Analysis and interpretation of acoustic array data: estimating horizontal movement

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Equipment for acoustic data collection

*Photo credit: Vemco.*
Example: Palmyra rubble pile array
Acoustic array data

Tag ID: 46894, # data: 32173
Sources of transmission error

- Time of day.
- Water movement (swells, currents).
- Water column stratification (thermocline etc.).
- Time since deployment (biofouling).
- Bottom topography (signal blocking).
Horizontal movements

Current approaches

- Kernel estimation.
- Local polynomial regression.

**Advantages**: Quick way to get an overview of data.

**Drawbacks**: No biological interpretation, no account for errors or uncertainties in data.
State-space model (SSM)

A model with two components:

- Process model (describing movement).
- Observation model (describing data collection).

Appealing model because it describes the mechanisms underlying the data.

Movement model

Simple random walk

\[ x_t = x_{t-1} + e_t, \quad e_t \sim N(0, 2Dt). \]

The parameter \( D \) is related to the movement rate of the fish.

Simulated RW

Espinoza et al. 2011
Observation model

What do we observe and how does it relate to location?
Observation model

What do we observe and how does it relate to location?

\[ P = f(d) \]
Likelihood of location given detection.

\[ L \propto f(d) \]
Ping rate is known from manufacturer.

\[ L \propto 1 - f(d) \]
Noise conditions

Use reference tag detection efficiency, $z_t$, as a proxy for noise conditions.

$$L_t \propto f(d, z_t)$$
Simulation study

Scenario 1 - constant noise conditions
▶ Check consistency of parameter estimates.
▶ Compare state-space model performance with other approaches.

Scenario 2 - varying noise conditions
▶ Compare results with and without using reference tag information.
Comparing SSM with other approaches
Covariate information from reference tag
Movement estimation (500 m btw receivers)

- True
- SSM no cov.
- SSM w cov. (dashed is 95% CI)

![Graph showing movement estimation results with time in hours on the x-axis and distance in meters on the y-axis. The graph compares true values with SSM without covariates and SSM with covariates (dashed line represents 95% confidence interval).]
Movement estimation (500 m btw receivers)

- Green: True
- Black: SSM no cov.
- Red: SSM w cov. (dashed is 95% CI)
Future work

- Apply to real data.
- Develop guidelines for acoustic array design.
- Applications to other types of presence/absence data.
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Thank you for listening!