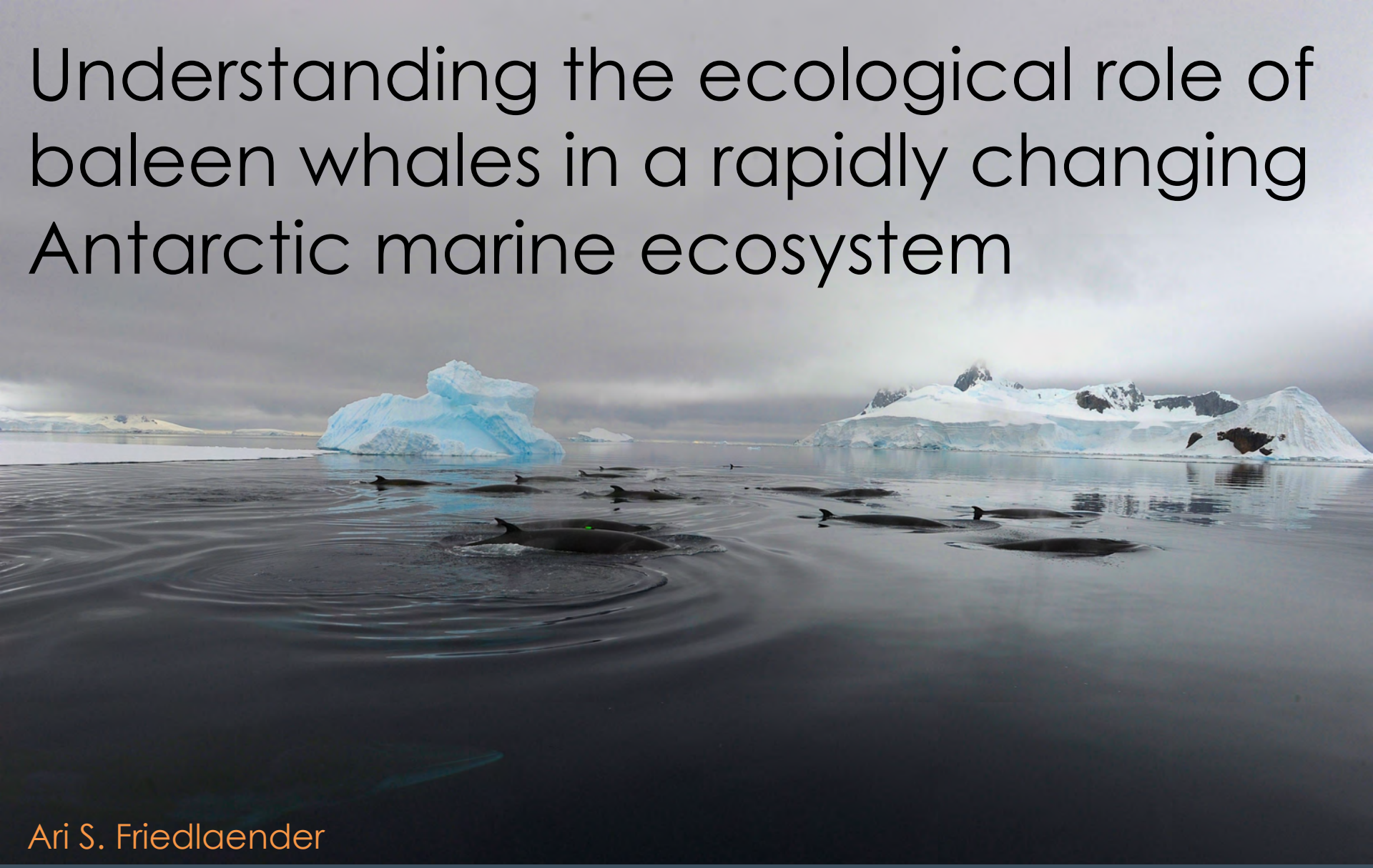
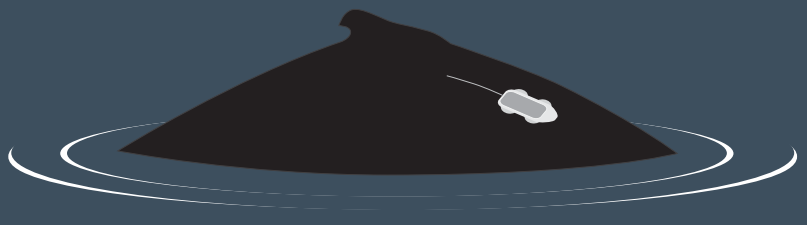
Understanding the ecological role of baleen whales in a rapidly changing Antarctic marine ecosystem



Ari S. Friedlaender



FRIEDLAENDER LAB

BIOTELEMETRY AND BEHAVIORAL ECOLOGY

Connecticut Yankee

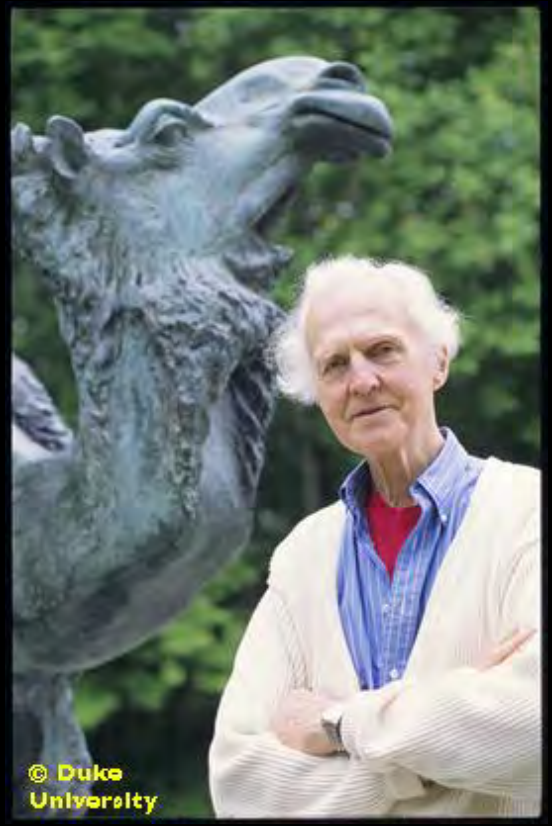
Yankee Whaling

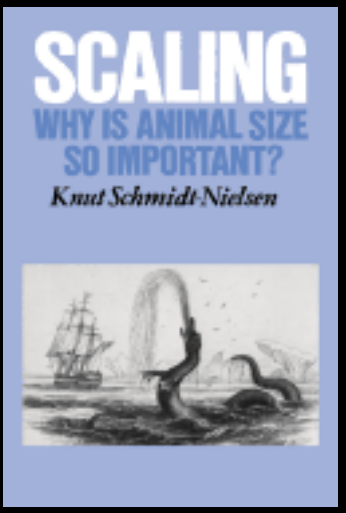
Nathaniel B. Palmer

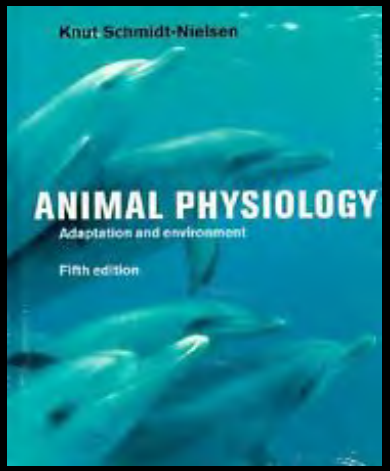
Yale Whale

Know where you come from

- Ann Pabst (UNCW) → Knut Schmidt Nielsen Functional Morphology, Anatomy & Physiology





