

# IRA PASSIVE ACOUSTIC MONITORING STRATEGIC INITIATIVE WORKSHOP REPORT

LA JOLLA, CALIFORNIA

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April 2024

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## CITATION

PAM-SI Meeting Repository

DRAFT

## 1. EXECUTIVE SUMMARY

The NOAA Fisheries Passive Acoustic Monitoring Strategic Initiative (PAM SI) is an Inflation Reduction Act (IRA) funded effort as part of NOAA Fisheries' \$349 million Climate Ready Fisheries initiative to build a dynamically managed fisheries system that accounts for climate change and supports science-based management and conservation. The PAM SI is one of seven Strategic Initiatives within the Essential Data Acquisition and Management component of Climate Ready Fisheries that focuses on development of advanced technologies in support of expanding and modernizing stock assessments, data systems, and infrastructure. In March 2024 the PAM SI team held a three-day workshop to identify specific priority projects that address common barriers and challenges across all PAM programs.

This report provides a brief background and situational context for the needs of the NOAA Fisheries PAM programs and lays out a target action plan to address each priority project identified. These priority projects represent an ambitious, collaborative effort to make transformational progress towards a modern National PAM enterprise that provides valuable scientific information about stock assessments, long-term species trends, and climate impacts on marine ecosystems. Any progress towards these PAM SI projects will provide the critical infrastructure - including human capital, hardware, and software - for continued success and expansion of the applications of PAM to the NOAA Fisheries protected species mission and mandates beyond the lifetime of the IRA funding. This is especially important because some components included here are unfunded.

NOAA Fisheries' PAM programs collect underwater sound recordings of the marine environment. Identification of the sounds produced by protected marine mammal species, fishes, humans, or the environment allows for an understanding of marine soundscapes and provides information on changes in species distribution, behavior and/or density. The technological revolution in PAM over the past decade has allowed both acoustic recorders and analytical approaches to increasingly become an integral part of NOAA Fisheries core science mission. PAM's capacity for creating long term time series makes it an ideal approach for evaluating changes in species stocks, ecosystem interactions, and climate change. There are currently 7 NMFS PAM programs including each NMFS Science Center and the S&T's Ocean Acoustic Program (OAP). The success and advancement of the Fisheries PAM programs also relies on close collaboration with the NOAA National Centers for Environmental Information (NCEI) and the NOAA Office of the National Marine Sanctuaries (ONMS). The transformational value of the PAM SI lies in bringing together representatives from each of these programs to work collaboratively on common high priority infrastructure and analytical needs.

The PAM SI working groups has identified four key objectives: 1) Accelerate Pacific-wide PAM-glider operations; 2) Establishing National PAM Operational and Archival Cloud Storage solutions; 3) Developing a National PAM Decision Support Tool; and 4) Advancing National PAM Analytical and Integration Approaches. Progress towards these objectives will implement transformational activities that will significantly change the way in which we collect, analyze, and make PAM data accessible for answering mission critical questions. Because PAM SI Objectives 1 and 3 are collaborations with the UxS SI and IRA North Atlantic Right Whale projects, respectively, they are not further detailed in this report. More information about those objectives can be found in the [PAM SI Proposal](#).

During the March 2024 workshop, the PAM SI team engaged in a series of eight Round Table Discussions focused on a common barrier or need for all PAM programs, each resulting in one or more priority projects.

Priority projects supporting Objective 2 include:

- a Google Cloud Project to establish national operational cloud storage and processing capabilities; and
- an NCEI archiving project to build a more streamlined archive workflow.

Priority projects supporting Objective 4 include:

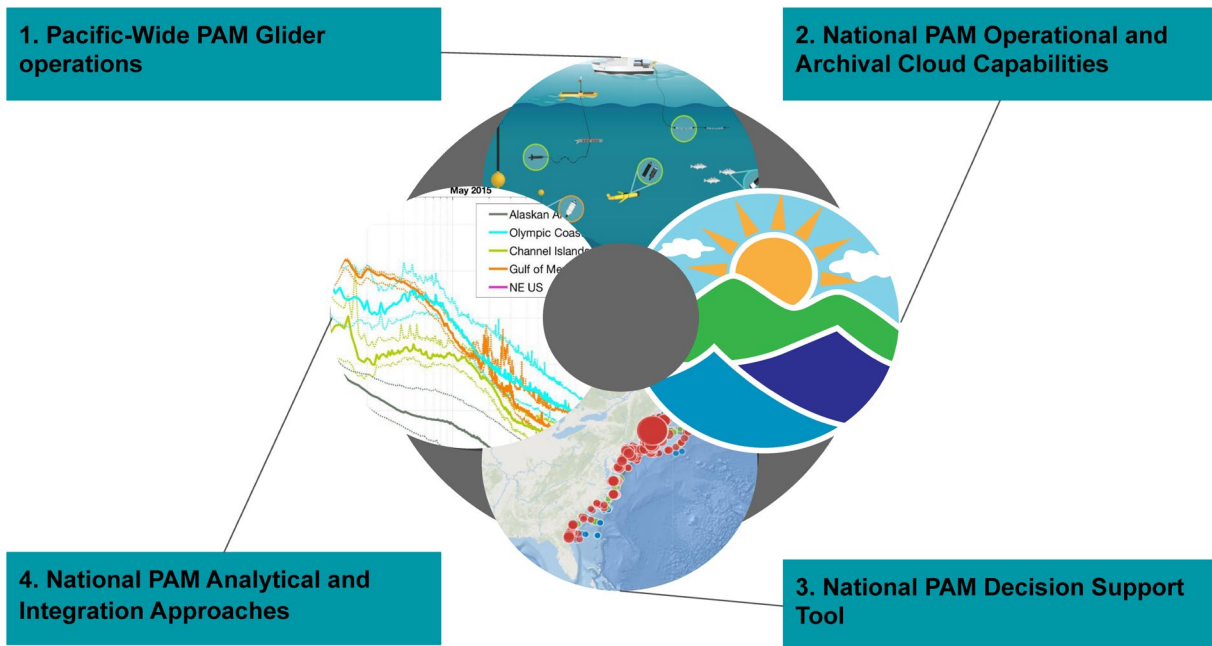
- a pilot project to evaluate long-term trends in nationwide humpback whale spatio-temporal distribution that will develop data integration tools that can be applied to any region or species of interest;
- three project options that would expand the applications of PAM data for stock assessments through density estimation and species distribution models;
- two projects to expand the applications of soundscape metrics and visualizations; and
- multiple projects focused on establishing an open science approach for information sharing to support collaborative analytical approaches across the regions.

Lastly, the PAM SI discussed the target management tools, metrics, and strategies relevant to stock assessments and climate that we strive to achieve through the SI. This report details the expected outcome, project leads, project team, action items, and target timeline for each of these priority projects.

## 2. INTRODUCTION

NMFS' Passive Acoustic Monitoring (PAM) programs focus on collecting underwater sound recordings of the marine environment. Identification of the sounds produced by protected marine mammal species, fishes, or humans allows for an understanding of marine soundscapes. PAM data collection provides information on changes in species distribution, behavior and/or density, in addition to assessing impacts of man-made noise. Exponential growth of the capability of PAM technologies over the past decade has allowed both acoustic recorders and analytical approaches to increasingly become an integral part of NMFS's core science mission. PAM's capacity for creating long term time series makes it an ideal approach for monitoring trends and evaluating changes in species stocks, ecosystem interactions and climate change. There currently are 7 NMFS PAM programs including each NMFS Science Center and the S&T's Ocean Acoustic Program. PAM data can be archival (recorder needs to be recovered at sea before data can be accessed) or real time (data is transmitted via cable or satellite as it is collected). Currently, NMFS PAM programs use all available acoustic platforms from stationary bottom mounted to mobile towed, drifting, or UxS platforms. However, each program varies in the level of technological development and operational capacity. Over the next 4 years we aim to work to resolve the core roadblocks that hold back PAM's ability to be fully operational across NMFS.

