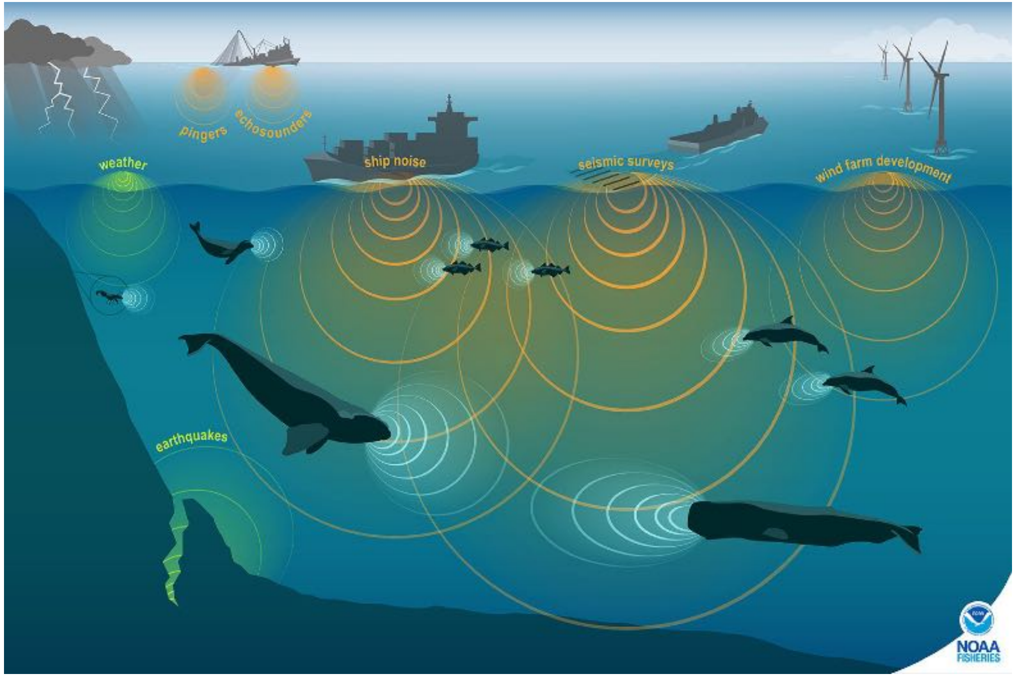
SoundCoop
Passive Acoustic Monitoring Access Network

Carrie Wall

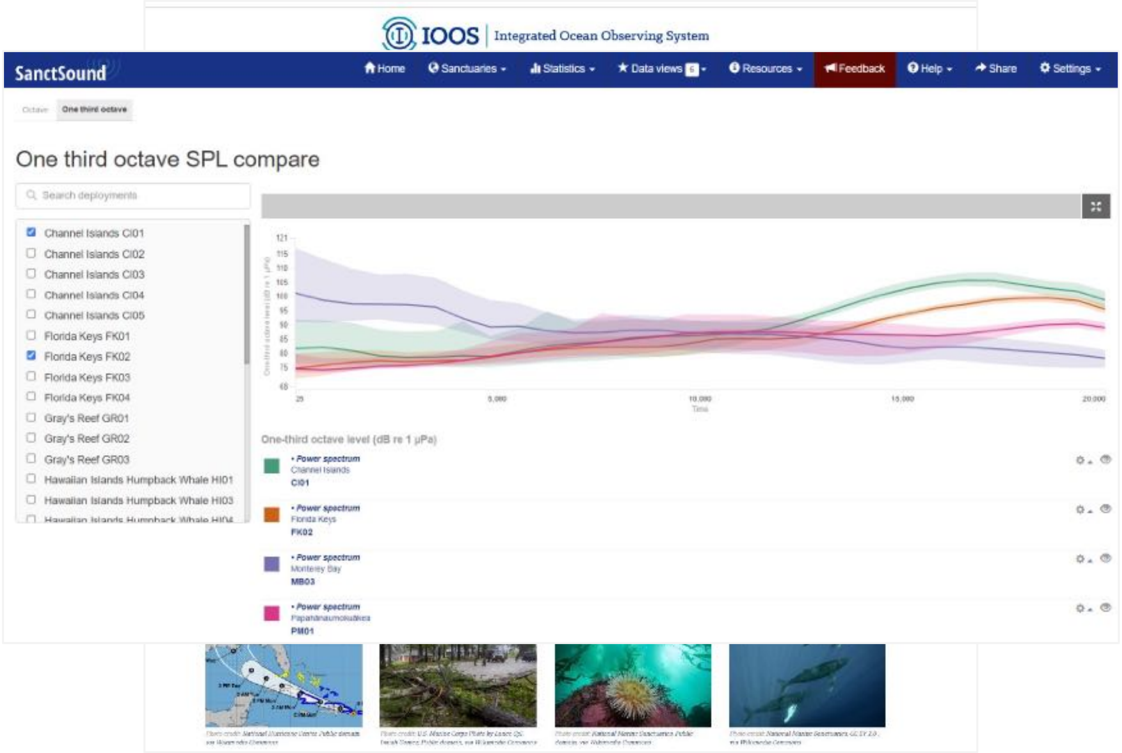
Leila Hatch, Rob Bochenek and Sofie Van Parijs

Federal acoustic monitoring and management:



Existing Portal Capacity to Compare or Access Standard Products across Projects

- ★ SanctSound
- ★ PACM
- ★ NCEI



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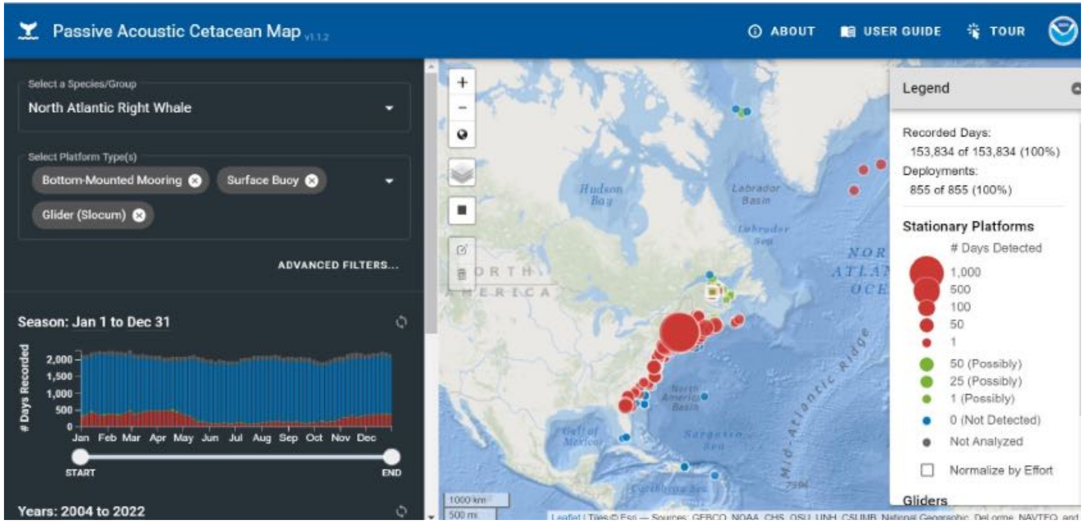

