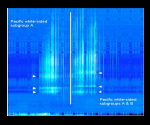
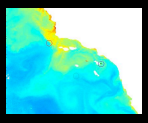
Building Delphinid Habitat Models with Passive Acoustic Monitoring Data

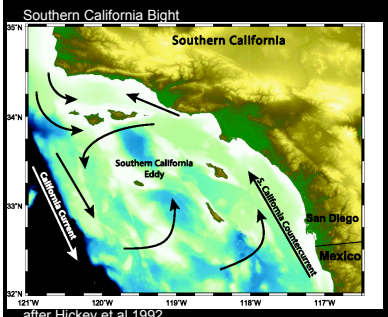




Melissa S. Soldevilla[1], Erin M. Oleson[1], Megan Ferguson[2], Sean M. Wiggins[1], John A. Hildebrand[1]

Outline

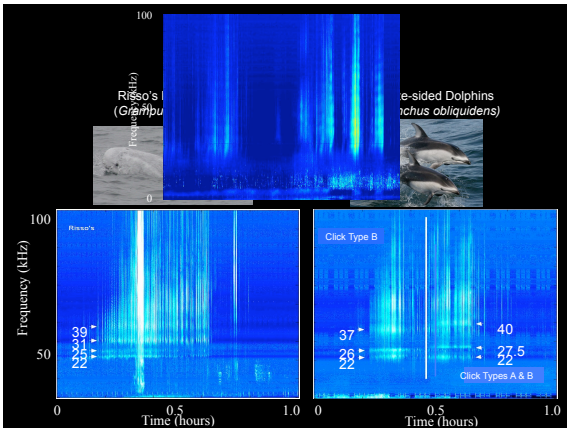
- Data Collection
- Model Challenges
  - True absence vs. false absence
  - Data sampling differences
  - Temporal scale of datasets
- Case Study
  - Pacific white-sided dolphins
- Discussion

Study Area



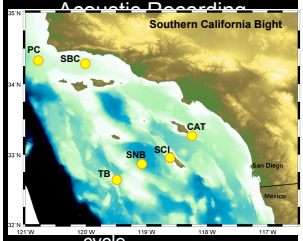
after Hickey et al 1992

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

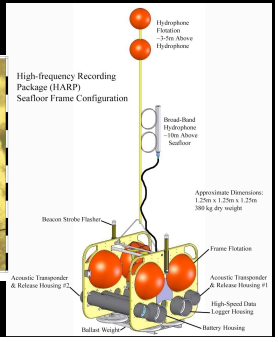


Instrumentation

- High-frequency

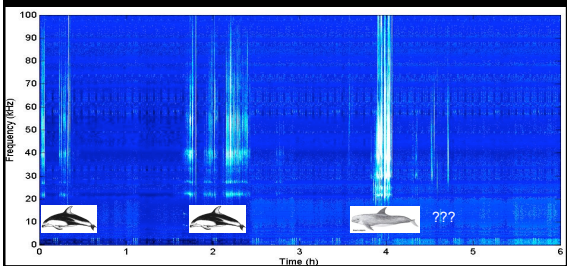


cycle



HARP Data Analysis

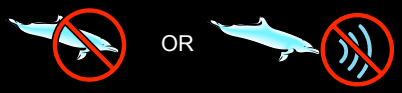
- Identify click bout start and end times
- Classify to species
- Assign one-hour time bins as P / A



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
  - 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

Echolocation Variability

Spinner Dolphins
Kaneohe Bay, HI

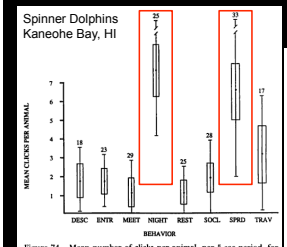


Figure 74. Mean number of clicks per animal, per 5-sec period, for different classes of behavior.