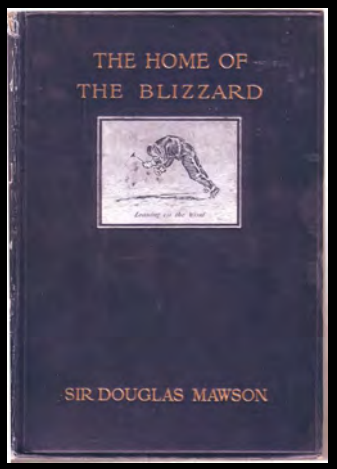


Know where you come from

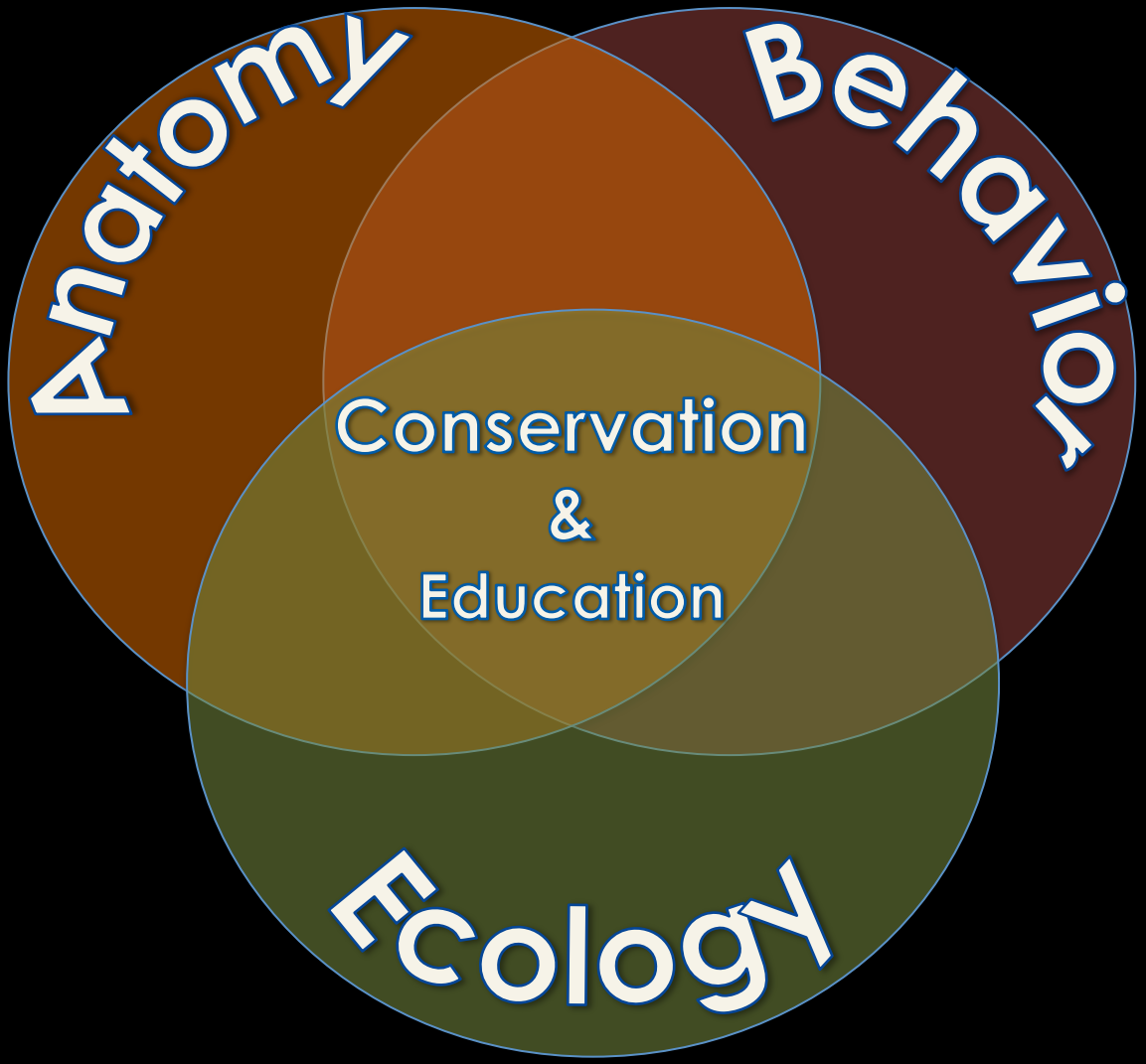
- Andy Read (Duke) → David Gaskin: Behavioral Ecology

Know where you come from

- Brian Skinner (Yale) → Douglas Mawson: Antarctic Explorer, & Geology



Philosophy



Ecological Foundation

- Cetaceans are the largest animals to have ever lived
- Morphological, physiological, and behavioral adaptations for bulk feeding
- Decisions
  - How does the distribution and behavior of prey affect cetacean foraging ecology
- Environment
  - How does the physical and biological landscape affect cetacean behavioral ecology

My Ecological Mantra

- Telemetry is an incredible tool to measure and understand cetacean ecology
    - fine and broad spatio-temporal scales

- Understanding cetacean ecology requires an understanding of their environment
    - inter-disciplinary collaboration is essential

- Analytical and visualization tools can provide context and convey information
    - Scientific community, curriculum for classes, public outreach and education

Art Meets Science

Science Meets Art:
Observation & Interpretation

'Once a painting is visually inventoried in as much detail as an analytical approach is introduced, using visual cues to draw conclusions and interpretations about the painting's content… the conclusions depend upon keen and thorough observation of fact, in an open-minded and unbiased manner, until the inventory is complete and the process changes from one of assemblage to interpretation'

Friedlaender & Friedlaender 2013

Objectives

- Quantify the movement patterns and behavioral ecology of baleen whales
- Relate foraging behavior to dynamic environmental features
- Understand population growth and health
- Evaluate the effects of disturbance (e.g. climate migration) on baleen whales
- Use knowledge to promote education and enhance conservation/policy measures

Quantitative whale movement ecology

Understanding movement causes and consequences for species distribution and behavior

Multi-Sensor Tags

- non-invasive
- suction cups
- up to 48 hours
- time, depth, temperature
- 3-axis accelerometers, magnetometers, gyros
- sensors sample up to 400 Hz
- audio to 242 kHz
- 2k Video
- VHF
- GPS