The PAM SI projects focus on; 1) establishing a Pacific region glider program to mirror that in the Atlantic, 2) developing National PAM Cloud capabilities to cope with exponential growth in data and processing needs, 3) expand the existing PACM decision support tool to a National level tool, and 4) streamlining analytical and data integration to remove redundancy and increase across program or financial management center (FMC) efficiencies.



The PAM SI Workshop in March 2024 was a three-day gathering to identify synergies and common challenges across NOAA Fisheries passive acoustic research groups and the agency more broadly, as well as to decide priority projects to accomplish during the Strategic Initiative. This workshop was an opportunity for folks from all NOAA Fisheries Regional Science Centers and our partners in the Office of Science and Technology,

Office of National Marine Sanctuaries, and National Centers for Environmental Information to gather together.

The first day of the workshop focused on identifying synergies and getting to know each other and the ongoing passive acoustic research better. Day two was spent in two Round Table Discussion sessions, offering extended periods of time for detailed discussion to identify and define priority projects that address the SI objectives as well as common goals and challenges faced. The workshop culminated with a series of demonstrations of existing PAM tools and a discussion of the target management outcomes and tools of the PAM SI, specifically focused on stock assessments and climate change.



**Workshop participants gathered at the Southwest Fisheries Science Center in La Jolla, CA. Back row (left to right): Kourtney Burger, Candice Emmons, Becca Van Hoeck, Sofie Van Parijs, Shannon Rankin, Carrie Wall, Megan McKenna, Melissa Soldevilla, Genevieve Davis, Yvonne Barkley. Front row: Ludovic Tenorio, Erin Oleson, Catherine Berchok, Jennifer McCullough, Marla Holt, Manolo Castellote, Jason Gedamke, Dan Woodrich, Taiki Sakai, Samara Haver, Annamaria DeAngelis, Ann Allen. Not pictured: Cory Hom Weaver.**



### 3. NATIONAL PAM OPERATIONAL AND ARCHIVAL CLOUD STORAGE SOLUTIONS

#### 3.0.1 TARGET OUTCOME

Developing a National PAM Cloud operational repository for data processing and storage.

#### 3.0.2 PROJECT TEAM

Sofie Van Parijs (NEFSC)

Daniel Woodrich (AFSC)

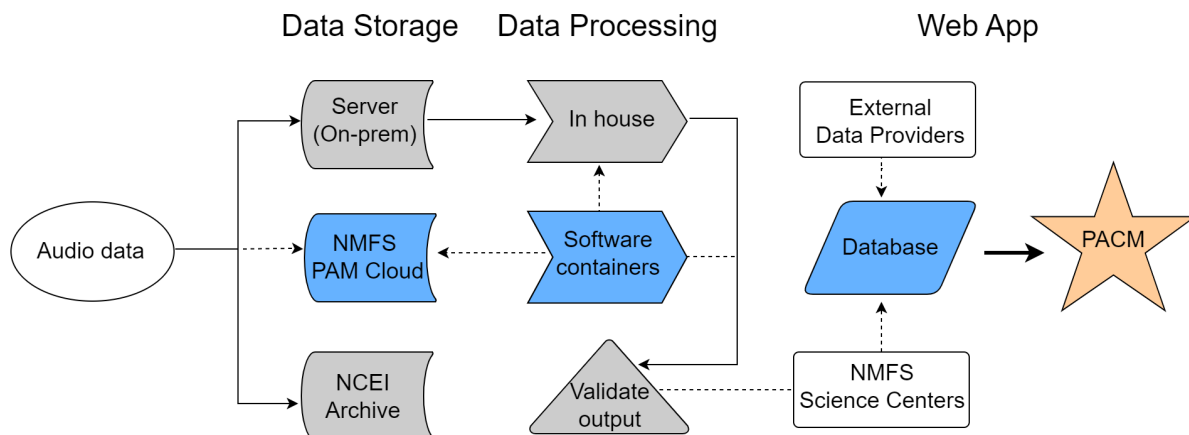
Ann Allen (PIFSC)

Taiki Sakai (SWFSC/NEFSC)

Ludo Tenorio (SEFSC)

#### 3.0.3 SUMMARY

We will work collaboratively with NMFS OCIO to create our Google Cloud Project (GCP) architecture with data buckets for each FMC. We will have a phased approach to testing and growing the project depending on the hurdles, cost models, and successes that we encounter. Once the GCP project is up and running we can have monthly check in calls. This project, along with our National PACM GCP project, fulfills the PAM SI Operational Cloud objective.



**Simplified flow chart of the connection between the cloud storage and Passive Acoustic Cetacean Map cloud projects.**

#### 3.0.4 ACTION ITEMS

1. **Phase 1:** Stand up the GCP project (Dan/NMFS OCIO team). *Deadline: April 2024*
2. **Phase 2:** Design performance evaluation metrics template (PAM SI GCP team). *Deadline: May 2024*
3. **Phase 3:** Upload 1 year-long data set for each of the following science centers: SEFSC, NEFSC, PIFSC, AFSC (Dan w FMC data experts). *Deadline: June 2024*
4. **Phase 4:** Software phase I: Upload and test software that are ready for GCP transfer e.g. Google AI, PyPAM, PamGuard, Raven, INSTINCT (NEFSC IT, Dan, Taiki). *Deadline: June - September 2024*



5. **Phase 5:** FLAC revisit: FLAC data and rerun all detectors for a second time to evaluate differences between non-FLAC data (Dan, Ludo, Taiki). *Deadline: October 2024*
6. **Phase 6:** Evaluate software phase I cost model (Sofie). *Deadline: November 2024*
7. **Phase 7:** Software phase II - revisit other software needs and options, decide on cross PAM group software (web app, validation, metadata integration between PACM and this GCP repository)(Dan, PAM SI + broader team discussion, FMC data experts, Jeff Walker). *Deadline: November 2024 - March 2025.*
8. **Phase 8:** Rerun our evaluation tests from Phase 2 (all). *Deadline: March 2025*
9. **Phase 9:** Evaluate software phase II cost model (Sofie). *Deadline: April 2025*
10. **Phase 10:** Expand PAM data upload, expand to other groups/FMC (Dan w FMC data experts). *Deadline: May - August 2025*
11. **Phase 11:** Group effort to run software through the entire developed data pipeline (Dan w FMC data experts). *Deadline: September 2025 - March 2026.*
12. **Phase 12:** Report out on final established PAM GCP project and cost model (Sofie). *Deadline: April 2026*

## 4. NCEI ARCHIVING

### 4.1 PROJECT 1: NATIONAL PAM ARCHIVAL STORAGE: NCEI ARCHIVING

#### 4.1.1 TARGET OUTCOME

Building efficient workflows to archive large volumes of NMFS PAM data

#### 4.1.2 PROJECT TEAM

Carrie Wall Bell (NCEI) Jason Gedamke (OST)

All Dataset POCs

#### 4.1.3 SUMMARY

The NCEI Passive Acoustic Data (PAD) Archive team will work collaboratively with each NMFS FMC to develop configurable tools that will facilitate FMCs to prepare numerous datasets in a more automated way for archiving at NCEI. This will allow this collective group to meet the PAM SI goal of archiving 900 TB of data in three years (Objective 3) and make significant progress towards meeting NOAA PARR requirements.

#### 4.1.4 ACTION ITEMS

1. **Archive Breakdown:** FMCs are asked to update this [spreadsheet](#) with revised information based on the original table of datasets to archive found in [PAM SI proposal](#) / [slide 12](#). The request is to provide

more details on prioritized datasets, target month(s) for data submission, identify POCs to work with the archive team, and describe how metadata are stored (e.g., spreadsheet, Oracle database).

