Apr 5th, 2:30 PM - 2:45 PM

Big Sharks in the Salish Sea: combining passive acoustics with the Salish Sea model to predict Sixgill Shark (Hexanchus griseus) presence

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Deep Data

Modeling Sixgill Shark (*Hexanchus griseus*) Movements

Alli N. Cramer
Dr. Steve Katz, Kelly Andrews, Dr. Daniel H. Thornton

@AlliNCramer  #SalishSeaSharks
For ecology, movement is important

- Animal movements impact connectivity
  - Within populations
  - Between communities

- Predator movements alter ecosystem structure

- Knowing where animals are likely to be helps develop effective management
The Technical Problem...

- What we want: estimates of probabilities for animal locations in time and space

- What we get: each technology has unique impact on the data used for those estimates.

How do we get from here to there?
How do we get from here to there?

Data Properties

GPS TRACKING

- Individual determinant
- Continuous in time and space

WILDLIFE CAMERAS

- Individual indeterminate
- Discontinuous in time and space

How do we get from here to there?

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BIG Sharks ... in Puget Sound

- Sixgill Sharks, *Hexanchus griseus*
- 600 lb sharks in downtown Seattle
- DEEP sharks
  - live in pure darkness where (most) humans never go
- Location Data
  - Northwest Fisheries Science Center, NOAA
- Environmental Data
  - Salish Sea Model
    - Pacific Northwest National Laboratory (PNNL) &
      Washington State Department of Ecology

Photo credit: NOAA Ocean Explorer 2016 https://www.flickr.com/photos/27077560@N05/26688971116/. Modified through cropping by Alli Cramer.
Why is Puget Sound interesting?

Fish Questions:

- Potential nursery for these fish
- Exploiting food resources (dogfish)
- Highly mobile species?

Puget Sound is a diverse & variable place
Questions of interest:

• How does environmental variability correlate with the presence or absence of the shark?

• Can we predict where the shark is likely to be?
Location Data
Location Data

Aerial View

300-800m

Side View
Environmental Data

- Temperature (°C)
- Salinity (ppt)
- Dissolved O₂ (DO)

Salish Sea Model
FVCOM model

Figure 1. An example of fitting a structured grid (left) and an unstructured grid (right) to a simple coastal embayment. The true coastline is shown in black, the model coastline in red. Note how the unstructured triangular grid can be adjusted so that the model coastline follows the true coastline, while the unstructured grid coastline is jagged -- which can result in unrealistic flow disturbance close to the coast. 
Values at sample nodes

- **Temperature (°C)**
- **Salinity**
- **Dissolved Oxygen (mg/l)**
At this location, what does the fish chose?

- **Approach**: Logistic regression with pseudo-absences data

- **Presence observations**
  - 2006
  - 13 sharks
  - 45 receivers – 39 within 800 m of a model node
  - 92,113 observations

- **Absence observations**
  - “Absences” inferred from background data
  - Absences from observation locations, but at random depths and times

- **Environmental data** – Salish Sea Model
At this location, what does the fish chose?

Whale Sightings
Channel Islands National Marine Sanctuary

Probability of Presence
Logistic Regression

Water Temperature °C

Present
Absent

Presence
At this location, what does the fish chose?
At this location, what does the fish chose?
All sharks model

All predictors p < 0.5

Present

Absent

Probability of Presence

Depth (m)  
0  50  100  150  200  250

Temperature °C  
6  8  10  12  14

Salinity ppt  
5  10  15  20  25  30  35

Dissolved Oxygen (mg/l)  
4  6  8  10  12
Take away from all these figures

- Making maps is possible!

- Sharks respond strongly to salinity

- Puget Sound is an estuary
  - water conditions are complicated
Take away from all these figures

- Making maps is possible!
- Sharks respond strongly to salinity
- Puget Sound is an estuary
  - water conditions are complicated

P value < 0.001
Future steps

• Add more years of environmental data
  • Working with PNNL and the Washington Department of Ecology to evaluate more years

• Look at Sex and Size

• Forecast locations based on environmental conditions
  • Develop suitability space for sharks
Acknowledgements

Dr. Steve Katz, Washington State University
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Center for Institutional Research Computing at Washington State University
Stephanie Labou, CEREO Washington State University
Michael Frederick Meyer, Washington State University
Dr. Steve Powers, CEREO Washington State University
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Check out the R Working Group!
@CougRstats
ceryo.wsu.edu/r-working-group
Key References

How to study shark movements?

Best option for deep, long term studies
Figure 1. An example of fitting a structured grid (left) and an unstructured grid (right) to a simple coastal embayment. The true coastline is shown in black, the model coastline in red. Note how the unstructured triangular grid can be adjusted so that the model coastline follows the true coastline, while the unstructured grid coastline is jagged -- which can result in unrealistic flow disturbance close to the coast.

Pairing FVCOM model with Telemetry Data
Pairing FVCOM model with Telemetry Data

- Single Environmental data point
- Three Environmental data points
Values at sample nodes

Temperature (°C)

Salinity

Dissolved Oxygen (mg/l)
More detailed info about sharks
Do decisions change in space?

- Are there different behaviors at different places?
  - Two receivers, each modeled separately
  - Midwater receivers located in basins of the sound
  - Pseudo-absences only from that receiver
All predictors p<0.5
AUC for individual Receivers
Salish Sea Model predicted vs observed model concentrations

* and estimates of model bias and RMSE.