Exxon Valdez Oil Spill
Long-Term Herring Research and Monitoring Program Final Report

Data Management Support

Exxon Valdez Oil Spill Trustee Council Project 16120111-C
Final Report

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<u>Study History:</u> This project provided core data management services for the *Exxon Valdez* Oil Spill Trustees Council's Herring Research and Monitoring program (Project 16120111) to help ensure data generated by this effort is available for long-term preservation, public discovery, and reuse. These activities were conducted over a five-year period from 2012-2016 (projects 12120111-C, 13120111-C, 14120111-C, 15120111-C, and 16120111-C). The work was coordinated with projects in the Herring Research and Monitoring program, and in partnership with the Alaska Ocean Observing System and the National Center for Ecological Analysis and Synthesis. Further, beginning in 2013 the scope of this effort was expanded under a supplemental project (projects 15150114-T and 16150114-T) to provide additional necessary data management support for the Herring Research and Monitoring projects.

<u>Abstract:</u> This project supplied the *Exxon Valdez* Oil Spill Trustees Councils Herring Research and Monitoring program with critical data management support to assist principal investigators in efficiently meeting their objectives and ensuring data produced or consolidated through the effort was organized, documented and available to be utilized by a wide array of technical and non-technical users. Specifically, a data management system was developed and implemented that supported the entire data lifecycle from sharing data among principal investigators, immediately after collection to eventual long-term preservation at a national data archive. The system was composed of tools including the Ocean Workspace, the Gulf of Alaska data portal, and the DataONE data repository. These combined services allowed for the query, discovery, and use of data and metadata through web-based search, catalog, and visualization interfaces for data generated to help ensure their long-term preservation, public discovery, and reuse. Beyond these tools, data management services were provided throughout the program to facilitate communication and coordination between the program leads, principal investigator, and data management staff about data and metadata generated through the program. Through this process, a rigorous data management support service was provided that combined experienced data management personnel, regional data management expertise, and advanced cyberinfrastructure in an end-to-end system where facilitated, full-lifecycle data management led to accelerated data use and scientific discovery by the program researchers, program and resource managers, and broader scientific communities. Through these efforts, we built a data management system that internally shared 32,000 data files and 1,450GB (1.4 TB) data among nearly 50 users in the Herring Research and Monitoring program Workspace group. Datasets from the program resulted in 29 data collections that are available publically through the Gulf of Alaska Data Portal. These datasets are discoverable among 300 additional GIS, environmental, numerical modeling and remote sensing data resources for the Gulf of Alaska. Ultimately, the datasets generated by the Herring Research and Monitoring projects are replicated in the DataONE

archive for long-term preservation and discovery by over 60,000 annual users.

Key words: data archive, data management, DataONE, data portal, Gulf of Alaska data portal, metadata, Ocean Workspace

Project Data: n/a

Citation:

Bochenek, R., Buckelew, S., Turner, C., Koeppen, W. 2018. Data management support for the
    Exxon Valdez Oil Spill Trustee Council Herring Research and Monitoring Program Final
    Report (*Exxon Valdez* Oil Spill Trustee Council Project 16120111-C). *Exxon Valdez* Oil
    Spill Trustee Council, Anchorage, Alaska.

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EXECUTIVE SUMMARY
In this project, the Alaska Ocean Observing System (AOOS), through its technical partner Axiom Data Science, provided core data management support and services to the Herring Research and Monitoring (HRM) program (16120111), funded by the *Exxon Valdez* Oil Spill Trustee Council (EVOSTC). These services included the development and enhancement of a central data management system to access, analyze and visualize information and products produced from the program effort and ensure their long-term preservation, public discovery, and reuse. The overall goal of this project was to provide critical data management support to project investigators and the program lead, and to assist them in efficiently meeting their objectives and ensuring data collected or consolidated through the effort is organized, documented, and available for their use and for future use by broader scientific communities.

This effort developed and implemented a central data management system for the EVOSTC's HRM program that supported the entire data lifecycle from sharing data among principal investigators (PIs) immediately after collection to eventual long-term preservation at a national data archive. The system was composed of several tools, including: the Ocean Workspace, a scientific collaboration and data management tool used to secure, centralize, and publish data files on public portals and catalogs; the Gulf of Alaska data portal, which provides public access to data, allowing users to visualize and integrate data from different sources, including the HRM program; and participation as a Member Node in the DataONE archive, to which HRM project data and metadata have been deposited through the Workspace via an automated submission pathway. All of these services allow for the query, discovery, and use of data and metadata through web-based search, catalog, and visualization interfaces for data generated the HRM projects to help ensure their long-term preservation, public discovery, and reuse.

Beyond these tools, data management services were provided to facilitate communication and coordination between program leads, PIs, and data management staff about data and metadata generated through the program. Through this process, we aimed to provide a rigorous data management support service that combined experienced data management personnel, regional data management expertise, and advanced cyberinfrastructure in an end-to-end system where facilitated, full-lifecycle data management leads to accelerated data use and scientific discovery by HRM researchers, management agencies, and broader scientific audiences.

Through these efforts, we built a data management system that internally shares 32,000 data files and 1,450GB (1.4 TB) data among nearly 50 users in the EVOSTC HRM program Workspace group. Datasets from the EVOSTC-funded research and monitoring programs resulted in 29 data collections that are available publically through the Gulf of Alaska Data Portal. These datasets are discoverable among 300 additional GIS, environmental, numerical modeling and remote sensing data resources for the Gulf of Alaska. Ultimately, the HRM projects datasets are replicated in the DataONE archive for long-term preservation and discovery by over 60,000 annual users. The DataONE archive, at present, hosts nearly 950,000 environmental data objects available through the DataONE search engine and a growing network of 40 data repositories,

including the AOOS and Axiom Data Science.

INTRODUCTION
Following the 1989 *Exxon Valdez* oil spill ("the spill"), several decades of scientific research has occurred to monitor the impacts and recovery to the Gulf of Alaska region and its resources. Over time, ecosystem impacts directly related to the spill have become more challenging to detect due to regime shifts, natural variability, climate change, and other anthropogenic changes. Data collected through long-term observations and focused research is fundamental to inform management decision-making by determining whether changes are related to natural or spill-related factors, and by identifying what potential recovery actions may be needed. To address these challenges and facilitate the recovery of injured resources, scientific and resource management communities need access to the most current scientific information and environmental intelligence tools to help make sound decisions.