*Deadline: April, 2024.*

2. **FLAC Check:** Confirm FLAC conversion doesn't alter audio values with Peter Dugan. *Deadline: April, 2024.*
3. **Kourtney's Kode:** Kourtney will share her [Passive Packer process](#) - using [semi automated code](#) to convert [deployment metadata](#) spreadsheet to Passive Packer ready database. *Deadline: April, 2024.*
4. **Metadata Madness:** Meeting with NCEI PAD team, Kourtney, Jeff Walker, and Genevieve Davis to review metadata fields and ensure alignment between NCEI Passive Packer / Kourtney's code / PACM. *Deadline: May, 2024.*
5. **Bracing for the Data Tsunami:** NCEI PAD team assesses data prioritization and metadata information provided by the FMCs (Action 1) and outlines a plan for building the necessary capabilities into Passive Packer and the archive pipeline. *Deadline: June, 2024.*
6. **Call Me Maybe:** Establish bimonthly meetings with NCEI PAD team and POCs to ensure regular communication regarding progress of archive development tasks and FMC dataset preparation. *Deadline: July, 2024.*

List of PAM projects to be provided to NCEI in FY24

FMC	Project/Data Sets	Data Type	Data Size	Data Location
NEFSC	MA-RI Wind Energy Areas (2020 - 2024)	Bottom Mounted	30 TB	Local Server
NEFSC	AMAPPS (NE 2011 - 2021)	Towed Array	24 TB	Local Server
SWFSC	HICEAS (2002)	Towed Array	5 TB	Analog Tape Drives
SWFSC	ADRIFT (2021 - 2023; ~100 datasets)	Drifter	40 TB	Local Server
SWFSC	ADRIFT (2021 - 2023; ~100 datasets)	Soundscape metrics	2.5 TB	Local Server
SWFSC	CCES (2018; ~20 datasets)	Drifter	20 TB	Local Server
SWFSC	CCES (2018; ~20 datasets)	Soundscape metrics	<1 TB	Local Server
SWFSC	PASCAL (~30 datasets)	Drifter	30 TB	Local Server
SWFSC	PASCAL (~30 datasets)	Soundscape metrics	1 TB	Local Server
PIFSC	PIPAN (2005 - 2021)	Bottom Mounted	50 TB	Local Server
AFSC	Altima - AURALS (2022 - 2023)	Bottom Mounted	4 TB	Local NAS
SEFSC	AMAPPS SE (2011 - 2021)	Towed Array	TBD	Local Server

List of PAM projects to be provided to NCEI in FY25.

FMC	Project/Data Sets	Data Type	Data Size	Data Location
NEFSC	Migratory Corridor 2.0 MARUs (2015 - 2018)	Bottom Mounted	20 TB	Local Server
AFSC	Altimar - AURALS (2020 - 2022)	Bottom Mounted	8 TB	Local Server
PIFSC	PIPAN (2005 - 2021)	Bottom Mounted	50 TB	Local Server
AFSC	Altimar - AURALS (2018 - 2020)	Bottom Mounted	11 TB	Local Server
NEFSC	Inshore GOM (2020 - 2024)	Bottom Mounted	60 TB	Local Server
AFSC	Altimar - AURALS (2016 - 2018)	Bottom Mounted	10 TB	Local Server
PIFSC	PIPAN (2005 - 2021)	Bottom Mounted	50 TB	Local Server
NEFSC	HARPs Shelfbreak (2015 - 2019; 2kHz)	Bottom Mounted	TBD	Local Server
NEFSC	HARPs Shelfbreak (2015 - 2019; 200kHz)	Bottom Mounted	50 TB	External Drives
AFSC	Altimar - AURALS (2013 - 2016)	Bottom Mounted	18 TB	Local Server
NWFSC	PNW coastal recorder PAL/EAR (2006 - 2011)	Bottom Mounted	10 TB	External Drives
NWFSC	PODS Cruise (2006 - 2016)	Towed Array	5 TB	Local Server
SEFSC	Rice's Whale Vessel Surveys	Sonobuoy	3 TB	External Drives
SWFSC	PacMAPPS - West Coast	Drifter	TBD	Local Server
SWFSC	PacMAPPS - West Coast	Glider	TBD	Local Server

List of PAM Projects to be provided to NCEI in FY26.

FMC	Project/Data Sets	Data Type	Data Size	Data Location
NEFSC	USTR Offshore GOM (2022+)	Bottom Mounted	41 TB	Local Server
NEFSC	HARPs Shelfbreak (2015 - 2019, 200kHz)	Bottom Mounted	50 TB	External Drives
AFSC	Altimar - AURALS (2010 - 2013)	Bottom Mounted	15 TB	Local Server
NEFSC	Mid-Atlantic WEAs STs (2022+)	Bottom Mounted	19 TB	Local Server
NEFSC	HARPs Shelfbreak (2015 - 2019, 200kHz)	Bottom Mounted	50 TB	External Drives
AFSC	Altimar - AURALS (2007-2010)	Bottom Mounted	3 TB	Local Server
PIFSC	PIPAN (2005 - 2021)	Bottom Mounted	50 TB	Local Server
NEFSC	HARPs Shelfbreak (2015 - 2019, 200kHz)	Bottom Mounted	50 TB	External Drives
NWFSC	Salish Sea SoundTraps (2023 - 2024)	Bottom Mounted	2 TB	External Drives
OAP	Noise Reference Stations (2014 - 2025+)	Bottom Mounted	30 TB	Local Server
AFSC	Altimar - non-AURALS (2007+)	Bottom Mounted	TBD	Local Server
NWFSC	PNW EAR (2011 - 2022)	Bottom Mounted	10 TB	External Drives

FMC	Project/Data Sets	Data Type	Data Size	Data Location
NWFSC	Salish Sea Duty Cycled (2020 - 2022)	Bottom Mounted	20 TB	External Drives
PIFSC	PacMAPPS - Pacific Islands (2017 - 2023)	Drifter	25 TB	Local Server
PIFSC	PIPAN (2005 - 2021)	Bottom Mounted	50 TB	Local Server
SEFSC	Rice's whale moorings	Bottom Mounted	100 TB	Local Server
NWFSC	Outer Coast (Huff)	Bottom Mounted	30 TB	TBD

## 4.2 PROJECT 2: NATIVE TO FLAC CONVERSION

Storing and processing audio data as FLAC files, a lossless compression format for audio data, saves substantial storage space and processing time. Fully integrating FLAC files into the PAM processing and storage workflow would require additional investment beyond the current PAM SI funding to develop software to convert from native to FLAC and ensure that common processing softwares accept FLAC formats. The PAM SI team will leverage existing effort to make progress towards this project as possible, but it is currently unfunded.

### 4.2.1 TARGET OUTCOME

A more time-efficient workflow that omits steps in the file conversion process prior to archiving.

### 4.2.2 PROJECT TEAM

Not Yet Defined

### 4.2.3 SUMMARY

The goal of this effort will be to eliminate the time-consuming step of converting native audio files into wav and then into FLAC by creating a workflow that directly converts native files into a FLAC format. It will also make progress on ensuring FLAC files will be accepted inputs from some of the most commonly used processing software.

### 4.2.4 ACTION ITEMS

1. **Convert to FLAC:** Develop processing pipeline to save native data formats to FLAC. This will include three sub tasks:
  1. Establish a list of what the native file formats are that we want to evaluate going from native to FLAC. *Deadline: May, 2024*
  2. Determine the level of effort to convert the formats listed in subtask 1 to FLAC and who will complete that work. *Deadline: September, 2024*
  3. Create processing code to convert identified native file types to FLAC. *Deadline: Fall 2025*
2. **Process FLAC:** Update common analysis software to read FLAC. This will include three sub tasks:

1. Establish a list of standard software to develop this capacity. *Deadline: May, 2024.*
2. Determine what is needed to adjust the software list in subtask 1 to input FLAC files. *Deadline: September, 2024.*
3. Issue contract to complete the work identified in subtask 2. *Deadline: Spring 2025*

## 5. PAM DATA INTEGRATION FOR CLIMATE AND LONG-TERM DATA TRENDS

### 5.0.1 TARGET OUTCOME

To advance data integration in support of creating tools for climate change applications with PAM data and to develop new tools for integration of PAM and environmental data to support climate change investigations.

