Long-Term Spectral Averaging LTSA

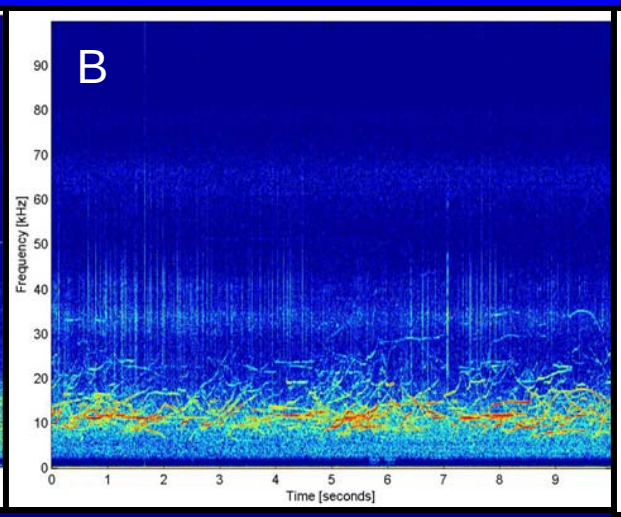
- Data compression scheme
- Calculate long-duration spectra & display as spectrogram (time-frequency plot)
- Provides overview of data and depicts events of interest
- Link between LTSA events and original raw XWAV data