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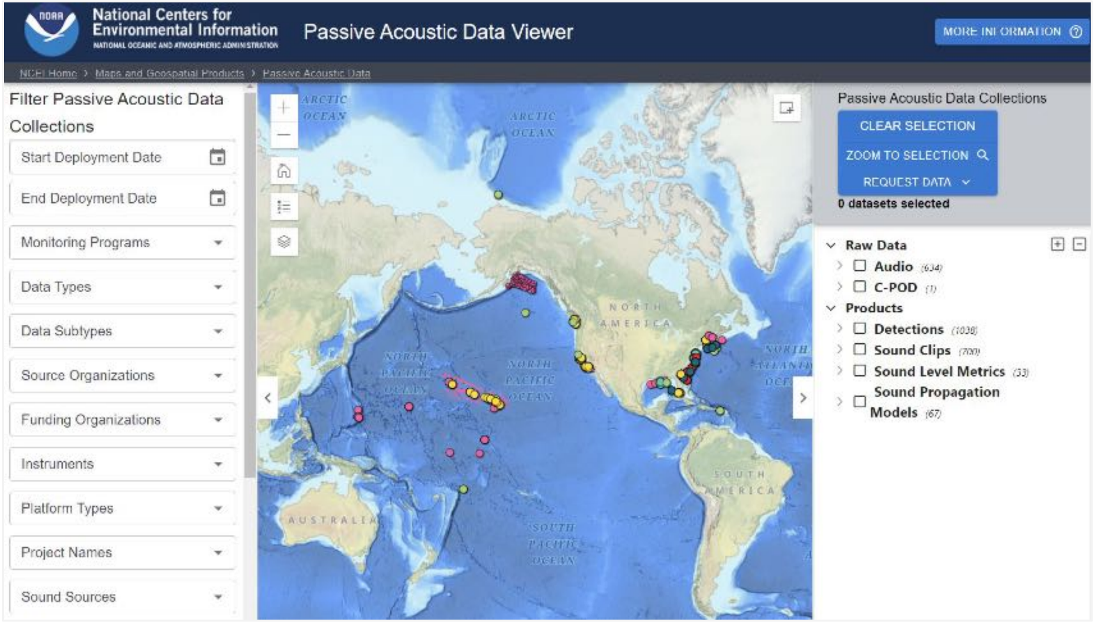
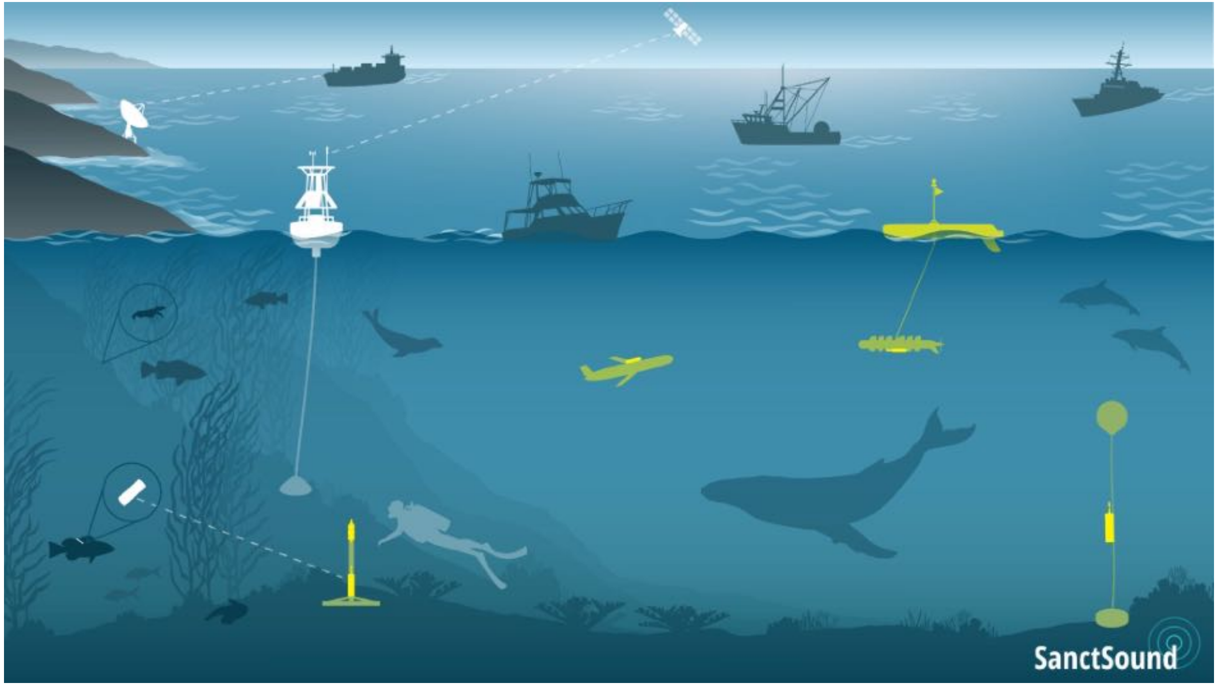


Advancing standards and community tools



Passive Acoustic Monitoring National Cyberinfrastructure Center (SoundCoop)

Pilot a community-focused, national cyberinfrastructure capability for passive acoustic monitoring data, technology, and best practices to promote improved, scalable and sustainable accessibility and applications for management and science.

Steering Committee

NOAA FISHERIES

IOOS Integrated Ocean Observing System

BOEM Bureau of Ocean Energy Management

living marine resources

Office of Naval Research ONR Science & Technology

MBARI

RWSC Regional Wildlife Science Collaborative for Offshore Wind

AWI

Interreg North Sea Region Jomopans European Regional Development Fund

EUROPEAN UNION

IQOE International Quiet Ocean Experiment

SoundCoop Progression

1. Build National Repository

Continue to build national archive for federally-funded and interagency-prioritized PAM assets at NCEI

Year 0

2. Integrated Access

Build infrastructure to discover and access existing raw files and data products across separate repositories

Year 1

3. Visualization Tools

Visualize comparable data products from separate repositories in a single portal

Year 2

4. Analysis & Assimilation

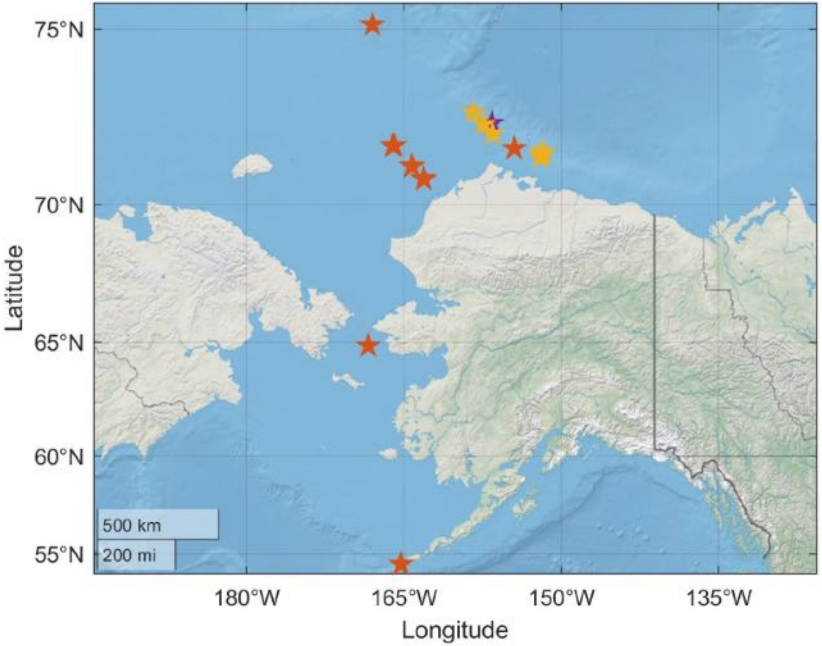
Enable users to apply the same processing routine on raw data from separate projects and visualize the results with complimentary environmental data