Norris, K. S., Wursig, B., Wells, R. S., and Wursig, M. **(1994).** *The Hawaiian Spinner Dolphin.* University of California Press, Berkeley.

Bottlenose Dolphins
Sarasota Bay, FL

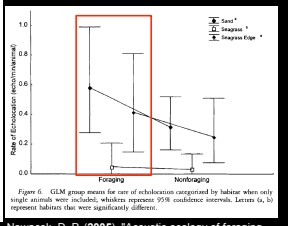


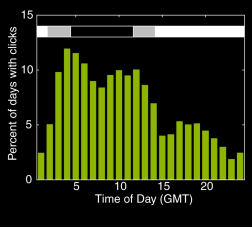
Figure 6. GLM group means for rate of echolocation categorized by habitat when only single animals were included; whiskers represent 95% confidence intervals. Letters (a, b) represent habitats that were significantly different.

Nowacek, D. P. (**2005**). "Acoustic ecology of foraging bottlenose dolphins (*Tursiops truncatus*), habitat-specific use of three sound types," Mar Mammal Sci **21**, 587-602.

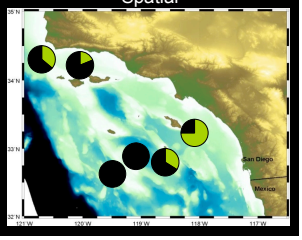
Echolocation Variability

Risso's Dolphins
Southern California Bight, CA

Temporal



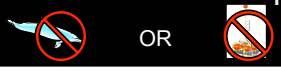
Spatial



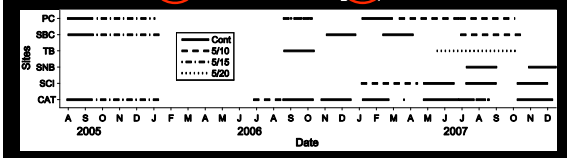
Assumptions

- 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?



OR

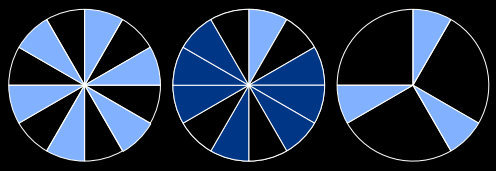


- Some periods sampled continuously
- Some periods on sampling schedule
- Problems:
  - How to compare between schedules ?
  - What is missed ?

Sampling Schedule Detection Probability

Subsample all data to same sampling schedule

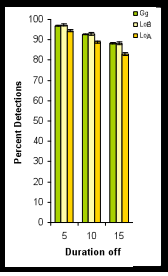
5 / 10 5 / 15 5 / 20



Sampling Schedule Detection Probability

Subsample continuous data at each sampling schedule

- Calculate probability of detection
- Calculate correction factor for sampling schedules



Detection probability

Duration (min)	Risso's	PWS A	PWS B
5	0.97	0.95	0.97
10	0.93	0.89	0.93
15	0.88	0.83	0.88

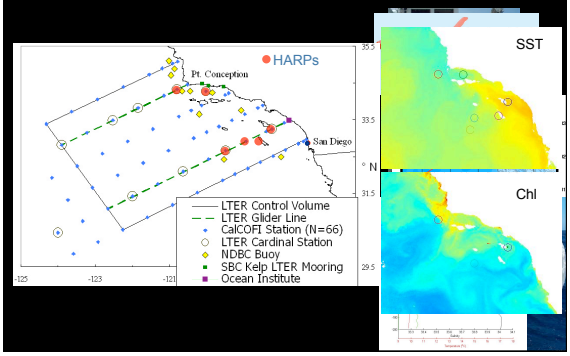
Correction factor

5	1.03	1.06	1.03
10	1.08	1.13	1.08
15	1.13	1.21	1.13

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



Satellite Telemtry 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

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

Can environmental conditions be used to predict dolphin click bout occurrence?