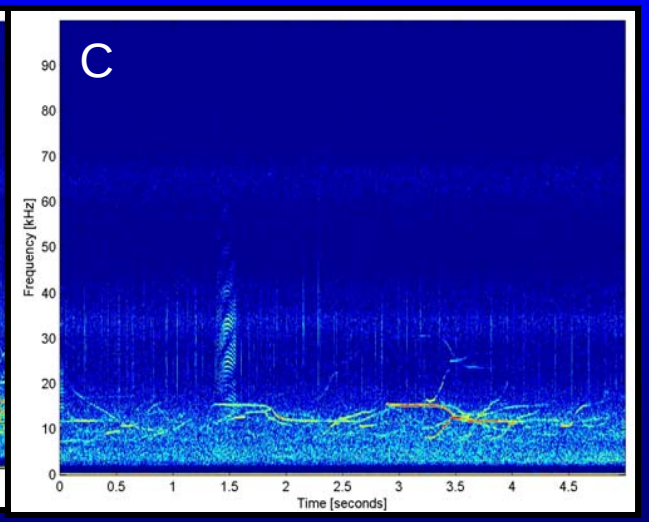


LTSA & fine-scale XWAV data









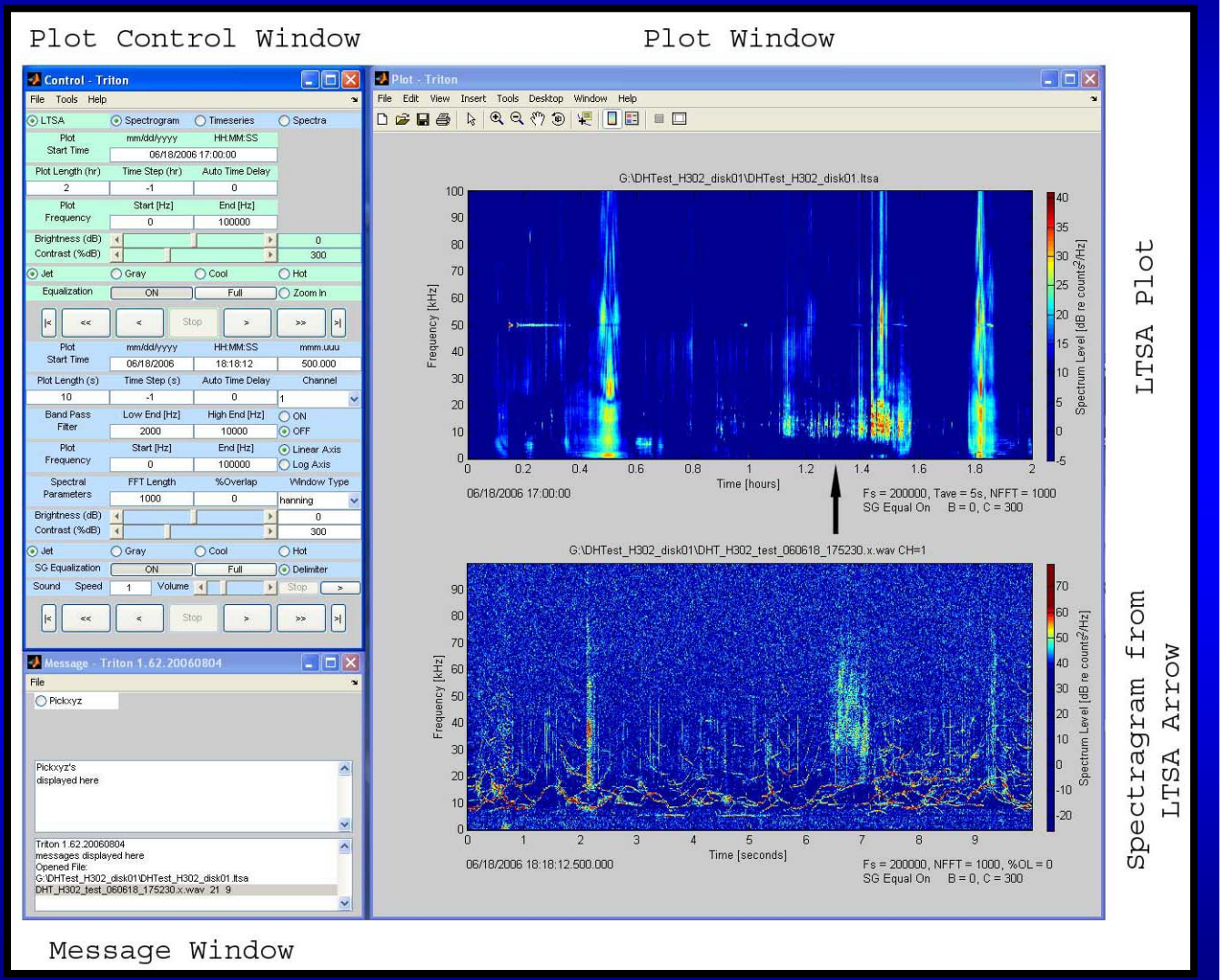
Triton Software

MATLAB based GUI

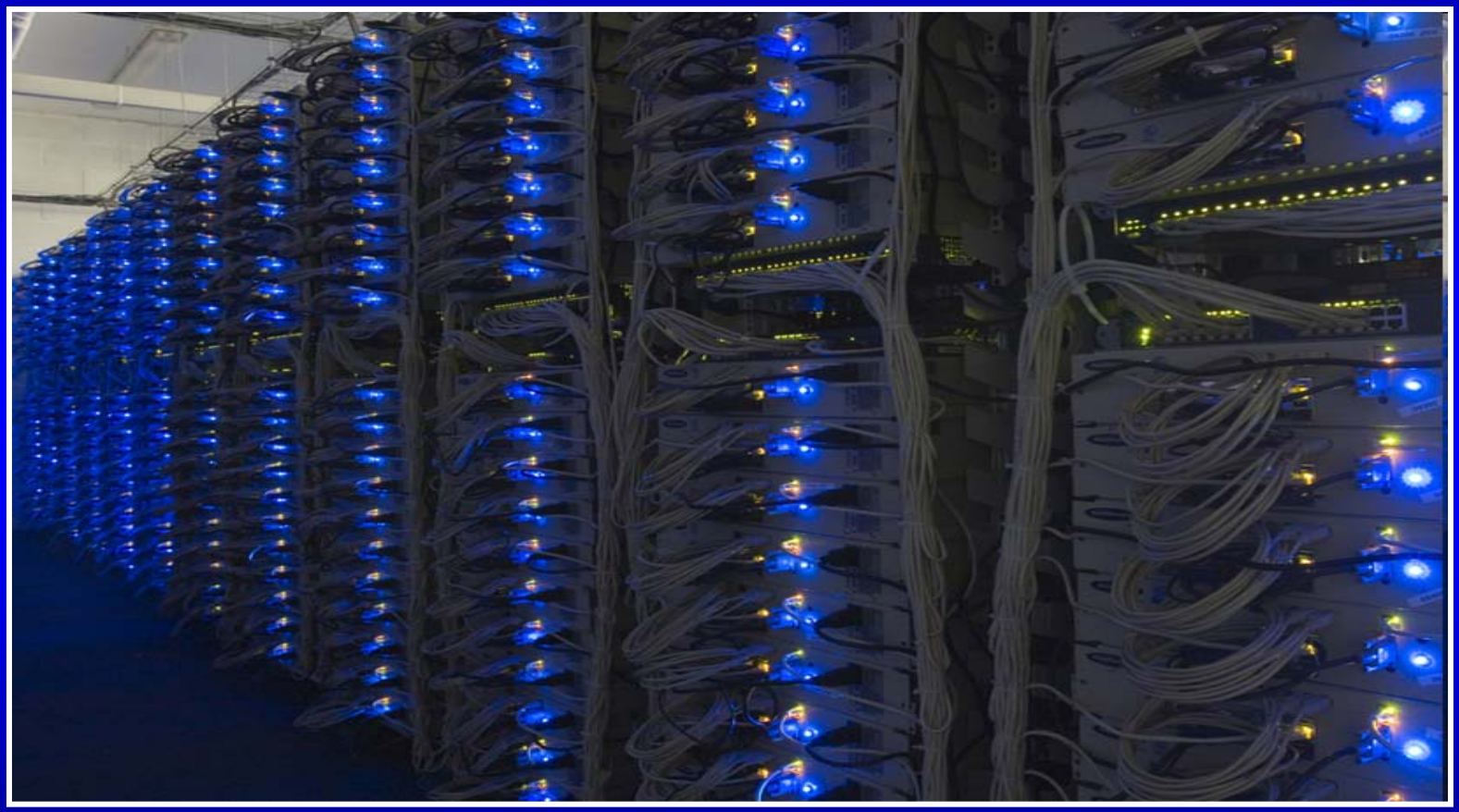
For WAV/XWAV files:

Display data as
- Time Series
- Spectra
- Spectrograms

Play audio
Decimate
Convert other formats
Calculate LTSAs
Link LTSA to raw data
Create log files of events
Automatic detectors



Cluster Processing



Summary

- Acoustic tools are revealing new insights into the lives of marine mammals
- Challenges to improve these devices:
  - Smaller tags with longer attachment times
  - Longer deployment autonomous recorders with higher frequency capabilities
  - New processing and detection algorithms for large acoustic data sets

Thank you

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