A Fish Optical and Acoustic Sensor Identification System (FishOASIS)

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Objective

- **develop acoustic-optical system to link fish species and their sounds**
  - deployment length capable of capturing episodic and long-duration events
  - capture good images in poor light conditions

FishOASIS

Camera system

Hardware

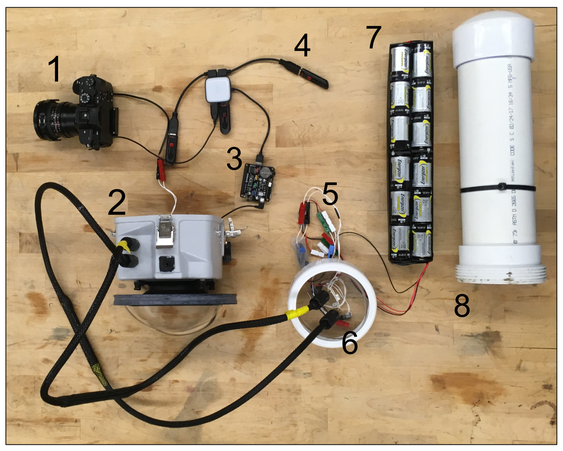

Figure 1. FishOASIS hardware components.

- **Components:** (1) Sony α7s II camera with fisheye lens, (2) custom-built Ikelite camera housing, (3) Raspberry Pi A+ with witty Pi real-time clock and power management board, (4) USB flash data storage, (5) step-down converters, (6) wet-mateable bulkhead connectors, (7) battery bank, (8) PVC battery housing, (not pictured) HOBO light and temperature logger
- **Capabilities:** low-light (max ISO 409,600), 180° field-of-view in horizontal
- **Cost:** ~ $4,700.00 ($2,400 for Sony α7s II camera)

Software

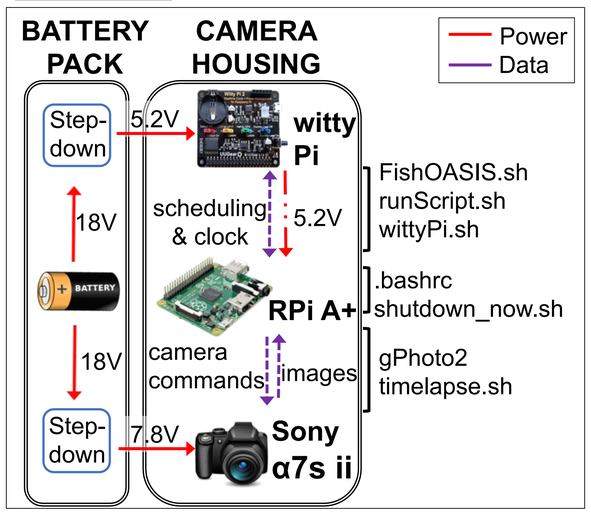

Figure 2. FishOASIS power and data flowchart.

- **Components:** Bourne shell (sh) scripts manage camera actuation, sampling and data storage, command-line client gphoto2 allows camera to be controlled via USB
- **Capabilities:** compatible with 547 cameras, user-defined sampling protocol, compatible with any Linux-based OS

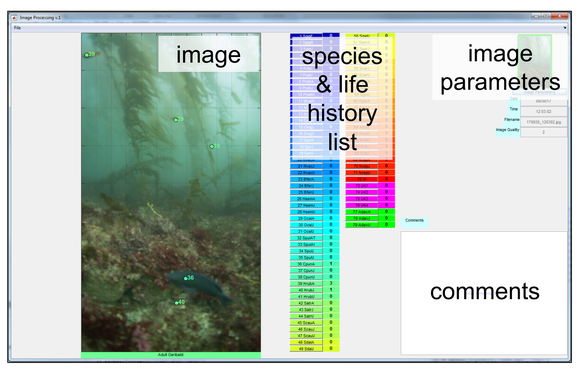

Figure 3. Screenshot of MATLAB-based image processing software for species identification.