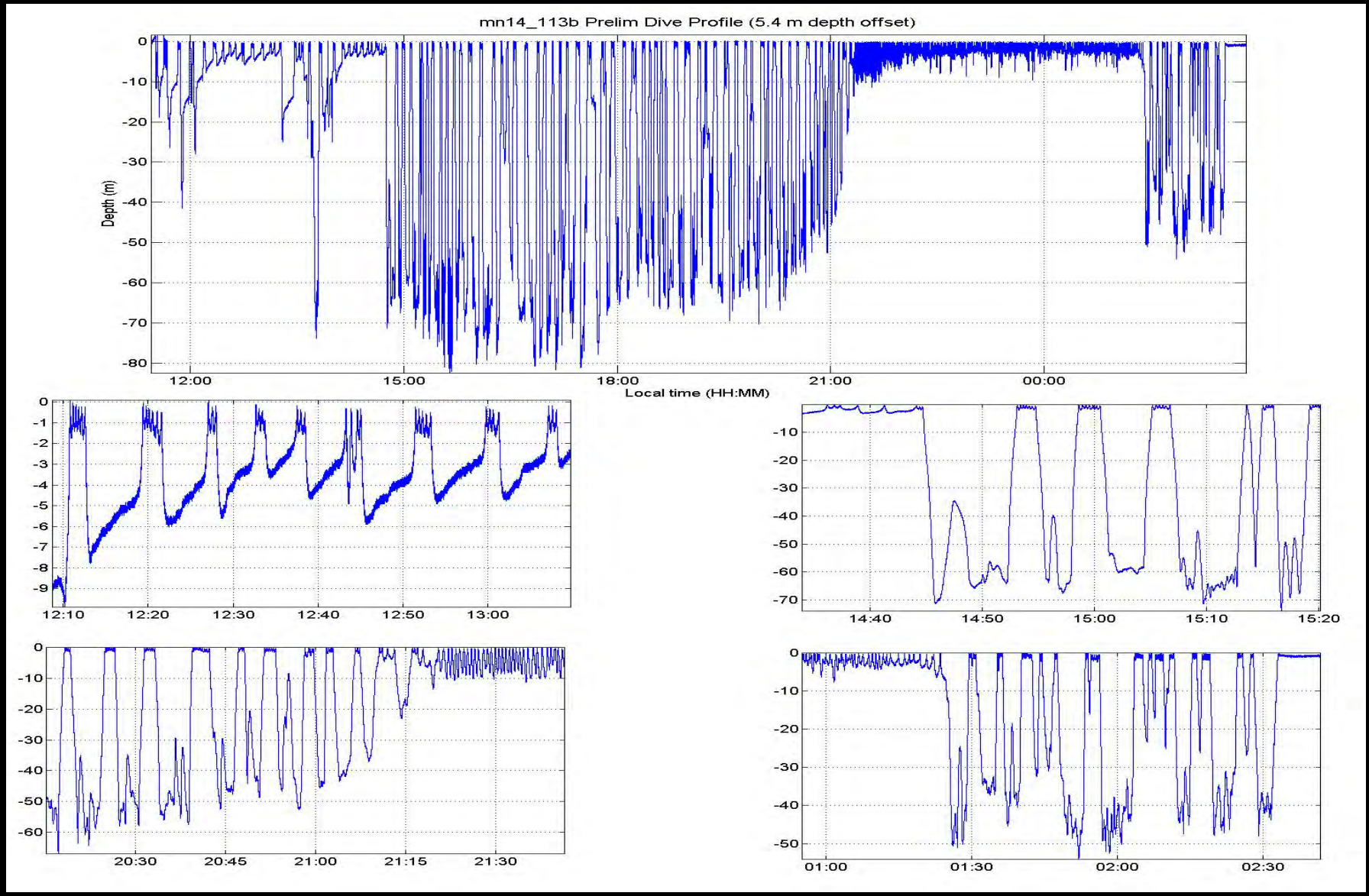
Humpback Whales

Foraging

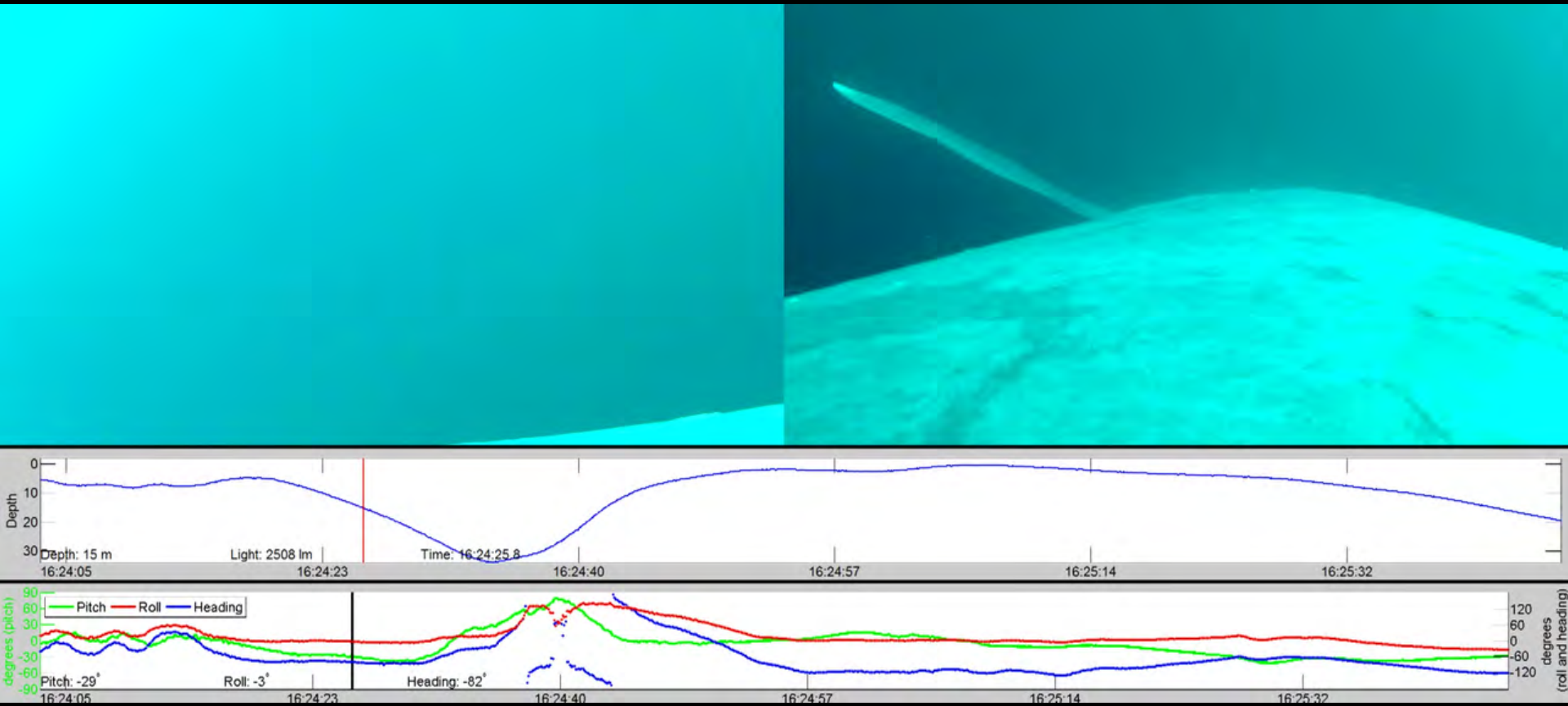
- Predator foraging strategies depend on:
  - Physical constraints
  - Prey behavior
- Behavior leading to prey capture vary
  - Timing, duration, constitution
- Plasticity in appetitive behaviors
  - Leads to higher predation rates
- Example…

http://animals.nationalgeographic.com/animals/fish/pufferfish.html

Tag Data

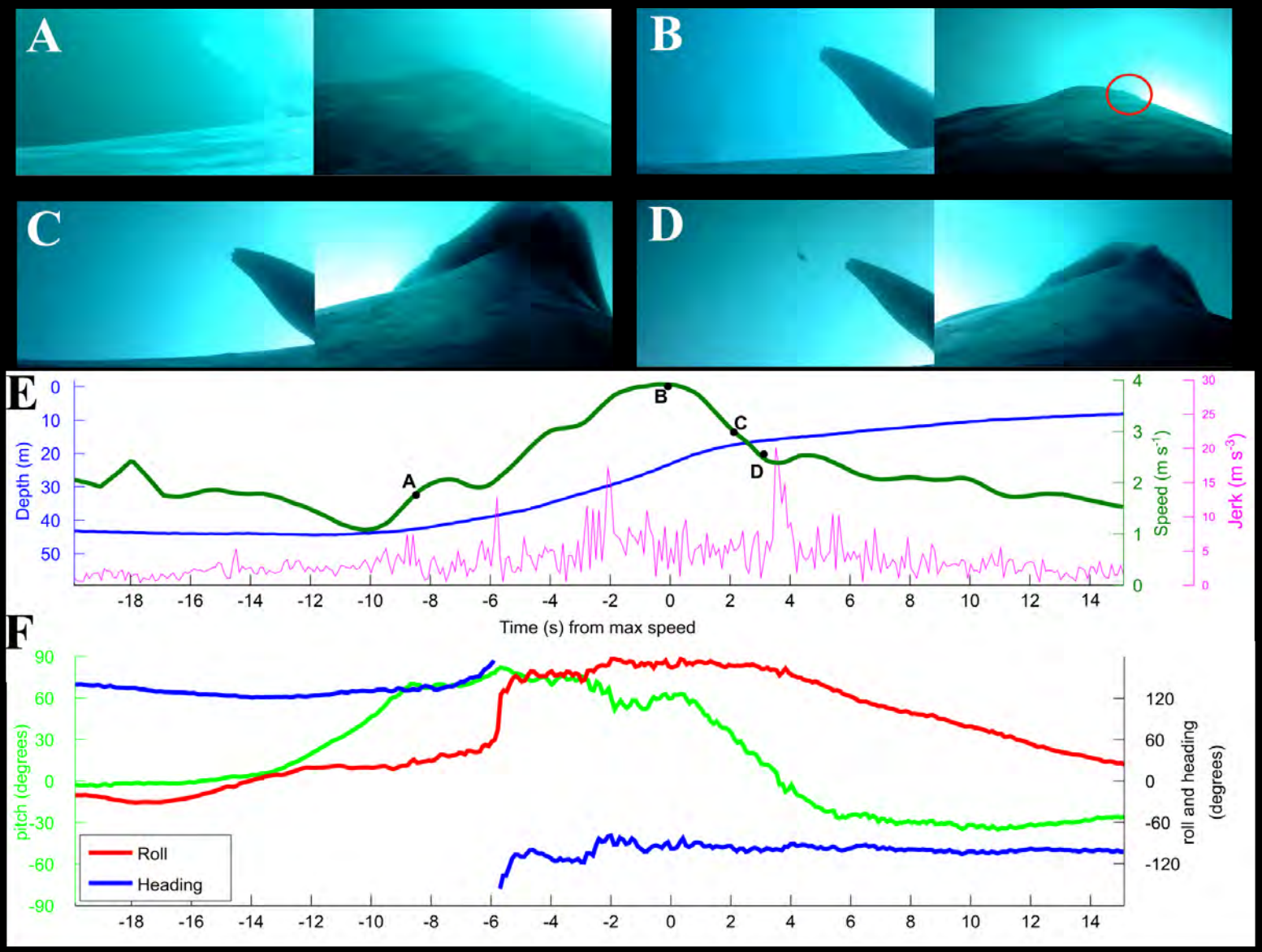

mn14_113b Prelim Dive Profile (5.4 m depth offset)
Depth (m)
Local time (HH:MM)
0
-10
-20
-30
-40
-50
-60
-70
-80
12:00
15:00
18:00
21:00
00:00
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
12:10
12:20
12:30
12:40
12:50
13:00
-10
-20
-30
-40
-50
-60
-70
14:40
14:50
15:00
15:10
15:20
0
-10
-20
-30
-40
-50
-60
20:30
20:45
21:00
21:15
21:30
0
-10
-20
-30
-40
-50
01:00
01:30
02:00
02:30