### 5.0.2 PROJECT TEAM

Genevieve Davis (NEFSC)	Catherine Berchok (AFSC)	
Candice Emmons (NWFSC)	Ann Allen (PIFSC)	Melissa Soldevilla (SEFSC)
Manolo Castellote (AFSC)	Shannon Rankin (SWFSC)	Samara Haver (PMEL)
Taiki Sakai (SWFSC/NEFSC)	Jeff Walker (NEFSC)	

### 5.0.3 SUMMARY

We will create a streamlined workflow to integrate PAM data with necessary ancillary datasets to address questions relevant to climate change and long-term species trends. This workflow will include: identifying PAM data to be included; identifying the climatological data to be included; creating tools for accessing, formatting, and integrating a subset of these data streams; and using these tools and approaches broadly across all regions and species of interest. The first goal of this project is to compare humpback whale occurrence trends nationwide. All regions will submit and format their humpback detection data into the Passive Acoustic Cetacean Map database. The second goal will be to identify and create tools to access and apply relevant climate data on the humpback whale dataset. This workflow will allow for a national comparison of one species to be able to identify and compare changes (or lack thereof) within and across regions. Once this structure has been established, these standardized data formats, tools, and environmental data streams can be applied across the range of project goals and regional needs, including regional-specific high-profile species. This project directly supports the PAM SI objective to advance PAM data analysis and integration approaches with an emphasis on addressing long-term trends.

### 5.0.4 ACTION ITEMS

1. **Data Identification:** Identify existing humpback detection data sets to be included. *Deadline: May, 2024*
2. **Environmental data identification:** Identify environmental data (i.e. parameters, spatio-temporal range, source) to integrate with daily PACM output. *Deadline: May, 2024.*

3. **Format data to PACM:** Get humpback detection data formatted and submitted into PACM, on an hourly or daily scale. This phase includes meetings, as-needed tutorials, consultation with Jeff Walker, as well as identifying and developing the tools needed. *Deadline: December, 2024.*
4. **Access and aggregate detection data from PACM:** Pull humpback detection data from PACM in standardized format aggregated at daily scale. This phase includes meetings, tutorials, identifying and developing tools as needed. *Deadline: January, 2025.*
5. **Develop and refine workflow:** Develop and refine processing workflow that extracts identified environmental data from various sources and integrates with daily PACM outputs. Includes creating open-source / github hosted repo that is tested and implemented across FMCs (Taiki). *Deadline: May, 2025.*
6. **Identify additional data:** Identify which additional data (regional-specific or other species-specific data) we'd want tools for to help predict movements and move towards addressing climate-related questions. *Deadline: May, 2026.*
7. **Output products:** Identify and draft collaborative questions, papers, products to compare across FMC's and regions. *Deadline: July, 2026.*
8. **Aspirational next steps:** Explore methods for incorporating additional PAM data into workflow from other platforms (mobile or drifting data) or from AI tools for species detection, as available. *Deadline: August, 2026.*

## 6. PAM DATA INTEGRATION FOR STOCK ASSESSMENTS

This section details three priority project options identified during the workshop that address data integration needs to support marine mammal stock assessments. As of May 2024, only one project was able to be selected for funding (Project 1: Incorporating glider data in a species distribution modeling framework). The other two projects are detailed here as they were proposed to capture the interest and need for additional investment to integrate PAM data into stock assessment relevant data products.

### 6.1 PROJECT 1: INCORPORATING GLIDER DATA IN A SPECIES DISTRIBUTION MODELING FRAMEWORK

#### 6.1.1 TARGET OUTCOME

Advancing the accuracy of stock assessments to capture seasonal and long-term changes in distribution using PAM glider datasets.

#### 6.1.2 PROJECT TEAM

Yvonne Barkey (PIFSC)	Janelle Badger (PIFSC)	
Shannon Rankin (SWFSC)	Selene Fregosi (PIFSC)	Yvonne Barkley (PIFSC)
Erin Oleson (PIFSC)	Other FMC representatives TBD	

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### 6.1.3 SUMMARY

This project would develop the analytical framework necessary to integrate PAM data from profiling gliders into quantitative assessments of population distribution and density. The PAM and UxS SIs are heavily investing in the testing and development of PAM-equipped gliders and this effort would ensure that those developments are more quickly leveraged to improve cetacean assessments. This project would focus on developing a statistical framework for integrating a density model created with PAM glider data with existing visual-based species distribution models (SDM) to achieve more accurate ensemble models with seasonal context. This project may leverage an OPR Climate IRA proposal by Badger & Whitney, if funded.

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### 6.1.4 ACTION ITEMS

1. **Evaluate resources required:** Evaluate required funding depending on other proposals and staffing. Deadline: May 2024
2. **Confer with PAM SI Working Group:** Working Group determines whether there is substantial interest and priority for continued pursuit of this project. If no-go, determine whether the project may be re-evaluated later based on funds available. Deadline: May 2024  
  
Note: In May 2024, the PAM SI Working Group determined that this project had the highest interest and feasibility on the timeframe of the SI. As such it has been selected for funding.
3. **Evaluate state of the science:** Connect with Center for Research into Ecological and Environmental Modelling, Duke, and other colleagues to assess the state of the science. *Deadline: May 2024*
4. **Identify datasets and species:** Collect and collate PIFSC, SEFSC, and SWFSC PAM glider data and identify priority species for modeling based on data availability and management needs. *Deadline: August 2024*
5. **Assess analytical next steps:** Establish a working group to assess suitable modeling frameworks that fit PAM glider data. Additionally, the PAM SI could convene a workshop or series of workshops that assess the state of the science for incorporating PAM data into species distribution model frameworks in support of this project. *Deadline: February 2025*

## 6.2 PROJECT OPTION 2: INCORPORATING STATIONARY DATA INTO A SPECIES DISTRIBUTION MODELING FRAMEWORK

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### 6.2.1 TARGET OUTCOME

Integrating long-term PAM data into species density models to provide seasonal and long-term changes in distribution and density.

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### 6.2.2 PROJECT TEAM

Lance Garrison (SEFSC)

Melissa Soldevilla (SEFSC)

Manolo Castellote (AFSC)

Ann Allen (PIFSC)

Marla Holt (NWFSC)

Genevieve Davis (NEFSC)

Jason Gedamke (OST)



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### 6.2.3 SUMMARY

This project would support the PAM SI objective of advancing data integration by leveraging stationary PAM data and visual data to improve the accuracy of stock assessments by capturing seasonal and long-term changes. This project would focus on developing a statistical framework for integrating a density model created with stationary PAM data with existing visual-based SDMs to achieve more accurate models with seasonal context. This project may leverage LISTEN GoMex funding to develop models for sperm whales and beaked whales.

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### 6.2.4 ACTION ITEMS

1. **Establish collaboration:** Meet with Lance Garrison to identify his interest and willingness to convene a working group to support his ongoing effort and work towards broader applicability of the outcomes. *Deadline: April 2024*
2. **Identify resources required:** Evaluate whether LISTEN GoMex requires more resources to make these methods broadly applicable. *Deadline: April 2024*
3. **Confer with PAM SI Working Group:** Working Group determines whether there is substantial interest and priority for continued pursuit of this project. If no-go, determine whether the project may be re-evaluated later based on funds available. *Deadline: May 2024*

Note: As of May 2024, this project was not selected for funding by the PAM SI Working Group. However, given the synergies between integrating stationary PAM data and mobile PAM data, the SI will leverage any PAM data integration workshops held to assess the state of the science for integrating both data types into species distribution modeling framework. This will advance our analytical readiness to pursue this project at a later time.

4. **Establish project team:** Establish working group, potentially including colleagues from Duke University, Fisheries and Oceans Canada, etc., to meet periodically with the LISTEN GoMex team to ensure broad regional relevance. *Deadline: May 2024*
5. **Expand capacity:** If funded, advertise post-doc position to support this effort. Alternatively, the PAM SI could convene a workshop or series of workshops that assess the state of the science for incorporating PAM data into species distribution model frameworks in conjunction with Project 1. *Deadline: September 2024*

## 6.3 PROJECT OPTION 3: IMPROVING SPERM WHALE AND BEAKED WHALE DENSITY ESTIMATION FROM TOWED ARRAYS

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### 6.3.1 TARGET OUTCOME

Expanding the utility of an existing automated tracking and localization tool to facilitate distance sampling-based density estimation from towed array surveys for sperm and beaked whales.