- **Post-processing:** software for manual identification of fish species from images, manual association between acoustics and images and data visualization in MATLAB

Passive acoustic recording system

- **Components:** SoundTrap ST4300 256 GB acoustic recorder, four HTI-96-MIN hydrophones
- **Capabilities:** sampling at 48-288 kHz, up to 14 days continuous recording at 48 kHz
- **Cost:** $5,020.00

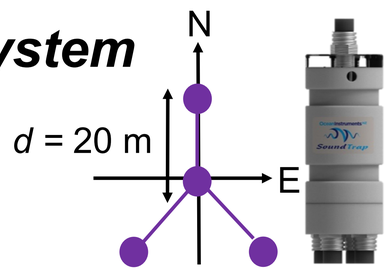

Figure 4. Configuration of passive acoustic system (purple circles are hydrophone locations).

Test Deployment

Study area

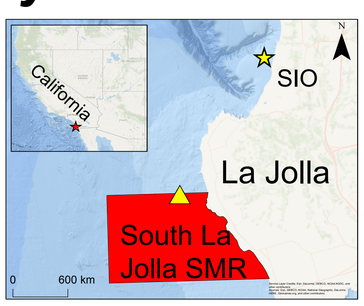

Figure 5. Location of two test deployment sites off the coast of San Diego, California.

FishOASIS

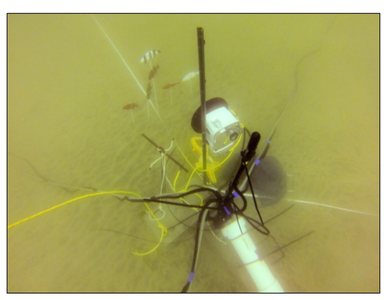

Figure 6. FishOASIS deployed off the SIO pier (yellow star in Figure 5).

Camera System Performance

Picture quality vs. ambient light

- camera captures good quality images in various levels of ambient light at a depth of 14 m
- fish can be identified to species level within 8 m from camera; genus level within 10 m

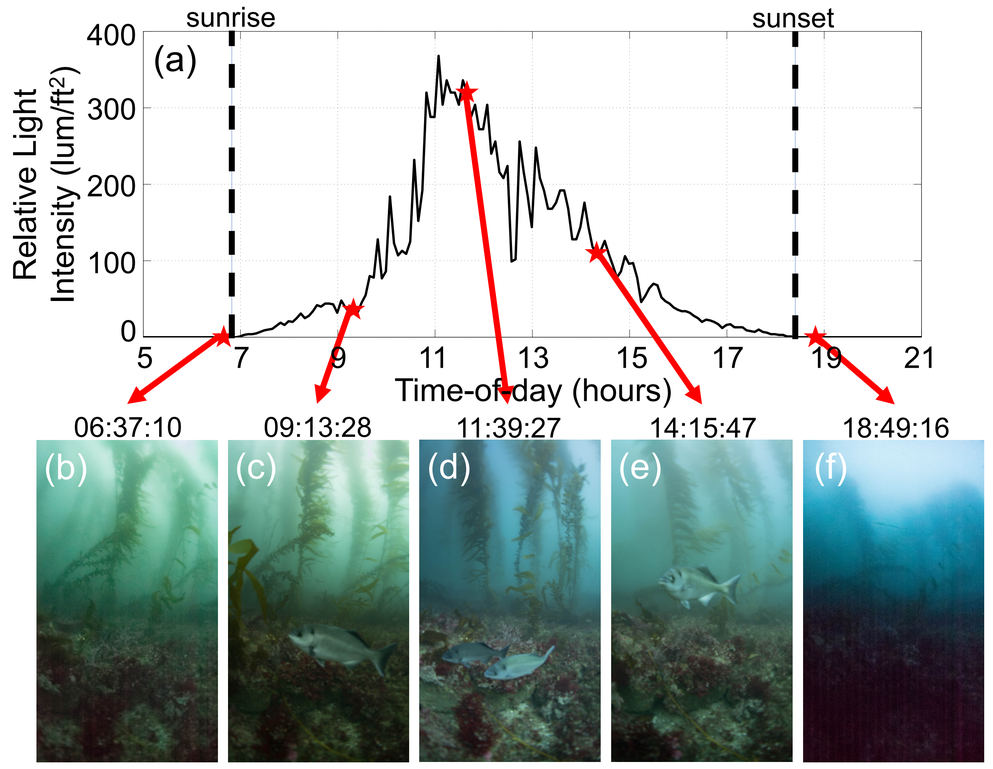

Figure 7. (a) Relative light intensity (lum/ft^2) during a test deployment and images taken using FishOASIS on October 2, 2017 at (b) 06:37:10, (c) 09:13:28, (d) 11:39:27, (e) 14:15:47 and (f) 18:49:16 in the South La Jolla State Marine Reserve (yellow triangle in Figure 5).