An integrated monitoring program requires information on environmental drivers and pelagic and benthic components of the marine ecosystem. Additionally, while extensive monitoring data has been collected thus far through EVOSTC-funded projects as well as from other sources and made publicly available, much of that information needs to be assessed holistically to understand the range of factors affecting individual species and the ecosystem as a whole. Interdisciplinary syntheses of historical and ongoing monitoring data are needed to answer remaining questions about the recovery of injured resources and impacts of ecosystem change.

Managing oceanographic data is particularly challenging due to the variety of data collection protocols and the vast range of oceanographic variables studied. Data may derive from automated real-time sensors, remote sensing satellite/observational platforms, field/cruise observations, model outputs, and various other sources. Variables can range from mesoscale ocean dynamics to microscale zooplankton counts. The resulting datasets are packaged and stored in advanced formats, and describe a wide spectrum of scientific observations and metrics. Due to the complexity of the data, developing data management strategies to securely organize and disseminate information is also technically challenging. Distilling the underlying information into usable products for various user groups requires a cohesive, end-to-end approach in addition to a fundamental understanding of the needs and requirements of the user groups and stakeholders.

Data management activities for oceanographic information can occur in isolated, physically distributed agencies, leading to low cross-agency utilization of data. Technical barriers, complex data formats, a lack of standardization and missing metadata have limited access to data and made the utilization of available scientific information cumbersome and daunting. As a consequence, existing data is underutilized and often has not undergone quality assurance.

In this project, we addressed these challenges by developing and implementing a central data management system for the HRM program that supported the entire data lifecycle from sharing

data among PIs immediately after collection to eventual long-term preservation at a national data archive. The system was composed of several tools, including: the Ocean Workspace, a scientific collaboration and data management tool used to secure, centralize, and publish data files on public portals and catalogs; the Gulf of Alaska data portal, which provides public access to data, allowing users to visualize and integrate data from different sources, including the HRM program; and participation as a Member Node in the DataONE archive, to which HRM project data and metadata can be deposited through the Workspace via an automated submission pathway. All of these services allowed for the query, discovery, and use of data and metadata through web-based search, catalog, and visualization interfaces hosted by AOOS and available for use by HRM researchers, management agencies, and broader scientific audiences.

OBJECTIVES
The specific objectives of this project were to:
1) Provide data management oversight and services for the HRM program data centric activities which include data structure optimization, metadata generation, and transfer of data between project teams.
2) Consolidate, standardize and provide access to study area datasets that are critical for retrospective analysis, synthesis and model development.
3) Develop tools for user groups to access, analyze and visualize information produced or processed by the HRM effort.
4) Integrate all data, metadata and information products produced from this effort into the AOOS data management system for long term storage and public use.

METHODS
The methods for this project focused on developing an end-to-end data management system that assisted in the organization, documentation and structuring of HRM-collected and study area data so that it could be transferred efficiently to long-term data archive and storage centers and made available for future use by researchers and other user groups. This was achieved by leveraging the AOOS cyberinfrastructure, long-term funding and other active data management projects being undertaken by that organization. Further, Axiom Data Science worked to coordinate activities across the HRM program roles, including PIs, program leads, the National Center for Ecological Analysis and Synthesis (NCEAS), and the EVOSTC staff, to ensure a cohesive and well-maintained effort throughout the data management lifecycle, from data inception, to quality review, data storage, documentation, and ultimate archive (Appendix 1). Datasets produced from the integrated research effort were served to users by extending existing data access, analysis and visualization interfaces supported and under continued development by the AOOS data management team. The specific components of the data management system were undertaken as follows.

INITIAL DATA ASSESSMENT
In Year 1 (fiscal year 2012), data management staff worked with HRM program PIs to assess the types of data that were to be collected during the program to inform that development of data

management practices for PIs. The intent was to identify the data management needs and the types of tools needed by researchers to increase their abilities to manage and share their data in an automated, standard fashion. The details of the assessment were then used to assist and guide PIs in strategizing the overall data management approach to the program.

OCEAN WORKSPACE

Using the results of the assessment, a shared program platform was developed by the data management team to facilitate data transfer, metadata generation and archiving for the entire HRM project data management lifecycle. Beginning in 2011, the data management group developed a web-based platform (called the Ocean Workspace) for PIs to manage project level datasets and author metadata. The Ocean Workspace was released in 2012 for the HRM program as a web-based data management application built specifically for storing and sharing data among members of scientific communities. HRM PIs and their teams use the Workspace as an internal staging area prior to public release of data. The Workspace provides users with an intuitive, web-based interface that allows scientists to create projects, which represent individually funded projects within the HRM program (Fig. 1). Within each project, users create topical groupings of data using folders and upload data and contextual resources (e.g., documents, images and any other type of digital resource) to their project by simply dragging and dropping files from their desktop into their web-browser (Fig. 2). Users of the Workspace are organized into campaigns, and everyone within a campaign can view the projects, folders and files accessible to that campaign. This allows preliminary results and interpretations to be shared by geographically or scientifically diverse individuals working together on the HRM program before the data is shared with the public. It also gives program leads, research coordinators and others a transparent and front-row view of how users have structured and described projects and how their program is progressing through time (Fig. 1).
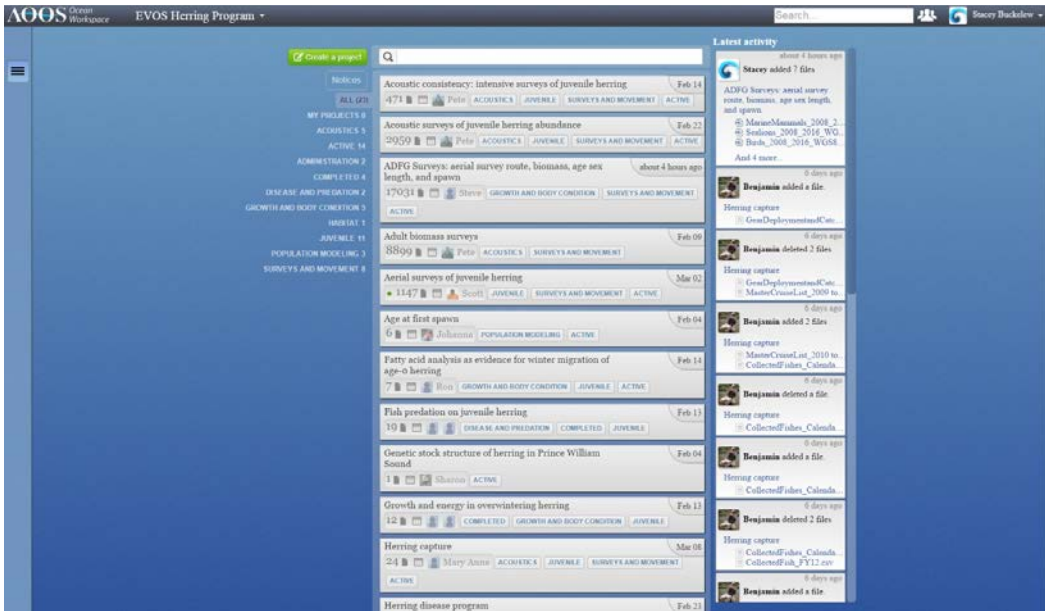
Figure 1. The overview page for the Herring Research and Monitoring (HRM) Workspace group. The group is organized by individual HRM projects, each of which contains ontological groupings of data files and products specific to those projects. The latest activity in the Workspace is shown in the right hand Activity Feed. This provides a real-time view of how the program is progressing through time.