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### 6.3.2 PROJECT TEAM

Yvonne Barkey (PIFSC)

Melissa Soldevilla (SEFSC)

Annamaria DeAngelis (NEFSC)

Jennifer McCullough (PIFSC)

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### 6.3.3 SUMMARY

Towed hydrophone arrays are a standard part of NMFS line-transect surveys. Oftentimes acoustic detection of species far out-numbers visual detections, such that inclusion of acoustically detected groups could increase the precision and accuracy of density analyses and improve stock assessments. PIFSC has developed an automated multi-target tracking tool for identification, tracking, and localization of false killer whale subgroups that can be adapted for use with other species. Current methods for density estimation using towed array acoustic detections of sperm whales and beaked whales are time-consuming and use of automated tracking and localization tools would increase efficiency and therefore utility of these datasets to improve the stock assessments for these species. This project will improve functionality of the existing multi-target tracking tool that is used by PIFSC to extract perpendicular distance information from data to support density and abundance estimation. Work will include testing, modifying, and validating the tool on sperm whale and beaked whale datasets from multiple regions (NEFSC, SEFSC). The outcome of this project would support the PAM SI objective of data integration to support stock assessments by advancing the technology readiness of PAM inclusion in Stock Assessment Reports in multiple NOAA Fisheries regions.

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### 6.3.4 ACTION ITEMS

1. **Identify challenges:** Yvonne and Jen work with Pina Gruden to understand what modifications to the current code are necessary for use for sperm whales and beaked whales, providing an estimate of the expected investment required to adapt the tool. *Deadline: April 2024*
2. **Confer with PAM SI Working Group:** Working Group determines whether there is substantial interest and priority for continued pursuit of this project. If no-go, determine whether the project may be re-evaluated later based on funds available.

Note: As of May 2024, this project was not selected for funding based on the outcomes of the consultation with the tool developer, Pina Gruden. Specifically, the time and amount of resources required are beyond the scope of the PAM SI.

3. **Prepare test datasets:** Gather test datasets from NE/SE/PI. *Deadline: May 2024*
4. **Training on Multi-target tracking tool:** Yvonne and Pina will train others on executing the tool in MATLAB. *Deadline: August 2024.*
5. **Test cases:** Basic assessment of the tool on NE and SE datasets to identify bugs. *Deadline: December 2024*
6. **Resolve bugs:** Pina or others address usability needs of all users. *Deadline: July 2025*
7. **Aspirational step to improve tool:** If time and capacity allows, consider attempting to integrate depth estimation for more accurate horizontal distance estimation for deep divers based on Yvonne/Annamaria's work. *Deadline: July 2026.*

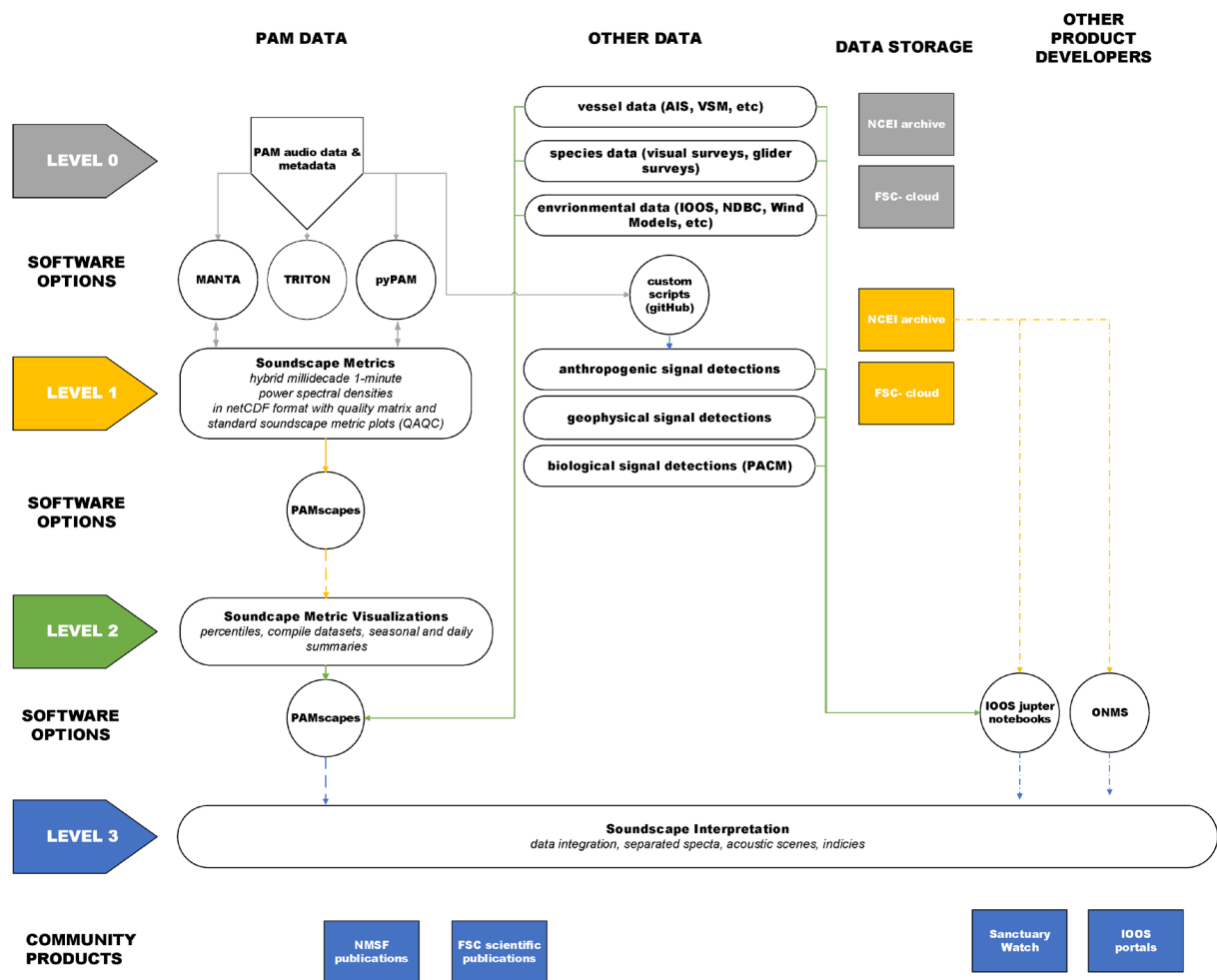
## 7. PAM DATA INTEGRATION FOR SOUNDSCAPE ANALYSES, METRICS, AND TOOLS

### 7.1 PROJECT 1: SOUNDSCAPE METRIC PROCESSING AND ARCHIVING

#### 7.1.1 TARGET OUTCOME

Identify, archive, and process soundscape metrics for priority SI PAM datasets to build capacity and consistency across programs.

#### Processing Pathways for PAM Soundscape Analysis *data/metadata, storage, software, data products, and sharing*



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### 7.1.2 PROJECT TEAM

Samara Haver (PMEL)

Megan McKenna (ONMS)

Melissa Soldevilla (SEFSC)

Karli Merkens (PIFSC)

Marla Holt (NWFSC)

Carrie Wall Bell (NCEI)

Becca Van Hoeck (NEFSC)

Catherine Berchok (AFSC)

Dan Woodrich (AFSC)

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### 7.1.3 SUMMARY

This project will add soundscape metrics for priority PAM SI datasets alongside audio files and other metrics to the NCEI Passive Acoustics archive. The soundscape metrics will be used to develop and demonstrate soundscape interpretation and visualization tools being developed as part of the SI. The datasets will also facilitate comparison of data sampled by multiple recording technologies and projects that are unique to select FMCs. A technical guide for processing and archiving PAM data will also be prepared as part of this project. This project will work with PAM SI cloud computing projects to operationalize soundscape metric processing software in the cloud environment. Streamlining and documenting methods to process and archive soundscape metrics supports PAM SI objectives to advance PAM data analysis and integration approaches, and advance archival cloud capabilities.

