Passive Acoustic Monitoring in California’s National Marine Sanctuaries

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Who we are

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Sound Waves

When we hit the drum, membrane of drum vibrates producing sound.

When we play a guitar, the string on it makes to and fro motion and produces sound.

Sound produced by vibrating prong of tuning fork.
What is sound?
Measuring Sound: Frequency

- High Frequency Wave
  - Pressure
  - Time

- Low Frequency Wave
  - Pressure
  - Time
Measuring Sound: Intensity

THE DECIBEL SCALE

- Breathing: 0 dB
- Resting leaves: 10 dB
- Whisper: 20 dB
- Refrigerator: 30 dB
- Moderate rainfall: 40 dB
- Conversation: 50 dB
- Car, city traffic: 60 dB
- Truck: 70 dB
- Hairdryer: 80 dB
- Helicopter: 90 dB
- Police siren: 100 dB
- Trombone: 110 dB
- Jet engine: 120 dB
- Fireworks: 130 dB
- Extremely loud: 140 dB
Sound Fixing and Ranging Channel
What happens to sound underwater?

- 4 x faster
- 2 x slower
- Same speed
What happens to sound underwater?

340 meters per second in air

1500 meters per second in seawater
**DISTANCE SUNLIGHT TRAVELS IN THE OCEAN**

- **Sea level:**
  - **Sunlight (euphotic) zone**
  - Sunlight rarely penetrates beyond this zone.

- **200 meters:**
  - **Twilight (dysphotic) zone**
  - Sunlight decreases rapidly with depth.
  - Photosynthesis is not possible here.
  - **Shrimp**
  - **Swordfish**
  - **Hatchet fish**

- **1000 meters:**
  - **Midnight (aphotic) zone**
  - Sunlight does not penetrate at all.
  - This zone is bathed in darkness.
  - **Octopus**
  - **Deep-sea fish**

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Importance of sound in the ocean
How animals use sound

Sound can be used “passively” and “actively”

- Settlement cues
- Foraging
- Defense
- Navigation
- Migration
- Communication
- Courtship/Mating
Sound production in aquatic animals

- Muscular vibration
- Stridulation
- Percussion on substrate
- Vocalization
- Echolocation
Toothed whales off California

- Common dolphin
- Harbour porpoise
- Dall's porpoise
- Bottlenose dolphin
- Pantropical spotted dolphin
- Risso's dolphin
- Northern right whale dolphin
- Pacific white-sided dolphin
- Striped dolphin
- Rough-toothed dolphin
- Pilot whale
- True killer whale
- False killer whale
- Pantropical spotted dolphin
- Bloody-bellied lemon shark
- Common dolphin
- Pacific white-sided dolphin
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Baleen whales off California

Sei whale

Blue whale

Humpback whale

Bryde’s whale

Minke whale

Fin whale

Gray whale
Which of these are known to sing?

- Toothed whales
- Baleen whales
Baleen whales
- Low frequency
- Song
- Do not echolocate

Toothed whales
- High frequency
- Clicks
- Whistles
- Echolocate
How do whales and dolphins use sound?
Abiotic Sounds in the Ocean
Which of the following generates sound or noise in the ocean?

- Bubbles
- Wind Turbines
- Ships
- Waves
- All of the above
Human-generated noise
How do we collect data?

- **Passive Acoustic Monitoring**
  - **Pros:**
    - Detect animals when we can’t see them
    - Less effort/cost for long-term data
  - **Cons:**
    - Can only determine presence
    - Can’t count animals
    - Some sounds unknown

- **Many tools to listen to underwater sound:**
  - a. Dip hydrophones
  - b. Acoustic tags on animals
  - c. Bottom mounted recorders
  - d. Autonomous gliders
  - e. Towed arrays/hydrophones
  - f. Real-time buoys
Why listen to NMS?

- Passive acoustic monitoring can help:
  - Determine when animals are nearby
  - Characterize human-generated sources
  - Evaluate tools to conserve habitats
Current Research in California NMS

- Soundscapes
- Whales
- Ships
Current Research in California NMS

- **Soundscapes**
  - What is making sound?
  - How do sources and levels compare in different areas?

- **Whales**

- **Ships**
Sound Monitoring

- Listen to low-frequency sound in multiple locations
- Comparable data collection
Natural Noises
Storms and earthquakes are intense sources. But the animals themselves add to the din—e.g., cod, which grunt a lot in the spawning season.

The Cost of Noise
A right whale calling to another faces the twin challenges—intensity and frequency—that noise poses to many marine animals.

Injury
Intense noises, such as air-gun blasts that ricochet off the seafloor, drown out animal sounds and may cause hearing loss and other damage.

Interference
Sounds close in frequency interfere, canceling each other. A ship's propeller miles away can mask a right whale's call.

Graphic: Stefan Fichtel. Sources: C. W. Clark, Cornell Lab of Ornithology; B. L. Soundall, University of California, Santa Cruz; K. Vigness-Raposa, Marine Acoustics.
Current Research in California NMS

- **Soundscapes**

- **Whales**
  - Migration timing
  - Whale behavior
  - Interactions with ships

- **Ships**
Blue whale research: migration timing

Bailey et al. 2009
Blue whale research: behavior

[Graph showing the annual cycle of calls, with peaks in February-June.]

[Image of a blue whale with a research vessel in the background.]

[Graph showing depth versus time of day, with peaks at 12:25 and 12:34.]
Blue whale research: ship interactions
Current Research in California NMS

- Soundscapes
- Whales
- Ships
  - Measuring ship noise near the Channel Islands NMS
  - Quantifying noise pollution reduction efforts
Noise Pollution Reduction Efforts in Channel Islands NMS

- Work with shipping companies to reduce noise pollution generated from commercial ships
What did we learn today?

- What is sound?
What did we learn today?

- What is sound?
- What makes sound in the ocean?
What did we learn today?

- What is sound?
- What makes sound in the ocean?
- How do scientists collect data?
What did we learn today?

- What is sound?
- What makes sound in the ocean?
- How do scientists collect data?
- Some amazing current research in National Marine Sanctuaries!
Thank you for listening! Questions?