Figure 2. A screenshot of file management for individual projects within the Workspace. The display shows how a researcher would organize data independent files into folders, and how the upload activity (including person and date) are tracked by the Workspace.

The Workspace was developed with the following use capabilities:

Secure group, user, and project profiles — Users of the Workspace have a password protected user profile that is associated with one or more disciplinary groups or research programs. The interface allows users to navigate between groups in which they are involved through a simple drop down control. Transfer of data and information occur over Secure Socket Layer (SSL) encryption for all interactions with the Workspace. The Workspace supports authentication through Google accounts, so if users are already logged into their Google account (e.g., Gmail, Google Docs, etc.), they can use the Workspace without creating a separate username and password.

Advanced and secure file management — Core functionality of the Workspace is the ability to securely manage and share any type of digital resource in real-time among researchers and study teams. Workspace users are provided with tools that allow them to bulk upload files or directory structures, organize uploaded content into hierarchically nested collections, create projects with predefined and user-created contextual tags, and control read and write permissions on files within projects. Version control for datasets is accomplished by tracking and providing access to past versions of datasets with the same file name. Integrated within the Workspace is an administrative file and metadata inventory tool that can be utilized to track progress on data submissions and metadata completeness.

STANDARDS-COMPLIANT METADATA

Properly describing and documenting the HRM program datasets with metadata allows users to understand and track important details about the research. Additionally, metadata facilitates the search, retrieval, and ultimate re-use of the data by a broader scientific community. Together with the Workspace, Axiom developed an integrated editor th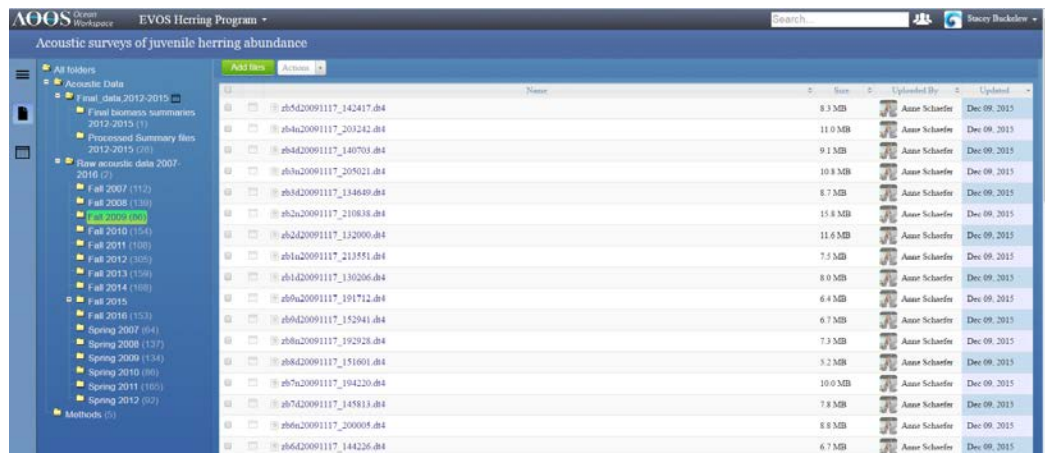at allows for PIs to author standards-compliant metadata for both projects and individual files. Because the Workspace is a cloud-based service, researchers can move between computers during the metadata generation process in addition to allowing team members and administrators to simultaneously review and edit metadata in real time.

Beginning in 2012, the metadata elements available to researchers in the Workspace were common to the Federal Geographic Data Committee (FGDC) endorsed successor to the Content Standard for Digital Geospatial Metadata (CSDGM) and the ISO 19115 standards for geospatial metadata, extended with the biological profiles of those standards. Axiom also developed an integrated FGDC biological profile extension editor that allows users to search the ~625,000 taxonomic entities of the Integrated Taxonomic Information System (ITIS) and rapidly generate taxonomic metadata.

In 2016, the metadata editor was updated to meet the standard, ISO 19115-2 compliant metadata. Features of the new editor included more metadata fields to allow for more robust descriptions of datasets and their connections to other resources, notably the historic EVOSTC datasets or time

