Environmental Studies Program: Studies Development Plan | FY 2022–2023

Title	Incorporating PAMGUARD into the Tethys Passive Acoustic Data Metadata System (NT-22-05)
Administered by	Headquarters
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Procurement Type(s)	Cooperative Agreement
Conducting Organization(s)	Saint Andrews University, Scotland, U.K., and San Diego State University
Total BOEM Cost	TBD
Performance Period	FY 2022–2025
Final Report Due	TBD
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PICOC Summary	
Problem	Metadata documentation of passive acoustic data acquired from moving platforms at the level that will best facilitate its secondary use is often done as an afterthought to the data collection effort, separated in time long enough for important details to be forgotten or time consuming to resurrect. Also, further development of the Tethys metadata system to accommodate future user needs would require an expensive overhaul of the core program.
Intervention	Merging the popular PAMGUARD data acquisition system with the Tethys metadata documentation system allows for metadata documentation to be done currently with the data acquisition from mobile platforms while the details of the data collection effort are fresh in the minds of the data collectors. That, combined with additional software provided by the intended archive, the National Centers for Environmental Information (NCEI) for formatting the data-metadata package into the NCEI archival format, enables the data collectors to walk off the boat with an archive-ready data set with no further work needed. Additionally, this study will create a user's programmable interface inside the integrated package, with which users can add functionality to Tethys without needing a major overhaul of core of the Tethys software. This is a low-cost alternative to the more typical way of upgrading software.
Comparison	Commonly, metadata are constructed after the data collection effort when details may have been forgotten or are time consuming to reconstruct. Also, adding functionality to software is usually done by a major overhaul of the core of the software. This is a time-consuming and expensive effort.
Outcome	This study will produce a well-integrated package for easy and practical metadata documentation concurrently with data collection from mobile platforms. It will also add a user's programming interface to easily add additional functionality as needed by the user community. Finally, it will enable post-processing of archived data to do analyses informed by documented, referenced ancillary data.
Context	Passive acoustic monitoring is ubiquitous in marine research and environmental protection conducted in many geographic locations of interest to BOEM for impact

	assessment and mitigation. Also, it is in common use by geophysical surveyors working under BOEM-permitted exploratory activities.

BOEM Information Need(s): Passive acoustical monitoring (PAM) has been an important part of many BOEM-funded studies to determine the occurrence, density, distribution, and migratory behavior of marine mammals and some species of fish. This information is fundamental in impact assessments and, possibly, in formulating mitigation strategies. In addition, BOEM must be able to distinguish between natural variability and changes caused by offshore energy development and mineral extraction. This is particularly important at this time of apparent rapid climate change. In order to observe change over many years and decades, it is a practical necessity to compare observations collected from many different data-gathering activities. Other kinds of research investigating long-term, wide spatial scale phenomena need to draw from data from many earlier, smaller-scope research. Also, questions like cumulative effects can be addressed by "secondary use" of archived ("historical") data, thereby enhancing BOEM's ability to assess impacts. Necessarily, data must be well documented and preserved in a way that is practical for subsequent investigations to access.

A biological opinion on the federally regulated oil and gas program activities in the Gulf of Mexico (GOM) (USDOC, NOAA, 2020a and 2020b), as well as recently issued regulations under the Marine Mammal Protection Act to authorize take of marine mammals incidental to conducting geophysical surveys during oil and gas program activities in the GOM (*Federal Register*, 2021), require all raw observational data of protected species (including acoustic observations from PAM) be made available to BOEM, BSEE, and National Marine Fisheries Service (NMFS). In addition, the biological opinion requires BOEM and BSEE to report and present "a summary of all PAM efforts" to NMFS during their Annual Activity Review. Consequently, a PAM data management system is needed to assist BOEM and BSEE in meeting their Endangered Species Act (ESA) reporting requirements. The Tethys metadata system will be that PAM data management system.

Background: Tethys is a passive acoustic monitoring metadata database system designed to organize and store acoustic metadata (http://tethys.sdsu.edu; see also Tethys (2013), Roch, et al. (2013), and Roch, et al. (2016)) . Tethys has been developed over many years through joint BOEM-Navy funding. The data schema (rules that govern how data is organized) were designed to permit representations of acoustic metadata that are comparable across long time frames by providing a consistent format. A set of schemata have been developed for describing instrumentation, effort, detections and localizations. In addition to the standard reporting fields, the schema permits the addition of user-defined information, thus letting PAM practitioners define their own information such as referencing physical oceanographic and meteorological data to help in the analysis and interpretation of the acoustical observations.