Year 3

Case Study 1 - Priority Federally-funded Datasets

Temporal sound level analysis in the Arctic Ocean

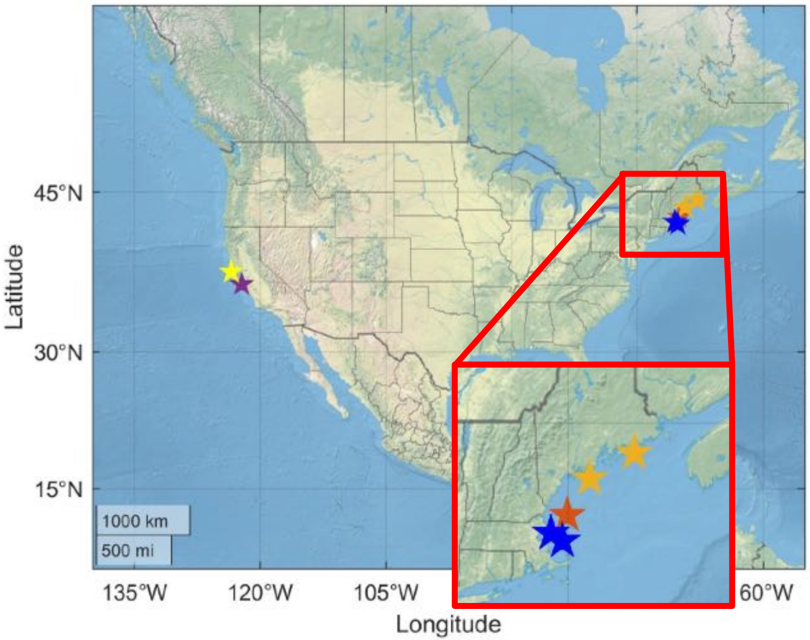
- SWAL - Kait Frasier
  - Beaufort Sea: Jul 29, 2002 ~ Sep 30, 2004
  - Arctic: Sep 26, 2006 ~ Aug 27, 2011
- NRS - Samara Haver
  - Alaskan Arctic: Oct 15, 2014 ~ Sep 25, 2022
- AFSC - Catherine Berchok
  - W Beaufort Sea: Aug 8, 2008 - Nov 11, 2021
  - Chukchi Sea: Sep 10, 2010 ~ Nov 27, 2021
  - Chukchi Plateau: Oct 9, 2016 - Oct 7, 2020
  - Aleutian Islands: Oct 1, 2016 - Sep 2, 2020
  - Bering Strait: Sep 24, 2016 - Sep 9, 2020



Case Study 2 - IOOS Regional Datasets

Spatial sound level analysis of NERACOOS, CeNCOOS & SECOORA assets in 2021

- ★ MBARI MARS - John Ryan
  - Monterey Bay
- ★ NRS - Samara Haver
  - Cordell Bank
- ★ AEON - Jen Miksis-Olds
  - AEON 5
- NEFSC - Tim Rowell
  - ★ GoMaine Monhegan Island & Petit Manan
  - ★ SBNMS SB01 & SB03
- USC - Eric Montie
  - May River

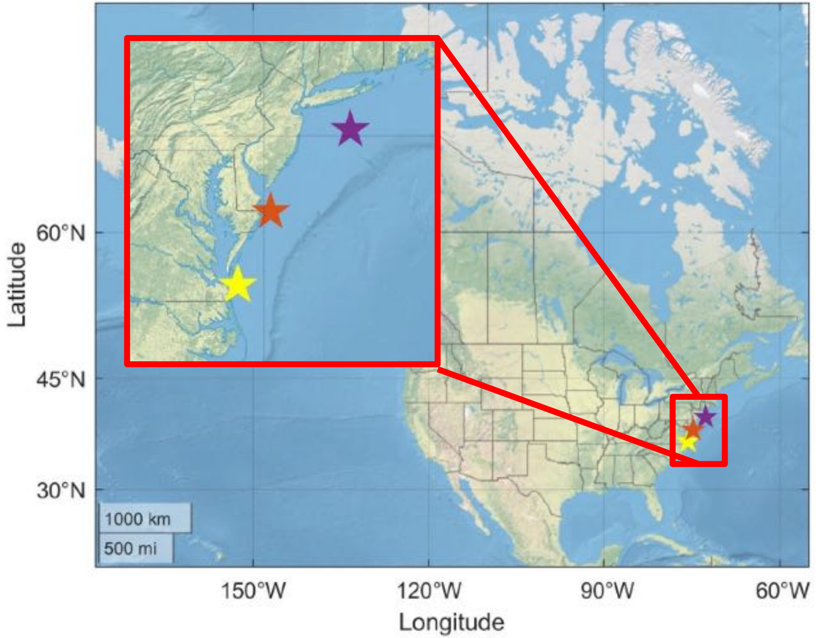


Case Study 3 - Offshore Energy Development Datasets

Integrate BOEM- and state-funded monitoring

- ★ NEFSC - Gen Davis
  - NYDEC-Cornell **NARW detections**: Oct 16, 2017 - Nov 1, 2020

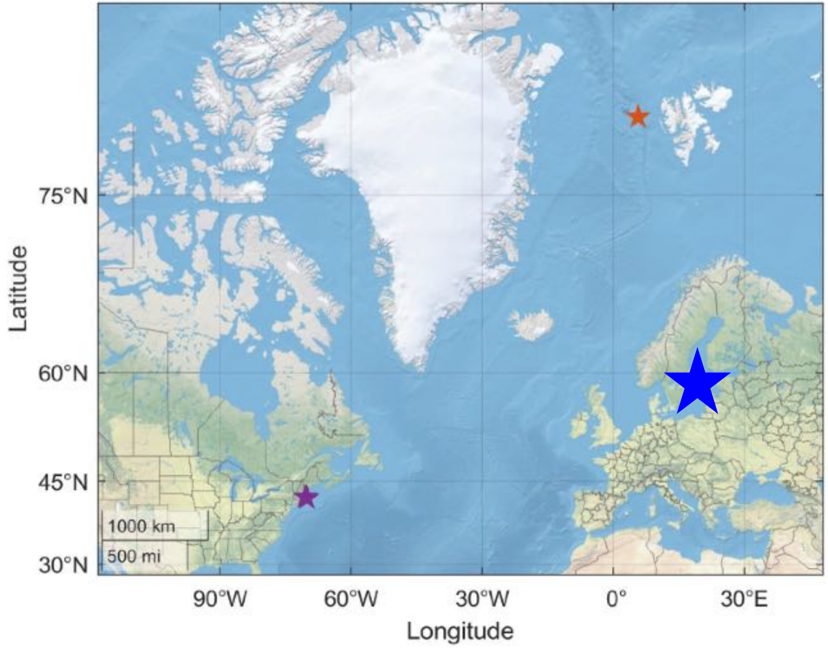
- Cornell - Aaron Rice
  - ★ BOEM-VA: Mar 10, 2016 - Mar 6, 2017
  - ★ BOEM-MD: Sep 17, 2015 - Jan 10, 2017



Case Study 4 - International Datasets

Demonstrate synergy with international efforts

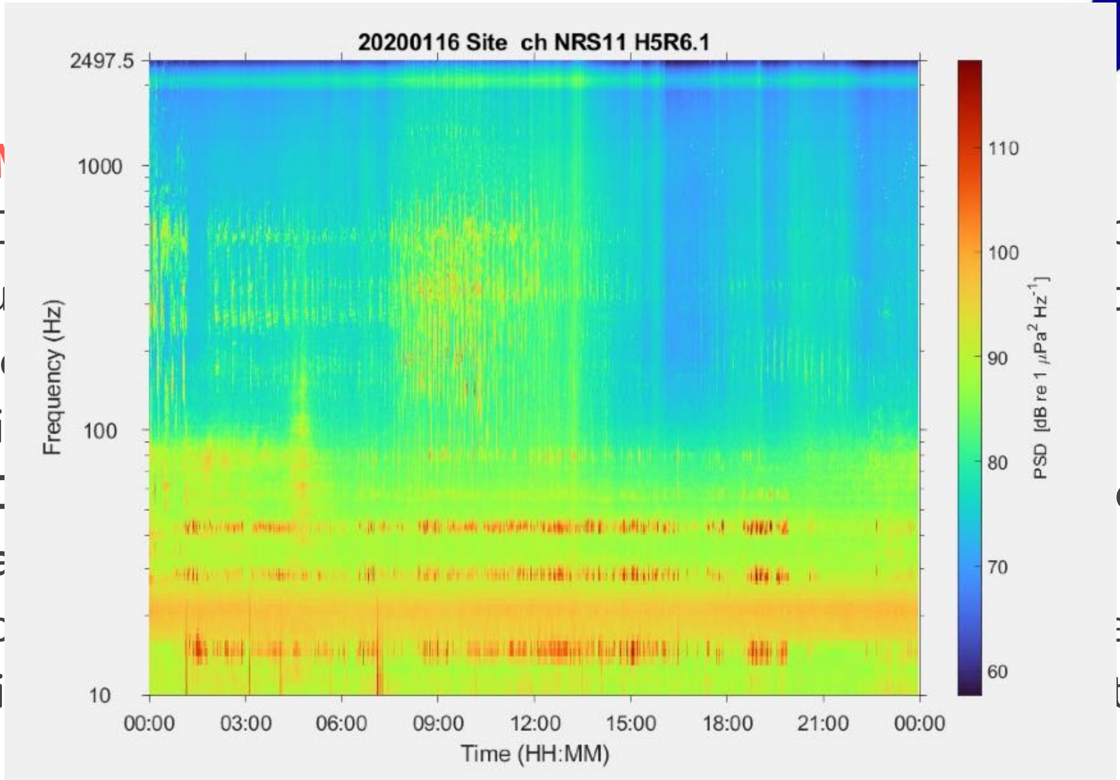
- ★ NEFSC - Tim Rowell
  - SBNMS SB01: Jan 26, 2021 - Feb 16, 2022
  - SBNMS SB03: Jan 26, 2021 - Feb 16, 2022
- ★ AWI - Karolin Thomisch & Olaf Boebel
  - OPUS-hosted FRAM: Sep 6, 2016 - Jul 18, 2017
- ★ JOMOPANS - Niels Kinneging
  - Connect to JOMOPANS **decidecade sound level netCDF files** in ICES database