series dataset that were salvaged under the project 16120120. Further, the new editor helped to ease the metadata generation process through short, modular, and easily understood entry forms. This cascading metadata allows for different levels of granularity within the metadata record, with metadata fields that define the attributes of the data file in a standards-compliant format enabled at the file and folder levels (Figs. 3 and 4).
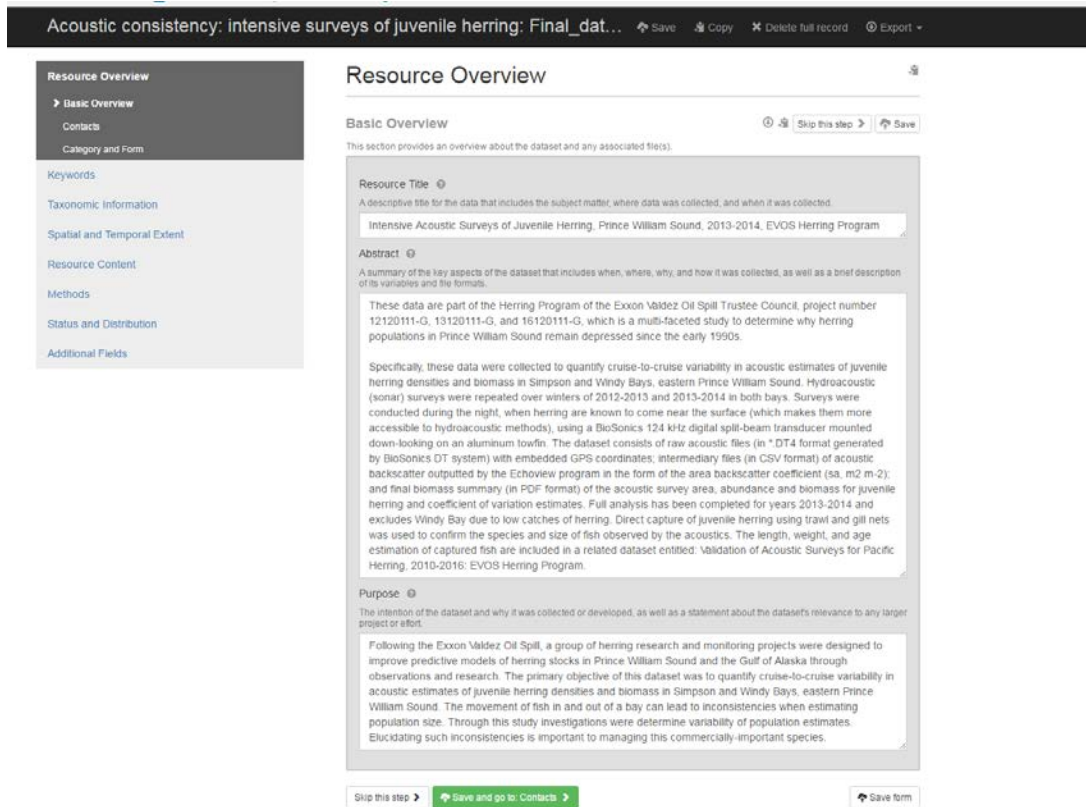
Figure 3. The metadata editor interface within the Workspace. The editor assists Workspace users in authoring robust, ISO standard-compliant metadata record alongside data objects. Individual fields are accompanied with help text and examples to guide users in creating metadata following best practice.

Figure 4. The metadata editor includes a feature that automatically reads and populates the attributes of data file in a standards-compliant format enabled at the file and folder levels. This feature was introduced as a time-saving step to expedite the metadata authoring process while still maintaining best practice.

TECHNICAL SUPPORT FOR METADATA

Beginning in 2013, metadata authoring by HRM PIs occurred at multiple points throughout the project lifecycle. Initially, high-level overview information about the project was documented, which included the location, project timeline, contacts, keywords, taxonomic species, and expected data to be generated. As the projects progressed and more data was collected and moved through the quality control, processing, and analysis phases, more descriptive metadata was captured by the PI and their research teams. As the project data matured, the completeness, content, and quality of the metadata record also matured to robustly describe the data and be formatted in the new editor version following the ISO format standard.

To facilitate metadata completeness, the Axiom data management workflow included technical support and oversight on metadata format and content throughout the project lifecycle (Appendix 1). A data inventory for the program was developed and used as the foundation to track actual data and metadata submission to the Workspace by PIs. In-person meetings with project PIs were scheduled with the data management team at the annual HRM program meeting to discuss data submissions and metadata authoring progress. Additionally, the data management team developed several tools to assist the PIs in authoring metadata, including written instructional

materials, hands-on instruction in the Workspace, and a written metadata questionnaire (an alternative to the metadata editor). Last, a metadata process was also established to ease the authoring process by PIs and to help standardize the metadata formats across projects. The process included the PI completing the metadata questionnaire document before the meeting that included a set of questions about the project research in order to organize content for the metadata record. The questionnaire was adapted from the USGS best management practices to adhere to ISO metadata standards. For those projects for which a reasonably complete metadata record already existed, the data management team instead utilized the metadata questionnaire as a completeness check. Prior to the meeting, the data management team reviewed the questionnaires and then used the meeting to assist the PIs in walking through creation of the content need to complete or revise the metadata record. While the workflow for creating metadata varied project-by-project, annual metadata revisions were also done to keep pace with new data submissions and changes to the collection procedures.

In the last phase of the metadata process, the data management team focused on quality control of the data and metadata, including data file formatting and documentation to ensure authoring meets best practices and accurately reflects data captured within individual data files. The quality control used the following steps: 1) primary completeness check for required metadata fields and content, and subsequent correction by PI; 2) a secondary quality control check resulting in a list of any issues in the metadata that need corrected the PI; and 3) a final check for ISO-format validation after metadata quality issues have been addressed and before submitting the dataset(s) to a national archive.

DATA SHARING, PUBLICATION AND ARCHIVE
To maximize data use for analysis, synthesis, review, and application, and to support the restoration and management of the spill- injured resources, data from the HRM projects have been made available through multiple pathways. During the data collection and analysis phases, provisional datasets from HRM projects were securely available for internal use through the Workspace (described above). As datasets were quality-reviewed and finalized, the data were also made available for exploration and discovery through a public-facing data portal, referred to as the AOOS Gulf of Alaska Data Portal ('portal'): http://portal.aoos.org/gulf-of-alaska.php (Fig. 5). Simultaneously, finalized datasets from the 2012-2016 HRM projects were archived through DataONE, where they will be preserved over the long-term. National repositories, such as DataONE, have the advantage of reaching wider audiences, thus expanding the access, discoverability, and active management of data collections generated through the HRM program.

Gulf of Alaska Data Portal
To consolidate and standardize relevant study area datasets and provide the HRM PIs with access to a large, diverse set of valuable information for retrospective analysis, synthesis, and model development, the Gulf of Alaska Data Portal was initiated in September 2013. The portal was designed to give access to hundreds of datasets from the Gulf of Alaska region that could be visualized, integrated with other data, and parsed both spatially and temporally and it includes

both catalog and interactive mapping interfaces. These data included significant amounts of atmospheric, terrestrial, oceanographic, and coastal data (Fig. 6).

Additionally, to simplify the publishing of data and metadata for PIs, the Workspace was designed as a gateway to publish HRM project data and associated metadata into the public-facing portal. Through the portal, these data can be discovered through an integrated search catalog interface that allows users to search by category or keyword and to download associated data and metadata files (Fig. 7). The portal uses the metadata and other contextual information that has been entered or created in the HRM program Workspace accounts to develop a series of search index utilizing a highly-scalable technology called Elastic search. Elastic search is a Java-based distributed indexing scheme that allows entire collections of documents, databases, and flat files to be indexed via several dimensions. With this feature, collections of information can be searched rapidly by spatial queries, time, text patterns, parameter and taxonomy. This technology facilitates data discovery and access to information, metadata, and data using a Google-like search interface.

