Acoustic and Visual Detections of Odontocetes from Line Transect Surveys off Southern California

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Abstract

Detailed knowledge of cetacean population dynamics is needed to evaluate potential impacts from anthropogenic sound sources such as naval training operations. Ship-based acoustic and visual line-transect surveys were conducted in waters off Southern California to assess the distribution, density, and abundance of odontocetes, and to appraise the effectiveness of using passive acoustic survey methods to detect and classify species. On 12 California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises from 2006-2008, odontocetes were detected acoustically using a six-element hydrophone array with a bandwidth of 2-96 kHz towed at 9 knots and a depth of 15 meters. The hydrophone array was towed more than 180 days covering 13,800 kilometers yielding 302 acoustical detections including at least 8 *Delphinid* species (N=280) and *Physeteridae* (N=22). The most common acoustically detected species were *Delphinus spp.* (43%), *Lagenorhynchus obliquidens* (10%), *Physeter macrocephalus* (7%) and *Grampus griseus* (4%). Of 294 on-effort (array under tow, 2 observers, sea state ≤ 5) acoustic and/or visual detections, 69% were documented with both methods, 22% were acoustic only, and 9% were visual only. Analysis of group size, sea state and distance from ship indicated two of these variables were significantly different between the detection methods (Kruskal-Wallis, p<0.05). The proportion of visual sightings with associated acoustic detections varied as a function of species and ranged from 57% (*Lissodelphis borealis*) to 100% (*Tursiops truncatus*). Species-specific click structures were used to classify 6 groups of *L. obliquidens* and 12 groups of *P. macrocephalus* that were not detected through visual methods. Of 76 unclassified acoustic only detections, 85% contained whistles. Currently, call classification methods for whistling species have relatively high error rates; however, refinements in species discrimination algorithms as well as the incorporation of prior probabilities will increase the utility of acoustic methods, potentially expanding strip-width and precision for line-transect surveys.

CalCOFI Marine Mammal Project

- The California Current Ecosystem is a highly productive and dynamic marine environment that sustains over 20 cetacean species and supports human activities including fishing, shipping, military and industrial operations
- Cetacean distribution, density and abundance in southern California has traditionally been assessed on broad temporal and spatial scales
- CalCOFI surveys provide comparatively high seasonal and annual coverage and a broad range of oceanographic indices

Basis for the Current Research

- Detailed knowledge of odontocete distribution, density and abundance off Southern California is needed to assess potential impacts from natural/anthropogenic sources of disturbance
- Visual survey methods are limited by daylight/environmental conditions and may miss submerged or distant animals
- Passive acoustic surveys may serve as an effective alternative/compliment to traditional visual survey methods

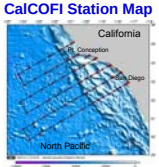
Objectives of the Research

- **Goal**
  - Develop passive acoustic survey methods to detect and classify odontocete calls to species.
- **Approach**
  - Identify species-specific call features; test, refine and apply the optimal call classification engines.
- **Future Application**
  - Perform ship-based acoustic censuses of odontocetes off Southern California.

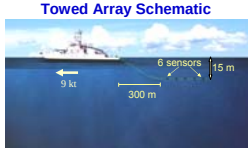
Field Methodology

- Odontocetes were visually identified and acoustically recorded on ship-based passing mode surveys utilizing two marine mammal observers and a six-element towed hydrophone array.

CalCOFI Station Map



Towed Array Schematic



Hydrophone Array: 6-elements with 2-96 kHz bandwidth encased in oil filled tube

Observer on "Big Eyes"

Visual Search: 7X Binos
Species ID: 25X Binos

Sighting Data/Detection Method

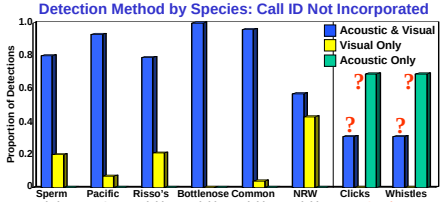
Variable	Acoustic Only	Visual & Acoustic	Visual Only
Sea State	3.2 *	2.6	2.8
Group Size	_	91 *	20
Distance	_	994 m	1367 m

Mean values for sea state, group size and distance from ship as function of detection method. * Significant difference (Kruskal-Wallis p<0.05)

On-Effort Odontocete Acoustic and Visual Detections

Field Year	Acoustic Only	Visual & Acoustic	Visual Only	Total Detections
2006	26	48	10	84
2007	10	79	10	99
2008	28	75	8	111
Total	64 (22%)	203 (69%)	28 (9%)	294 (100%)