SoundCoop's Task

There are

1. Run
   - D ... and spectra
2. Evalu ... tive tool to creat
3. Archi
   - **D ... or MANTA a**
4. Estab ... es
5. Co-vi ... tal data



MANTA
powered by Raven-X

Developing netCDF Standard for Sound Levels

- **What?** netCDF is a self-describing, machine-readable data format that supports access and sharing of array-oriented scientific data
- **Why?** Metadata and hybrid millidecade results in a single file, facilitates development of scalable visualization and analytical tools
- **How?**

MANTA

Matrix of hybrid millidecade w/ time, freq and effort (# sec/min)
Daily CSVs

Metadata containing processing and calibration information & plots
Daily netCDFs

+

PassivePacker

Deployment metadata and additional processing details
Deployment-level JSON

+

Community Standards

=

SoundCoop netCDF

Standards-compliant file with complete metadata and hybrid millidecade
Daily netCDFs

The Power of Millidecade and netCDFs

Journey of a SoundCoop dataset

Audio Data

Volume: **4 TB**

# of Files: **51,713**

File Size: **~77.4 MB**

Format: Wav

→ MANTA powered by Raven-X →

Hybrid Millidecade Spectra

Volume: 5.4 GB

# of Files: 1,440

File Size: ~14.8 MB

Format: CSV, netCDF, and pngs

→

Hybrid Millidecade Spectra

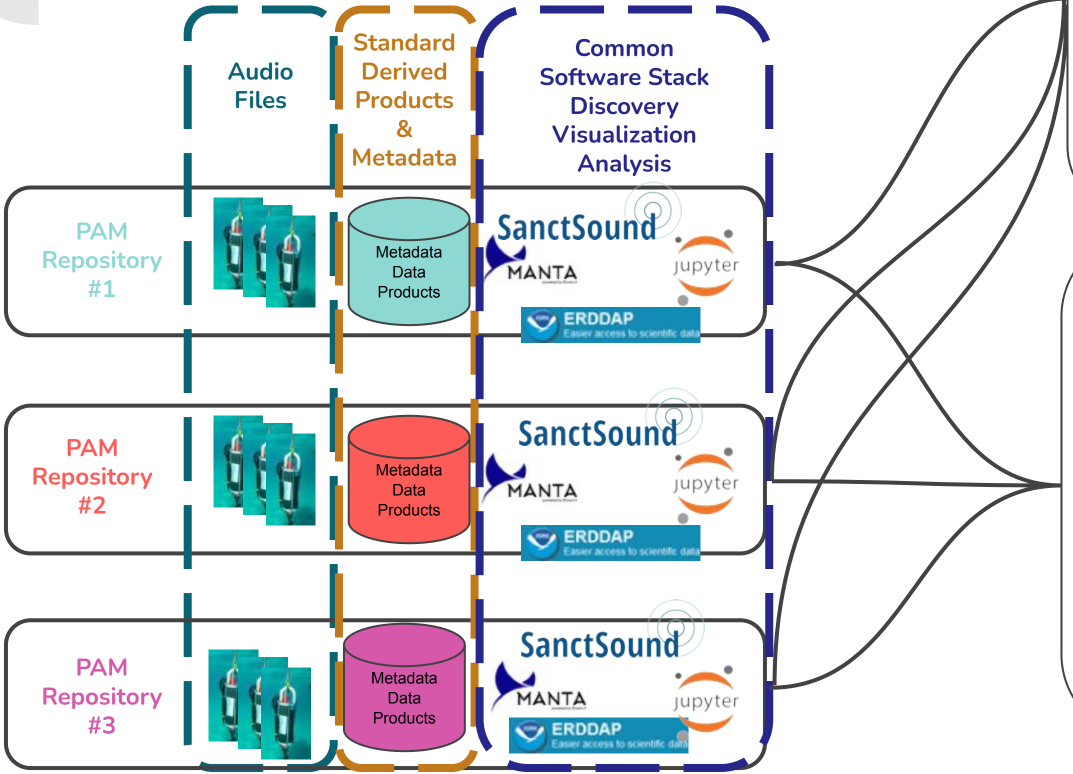
Volume: **10.3 GB**

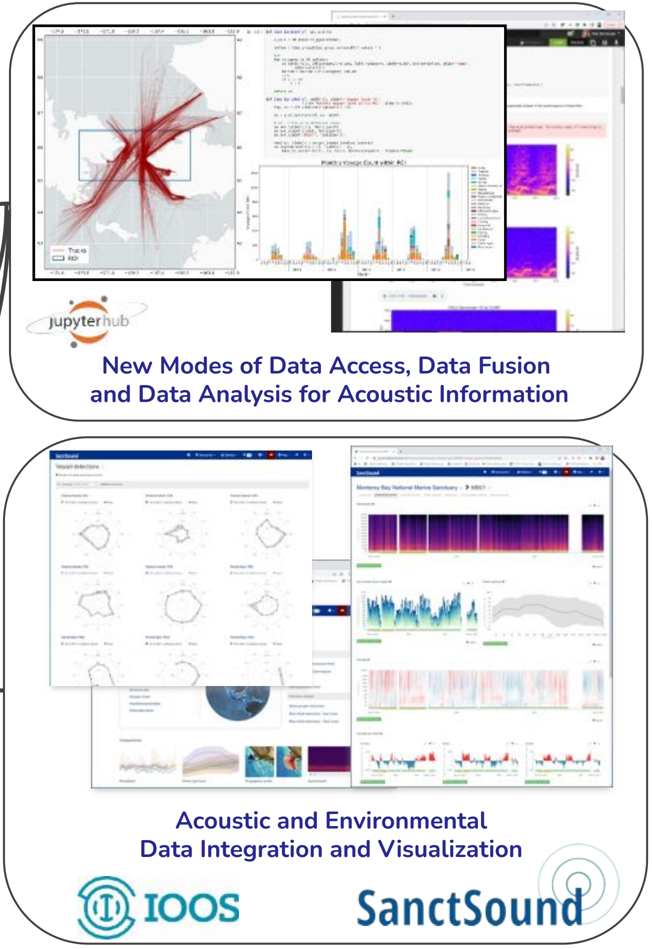
# of Files: **360**

File Size: **~28.5 MB**

Format: netCDF

Cyberinfrastructure Framework





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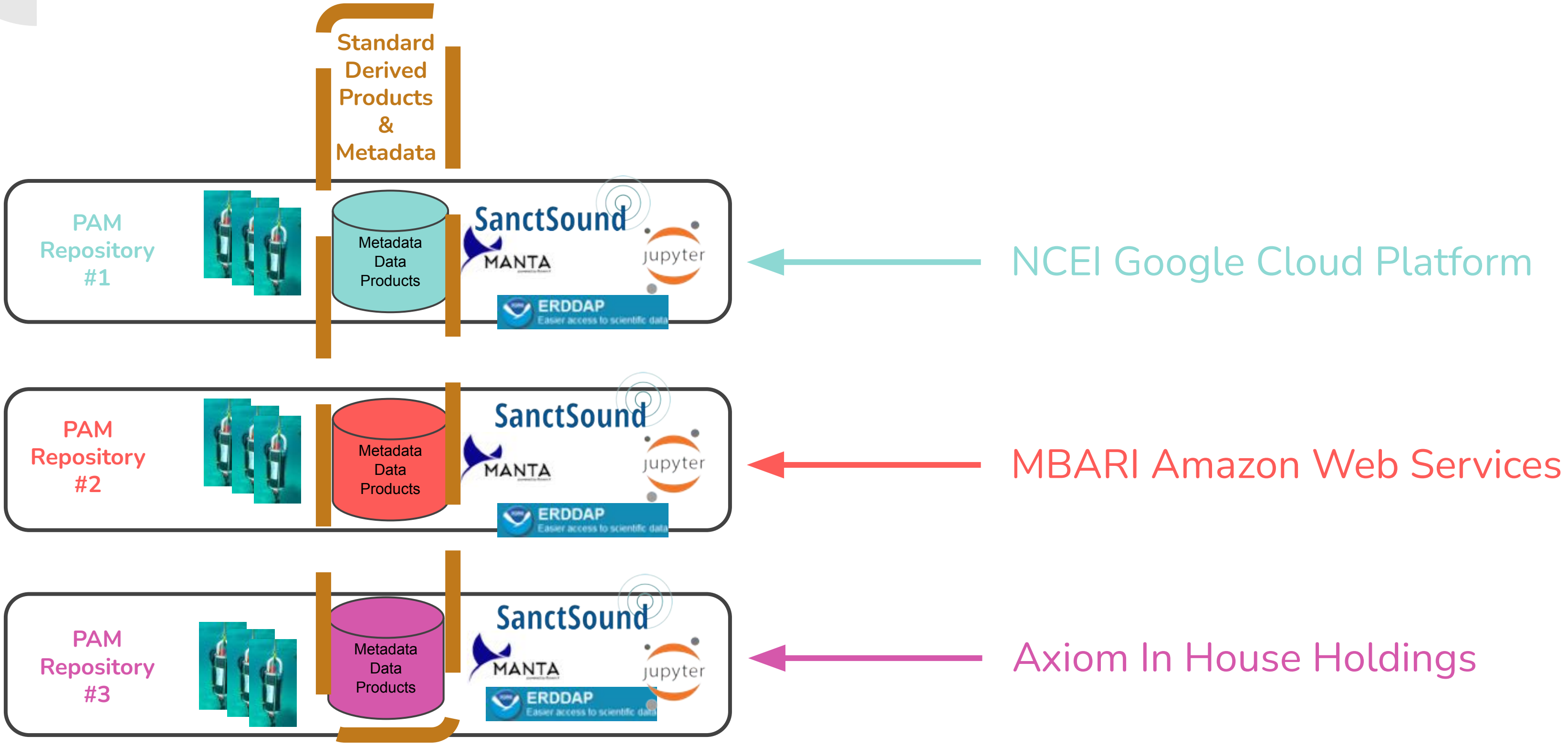
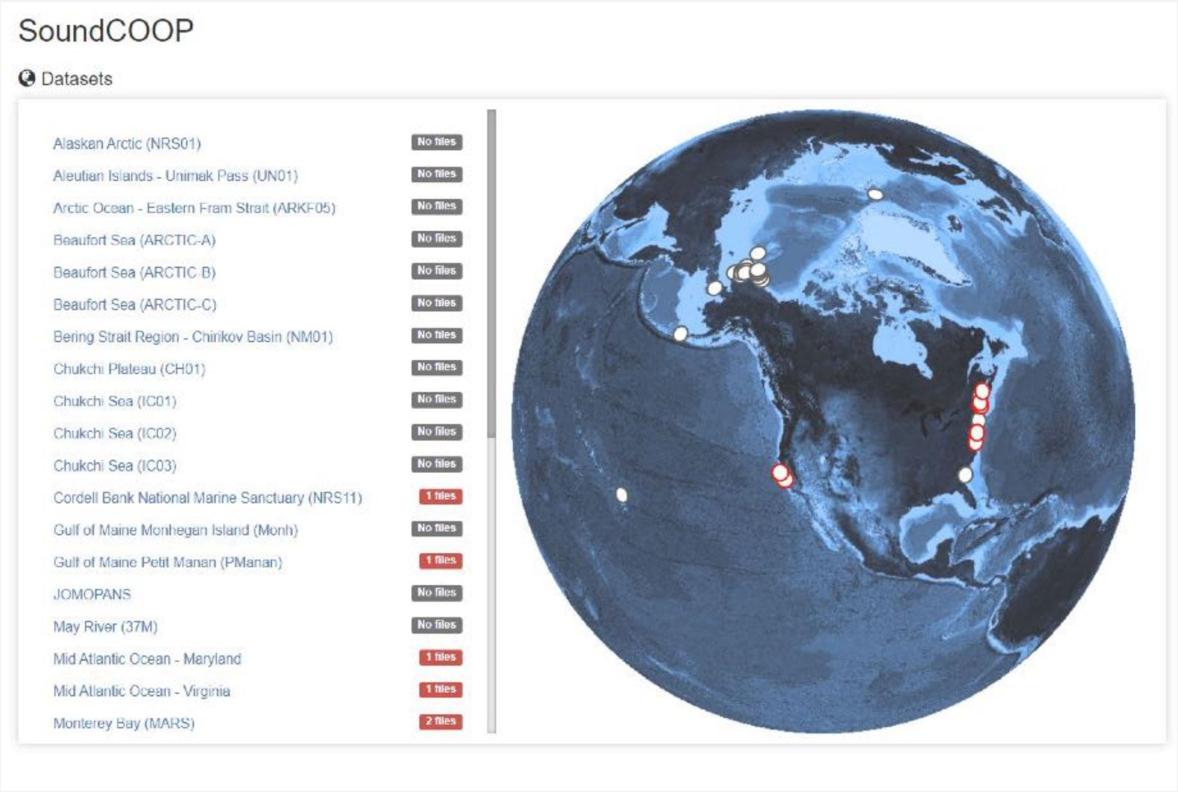


Accessing Repositories of Hybrid Millidecade

- NCEI GCP
    - Hybrid millidecade results from 14 recording sites across 8 separate monitoring efforts processed using **MANTA v9.6.14**
        - Daily files: netCDF
- MBARI AWS
    - Hybrid millidecade results from 1 recording site processed using **pypam 0.2.0**
        - Daily files: netCDF
- Axiom In House
    - **In Progress**: Hybrid millidecade results from 1 recording site using MANTA