To integrate data into the Gulf of Alaska Data Portal and enhance its use by HRM PIs and the public, data visualizations were completed for several EVOSTC long-term monitoring datasets, including the Long-Term Monitoring Gulf Watch Alaska program (project 16120114). The goal of visualizations was to provide a clear and efficient visual communication of data by making complex or long-term information more accessible, understandable, and usable. Additionally, visualizations helped researchers to make comparisons to related environmental datasets.
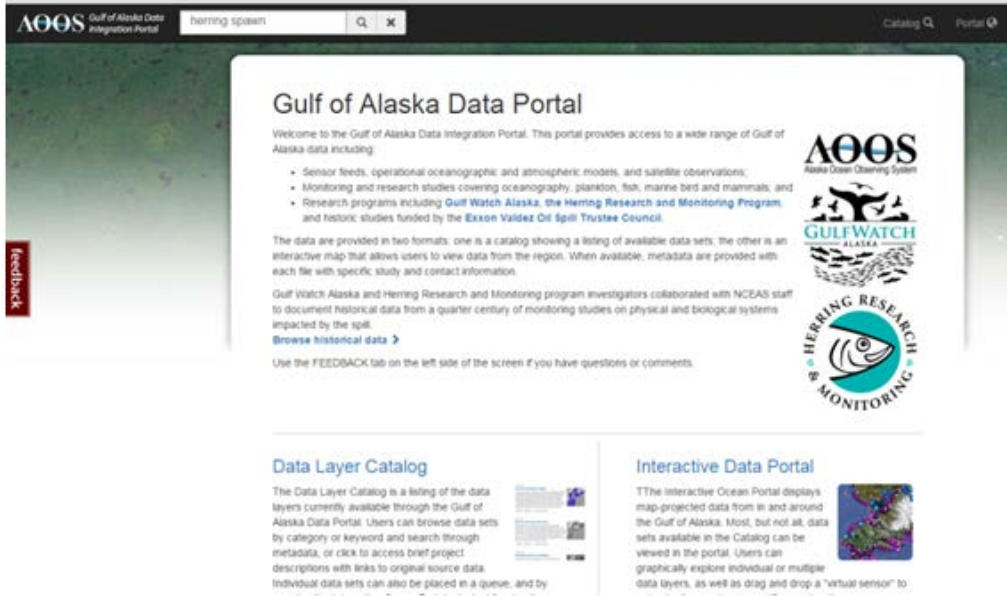
Figure 5. The overview page to the Gulf of Alaska Data Portal which highlights the availability of information from the EVOSTC-funded HRM and Gulf Watch Alaska programs as well as historical data available through the Gulf of Alaska Historical Data Portal. From here, users can access the catalog or the interactive mapping interface.
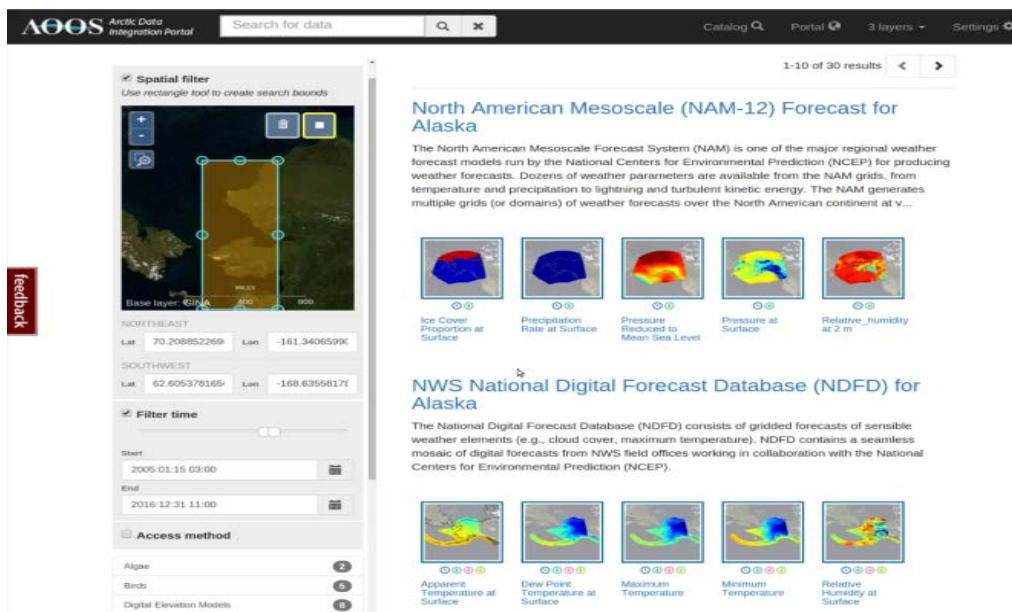
Figure 6: The catalog search interface where datasets within the portal can be searched. The catalog includes spatial and temporal filters, shown on the left side of the screen.
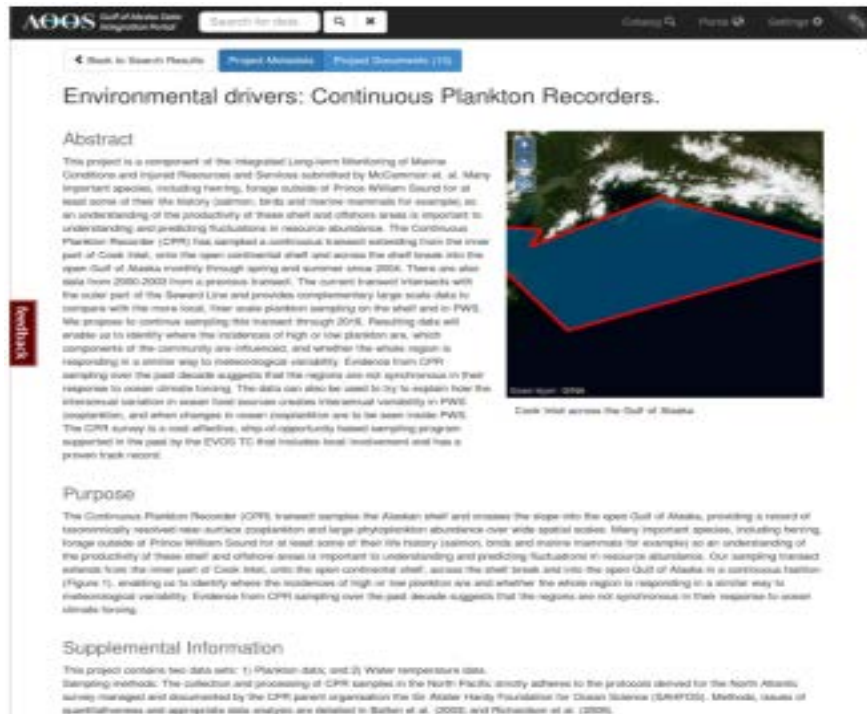
Figure 7. Screenshot of metadata imported from the Ocean Workspace into the public Gulf of Alaska Data Portal, which includes metadata for projects, folders (e.g. a collection of related data files), and single data files. This metadata facilitate the discovery of data within the portal through an integrated search catalog that searches by category or keyword, and allows users to download associated data and metadata files.