Combining video & movement data to study maneuverability and prey type



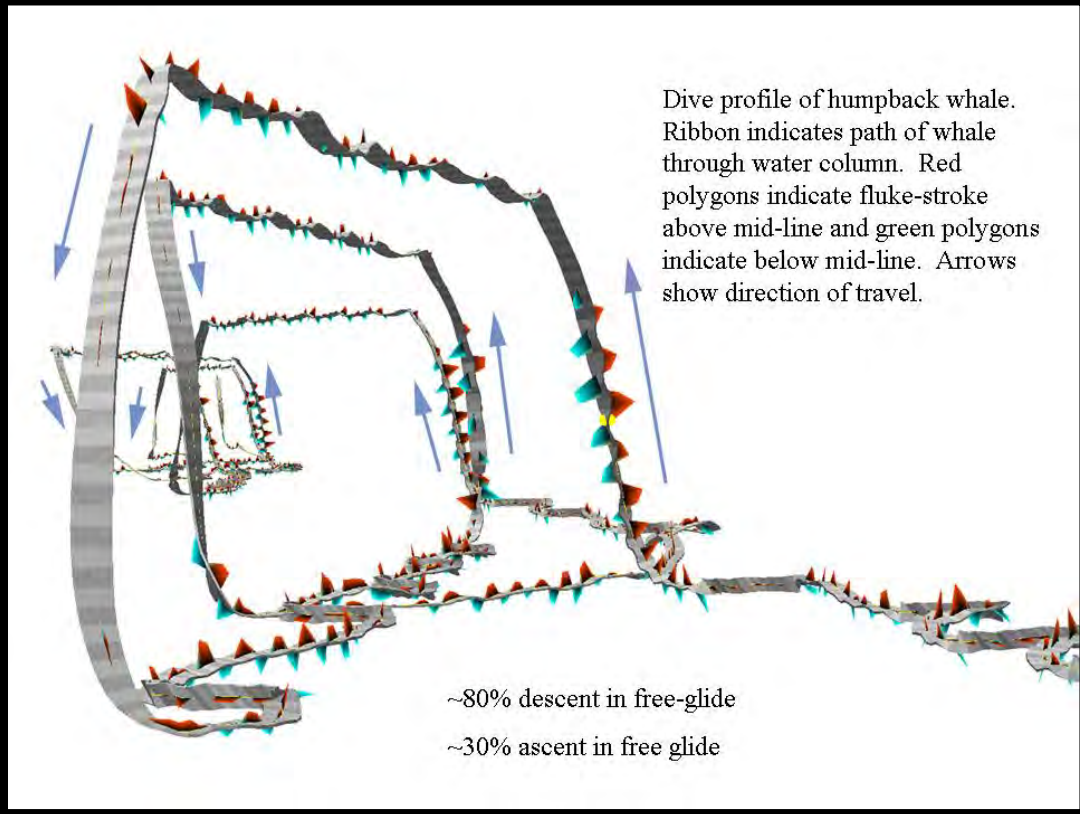
Depth, Pitch, Roll, Heading

Goldbogen et al. 2013, Friedlaender et al. 2016, Cade et al. 2016


A
B
C
D
E
Depth (m)
0
10
20
30
40
50
A
B
C
D
Speed (m s-1)
Jerk (m s-3)
-18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14
Time (s) from max speed
F
pitch (degrees)
90
60
30
0
-30
-60
-90
Roll
Heading
roll and heading (degrees)
120
60
0
-60
-120

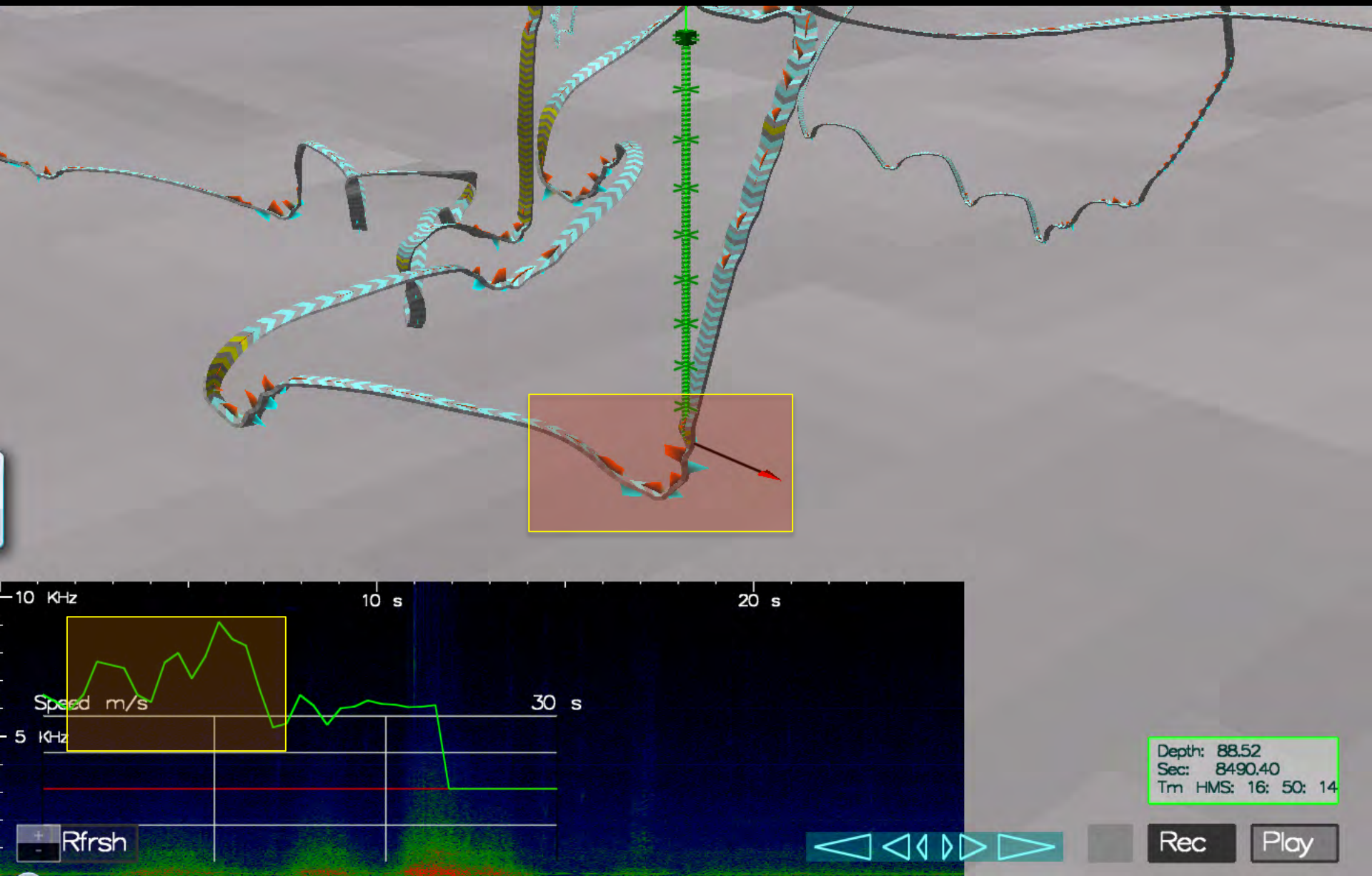
Whale Tag Analysis

- Trackplot (Ware et al. 2006)
  - Visualize underwater movement patterns
- Behavioral Sequencing
  - Link observed and tag behaviors
- Ribbons indicate the orientation of the whale
- Red and blue teeth are fluke strokes