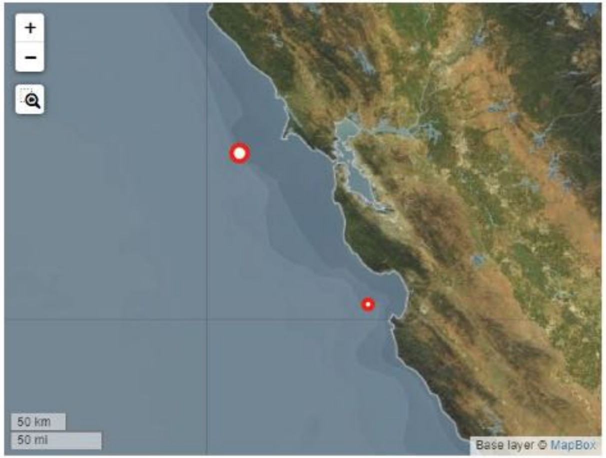
Visualizing Results



SoundCOOP Home Settings Share Help Feedback

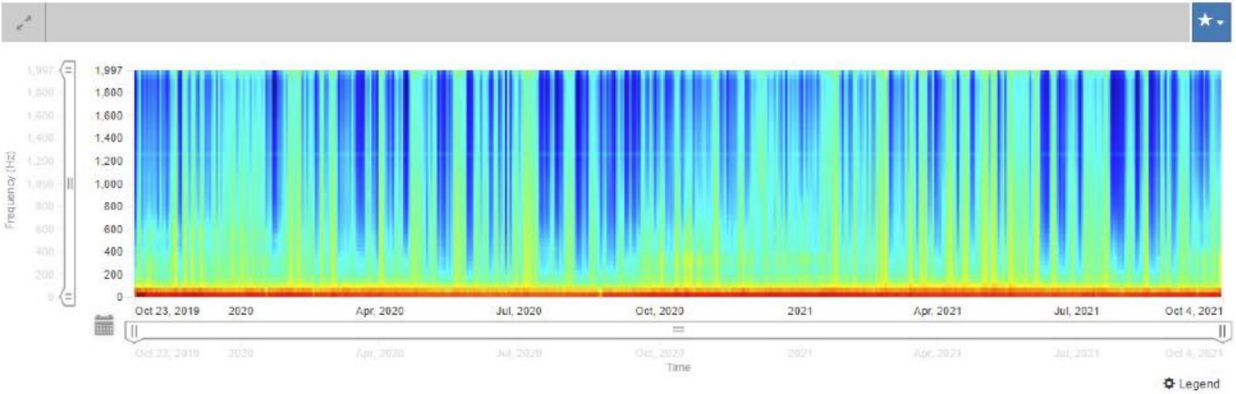
Monterey Bay

Dataset: Cordell Bank National Marine Sanctuary (NRS11)

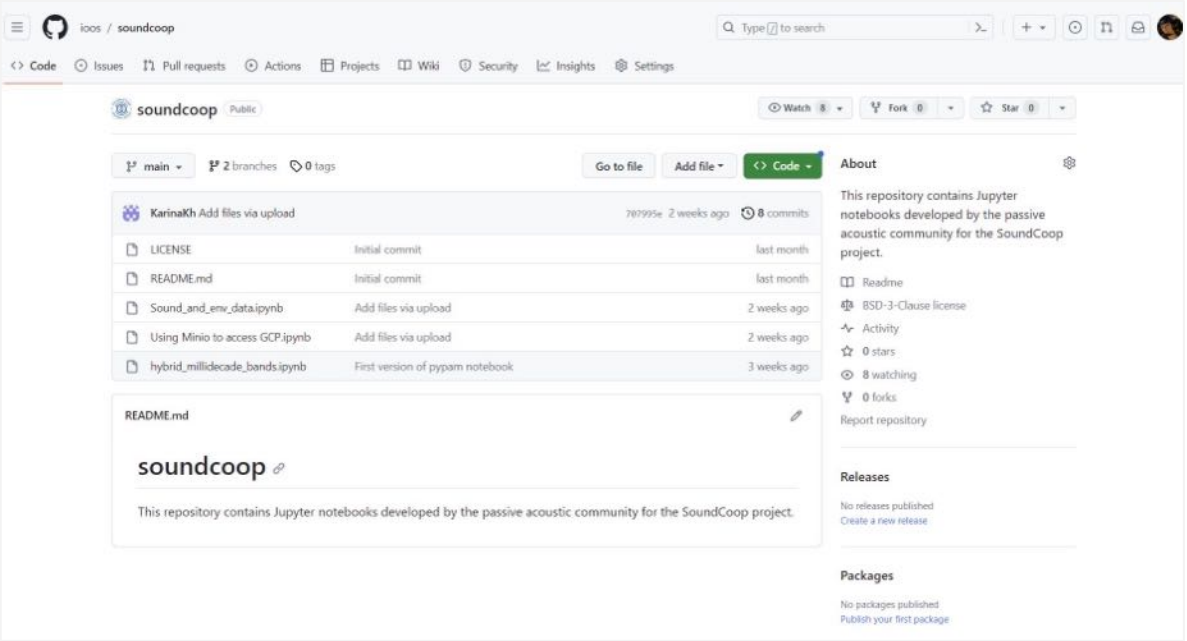


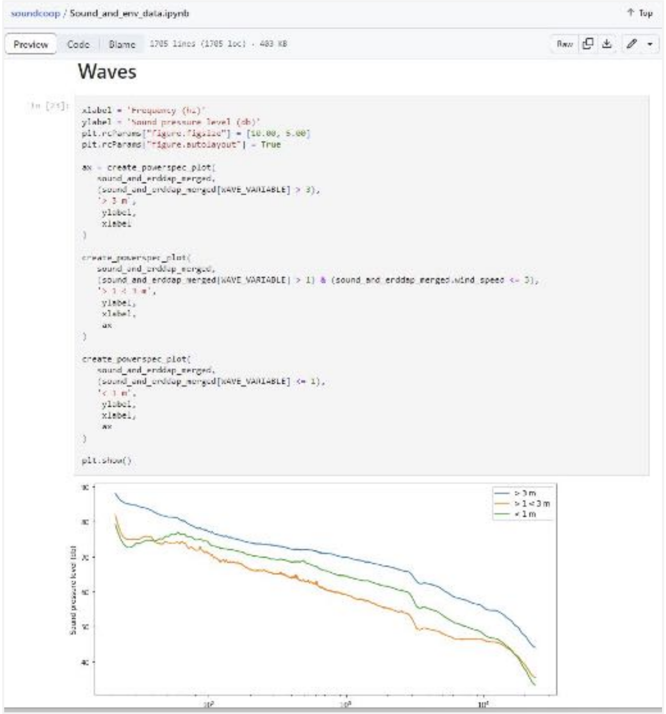
High resolution spectrogram *Cordell Bank National Marine Sanctuary (NRS11)*

Sound pressure spectral density levels per hour at 1 Hz resolution converted to decibels (dB re 1 μPa²/Hz).



Development of Community Tools





Next Steps

- Finalize processing of all SoundCoop datasets
- Develop user environment to pull raw data from different repositories and create standard metrics
- Finalize SoundCoop portal, co-visualize results
- Finalize integration of environmental variables with acoustic data
- Finalize Jupyter notebooks so community to apply the same methods

Thank you!

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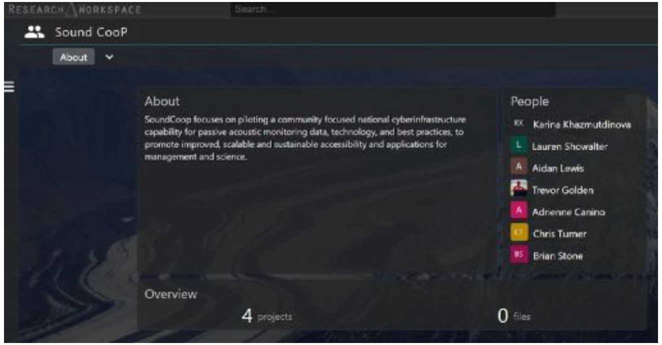
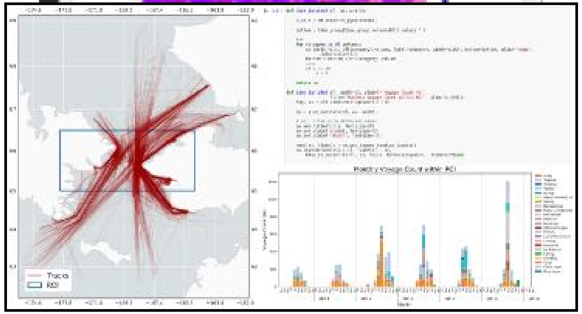
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