Long-Term Data Archive: DataONE
To facilitate the long-term storage and public-use of HRM project data, final data and metadata were submitted to the Data Observation Network for Earth (DataONE), a nationally recognized long-term archive for scientific data. DataONE is a platform for innovative, collaborative environmental and ecological science, using sustainable cyberinfrastructure and a distributed framework to provide open, robust, persistent and secure access to Earth observational data. DataONE links together existing cyberinfrastructure to provide a distributed framework that enable long-term preservation of diverse multi-discipline observational data. The distributed framework is composed of geographically-distributed Member Nodes that provide resources for their own data and replicated data, and focus on serving their specific constituencies and diverse implementations. Axiom Data Science is the 41st Member Node of the DataONE federation.

RESULTS
OCEAN WORKSPACE
During the initial phase of this project, the HRM Workspace group was established with 23 projects, with 19 of these representing individual research efforts and 2 projects dedicated to aspects of program coordination and outreach. The Workspace was utilized consistently through

the program duration as the internal location for file storage for data and program file sharing among the PIs. From 2012 to 2013 there was relatively limited use of the Workspace as the program was becoming established and PIs were familiarizing themselves with the system (Figs.8 and 9). Beginning in early 2015, after two complete field seasons and with the additional of the supplemental project entitled *Supplemental Data Management Support for EVOSTC Monitoring Programs* (project 15150114-T), the use of the Workspace and data stored there began to steadily rise from less than 1,000 to nearly 5,000 data files by year-end. Following the 2015 field season, however, PIs began to realize the full capacity of the data system. The files stored internally doubled to 10,000 and the volume of stored data rose exponentially to 600 GB. Data storage to the Workspace maintained a similar growth rate throughout 2016 and concluded with over 30,000 files and 1.4TB of available HRM project data. As such, the Workspace was successfully relied upon as the primary location used by HRM programs leads, PIs, and project team members to facilitate the logistical, curatorial, and preservation-oriented aspects of data collection and management.
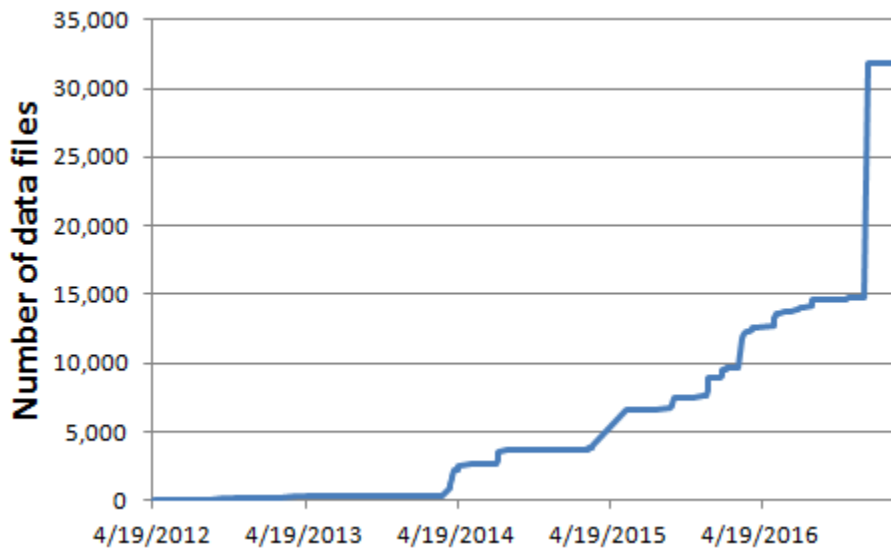
Figure 8. The total number of data files uploaded to the HRM program Workspace by project PIs from 2012 to 2016.
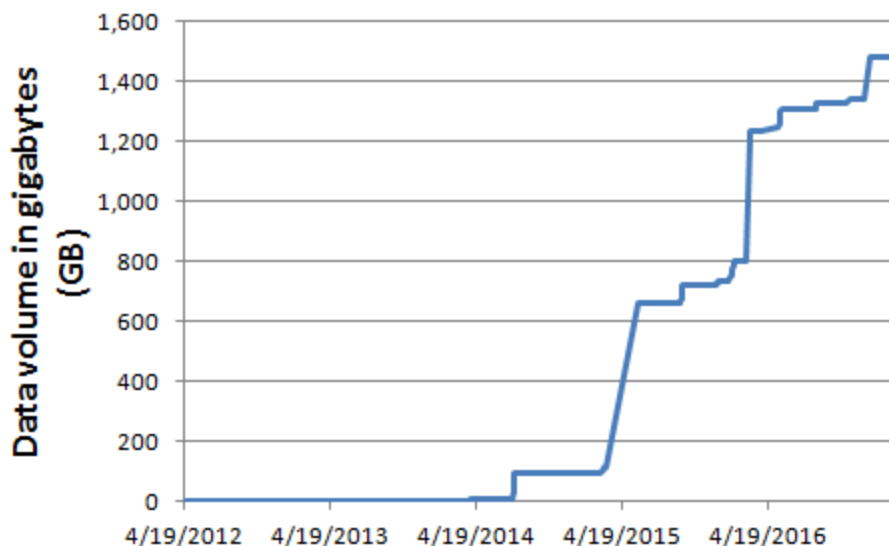
Figure 9. The total volume of data uploaded to the HRM program Workspace by project PIs from 2012 to 2016 for long-term storage.

Over the course of the program the data management team provided both technical support to users and new features to improve the Workspace capabilities and use by HRM PIs. Axiom staff provided training throughout the program via webinars and support through email and in-person meetings to help PIs develop their proficiency. Software engineers at Axiom also routinely provided support for the Workspace, including resolving bugs and implementing new functionality in response to user feedback. This level of support facilitated the Workspace becoming the primary internal staging area for all HRM program data and work products. As of December 2016, all of the 2012-2016 data and products have been posted in the Workspace, per the Program Management data sharing protocols. Beyond the data from these years, some projects included data from a longer time series extending beyond the HRM effort.