Recording duration vs. sampling rate

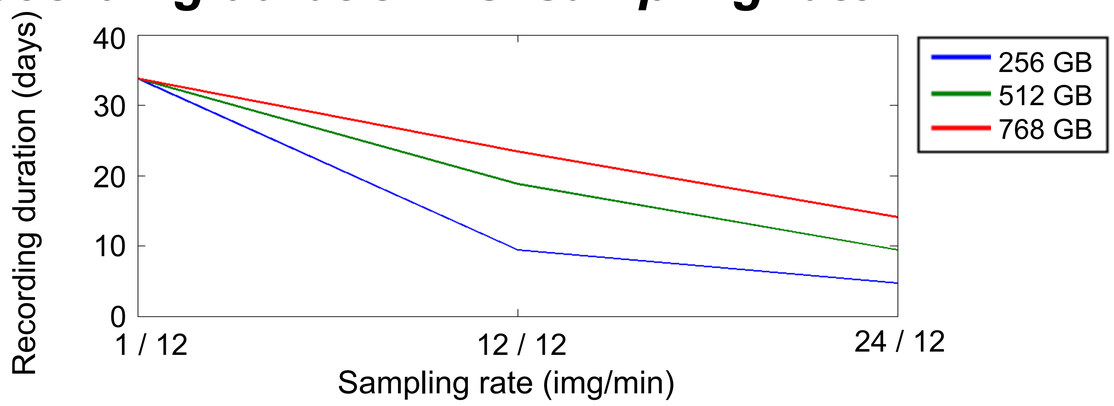

Figure 8. Recording duration (days) of the camera system for different sampling rates (img/min) & data storage capacities (GB).

Example of species-sound association

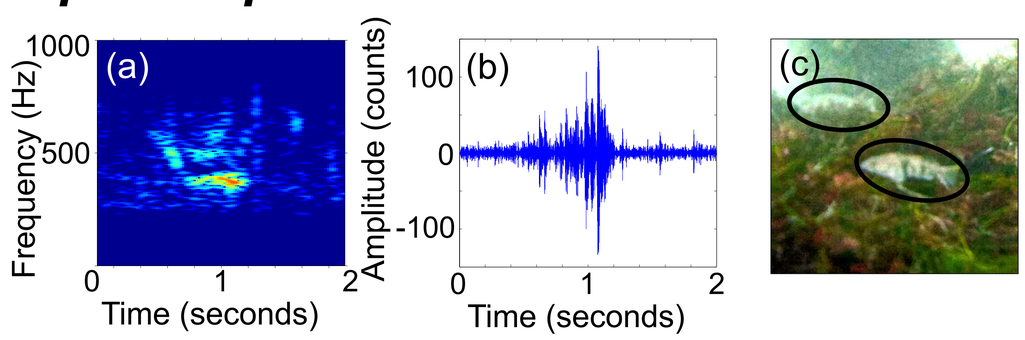

Figure 9. (a) Spectrogram and (b) time series of barred sand bass (*Paralabrax nebulifer*) call on October 18, 2017 at 07:08:04 (Hanning window, Fs = 48 kHz, NFFT = 8192, overlap = 90%; band pass filter = 250-700 Hz. Color represents spectrum level, with red indicating highest intensity.) (c) Image of barred sand bass taken using FishOASIS on October 18, 2017 at 07:08:00.

Conclusions & Next Steps

- developed a camera system that can be coupled with a passive acoustic recording system to optically identify soniferous species of fish in low-light conditions
- need to develop method for inter-calibration of the camera and passive acoustic systems, and post-processing software that automatically detects, classifies and localizes sounds

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