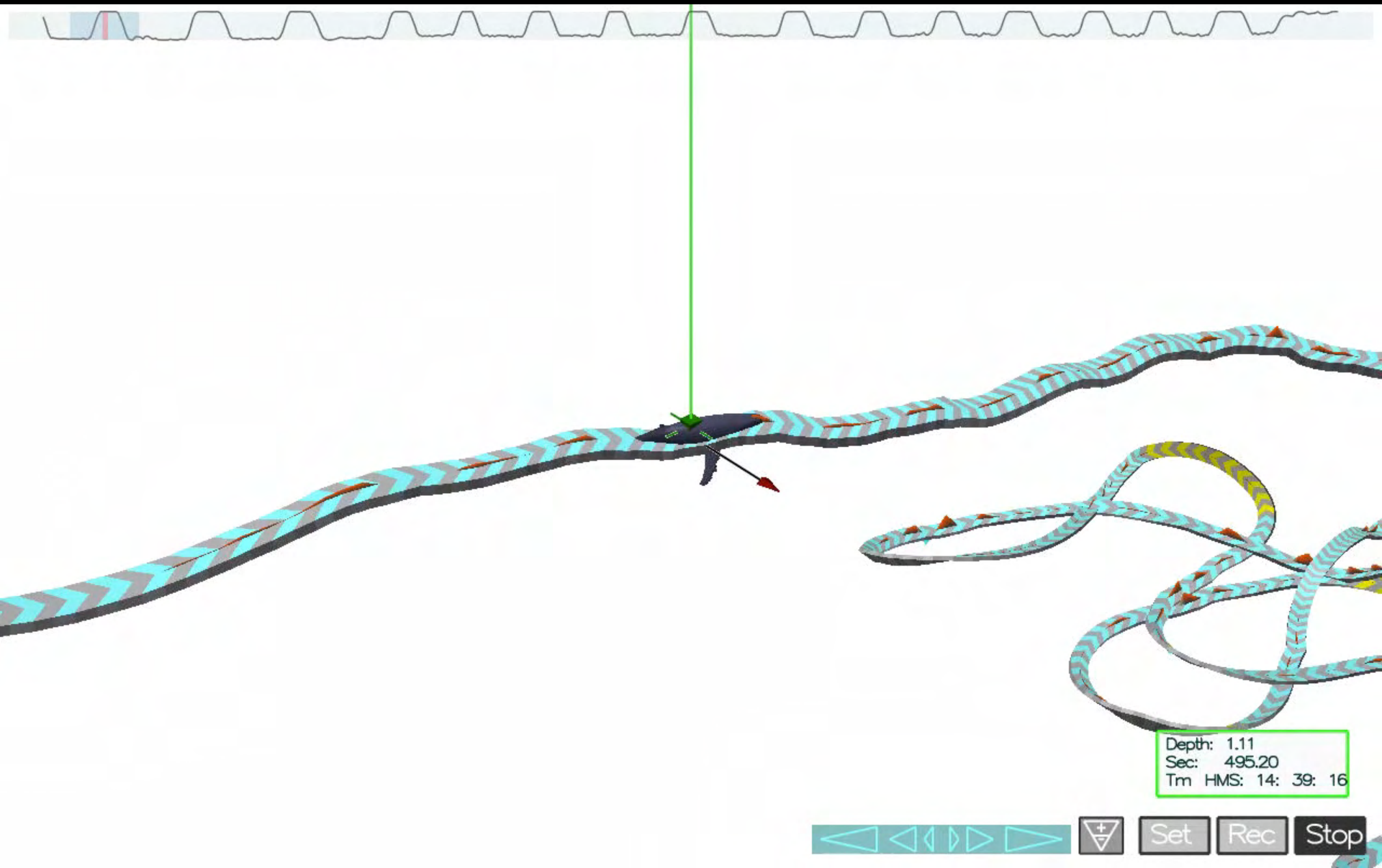
Ware et al. 2010

Using sound to find feeding

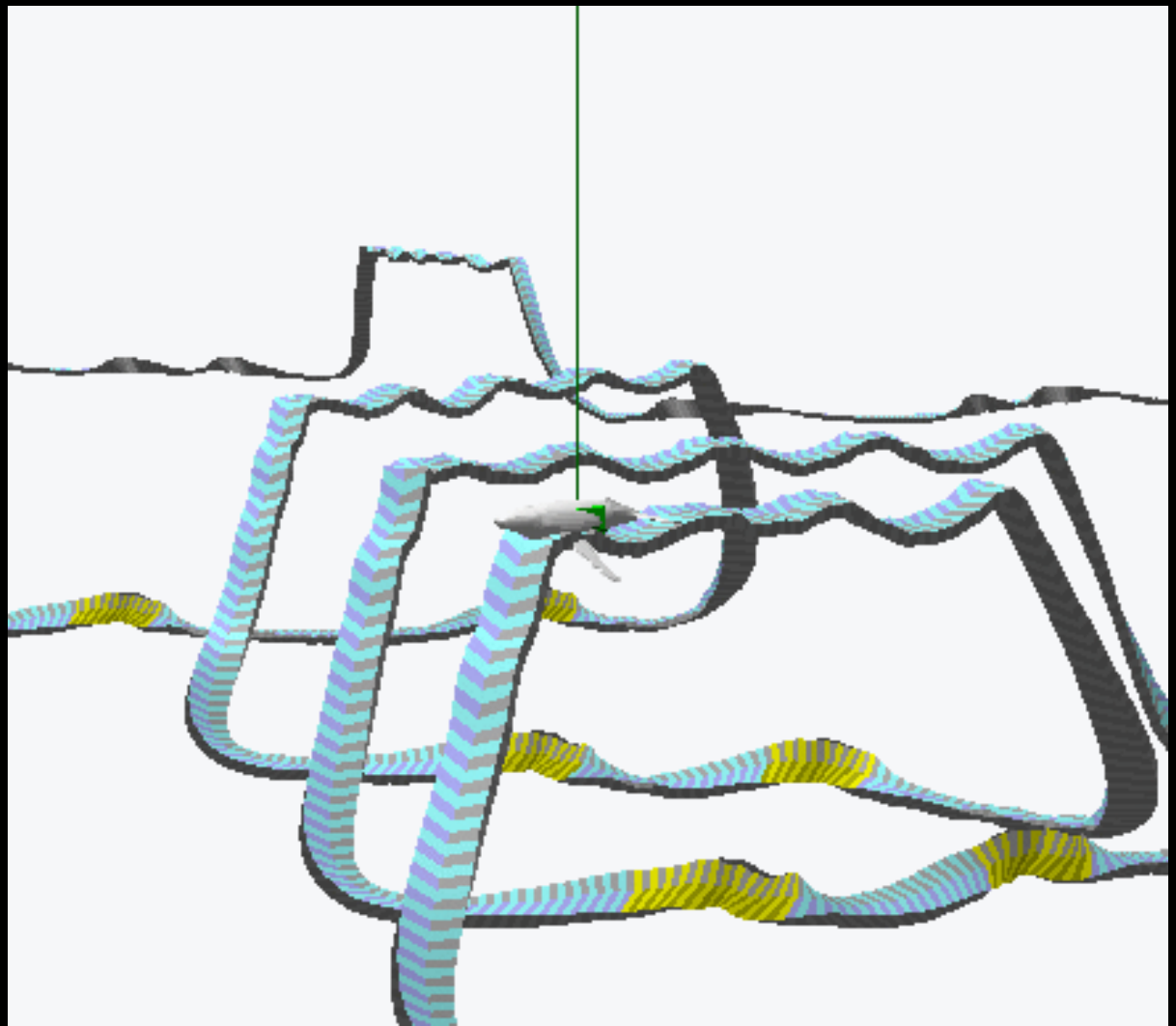


Friedlaender et al. 2009, 2015, Ware et al. 2010

