Talk Outline

Title: *Sound and Signal – How Fishes Hear and Communicate Through Sound*

Speaker: Joseph A. Sisneros, Professor of Psychology (University of Washington)

1. Introduction & Personal Background

- Personal journey and inspiration
    - Early influences: Jacques Cousteau, fascination with marine life.
    - Early training in marine biology (BS, MS), eventual path to "fish psychologist."
- Research overview: 21 years of exploring fish hearing and bioacoustics.
- Framing question: How do fishes detect, process, and localize underwater sound?

2. The Underwater Acoustic World

- Debunking the "silent world" myth.
- Biological importance of underwater sound: (https://dosits.org/animals/sound-reception/how-do-fish-hear/)
    - Prey detection
    - Avoiding predators
    - Navigation in complex environments
    - Social communication
    - Mate location
- Definition of **sound**: pressure waves & particle motion. (https://dosits.org/animals/advanced-topics-animals/components-of-sound/)
- Relevance: fishes rely on both acoustic pressure and particle motion.

3. Fish Auditory System

- Anatomy of the fish inner ear: semicircular canals, utricle, saccule, lagena.
- Two modes of fish hearing:
    1. **Inertial (ancestral) mode** – direct detection of particle motion.
    2. **Pressure (derived) mode** – indirect detection of sound pressure via gas-filled structures.

- Variability of pressure sensitivity across fishes.

4. Why Study the Auditory System?

- Auditory neuroscience goal: decode how vertebrate systems process social vocalizations.
- Broader relevance: insights into how humans recognize and interpret complex vocal signals.
- Comparative advantage of fish:
    - Simpler repertoires of acoustic signals.
    - Organized auditory and vocal pathways like mammals.
    - Provide tractable models for fundamental auditory principles.

5. The Plainfin Midshipman as a Model System

- Introduction of *Porichthys notatus* as a model organism.
- August Krogh's Principle: some problems are best studied in particular animals.
- Three reasons for midshipman:
    1. Common and non-commercial species.
    2. Adapted to harsh intertidal zone during breeding.
    3. Acoustic communication is essential for reproductive success.
- Life cycle: offshore deep water most of year → migrate to rocky intertidal in late spring/summer.
- Sexual phenotypes: females, Type I males (nest-builders, parental care), Type II males (sneakers).

6. Acoustic Communication in Midshipman

- Sound is central to their life history. (https://dosits.org/animals/sound-production/how-do-fish-produce-sounds/)
- Three vocalizations: (https://dosits.org/galleries/audio-gallery/fishes/plainfin-midshipman/)
    - Grunts (agonistic)
    - Growls (agonistic)
    - Hums (mate calls; "California singing fish")
- Show examples (audio/video clips).

- How sound mediates courtship, competition, and parental behavior.

7. Auditory Neurophysiology

- Electrophysiological recordings from saccular afferents.
- Frequency encoding mechanisms:
    - Place code vs. temporal code.
    - Vector strength as measure of temporal coding.
- Seasonal plasticity in female auditory sensitivity:
    - Summer females show expanded frequency sensitivity.
    - Adaptive role: increased likelihood of detecting male hums.

8. Sound Source Localization Mechanisms

- Schuijf's phase model: need for both pressure and particle motion.
- Behavioral evidence from dipole source experiments.
- Swim bladder experiments:
    - Deflation eliminates localization ability.
    - Pressure reception essential for accurate localization.

9. Morphological Specializations

- Swim bladder sexual dimorphism:
    - Females and type II males with rostral extensions ("horns").
    - Proximity to inner ear enhances sound pressure sensitivity.
- Implication: coupling of morphology and behavior for effective communication.

10. Summary & Conclusions

- Fish auditory systems provide fundamental insights into vertebrate audition.
- The midshipman demonstrates how sound is important for social and reproductive behaviors.
- Comparative models in fish can illuminate general auditory mechanisms relevant to mammals, including humans, and provide insights into seasonal and hormone-dependent auditory plasticity and the evolution of spatial hearing in vertebrates.