How to study dolphins without really trying

Underwater acoustics, deep scattering layers, and odontocete foraging in Monterey Bay

Dr. Sam Urmy
Monterey Bay Aquarium Research Institute
urmy@mbari.org
@ElOceanografo
Things I have studied before:

• Krill
• Acoustics and sonar
• Alaskan pollock (aka McDonalds Filet-o-Fish)
• Zooplankton in lakes
• Seabirds
• Radar

Things I have not studied before:

• Dolphins
IS ANYONE HERE A MARINE BIOLOGIST?
“Oh my God! I always wanted to be a marine biologist! Do you study dolphins??”
Son of a bitch, I'm sick of these dolphins.
WELL. HOW DID I GET HERE?
How did I get here?

• Grew up in Boston, always interested in science, ocean, boats

• Majored in Earth Systems (Oceans focus) at Stanford

• Research assistantship senior year: processing acoustic surveys of krill in Gulf of Farallons

• MS at University of Washington

• PhD at SUNY Stony Brook
Sound is the way to see in the ocean

- Fisheries acoustics: counting and mapping fish with sonar
- The ocean is huge, and 95% of it is dark
- Sound travels faster and farther in water than in air
The Sea's Deep Scattering Layers

The sound pulses of devices used to measure the depth of the ocean are often scattered by several "phantom bottoms" that rise by night and sink by day. The animals that make up these layers are now being identified.

by Robert S. Dietz

"DEEP SCATTERERS" rise from depths at night to feed in photic zone. The myctophids (lantern fish) eat copepods; the euphausiids (crustaceans) consume the phytoplankton.
The ocean's Twilight Zone can feed the world, but at what cost?

March 17, 2016, Technical University of Denmark

The Twilight zone is the zone in the sea, where daylight cannot reach. The most common fish here are lanternfish with one species of Bristlemouth Cyclothone, considered to be the most abundant vertebrate species on the planet. Credit: Peter Rask Møller, University of Copenhagen

Life in the Twilight Zone constitutes a huge potential source of fishmeal and omega 3 fatty acids that could feed the world's population. However, it exists in an unregulated space where there are no rules for fishing. And there exists a lack of understanding of the biological processes in the Twilight Zone making it impossible to accurately estimate the fishing pressure the stocks can sustain.
DEIMOS echosounder at MARS

- Deep-water Echo Integrating Marine Observatory System
- Feb 2009-Aug 2010
- 875 m (2,900 ft) deep
- Large zooplankton, fish, squid
The ocean is patchy and variable
Find the whale!
MARS Hydrophone

- Passive acoustics: listening only
- Recording soundscape 24/7 since 2015: weather, ships, animals
- 10 Hz to 120 kHz
  - Human hearing: 20 Hz-20 kHz
  - Humpback whale: 100 Hz-10 kHz
  - Clicking odontocetes: 10-50 kHz
- Use echolocation clicks to estimate abundance of odontocetes
Odontocete
“Toothed whale”
Hunting with echolocation

Mysticete
“Moustached whale”
Filter-feeding with baleen
Big questions…

• What odontocetes are clicking out there?
• What times of year, and how often?
• What do the deep scattering layers look like then? What prey animals are in them?
• How do odontocetes respond to variability in the DSL? Can they track patches of prey, or not?
Surveying the spectral soundscape
Detecting echolocation clicks
Machine learning ID’s clicks

- 250 million clicks so far
- **Unsupervised learning:** Use statistics to find common features of clicks and group them
- Human labels click types afterwards
- Can apply automatically to whole dataset
Work to come…

• Redeploy DEIMOS
  • Simultaneous, continuous detection of predators and prey!

• Acoustic surveys using WaveGlider (wave-powered robot)

• Remotely-operated vehicle (ROV) dives to see what prey are down there

• Stay tuned!
How to study dolphins

• Don’t actually try to study dolphins
• Learn useful scientific skills:
  • Math and statistics
  • Computer programming
  • Genetics and molecular bio
  • Chemistry and stable isotopes
  • Acoustics
• Look for research opportunities
• Be nice and make connections
• Expect the unexpected!
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ocean exploration progress bar

10:23 AM - 10 Sep 2018

473 Retweets 2,002 Likes
Thanks and shout-outs

• John Ryan and hydrophone team: Danelle Cline, Craig Dawe, David French, George Matsumoto, Paul McGill, Yanwu Zhang
• Kelly Benoît-Bird and Chad Waluk
• Marine Operations crews and ROV pilots
Thank You!

Sam Urmy
urmy@mbari.org
@ElOceanografo
Links to more resources

• MARS Hydrophone
  • Homepage: https://www.mbari.org/technology/solving-challenges/persistent-presence/mars-hydrophone/
  • Listening room (prerecorded sound clips): https://www.mbari.org/soundscape-listening-room/
  • MBARI YouTube channel (has hydrophone recordings and livestream): https://www.youtube.com/user/MBARIVideo

• General acoustics
  • Explore Sound (from Acoustical Society of America, has lots of resources for educators): https://exploresound.org/
  • Discovery of Sound in the Sea (DOSITS): https://dosits.org/

• Marine mammals
  • Miscellaneous resources from National Marine Fisheries Service: https://www.westcoast.fisheries.noaa.gov/education/marine_mammals.html
Video links

• Google video on MBARI summer intern Daniel DeLeon and his machine-learning/acoustics project: https://www.youtube.com/watch?v=GyCv_S42Tak

• George Costanza, marine biologist: https://www.youtube.com/watch?v=0u8KUgUqprw