Based on the success of the Workspace in the HRM program, this tool has become widely used in other ecosystem synthesis studies throughout Alaska. While these efforts were not funded by the EVOSTC, the HRM program as a whole benefited from collective improvements and enhancements that were leveraged across programs. As of this writing, the system serves over 400 users, including a number of large-scale scientific research programs: the North Pacific Research Board, Chukchi Sea Environmental Studies Program, Russian-American Long Term Census of the Arctic (RUSALCA), Marine Biodiversity Observation Network (mBON), NOAA's Marine and Estuarine Goal Setting for South Florida (MARES), Central and Northern California Ocean Observing System (CeNCOOS), Southeast Coastal Ocean Observing Regional Association (SECOORA), and several other integrated multidisciplinary programs. In total, users of the Workspace across all programs have uploaded over 1.1 million files totaling 34 TB spread

across nearly 70 different Workspace groups.

STANDARDS-COMPLIANT METADATA
In December 2016, the new metadata editor was released into the HRM Workspace. The new editor was designed to be more flexible and to completely describe various dataset and project types. The editor also generates metadata in the ISO 19115-2 standards format that is necessary for preservation and publication in a DataONE member node. Historically, the metadata editor in the Ocean Workspace had allowed users to only write metadata for files and projects. This had created some confusion when the dataset to be shared, described, and archived was larger than a single or collection of data files, but smaller than the entire project dataset. The new editor addressed this problem by also enabling metadata creation at the folder level. This provided a simple way to describe a group of content as a single dataset (as opposed to having multiple redundant copies of metadata at the individual file level), and streamlined the archive of long-term monitoring datasets within DataONE.

Coupling the launch of the new editor, all existing HRM project metadata records were migrated to the standards-compliant format and populated with more information, as applicable by the additional metadata fields in the ISO standard. The 2012-2016 HRM program generated 29 unique data collections, each of which are accompanied with robust metadata documentation to help ensure these datasets are understandable, discoverable, and reusable into the future. A list of these metadata records and the location where they can be found in the Workspace and DataONE archive are in Appendix 2.

Beyond the release of the new metadata editor format, Axiom software engineers redesigned the display for metadata created in the Ocean Workspace and imported into the Gulf of Alaska Data Portal. The design of the metadata pages in the portal underwent several design iterations based on user feedback before settling into their current form. Upon initial release of the portal in 2013, project metadata created in the Workspace was visible as an HTML webpage and file-level metadata from the Workspace was available in the portal as raw, unstyled JSON documents. Since that time, the metadata editor in the Ocean Workspace has been harmonized to provide the same interface and fields for project and file metadata, and also expanded to accommodate the new metadata fields. Further, the metadata in the editor can be converted to a standard metadata XML format and exported as a XML file for sharing (Fig. 10). The XML data file format is intended principally for processing by machines. Axiom also created a new stylesheet to display both the project and file level metadata from the Workspace into a human-readable form to facilitate its reuse by a broad audience of researchers, manager, and other members of the public.

Figure 10. A screenshot of metadata converted to a standard metadata XML format and exported as a XML file for sharing. The XML data file format is intended principally for processing by machines.

DATA SHARING, PUBLICATION AND ARCHIVE

Gulf of Alaska Data Portal
The primary results for this task include the acquisition and documentation of historical and HRM program datasets and the aggregation of ancillary environmental datasets for integration into the public-facing AOOS Gulf of Alaska Data Portal. The individual HRM project descriptions, sampling activities, datasets, and other products are showcased within the portal while being coupled with historical data and other Gulf of Alaska models, sensor feeds, and GIS datasets for use by managers and scientists within Trustee Council agencies.

Historical Data
In a collaboration lead by the NCEAS, 126 historical datasets spanning the 25-year period since the *Exxon Valdez* oil spill were rescued and preserved. These activities are described in detail in Jones et al. (2017). Through interviews with original investigators, these historical datasets were recovered from projects funded over that time period by the EVOSTC, documented using detailed metadata describing their structure and contents, and preserved in the Gulf of Alaska Historical Data Portal (https://goa.nceas.ucsb.edu). The Gulf of Alaska Historical Data Portal is a data repository that was established by NCEAS in partnership with the data management team using the Metacat data repository system. This repository allowed the datasets to be replicated within the DataONE federation of repositories to ensure their long-term preservation, and it is also made available from within the main Gulf of Alaska Data Portal where it is discoverable along with more recent HRM project data and ancillary environmental datasets. Datasets that

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were recovered spanned a huge variety of disciplines, including lingering oil, oceanography, habitat, invertebrates, fish, mammals, birds, plankton, and socio-ecological interactions between people and the environment.

HRM Project and Environmental Data

In September 2013 the Gulf of Alaska Data Portal was released to integrate data and project information produced by HRM PIs with more than 300 additional GIS, environmental, numerical modeling and remote sensing data resources. A final list of the datasets available through the portal are listed in Appendices 3 and 4. This list includes finalized datasets and metadata documentation generated by research and monitoring projects of the HRM program. Additionally, because the HRM and GWA programs are users of a central data management system, data from both programs are available in the portal. The availability of data in one shared location is intended to facilitate collaboration and to provide a comprehensive, cross-disciplinary portrait of the conditions monitored in the Gulf of Alaska by both programs.

Throughout the life of the programs, the portal was maintained and expanded upon to incorporate new data and capabilities. After the initial release of the catalog and mapping interface, features were developed or enhanced over the course of the program to improve the utility of portal including the following:

- Updated the EVOSTC project catalog entries to preview the area covered by the project.
- Rebuilt the search tool to improve the precision and relevancy of search results.
- Expanded the range of material indexed for search to include all file-level metadata imported into the Gulf of Alaska Data Portal from the Workspace.
- Provided quick links to directly access files from search results.
- Added advanced catalog search options, which provided the ability to filter datasets by time, access method, and/or geographic area by drawing a polygon on a map or setting latitude and longitude bounds.
- Redesigned the display of the HRM and GWA project metadata. Upon initial release of the portal, project metadata generated in the Ocean Workspace was visible as an HTML webpage, and file-level metadata from the Workspace was available in the portal as raw, unstyled JSON documents. In the time since the launch of the portal, the metadata editors in the Ocean Workspace have been harmonized to provide the same interface and fields for project and file metadata, and have expanded to provide new metadata fields. Axiom's interface designer created a new stylesheet to display the both the project- and file-level metadata in a much more human-readable form. The design of the metadata pages in the portal underwent several design iterations based on user feedback.
- Streamlined PI-driven publication of individual folders within Ocean Workspace Projects.
- Added support for NOAA Charts, USGS topographic maps, and the General Bathymetric Chart of the Oceans (GEBCO) basemaps in the interactive mapping portal.