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### 7.1.4 ACTION ITEMS

1. **Convene working group:** Establish data processing group, [Google doc folder](#), regular check-in schedule. *Deadline: March 2024.*
2. **Identify priority datasets:** In coordination with Carrie Wall Bell and NCEI Archiving group decide on soundscape priority datasets for each FMC and flag in the overall PAM SI priority [dataset table](#). *Deadline: April 2024.*
3. **Prepare analyses:** For priority soundscape datasets: Prepare metadata, share QA/QC protocol/tools, prepare and submit audio data and soundscape metrics (if already processed locally) to NCEI for archiving. *Deadline: April 2024 - December 2024.*
4. **Test in pyPAM:** Coordinate with PAM SI Cloud team to test pyPAM cloud processing from NCEI GCP on priority NRS audio data sets. *Deadline: June 2024 (pending pyPAM software development).*
5. **Establish software standards:** Identify standard software options available for use and test Noise Reference Station (NRS) dataset results from multiple software outputs. *Deadline: May 2024 (MANTA, PyPAM), any other by Sept 2024.*
6. **Compare soundscape software options:** Provide soundscape software options available (MANTA, pyPAM, updated Triton toolbox, etc.) with comparison documentation for example datasets (NRS or others if necessary). *Deadline: December 2024.*
7. **Generate Hybrid Milli-Decade (HMD) output:** FMCs will conduct HMD processing either locally or through the PAM SI Cloud computing and save to NCEI or internal PAM SI cloud environment. *Deadline: Jan 2025 - March 2025.*
8. **NCEI archive data products:** All HMD outputs will be processed and sent to NCEI archive for level 2-3 data products. *Deadline: April 2025.*

9. **Facilitate more complex soundscape analyses:** All priority soundscape datasets and HMD level 1 products will be cloud archived at NCEI for use in the Soundscape interpretation and visualization project. *Deadline: May 2025.*
10. **Create supporting documents:** Develop technical reports and tutorial videos for HMD metric processing, minimum QA/QC, and visualization routines developed in coordination with SoundCoop efforts, and PyPAM and PAMscapes software development efforts. *Deadline: December 2025.*
11. **Support comparison across platforms:** Comparison of soundscape metric results from simultaneously co-deployed platforms; develop tools to support this type of comparison (ie. PAMscapes). The data processing groups will establish methods for comparison, ongoing opportunistic evaluation will occur throughout the SI, and results will be added to the GitHub Soundscape Group and reported with example datasets. For SoundTrap comparisons, SoundTrap models will be specified at the time of comparison. *Deadline: Dependent on data availability and participation.*

<b>Lead</b>	<b>Platform 1</b>	<b>Platform 2</b>
Catherine Berchok	AURAL	SoundTrap
Melissa Soldevilla	HARP	SoundTrap
Marla Holt	EAR	SoundTrap
Jason Gedamke/Samara Haver	Haruphone	SoundTrap

12. **Support comparison across datasets with known differences:** Develop a format or tool to support comparison of datasets with known differences, such as perfect timing (MARS), dropped time (SoundTrap), duty cycled (AKFSC, NWFSC), frequency-dependent calibration (NRS, HARP), file format (XWAV). *Deadline: Dependent on participation*

## 7.2 PROJECT 2: SOUNDSCAPE METRIC INTERPRETATION AND VISUALIZATION

### 7.2.1 TARGET OUTCOME

Create a set of soundscape metric interpretation open-source processing pathways and visualizations for cross-FMCs comparisons and FMCs-specific soundscape priorities.

### 7.2.2 PROJECT TEAM

Samara Haver (PMEL)	Megan McKenna (ONMS)	
Becca Van Hoeck (NEFSC)	Marla Holt (NWFSC)	Catherine Berchok (AFSC)
Melissa Soldevilla (SEFSC)	Carrie Wall Bell (NCEI)	Dan Woodrich (AFSC)
Karli Merkens (PIFSC)	Genevieve Davis (NEFSC)	Sofie Van Parijs (NEFSC)
Jason Gedamke (OST)		

### 7.2.3 SUMMARY

This project will build on existing tools in PAMscapes (R/CRAN) to create and document processing pathways for soundscape metric interpretation. NOAA Noise Reference Station soundscape metrics will be used to build the pathways and evaluate outputs. Additional soundscape metrics from PAM SI priority data sets will be

incorporated based on availability from priority project #1 for soundscapes. This priority supports PAM SI objective #2 by creating decision-support tools that are relevant at regional and national scales. It also supports #4 by integrating PAM data with variables to provide context for different soundscapes (environmental data, species-detections, etc).

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#### 7.2.4 ACTION ITEMS

1. **Establish working group:** Establish working group and create folder in shared Google doc folder. *Deadline: March 2024*
2. **Identify datasets:** Decide on priority Noise Reference Station (NRS) datasets for metric development. *Deadline: April 2024*
3. **Data products to NCEI:** NRS Hybrid Milli-Decade (HMD) products to be included in initial comparison sent to NCEI. *Deadline: May 2024*
4. **Identify visualization options:** Organize and expand on options for HMD data visualizations as originally prepared for PAMscapes, share with working group via Google doc folder for discussion of level 1 visualization goals. Ideas and inspiration will be organized for project team brainstorming and feedback meeting. *Deadline: July 2024*
5. **Develop workplan:** Set-up work plan with Taiki Sakai to evaluate HMD QA/QC with visualizations in PAMscapes including level 1 visualizations such as percentiles, LTSA, and bringing together MANTA and pyPAM default outputs. *Deadline: June 2024*
6. **Present initial results:** Updated PAMscapes tool for HMD QA/QC level 1 visualization will be shared with project team for feedback and further development. *Deadline: December 2024 (dependent on Taiki's availability)*
7. **Level 2 data product planning:** In coordination with QA/QC tool development, and informed by ongoing collaboration with SoundCoop partners, the Soundscape group will develop level 2 visualization for HMD output by: integrating environmental data (currents, wind, ice, etc.) and time/frequency bins for quantitative visualization (e.g., SPD). The option to integrate these visualizations as additional PAMscapes functionality or publish as separate code on GitHub will be evaluated. *Deadline: March 2025 (discuss and gather feedback at 2025 SI Workshop)*
8. **Level 3 data product planning:** Plan the development level 3 products from HMD that prioritize and reflect the needs of SI and FMCs including: integration with PACM; noise budgets; sound propagation; automated soundscape analysis; co-variate for species models; categorization from HMD data; repository of labeled HMD data; integration of AIS data. *Deadline: Working group meeting at 2025 SI Workshop*
9. **Cloud processing:** Following Cloud Computing project Phase 7 (Software phase II validation), conduct cloud processing for HMD and PAMscapes to apply relevant methods on FMCs priority datasets. *Deadline: 2025 -2026 in coordination with Dan/Cloud team, Taiki, PyPAM development team*
10. **Facilitate national comparisons:** Develop additional products or visualizations for nationwide comparison of FMC priority soundscapes. *Deadline: Report out at March 2026 meeting for broader group feedback*

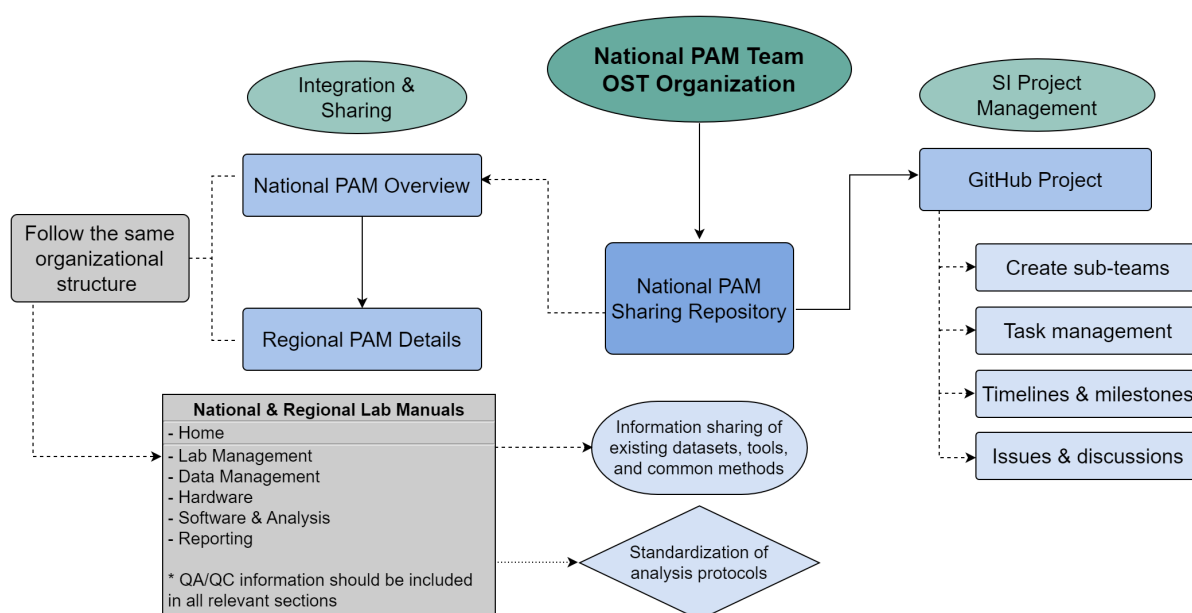
11. **Present project outcomes:** Present tested and functional cloud processing routines for level 1-3 products for all priority data sets for PAM SI reporting and additional science needs. *Deadline: End of project – 2026*

