Building Delphinid Habitat Models with Passive Acoustic Monitoring Data

Outline

- Data Collection
- Model Challenges
  - True absence vs. false absence
  - Data sampling differences
  - Temporal scale of datasets
- Case Study
  - Pacific white-sided dolphins
- Discussion

Study Area

- Currents
  - California Current
  - Southern California Eddy
  - Southern California Countercurrent
- High Productivity
  - Coastal upwelling
  - Topography
  - Submesoscale eddies
- Human Activity
  - Shipping
  - Fisheries
  - Naval bases

Instrumentation

- High-frequency

HARP Data Analysis

- Identify click bout start and end times
- Classify to species
- Assign one-hour time bins as P / A
Absence = not vocalizing?

- True absence
- Animals not vocalizing
- HARP not sampling
- High ambient noise conditions mask sound
- Missed detection

Absence = not sampling?

- Calls are behavior dependent
  - Not necessarily vital function
  - May not be produced by all population members
  - May vary in temporal production
  - May vary in spatial production
  - e.g. whale song

- But these do not hold for dolphin echolocation

Dolphin Occurrence

- Presence
  - Animals present
  - Animals vocalizing
  - HARP sampling
  - Low ambient noise
  - Acoustic detection

- Absence
  - True absence
  - Animals not vocalizing
  - HARP not sampling
  - High ambient noise conditions mask sound
  - Missed detection

Absence = not vocalizing?

- Calls are behavior dependent
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Echolocation Variability

- Risso’s Dolphins
  - Southern California Bight, CA

Temporal

- Number of time intervals

Spatial

- Time of Day (GMT)

Assumptions

- Risso’s and Pacific white-sided dolphin click most when foraging
- Dolphins need to forage daily
- Quality foraging habitat can be represented by the amount of time echolocating dolphins spend in it
- Absences due to high noise or observer are not biased by habitat conditions

Absence = not sampling?

- Some periods sampled continuously
- Some periods on sampling schedule
- Problems:
  - How to compare between schedules?
  - What is missed?
Temporal Resolution: Autocorrelation & Matching datasets

- Dolphin sampling
  - Minimum of hours per day
  - Hours per week best
- Environmental sampling
  - Variable scales
    - Daily
    - Weekly
    - Monthly
    - Quarterly

Environmental Data

Summary of Data Included in Model

- Dependent variable
  - Hours per week with dolphin clicks present
  - Correction factors
    - HARP sampling schedule correction
    - Hours per week with recordings
- Independent variables
  - Satellite Telemetry (SST & Chl)
  - Upwelling Index
  - Temporal variables – Week and Lunar Phase index

Satellite Telemetry Data

Pros
- Readily available to management
- Appropriate temporal scale
- Weekly scale ideal for coverage and autocorrelation

Cons
- No depth information
- Cannot sample zooplankton
- Cannot sample nekton
Can environmental conditions be used to predict dolphin click bout occurrence?

**Generalized Additive Model (GAM)**

\[ g(\mu) = \alpha + \sum f_i(x_i) \]

- Intercept
- \( f_1(\text{SST}) + f_2(\text{SST CV}) \)
- \( f_3(\text{Chl}) + f_4(\text{Chl CV}) \)
- Region \(* f_5(\text{Week}) \)
- \( f_6(\text{Lunar Phase}) \)
- \( f_7(\text{Upwelling}) \)

**Model Selection**

- **Predictor Terms**
  - Forward-backward stepwise algorithm
  - Akaike's Information Criterion (AIC)
- **Cross-validation & Predictions**
  - Pseudo-jackknife method
  - 80 % training data
  - 20 % test data
  - 5 models total
  - Average Squared Prediction Error (ASPE)

**Case Study: Pacific White-sided Dolphins**

- **Distribution**
  - Cool temperate waters
  - Baja California to Alaska
- **Prey types**
  - Squid
  - Mesopelagic fish
  - Epipelagic schooling fish
- **Population structure**
  - Two populations in SCB
    - Baja California
    - CA / OR / WA

**Cross-validation Model Comparison**

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<th>ASPE</th>
<th>Upwelling</th>
<th>Moon Phase</th>
<th>Chl</th>
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- % Models including term:
  - 0 | 0 | 20 | 80 | 100 | 100

**Pacific white-sided dolphins Type B Model Fits**

- **Habitat characteristics**
  - Homogenous 18°C waters
  - Upwelling
  - Fall-winter season

**Observed Data and Model Predictions**

82 % Explained deviance
Case Study Conclusions

- Fall-winter season, increased upwelling, and homogenous 18°C waters
- Large confidence intervals at high SST and SST-CV
- High explained deviance compared to visual studies

Modeling Summary

- Modeling hours per week with calls provides quantitative measure of habitat importance
- Calculating detection probability effective for handling variability in sampling schedule
- Ensure appropriate temporal resolution for all model variables and consider autocorrelation

Issues

- Clicks are also used in communication and navigation
- Models represent time spent in habitat, but do not indicate number of animals
- Dolphins may produce additional unknown/unidentified click types
- Mechanisms – Prey availability? Predator avoidance? Competitive interactions?

Future work

- Click production and behavior comparison
- Quantify animals based on calls
- Develop models with in-situ data for comparison
- Include measure of prey abundance
- Include competing species and predators
- Expand spatial coverage

Acknowledgements

SIO Whale Acoustics Lab
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Questions?
Time Series Comparison
Pacific white-sided occurrence, SST and Chl
Santa Catalina Island, CA