Generalized Additive Model (GAM)

$$g(\mu) = \alpha + \sum_{i=1}^{n} f_i(x_i)$$

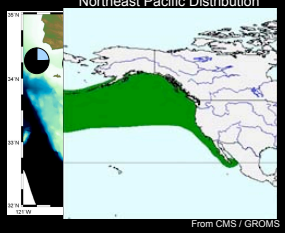
Log (Hours / week with click bouts present) + Offset variables = Intercept + f_1(SST) + f_2 (SST CV) + f_3 (Chl) + f_4 (Chl CV) + Region* f_5(Week) + f_6(Lunar Phase) + f_7(Upwelling)

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



Northeast Pacific Distribution

From CMS / GROMS

Prey types
- Squid
- Mesopelagic fish
- Epipelagic schooling fish

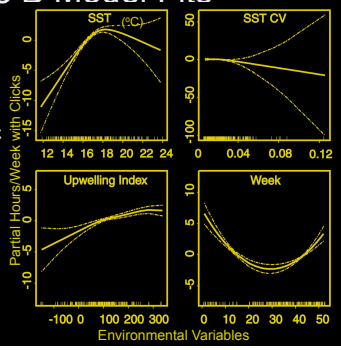
Population structure
- Two populations in SCB
  - Baja California
  - CA / OR / WA

Cross-validation Model Comparison

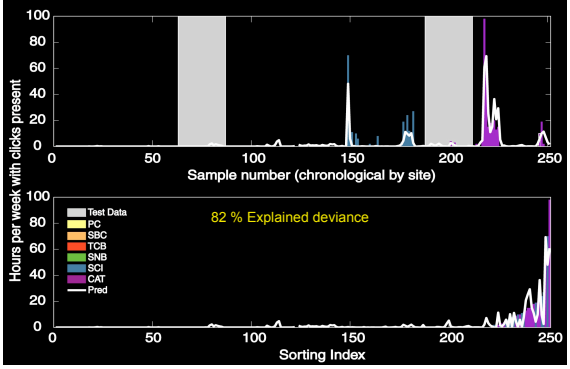
	AIC	ASPE	Upwelling	Moon Phase	Chl residual	Chl CV	SST mean	SST CV	Week
Model 1	367.09	500.31	s3	-	-	-	-	s3	p2
Model 2	**563.13**	**5.39**	**s3**	**-**	**-**	**-**	**s3**	**s3**	**p2**
Model 3	695.75	5.65	s3	s2	-	-	s3	s3	p2
Model 4	529.54	111.00	-	L	L	-	L	s3	L
Model 5	507.25	30.57	-	L	s3	-	L	s3	p2
% Models including term			60	60	40	0	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



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

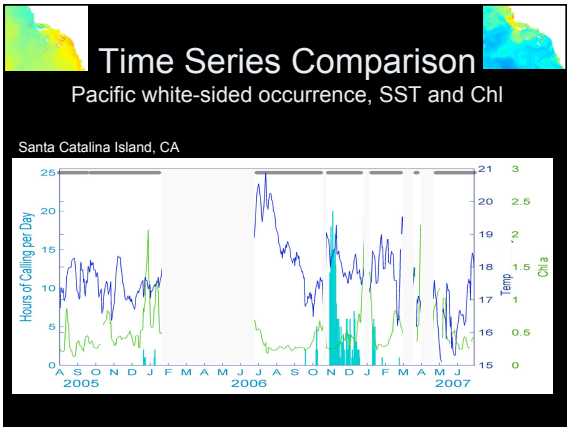
- Modeling hours per week with calls provides quantitative measure of habitat importance
- Calculating detection probability effective for handling variability in sampling schedule
- Ensure appropriate temporal resolution for all model variables and consider autocorrelation

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


Time Series Comparison
Pacific white-sided occurrence, SST and Chl
Santa Catalina Island, CA
Hours of Calling per Day
Temp
Chl a
A S O N D J F M A M J J A S O N D J F M A M J
2005
2006
2007