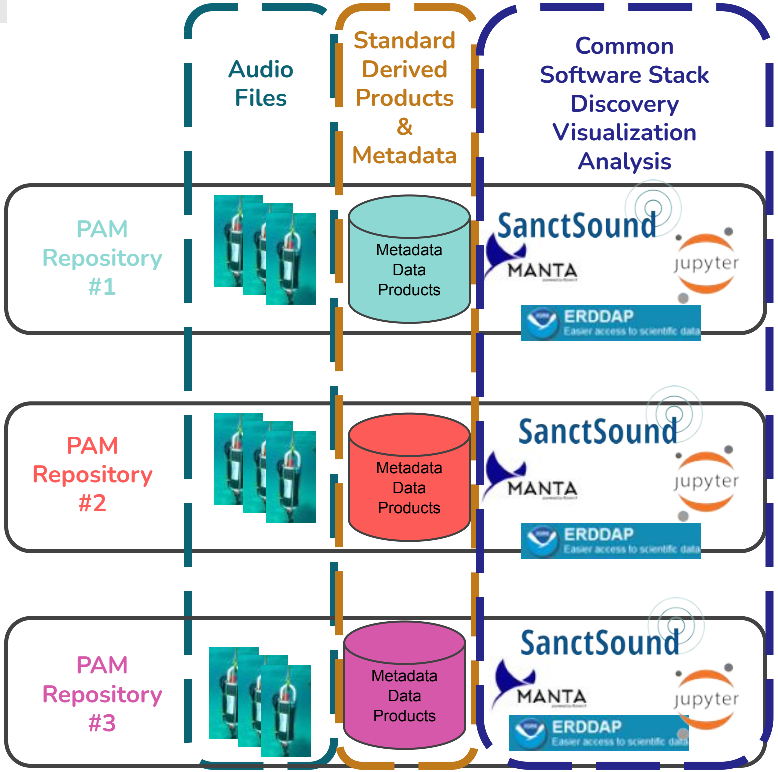
Research Workspace & JupyterHub





Accessing Repositories

PAM Repository #4 will be the ICES database of JOMOPANS decidecade sound levels



NCEI Google Cloud Platform

MBARI Amazon Web Services

Axiom In House Holdings

Sound Level Metrics and this workshop: Balancing objectives

- Nurture the long term objectives:
  - Many fully open source PAM analysis tools that do many things.
    - At least one/a subset that can efficiently derive a common set of metrics from very large datasets collected using different instrumentation (different calibration)and representing long time series.
    - At least one/a subset that can operate in the same environment as other big data analytical routines (e.g., run remotely on large cloud-based repositories)
- Based on what's available now, implement group-determined methods so that we have datasets that can support next integration/visualization steps NLT March 2023:
  - What we are **not** doing: standardizing soundscape metrics for the global community, nor are we developing new code
  - What we **are** doing:
    - Making decisions about what will work for the purposes of having standard datasets to compare for this project and what has the potential to be the most scale-able, so that our examples do their best to move things forward
    - Highlighting important gaps/areas for further investment

Sound Level Metrics and this workshop: Balancing objectives

- ★ Thoughts to keep in mind during this morning's presentation and discussion:
  - Ideally, we move towards everyone using the same, open-source analysis tool for levels. This is not necessary for our workshop participants, but it is necessary for the community. However, we will have to talk about whether the tools are ready for this (it has to be efficient, able to be used across instruments and truly open-source.)
  - Regardless of whether we use the same tool or not (but even more important if we don't) we need to agree on a common metric for this project's comparisons
    - Again, it does not need to be a forever answer, BUT our files need to be a size that is scalable and can be used easily in our additional sharing/visualization steps.
    - Current front-runners from global work are: decidecade/1 sec or 1 min or 1 hr or 1Hz/1 min or 1 hr. SanctSound did geometric means but the lower common denominator across projects is likely to be arithmetic means for time bins.
  - For detectors, Sofie can speak to the lay of the land for deriving comparable L2 detection results for animals like whales across different detector output (PACM). We also did a lot of this work in SanctSound and these will be discussed as baselines moving forward.

Visualization/Portal Capacity: Balancing objectives

- ★ Nurture the long term objectives
  - Regional to global comparisons (spatial)
  - Decades of data (temporal)
  - User interaction, including both:
    - Seeing many, many canned/pre-processed products and being able to zoom in and out of them
    - Generating new visuals based on on-the-fly reprocessing across many, many raw datasets
- ★ Reasonable steps for this project to take in our case studies
  - Implement/build on existing capacities to visualize standard levels and detections across projects
  - Build user interface for existing regional capacity to integrate ocean observing variables including sound-derived products

Visualization/Portal Capacity: Balancing objectives

★ Focus points for our discussion and choices for case study advances:
- We are interested in web enabling long term observational data over large spatial scales (scalability is key)
- We want to keep both technical and non-technical audiences in mind as users (lean towards more quickly interpretable visuals)
- Give premium to visualizations that lend themselves to integration with non-acoustic time series variables over similar scales (large, long), e.g.:
  - Histograms, lines/spectra are the basics
  - Clock plots can show cyclic trends across variables
  - Animations can help

Archive Metadata - Deployment

For whole project

Lead Scientist(s)
Organization
Funding organization
Deployment title
Deployment purpose
Abstract (full description of dataset)
Metadata author/POC

Detectors and other data products

Recorder specs → Pre-deployment setup → Deploy instruments → Retrieve instruments → Data QC → Data packaging → Data submission

Recorder specs

Instrument type
Serial #s
Cal info

Pre-deployment setup

Channel #
- Duty cycle
- Sample rate
- Sample bits
- Gain

Deploy instruments

Platform type
Lat/Lon
Water Depth
Instrument depth
Timestamp (UTC)
Comments
Vessel name
IHO sea area

Retrieve instruments

Lat/Long
Water Depth
Instrument depth
Timestamp (UTC)
Comments
Vessel name
IHO sea area

Data QC

Data Quality
- Frequency
- Time
- Channel
- Methods of review
- Reviewer name

Data packaging

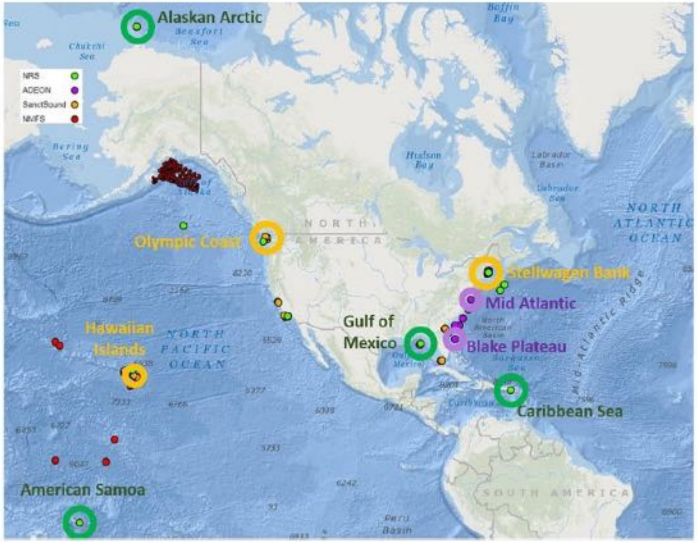
Use NCEI's PassivePacker

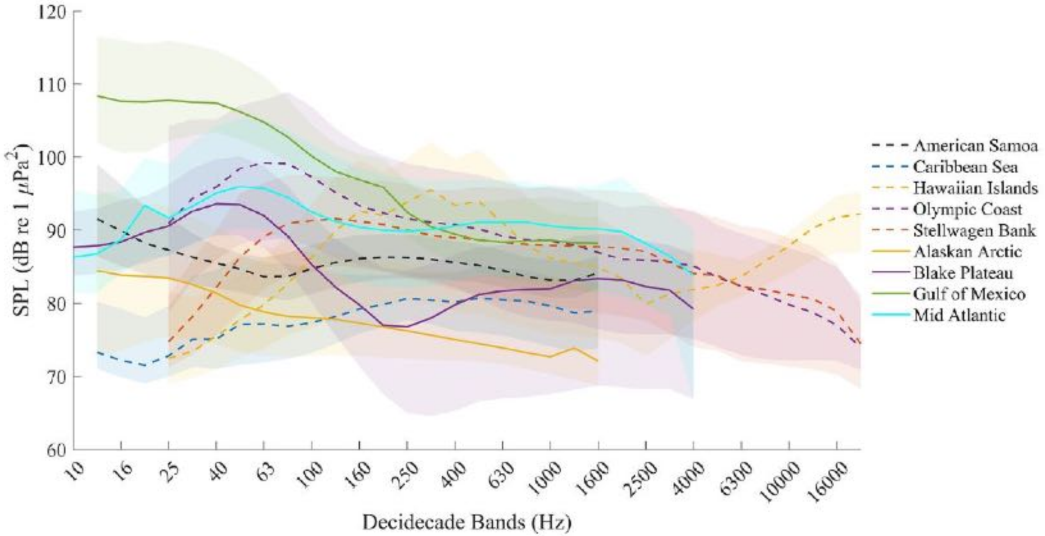
Data submission

Send to NCEI

Navy clearance needed for sites/times of concern prior to packaging and sending data to NCEI

