Poster prepared for:

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Marine Mammal Tracking On Navy Ranges (M3R)

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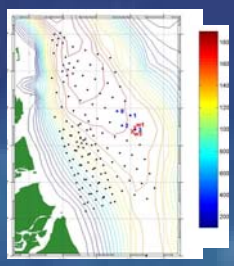
Goal: Provide Real-Time Detection, Tracking, and Classification Tools for Marine Mammal Monitoring

Applications: Mitigation, Behavioral Studies, Long-Term Abundance Estimates



Test Area: Atlantic Test and Evaluation Center Sensor Layout

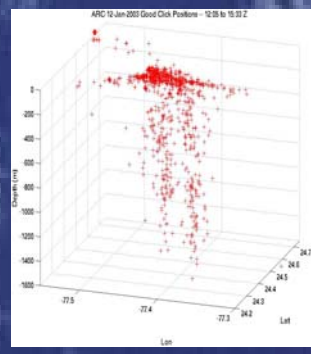
Signal Detection/Association Problem

-- Detect widely varying species calls on a minimum of 4 sensors

-- Accurately determine the times of arrival of the signal at the hydrophones
  -- Timing uncertainty of a millisecond leads to position uncertainty of meters

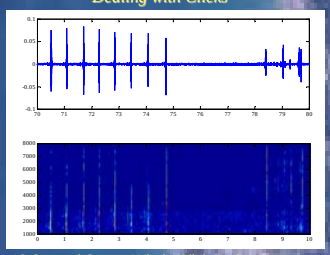
-- Detect multiple signal sources possibly on separate groups of sensors

-- Operate in real-time



3-D Sperm Whale Localizations
AUTEC 12 January, 2003

Whale Call Detection Part 1 Dealing with Clicks



10 Second Sperm Whale Click Train

Click Detection and Association

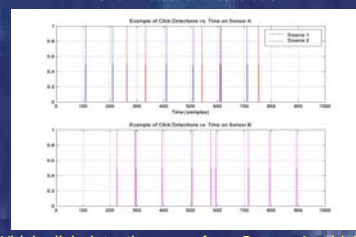
--Clicks are detected using a broadband energy detector

-- Is the detection received on phone A at time tA from the same source as the detection on phone B at time tB?

-- Click detections for each receiving hydrophone are represented by a binary time-domain signal

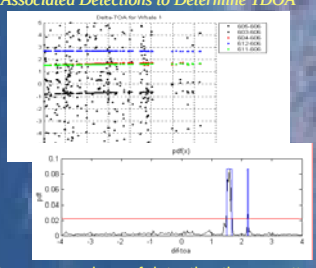
-- Master channel is selected and "scanning sieve" algorithm used to determine Time Difference Of Arrival (TDOA) by finding common click patterns on multiple sensors

Click Detection Association



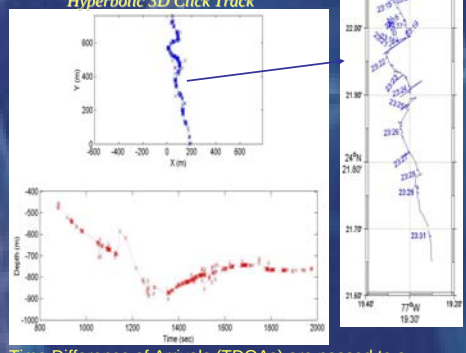
Which click detections are from Source 1, which are from Source 2 ? Look for click patterns by comparing a master phone to detections on surrounding phones.

Associated Detections to Determine TDOA



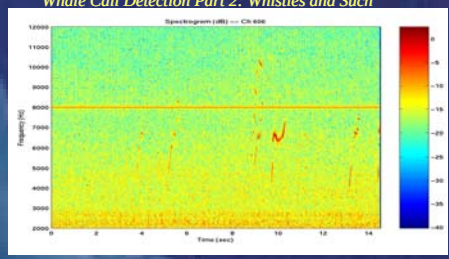
Upon comparison of detection times, patterns emerge. Only the 3 channels with the highest correlation with the 'master' channel are used for tracking. All black detections are ignored.

Hyperbolic 3D Click Track



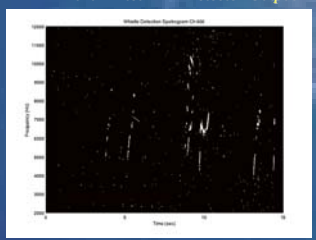
Time Difference of Arrivals (TDOAs) are passed to a hyperbolic tracking algorithm to localize the animal. A track of a single sperm whale in X,Y, & Z is given above.

Whale Call Detection Part 2: Whistles and Such



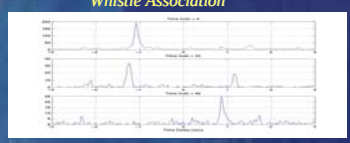
Spectrogram of short-finned pilot whale calls

Hardlimited FFT Detector Output

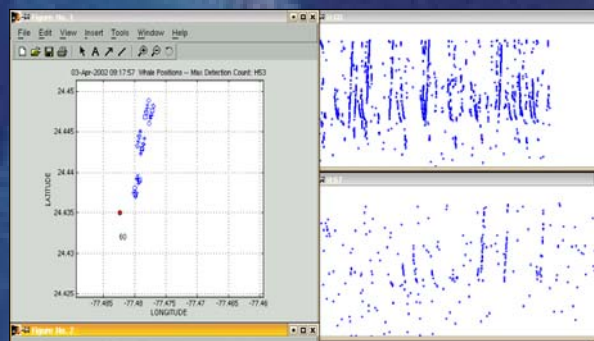


A hard-limited spectrogram of up to 6 hydrophones is cross correlated with the spectrogram of the array center hydrophone.

Whistle Association



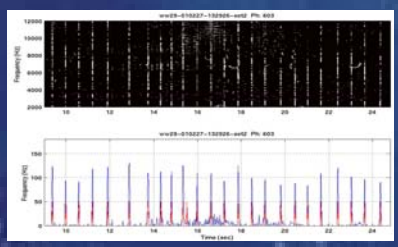
Spectrogram Cross Correlation peaks are used to extract TDOAs from hydrophone pairs for tracking

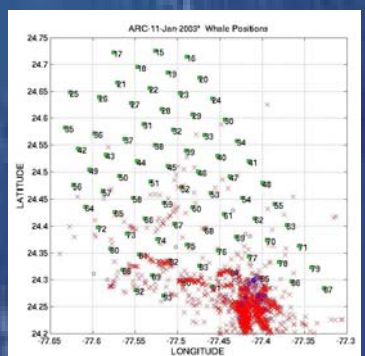


Real-time displays for whistle track of group of rough-toothed dolphins and melon-headed whales along with the hard-limited spectrograms from tool hydrophones

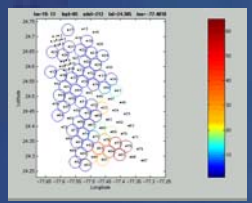
"Unified" Whale Detection Theory

Solution is to form click detections from detection spectra, then can use whistle methodology on the remaining spectra.





Combined whistle (blue) and click localizations at AUTEC January, 2003



Detector outputs can be used as a broad indicator of animal activity. Real-time activity monitor displays that present total detections per hydrophone and the statistics based on all hydrophones are given above.