The Tethys metadata system has been adopted as the community standard by NOAA's National Center for Environmental Information (NCEI), now serving as the permanent archive of raw marine acoustical observations. This study, in conjunction with an ongoing, companion project funded by the Navy's Living Marine Resources (LMR) Program, is the final increment in Tethys' development, bringing Tethys to maturity to give NCEI a reliable, user-friendly metadata tool that also meets the needs of the scientists and natural resource managers wanting to make secondary user of the archived data.

PAMGUARD, the software package that this study seeks to incorporate into Tethys, is a semiautomated, open source software for real-time acoustic detection and localization of cetaceans and other species from mobile platforms. It can also be used as a stand-alone tool for analysis of previously collected acoustical observations. With the recent efforts at standardizing and optimizing the methods of

acoustical measurements from moving platforms (e. g. LMR, 2018, and Barkaski and Thode, 2021), PAMGUARD has become a preferred tool in the collection and analysis of marine acoustical data and is the most common software used for BOEM permitted geological and geophysical surveys with PAM requirements in the GOM. Tethys integrated with PAMGUARD affords metadata documentation concurrently with data collection rather than at a post-processing stage when important details can be forgotten or misrepresented. In addition, this study includes creating a programmer's interface for the integrated package that will allow adding future functionality to Tethys without requiring a major overhaul of the core program.

Objectives:

1. Integrate PAMGUARD into the Tethys metadata system with a user-friendly interface for the combined packages enabling metadata documentation concurrently with data collection.

2. Add improved functionality for batch processing of large offline datasets (data previously collected from ship-based surveys, drifters, fixed archival recorders, gliders, etc.).

3. Develop an interface to other programming languages so that detection, classification and localization (DCL) algorithms written in the Matlab or Python programming languages can be called from within PAMGUARD. This will enable the integrated package to acquire additional functionality without needing a major overhaul of the core of the integrated package.

Method: Experts with each software package will learn the minutiae of the other software and jointly make the necessary modifications and code verification to achieve the objectives. PAMGUARD expert Douglas Gillespie, Senior Research Fellow at the University of St Andrews, Scotland, U. K. and Tethys creator Marie Roch, Professor of Computer Science at San Diego State University, formally proposed this project to the LMR program, BOEM's partner in the development of Tethys. LMR ended up funding other developmental objectives that BOEM did not fund, and, with this study, BOEM will fund the proposed Tethys-PAMGUARD integration.

Specific Research Question(s): This study does not address a specific research question. It enhances the community-accepted metadata standard for the preservation and secondary use of passive acoustical data, including those collected from moving platforms. There is a wealth of data now from BOEM-permitted seismic surveying operations, and these data, suitably documented and archived, can inform may research questions concerning impacts to living marine resources and practical questions like what kinds of mitigation strategies are possible and practical. Also, when enough data accumulates covering long periods of time and wide geographic areas, research questions concerning climate change can be addressed.

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: https://tethys.sdsu.edu/

References:

Barkaski M J, Thode A. 2021. BOEM report pending from BOEM environmental study:
https://www.boem.gov/sites/default/files/documents/environment/environmental-studies/Optimization%20of%20Towed%20Passive%20Acoustic%20Monitoring%20%28PAM%29%20Array%20Design%20and%20Performance.pdf

Federal Register. 2021. Taking and importing marine mammals; taking marine mammals incidental to geophysical surveys related to oil and gas activities in the Gulf of Mexico; final rule. 86 FR 5322, pp. 5322-5450. January 19, 2021.

LMR, U.S. Navy's Living Marine Resources Program Report 2018, specifically: https://navysustainability.dodlive.mil/files/2017/05/LMRFactSheet_Project28.pdf contained within the full report: https://www.navfac.navy.mil/content/dam/navfac/Specialty%20Centers/Engineering%20and%20Expeditionary%20Warfare%20Center/Environmental/lmr/LMRAnnualReport2018v2.pdf

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