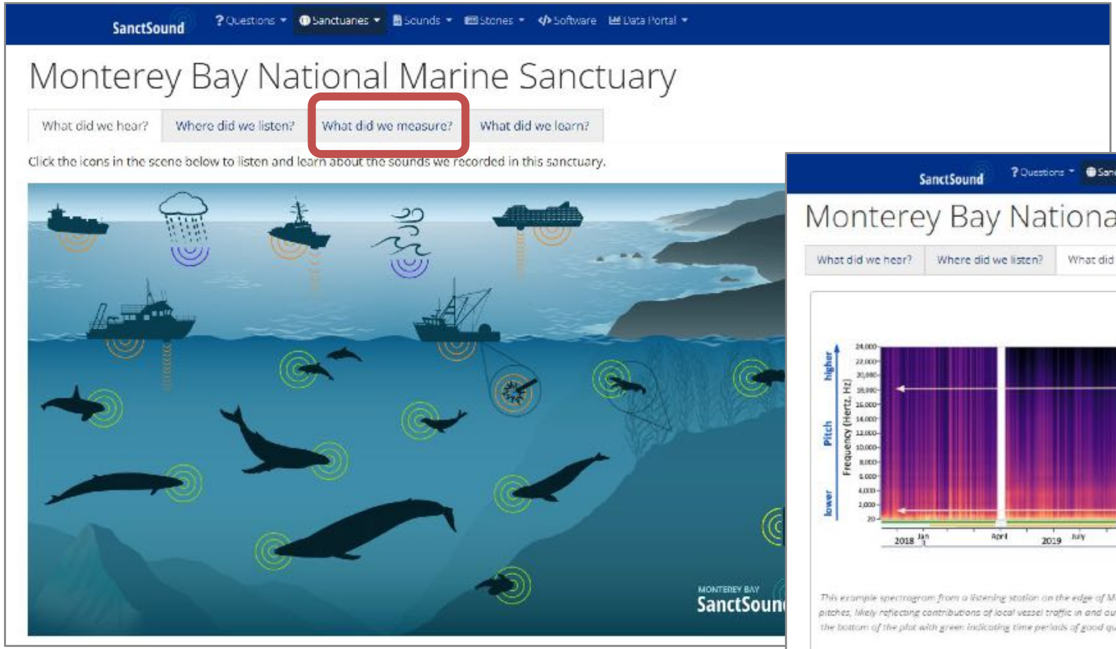
Comparing sound levels across multiple projects … for peer review

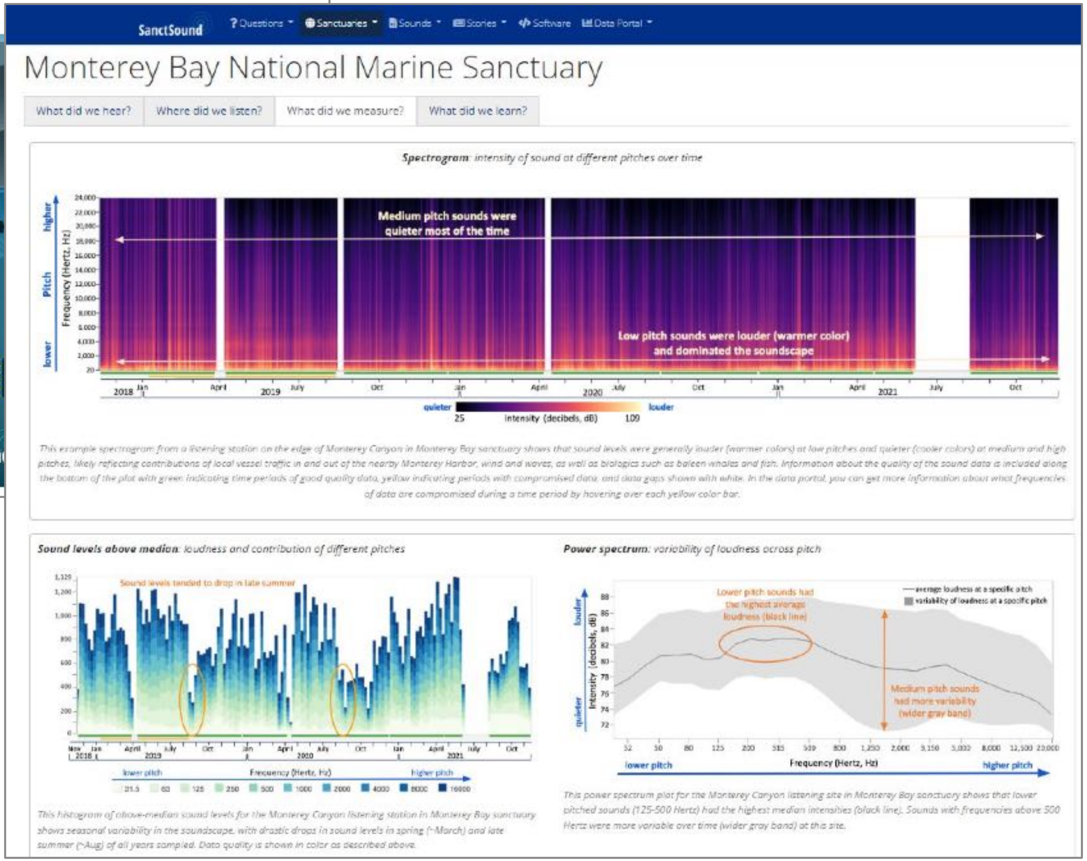




Wall et al., 2021

sanctsound.ioos.us





Leveraging SanctSound's Framework

- ★ Applied standardized processing to extract ambient sound levels and signal detections in large volumes of data, collected across large spatial area over 3 years
- ★ Developed visualization framework to handle a diversity of acoustic detections and sound level metrics
- ★ Established a workflow for data management, in connection with NCEI Passive Acoustic Archive
- ★ **However, SanctSound project is now complete. It's not the only effort to have/currently executing these goals.**

Setting the Stage

GOALS:

- Increase the **longevity** of and **access** to these data (archive)
- Increase the **usability** of these data (documentation, standardization, visualization)
- Increase the **interoperability** of these data with other observations (standardization, documentation, visualization)
- Increase the **interpretability** of these data for natural resource management (method and software development)

PRIORITIES:

- **Scalable solutions** (hundreds of providers: national to international)
- **Efficient solutions** (petabytes of data running on standard fast computer, cloud-based computing)
- **Accessible solutions** (freeware, ideally with user interface that supports lower entry level, cloud-based environments)
- **Standard-compliant solutions** (ISO documentation and supporting maturation and implementation of measurement standards)
- **Ecologically-relevant solutions** (stable derived indicators to detect ecosystem change)

SYNERGIES:

- International Quiet Ocean Experiment and GOOS Sound EOV development
- ISO ambient sound measurement working group
- EU's TG Noise Working Group (Marine Strategy Framework Directive)
- NOAA Center for Artificial Intelligence