Detection Method by Species: Call ID Not Incorporated

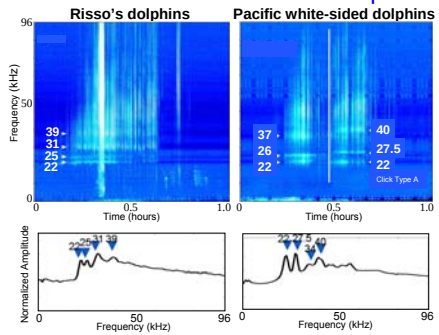


The proportion of species identifications with associated acoustic detections varied with species and ranged from 57% to 100%. Acoustic detections with no species ID were divided based on the primary call type: clicks or whistles.

Acoustical Analysis Methods

- Signal Processing
  - Detected, classified and measured odontocete clicks and whistles from time series and spectral representations.
- Call Analysis
  - Odontocete calls with no visual species identification were further examined for unique click and/or whistle structures.

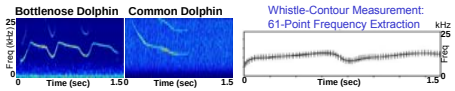
Echolocation Click Structure Comparison

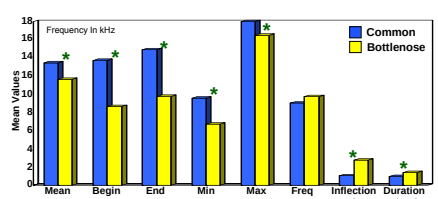


Species-specific click characteristics for two dolphin species off southern California.

Long term spectral averages and mean spectral plots of clicks indicated consistent and unique spectral peaks for Risso's and Pacific white-sided dolphins. Bottlenose and common dolphin clicks did not exhibit consistent spectral peaks within the 2-96 kHz frequency band.

Whistle Structure Comparison





Comparison of whistle variables measured from bottlenose and common dolphins.

Spectrogram measurements of whistles from bottlenose (n=154; 5 groups) and common dolphins (n=77; 20 groups) suggest species-specific differences. Common dolphin whistles had significantly higher mean values for all frequency measures except range while bottlenose dolphin whistles had significantly more inflection points and longer durations (*ANOVA p<0.01).

Linear Discriminant Analysis: Whistles

Actual ID	Predicted ID: Tt	Dd	chance
Tt	90%	10%	50%
Dd	30%	70%	50%

61-Point Frequency + Duration + IP

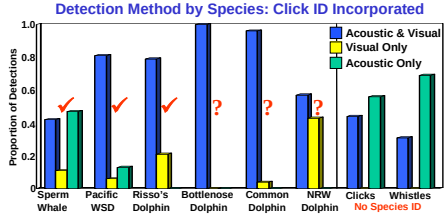
Actual ID	Predicted ID: Tt	Dd	chance
Tt	86%	14%	50%
Dd	31%	69%	50%

Eight Whistle Variables

Whistle classification matrix for bottlenose (Tt) and common dolphins (Dd) for the two optimal LDA models

Percent correct classification scores were all significantly above chance alone (X^2 test, p<0.05) and ranged from 86-90% for Tt and 68-70% for Dd. Training/Testing Ratio = 1:1

Detection Method by Species: Click ID Incorporated



Species-specific click structures were used to classify 6 groups of Pacific white-sided dolphins and 12 groups of sperm whales that were not visually identified. Dolphin whistle classification tasks will be integrated into future analyses.

Conclusions

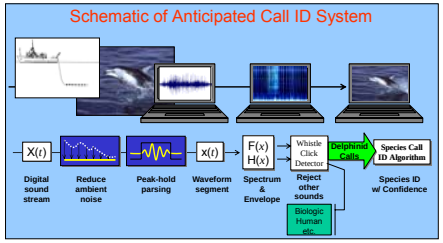
- Echolocation clicks can be used to differentiate between Pacific white-sided and Risso's dolphins.
- Whistles can be used to differentiate between bottlenose and common dolphins.
- Acoustic call classification improves the ability to identify odontocete species during ship-based surveys.

Species Call ID System

Acoustic ID of species-specific odontocete calls has several potentially important scientific applications:

- Expand rate and distance of odontocete detections.
- Increase precision for line-transect density and abundance estimates and expand knowledge of habitat use.

Schematic of Anticipated Call ID System



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