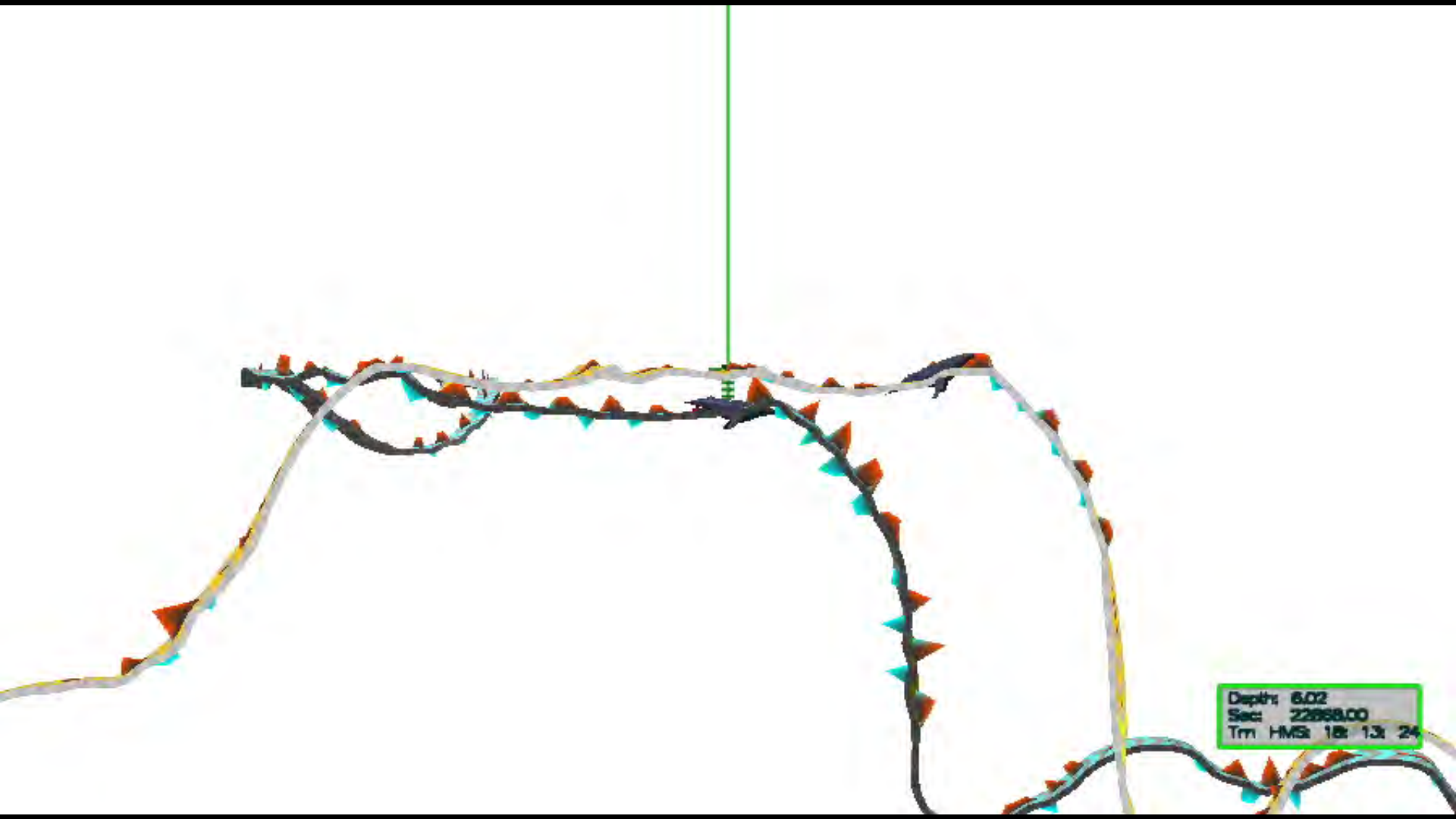
Quantifying foraging behavior



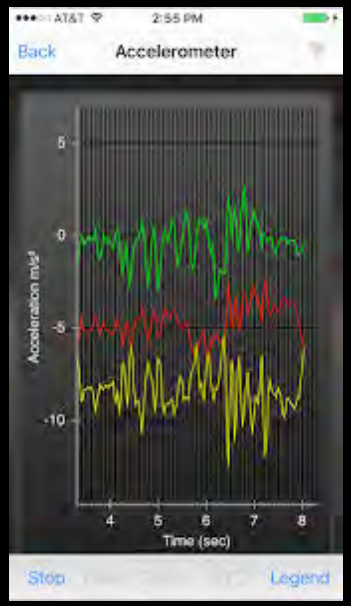
Bottom Feeding



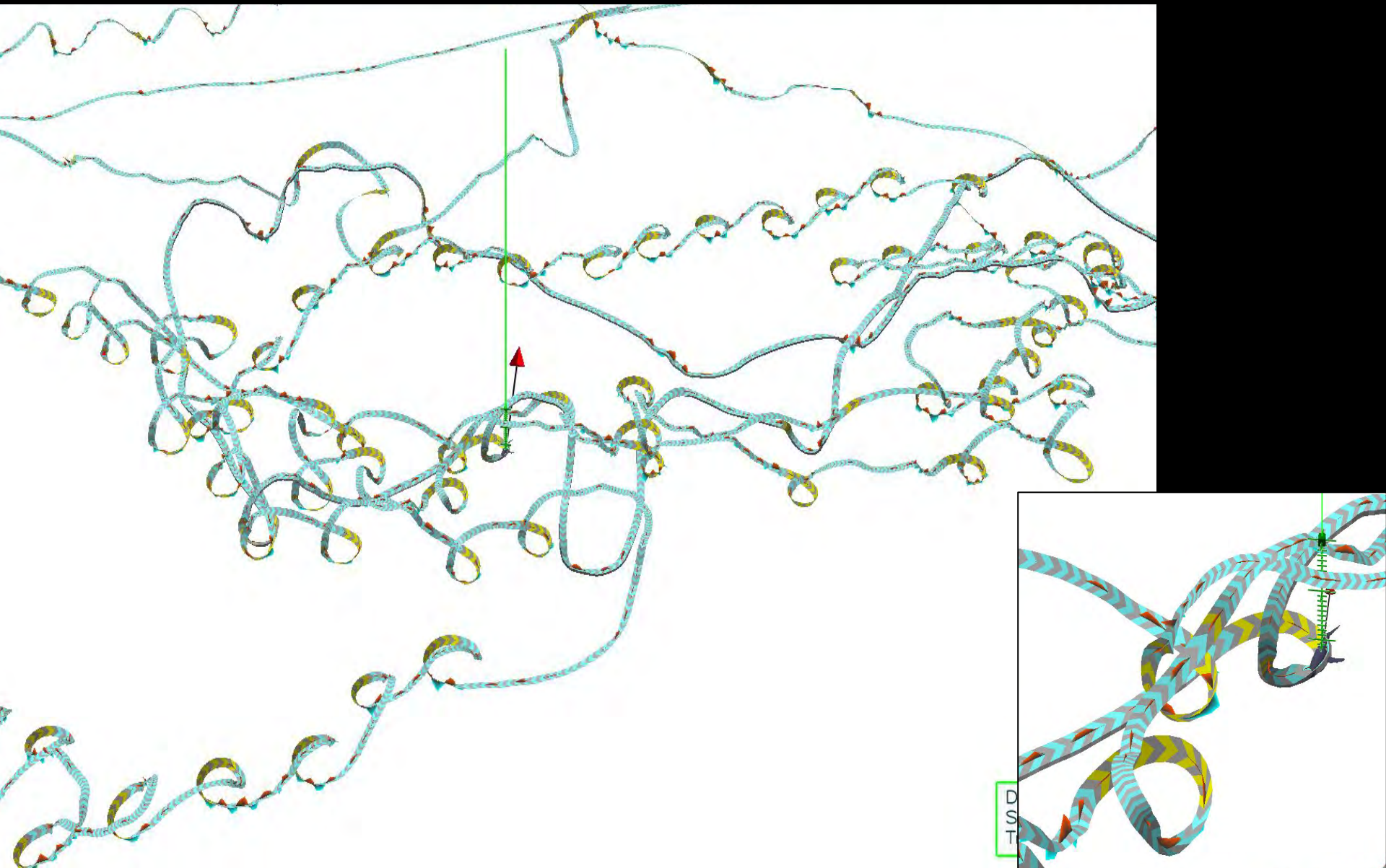
Mom & Calf