## 8. PAM DATA INTEGRATION AND SI COORDINATION THROUGH GITHUB

### 8.1 PROJECT 1: PAM SI COORDINATION

#### 8.1.1 TARGET OUTCOME

Efficient and effective coordination of the PAM Strategic Initiative to support successful implementation.



**Work flow outlining the process and products expected for the PAM SI GitHub work.**

#### 8.1.2 PROJECT TEAM

Becca Van Hoeck (NEFSC)

Sofie Van Parijs (NEFSC)

PAM SI Working Group

#### 8.1.3 SUMMARY

The PAM SI consists of multiple objectives and priority projects with various subsets of the full PAM SI working group. Coordination of the PAM SI through GitHub will serve to create an easy to access record of PAM SI meetings, provide project management support, and facilitate learning of how to collaborate through GitHub.

#### 8.1.4 ACTION ITEMS



1. **Workshop Report:** Generate and finalize the March 2024 PAM SI Workshop Report. *Deadline: April 2024*
2. **Identify Coordination Needs:** Define high priority coordination needs and workflows based on workshop discussion. *Deadline: April 2024.*
3. **Coordinate with UxS SI:** Check in on Pacific Glider objectives and develop a PAM Glider Repository to be shared with the PAM SI. *Deadline: June 2024 (start)*
4. **Ongoing Coordination:** Continue coordination of the PAM SI priority objectives through GitHub Issues, Project cards, and Discussions. *Deadline: ongoing throughout SI.*

## 8.2 PROJECT 2: CREATE NATIONAL PAM SHARING STRUCTURE

### 8.2.1 TARGET OUTCOME

Enhance National PAM collaboration among the NOAA Fisheries Science Centers through a common GitHub structure.

### 8.2.2 PROJECT TEAM

Becca Van Hoeck (NEFSC)

Sofie Van Parijs (NEFSC)

Kourtney Burger (SWFSC)

Science center representatives TBD

### 8.2.3 SUMMARY

A priority objective of the IRA PAM Strategic Initiative is to streamline processes to remove redundancy and increase cross-FMC efficiencies. To achieve this objective, a framework for improved information sharing across the FMC's is required. This project will create a standardized method of information sharing across the NOAA Fisheries science center PAM teams through GitHub. By collectively hosting information on GitHub we will create a foundation and culture for sharing that will build in complexity over time to include specific analysis protocols, data outputs, and other necessary tools.

### 8.2.4 ACTION ITEMS

1. **GitHub training:** Kourtney will train Becca on how to create a GitHub lab manual. *Deadline: March 2024*
2. **Develop and demonstrate National PAM Sharing Structure:** Develop and demonstrate the National and Regional PAM Sharing structures with SWFSC and NEFSC use case examples. *Deadline: May 2024.*
3. **Establish NMFS PAM Team:** Establish NOAA Fisheries PAM GitHub Team on the Office of Science and Technology GitHub Organization. *Deadline: June 2024*
4. **Publish National PAM Github Lab Manual:** Publish a National PAM Github Lab Manual on GitHub. *Deadline: July 2024*

5. **Create Regional PAM Lab Manuals:** Support each science center in creating a lab manual that aligns with the National sharing structure. *Deadline: July 2025*
6. **Expand information sharing:** Add the lists created by the Acoustic Detection Software team to the National PAM GitHub. *Deadline: July 2025*
7. **Convene GitHub working group:** Convene a working group of PAM SI members to continue discussing how to advance PAM sharing for analysis, QA/QC methods, and protocols, etc. *Deadline: July 2025*

## 8.3 PROJECT 3: PARTICIPATE IN OPENSAPES

### 8.3.1 TARGET OUTCOME

Facilitate learning and effective collaboration while creating the NMFS PAM Sharing structure.

### 8.3.2 PROJECT TEAM

Becca Van Hoeck (NEFSC)

Shannon Rankin (SWFSC)

Science center representatives TBD

### 8.3.3 SUMMARY

OpenScapes is an open science initiative to support more efficient collaboration and better science. Through a cohort based short-term sprint, participants are provided resources and training to support open science collaboration. One representative from each science center will participate in a PAM SI Openscapes cohort to develop the NMFS PAM Sharing structure (see previous project) in real-time, while bringing the lessons learned back to their broader science center PAM group. Participation in OpenScapes would build foundational knowledge and practical experience collaborating to support successful implementation of all PAM SI objectives and priority projects.

### 8.3.4 ACTION ITEMS

1. **Confirm OpenScapes cohort:** Identify potential OpenScapes Champions workshops that can accommodate the NMFS PAM SI cohort. *Deadline: June 2024*
2. **Sign-up for OpenScapes:** Pending confirmation of the OpenScapes cohort, Shannon will confirm that the PAM team is registered for the cohort. *Deadline: June 2024.*
3. **Identify cohort:** Each science center will recommend at least one participant for the OpenScapes cohort who can dedicate at least 3 hours a week to the collaboration. *Deadline: June 2024*
4. **Identify cohort priority:** The PAM team will convene a meeting prior to the start of the OpenScapes cohort to discuss and agree on project priorities from the list provided during the PAM SI Workshop. *Deadline: June 2024*
5. **Participate in OpenScapes:** OpenScapes is a 6-week sprint scheduled to begin in Spring/Summer 2024 *Deadline: TBD*

6. **Report back to Science Centers:** Following conclusion of the cohort we will facilitate knowledge sharing between the science center representatives and the broader regional PAM teams. *Deadline: within 2 months from the end of the OpenScapes workshop.*

#### PAM SI Priority GitHub Projects

Use	Urgency	Importance	Complexity	Barrier to Entry
More efficient QA/QC	High	High	Med	Med
Standardized Analyses	Med	High	High	High
PAM SI Coordination	High	High	Med	High
Standardized data outputs & associated code	Med	High	High	Med
Hardware Uses/Methods	High	High	Low	Low
Lab Manuals	Low	High	Low	Med
Reporting templates	Low	Med	Med	Med
Analysis protocols	Med	High	High	Low

## 9. PAM DATA INTEGRATION FOR ACOUSTIC DETECTION SOFTWARE

### 9.1 PROJECT 1: CREATE A LIST OF CURRENT TOOLS

#### 9.1.1 TARGET OUTCOME

Identify the passive acoustic tools currently used and in development as well as strategize what tools are needed to efficiently analyze passive acoustic datasets.

#### 9.1.2 PROJECT TEAM

Annamaria DeAngelis (NEFSC)	Taiki Sakai (SWFSC/NEFSC)	
Jennifer McCullough (PIFSC)	Daniel Woodrich (AFSC)	Cory Hom-Weaver (SWFSC)
Candice Emmons (NWFSC)	Ludovic Tenorio (SEFSC)	

#### 9.1.3 SUMMARY

Create a National table in GitHub that describes what software/tools are available NOW (what species they cover, are they multi/single species, is it retrainable, is it single/cross platform, how stable/mature, where can you find the documentation on how to use them / is there documentation on them)? This supports the National PAM SI Data Integration objective.

