OBJECTIVES
To develop and test a low-cost, easy to use, modular, passive acoustic recording system with sound localization capabilities.

DESIGN GOALS
- Ease of use
  - Quick setup, deployment and data recovery.
  - Minimal need for special expertise or tools.
- Modular design (to support expansion and upgrades).
- Commercial Off-The-Shelf (COTS) components
- Multiple operating modes means flexibility (see below)
- Extended mission durations up to 1 year (depends on sample rates & duty cycle)
- Affordable pricing (~$2-5k per recorder, surface buoy, pinger, or release device)

SYSTEM COMPONENTS & SPECIFICATIONS

**Surface Buoy & Components**
- Integrated:
  1. Solar Panels - for supplemental power
  2. GPS - for location and time synchronization
  3. Local or ARGOS modem - for status reports
  4. Antenna - for ARGOS/locally modulated transmissions

**Deck Box**
- For release device comms, ranging & actuation
- Over-the-side or through-hull transducer configurations possible

**Autonomous Recorder**
- Sample Rate: up to 416 kHz
- Depth Rating: 1000m
- Memory: up to 4TB (using 8 SD cards)
- Endurance: 100kL - > 95 days
- Check drift: 80 ppb (~100 miles)
- Integrated Depth sensor (up to 100m)
- RS485 data connection (w/extra power)

**Ruggedized Comm. Cable**
- Electronic cable to recorder for power and GPS time synchronization

**Synchronization Pinger**
- 34kHz standard-vst: 3km max range
- 8kHz long range vers: 10km max range
- Depth Rating: 1000m
- Endurance: 1 year @ 1 ping per hour

**Acoustic Release Device (ARC-I)**
- Fast acting, reliable fail-safe release mechanism
- Endurance: 10 months
- Breaking strength: >800lbs, working load: 400lbs

DEPLOYMENT CONFIGURATIONS
Several deployment configurations are possible through simple 'plug and play' of modular components (see above).

1. **OCEAN SEAFLOOR ARRAYS**
   A) Each recorder deployed with acoustic release (e.g. ARC-I).
   Pre-deployment auto-synch & precision clock calibration achieved via integrated GPS. Clock drift (80 ppb) ~10/individual local error.
   B) Precision pinger co-deployed with one recorder in the array. For longer (> 1 week) deployments of up to 1 year, synchronization is achieved via a pinger co-located with one recorder to correct for clock drift. Depth rating to 1000m.

2. **OCEAN DRIFTERS & MOORED SEAFLOOR ARRAYS**
   A) Multiple units can be deployed as a (short-term) drifting array. Synchronization, solar power, status and buoy location reporting provided by the surface buoy (cabled to recorder below). GPS position reports (via the RF local modem) provides real-time information (e.g. to recover units).
   B) Single units deployed as (long-term) global drifters. Individual buoys/recorders can be deployed as drifters in the open ocean. Similar configuration as (A) with solar power assist for long endurance deployments. Satellite (ARGOS) modem reports buoy location and status.
   C) Moored 'semi-permanent' shallow water arrays: Similar configuration as (A) with a tether to a shallow (up to ~10m) seafloor mooring.

DATA-PRODUCTS

Example of SonarPoint data product: Time synchronized multi-channel .wav files suitable for importing into Ishade, PAMGuard, Raven, or other bioacoustic analysis software. For drifters deployments, GPS data is saved in .wav file header and extracted as a .CSV file. A custom-written Python algorithm is used to easily plot localizations (estimated by Ishade) onto Google Maps display in a browser window (see examples below, right panel).

FIELD TESTS

We conducted tests at three field sites:
1) San Justo Freshwater Reservoir, California, USA.
2) San Juan Islands, USA and Vancouver Islands, Canada.
3) Monterey Bay, Central California, USA.

We are planning to use SonarPoint to collect data on marine mammals for a pilot study on acoustic behaviors and density estimation of marine mammals off the West Coast of USA.

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