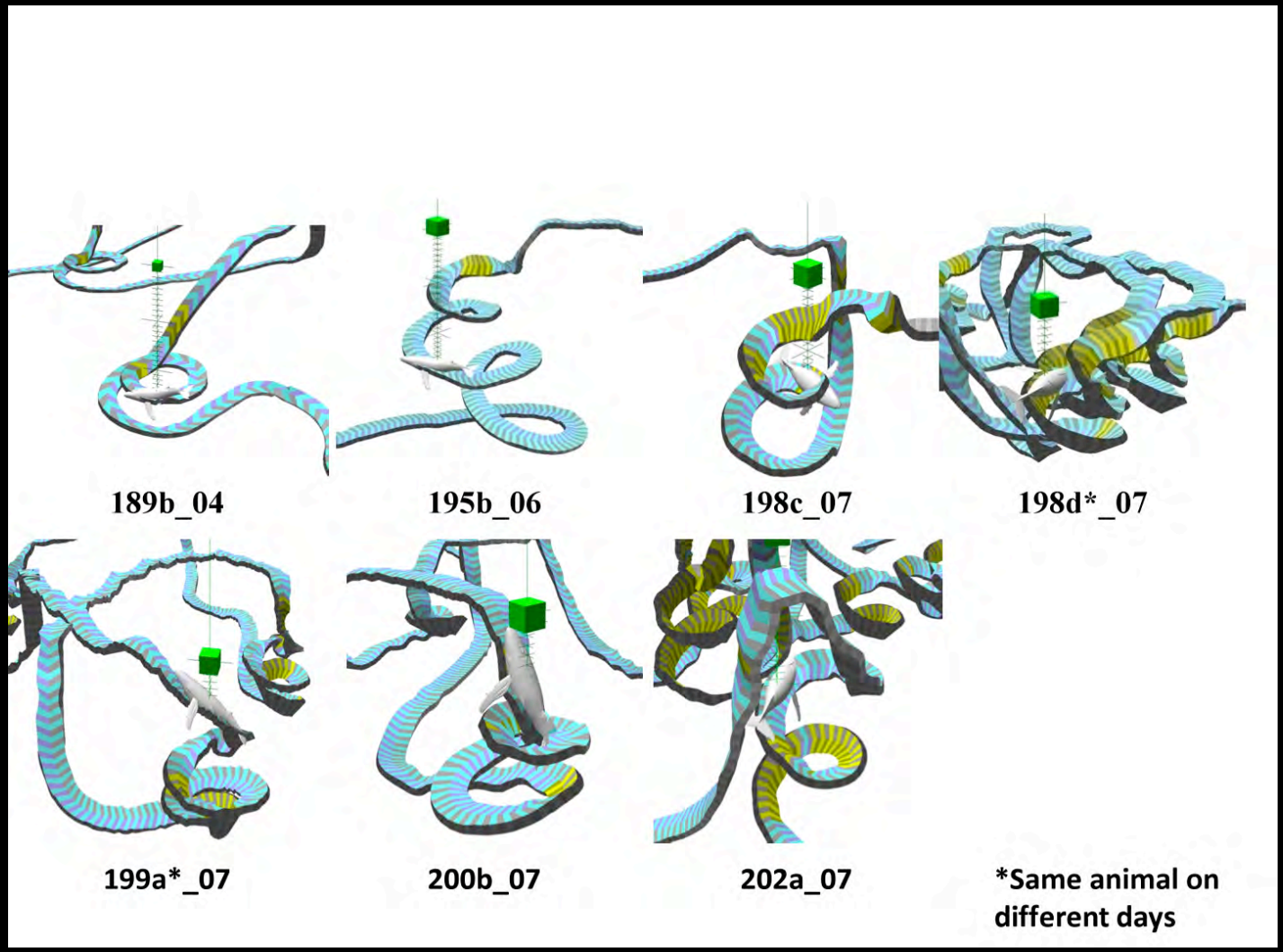
Playing with tag data



Bubble net feeding in Antarctica

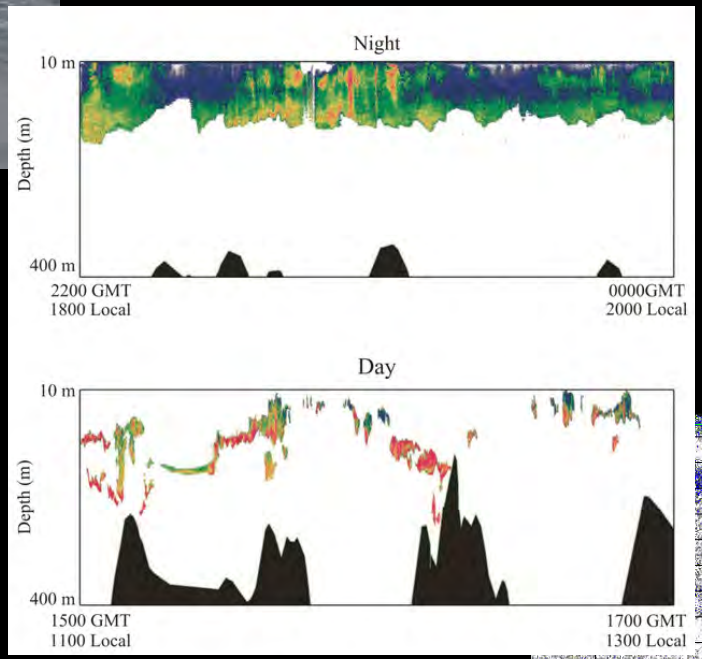


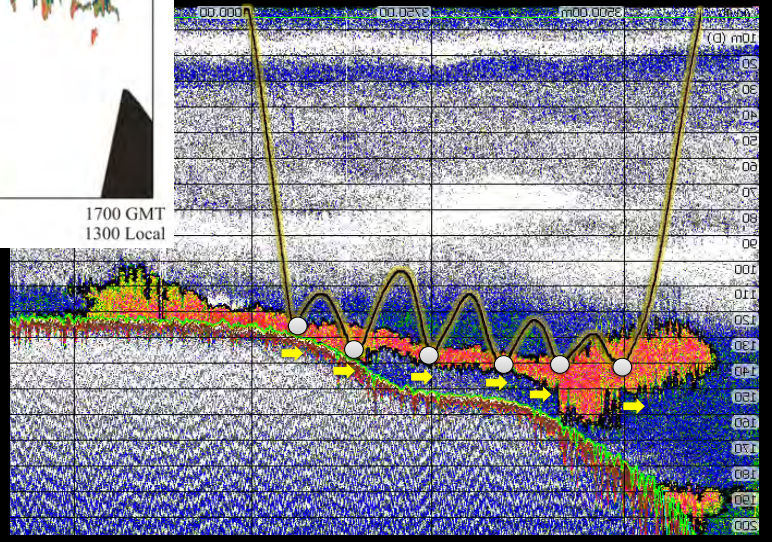
How do you eat?