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#### 9.1.4 ACTION ITEMS

1. **Create table template:** Create a table template and share with PAM SI folks. Each FMC lead compiles a list of detectors/classifiers/ancillary tools used by their lab. Include which tools need to be Cloud compatible. POCs: Annamaria DeAngelis & Jennifer McCullough *Deadline: September, 2024.*
2. **Research Matlab compiler:** Learn how to use the Matlab Compiler Toolbox to create standalone Matlab executables for Matlab code. POC: Ludovic Tenorio *Deadline: June, 2024.*
3. **Tool conversion:** Identify which tools need slight modifications/conversion to open-source programming language or wrappers, including which tools should go to R vs Matlab. POCs: Annamaria DeAngelis, Taiki Sakai, Ludovic Tenorio *Deadline: December, 2024.*
4. **Push to National GitHub:** Be sure that all documentation is in the correct spot in the National GitHub repository. POC: Annamaria DeAngelis *Deadline: Contingent on GitHub National Development.*

### 9.2 PROJECT 2: CREATE A LIST OF FUTURE LONG-TERM TOOL NEEDS

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#### 9.2.1 PROJECT TEAM

Daniel Woodrich (AFSC)

Jennifer McCullough (PIFSC)    Annamaria DeAngelis (NEFSC)

Sofie Van Parijs (NEFSC)        Taiki Sakai (SWFSC/NEFSC)

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#### 9.2.2 SUMMARY

Create a cross FMC list of short-term and long-term software development needs. Create a table in GitHub to coordinate the software needs of the various centers in one location. This will include both short-term needs that might need development during the IRA funding window, as well as long-term needs that serve to guide available development time. This supports the National PAM SI Data Integration, archiving, and decision support tool objectives.

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#### 9.2.3 ACTION ITEMS

1. **Create wish list:** Create and curate a living document of what it is that is needed for detector software. POC: Daniel Woodrich *Deadline: December, 2025.*
2. **Push to National GitHub:** Be sure that all documentation is in the correct spot in the National GitHub repository. POC: Annamaria DeAngelis *Deadline: March, 2026.*

### 9.3 PROJECT 3: CREATE A LIST OF ANNOTATED DATASETS

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#### 9.3.1 PROJECT TEAM

Canidce Emmons (NWFSC)

Jennifer McCullough (PIFSC)

Sofie Van Parijs (NEFSC)

Annamaria DeAngelis (NEFSC)

Taiki Sakai (SWFSC/NEFSC)

Cory Hom-Weaver (SWFSC)

Ludovic Tenorio (SEFSC)

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### 9.3.2 SUMMARY

Create a table in GitHub listing the annotated datasets available at various FMCs. The table will contain the species that are annotated, availability of the underlying data, and point of contact. Users will also be encouraged to upload these annotations when archiving data with NCEI if applicable. This supports our ability to develop and test new detection and classification algorithms by creating a centralized list of the potential training data that might be available, which is a key component of developing new tools. This supports the National PAM SI Data Integration and archiving objective.

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### 9.3.3 ACTION ITEMS

1. **Create dataset annotation table on GitHub:** Create table on GitHub listing annotated datasets at centers. POC: Candice Emmons *Deadline: September, 2024.*
2. **Keep up to date with NCEI:** When archiving with NCEI, include annotations if available/applicable. *Deadline: As needed.*

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## 10. MANAGEMENT OUTCOMES AND TOOLS

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### 10.0.1 TARGET OUTCOME

One of the primary goals of the IRA Climate Ready Fisheries Strategic Initiatives is to modernize stock assessments to account for climate change by investing in advanced technologies and data modernization. In support of this goal, the PAM SI group held a brainstorming session centered around the target management tools, metrics, and strategies we strive to achieve through the SI. This session included two separate, but connected discussions, one on stock assessments and one on climate trends. The outcomes of both discussions highlighted numerous ways we can demonstrate the effectiveness and benefits of PAM for inclusion in stock assessments and monitoring long-term trends as well as areas for advancement of PAM methods and tools. We split the discussion into three parts, tools, metrics and strategies.

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### 10.0.2 DISCUSSION LEADS

Sofie Van Parijs (NEFSC)   Jason Gedamke (OST)

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### 10.0.3 SUMMARY

*Stock Assessments:*

**Priority tools** identified to advance incorporation of PAM data in stock assessments focused on visualizations that demonstrate changes in species distribution over time, where PAM data can fill gaps in existing traditional sampling efforts, and integrate multiple data outputs with existing visualization tools such as the Passive Acoustic Cetacean Map (PACM).

Relevant **management metrics** discussed highlighted the need for incorporation of soundscape metrics and noise budgets in Biological Opinions and other NMFS evaluations in order to provide species condition reports in addition to summarizing trends in relative density or abundance and other metrics to be used as a proxy for abundance.

**Identified strategies for management** outcomes focused on highlighting the value of PAM and soundscape monitoring to stock assessments, specifically through decision support tools (e.g. PACM), questions that could be answered with greater understanding of PAM data, co-benefits of PAM (ie. reducing vessel strike and entanglement risk), and expanding SARS to include PAM monitoring data.

*Climate trends:*

**Priority tools** discussed focused on the value of data integration - passive acoustics, environmental variables, soundscape metrics, AIS tracks, fishing metrics, species distribution model outputs - to support evaluation of long-term trends and cross-site comparisons as well as inclusion in visualizations or decision support tools.

**Key metrics to support management** included developing metrics of species distribution change, specifically a metric that aligns with oceanographic metrics of climate change, such as anomaly from an average. Additional key metrics included developing engagement reports for managers from decision support tools, such as PACM, and metrics of ambient noise, noise exceedance, and acoustic data for inclusion in site/regional condition reports.

**Strategies** to advance the management applications of PAM included expanding existing efforts to support regional functionality (ie. SoundCoop), engaging with users of PAM tools, contributing PAM Data to State of the Ecosystem reports, and calculating year-long noise exposure for an average animal throughout its migration.

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#### 10.0.4 MANAGEMENT GOALS FOR THE IRA PAM SI EFFORTS

1. **Develop a National PAM Decision Support Tool:** Expand the Passive Acoustic Cetacean Map (PACM) to be a National tool, including evaluating need for additional functionality with the PAM SI and provide learning opportunities for PACM users to promote understanding and proper use of the tool.
2. **Expand inclusion of PAM data in management documents and requirements:** The PAM SI will identify NMFS management documents and requirements where PAM data can improve knowledge of stock assessments or climate change (ie. Biological Opinions, SAR, CEFI, State of the Ecosystem reports, etc.). We will work to add relevant PAM data and showcase the value added in several examples.
3. **Work towards an integrative environmental trends and PAM Decision Support tool:** The PAM SI working group will:
  1. Explore the creation of a portal-based tool following the examples of SoundCoop and SanctSound.
  2. Identify desired data sources - passive acoustics environmental variables, soundscape metrics, AIS tracks, fishing metrics, species distribution model outputs
  3. Develop several PAM metrics to support evaluation of long-term species or environmental trends and cross-site comparisons for inclusion in the tool. This will include calculating year-long noise exposure for an average animal throughout its migration, and developing metrics for quantifying changes in species distribution relative to environmental change

## 11. ACKNOWLEDGEMENTS

The PAM SI working group acknowledges the support from the Inflation Reduction Act and NOAA's Climate Ready Fisheries investments for supporting the Essential Data Acquisition component that the PAM Strategic Initiative is a part of. Thank you to the Climate Ready Fisheries and Essential Data Acquisition staff for their administrative support of the PAM Strategic initiative. The PAM SI working group especially acknowledges all participants of the March 2024 workshop whose valuable time, thoughtful engagement, and productive discussion made the success of this workshop possible.

Thank you to NOAA Fisheries Office of the Chief Information Officer for their support of the cloud computing projects and to Jeffrey Walker for his work on the PACM cloud transition. Thank you to the UxS Strategic Initiative for their collaboration on the Pacific Glider projects.

Funding for participation of Taiki Sakai was provided by the Bureau of Ocean Energy Management (G14 M20PG00013).