Prey Mapping

- Use echosounders to determine: distribution, abundance, and density of krill

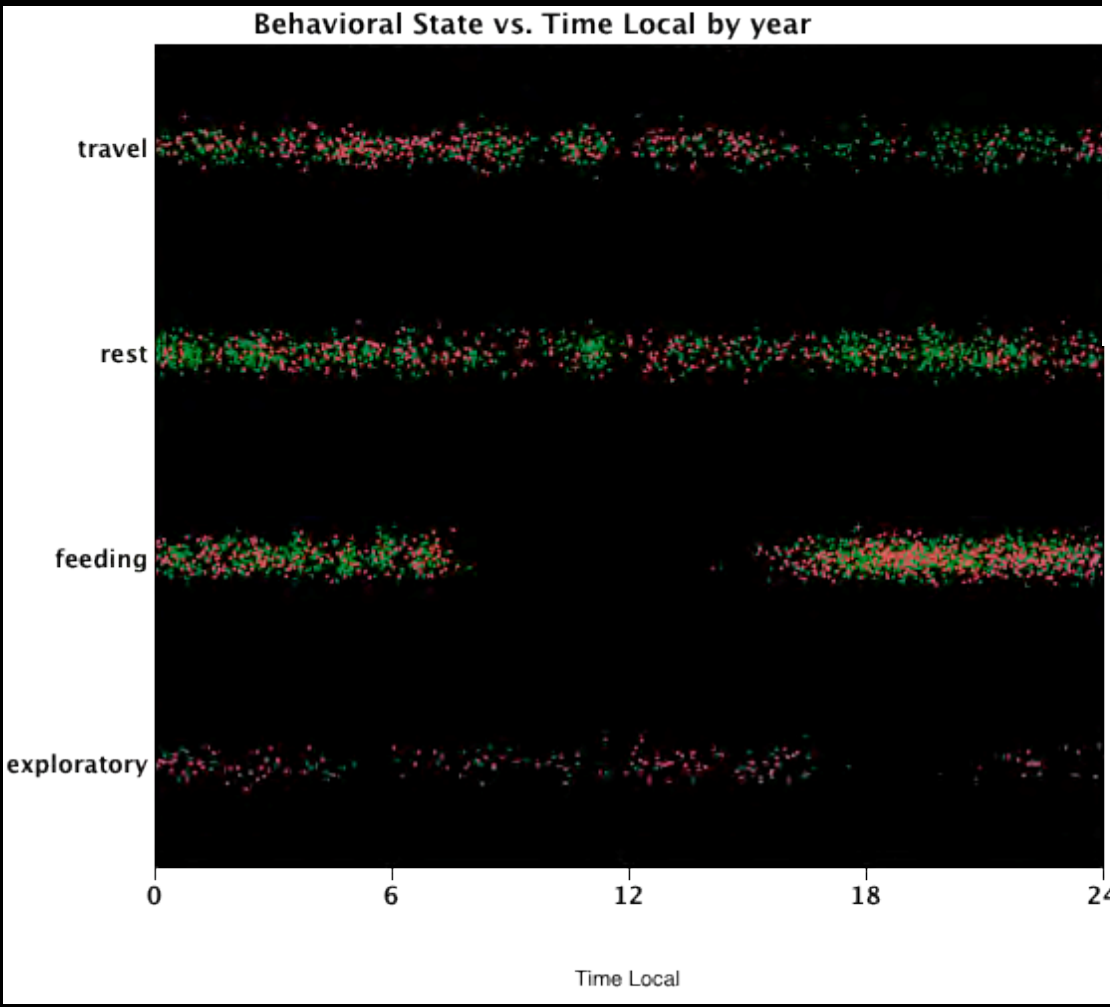


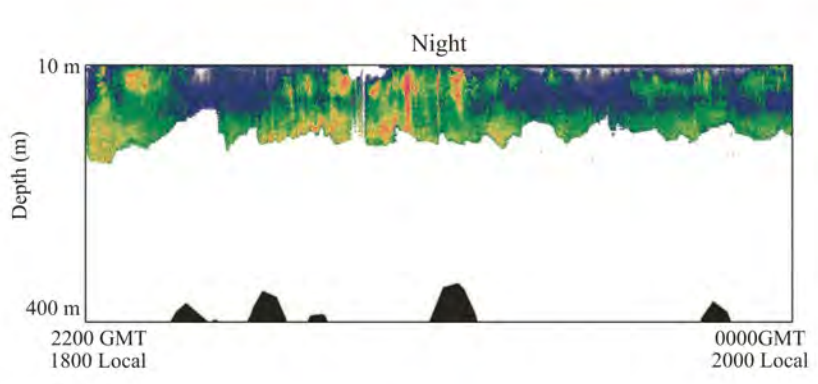


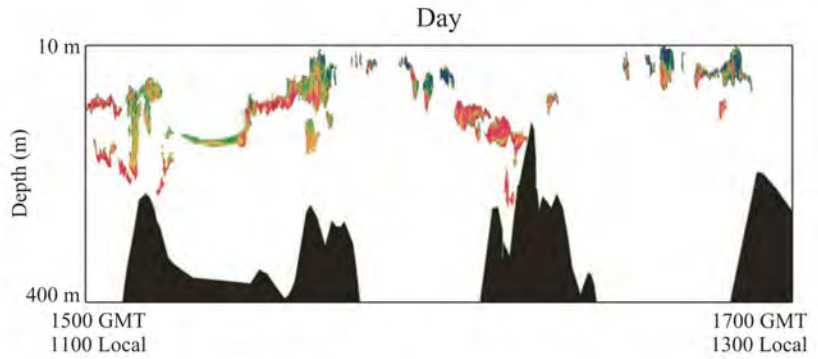
- Link fine-scale foraging behavior with prey

Goldbogen et al. 2013, Friedlaender et al. 2011, 2015, 2016

Foraging Decisions

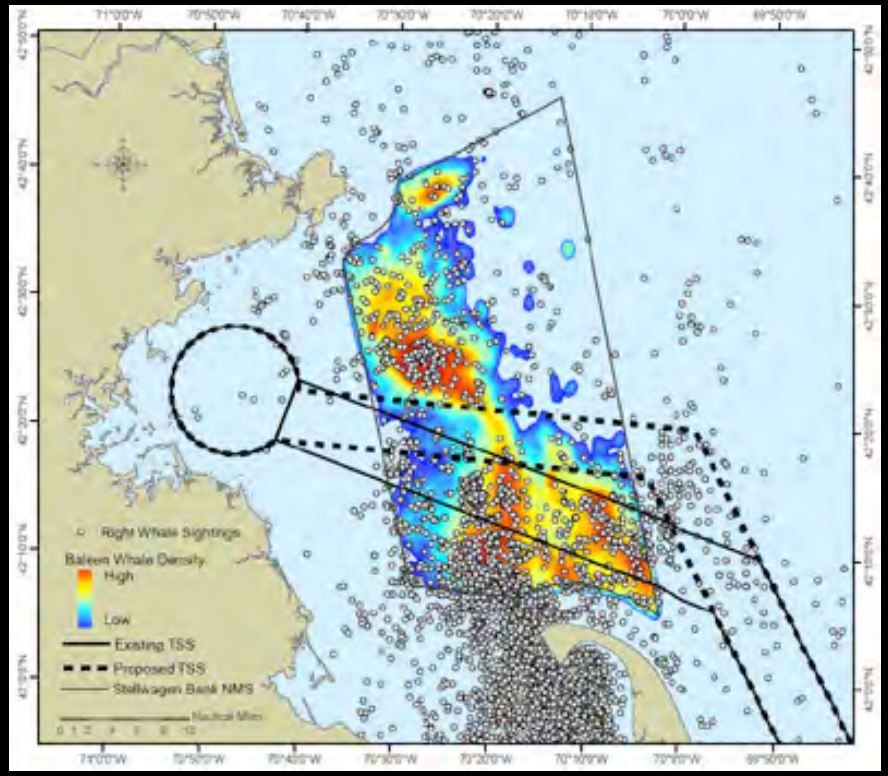


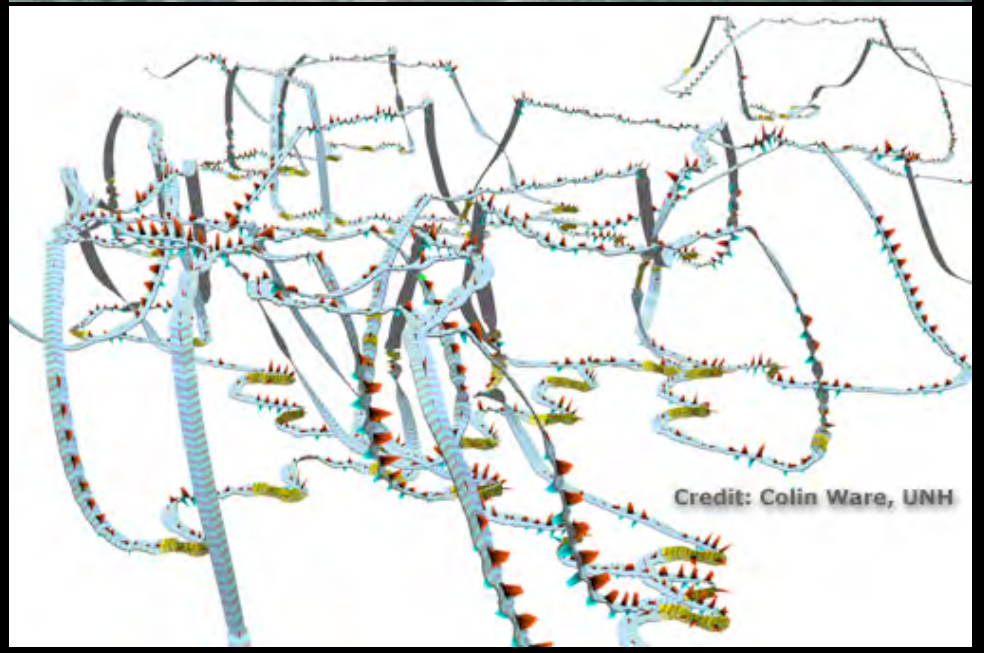




Friedlaender et al. 2015, Tyson et al. 2015

Conservation





Human-Whale Interactions

- Entanglement in fishing gear
  - Bottom set lines
  - mid-water nets