- Added an updating scale bar, collapsible legend, and ability to zoom by dragging a polygon to the interactive map.
- Added functionality to allow search results to be added to the mapping portal from the portal search bar.

Data Visualizations

To integrate data into the Gulf of Alaska portal and enhance its use by HRM PIs and the public, data visualizations were completed for several EVOSTC long-term monitoring datasets. The goal of visualizations is to provide a clear and efficient visual communication of data by making complex or long-term information more accessible, understandable and usable. Additionally, visualizations help researchers to easily reason about data and make comparisons to other related or environmental datasets.

An example of these visualizations in the portal includes observations made of humpback whales during surveys conducted from 2006 to 2014 (projects 10100804, 090804, 080804, 070804, 12120114-N, 13120114-N, and 14120114-N). The location, time, and notes about the observation (e.g. photos taken or individual whale identification) were mapped in the portal (Fig. 11). Using a time slider or seasonal filter, the change in humpback whale distributions over time can be explored. To aid the user in generating summary statistics about these observations, the polygon tool can be used to manually draw a polygon around a spatial area to generate a summary chart of the number of animals observed over time within that area (Fig. 12). To further summarize data over large spatial extents, a hexed heat map is generated when the user zooms out. The heat map displays the areas where humpback whales have been most frequently observed (Fig. 13). Using a time slider or seasonal filter to the heat map, the change in humpback whale distribution can also be explored.
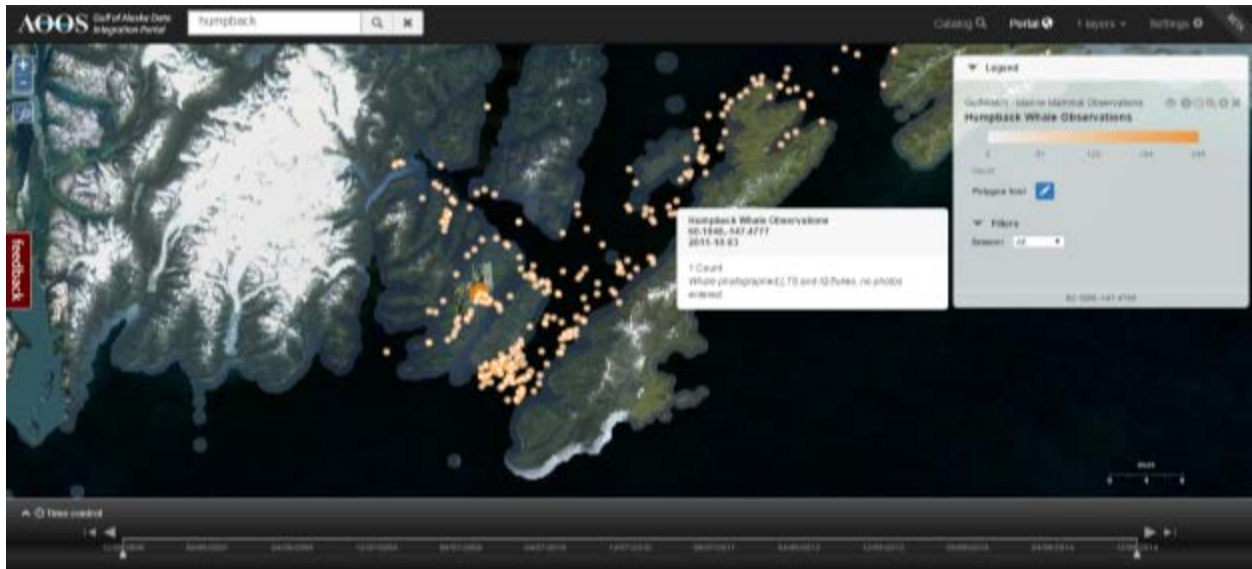
Figure 11. Screenshot of AOOS Gulf of Alaska Data Portal showing humpback whales survey observations made under the GWA program. Color represents counts of humpbacks in Prince William Sound. The date, time, location, and comments of interest (e.g. individual humpback ID) can be shown for each observation.
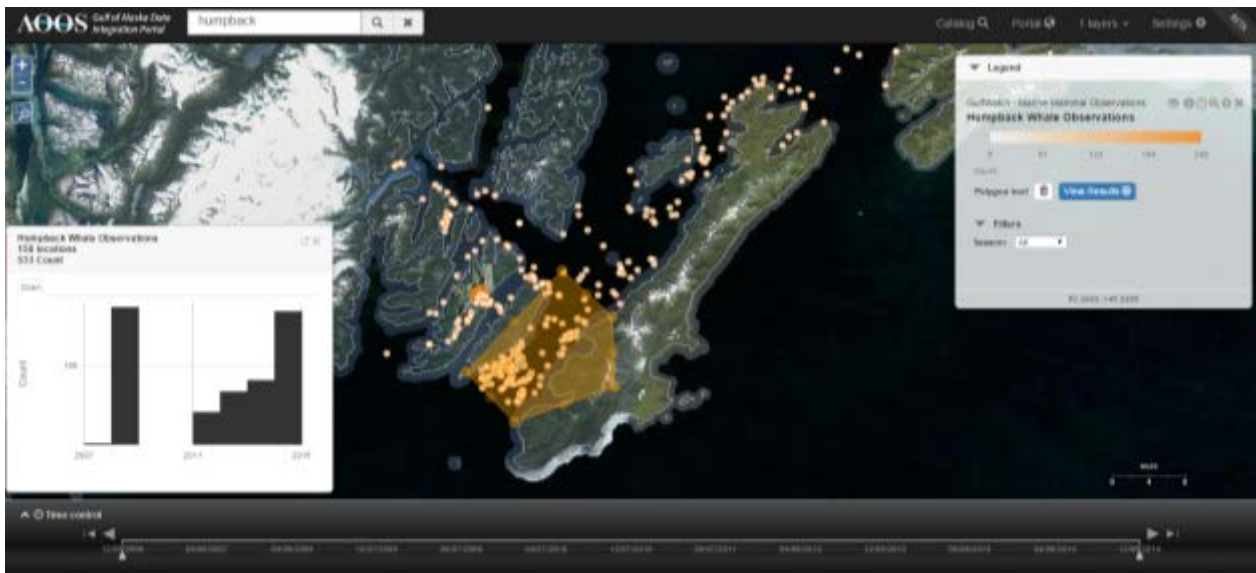
Figure 12. Screenshot of AOOS Gulf of Alaska Data Portal showing polygon tool that automates summary statistics within user-defined spatial areas. A histogram of the number of humpback whales observed surveys are shown over time.
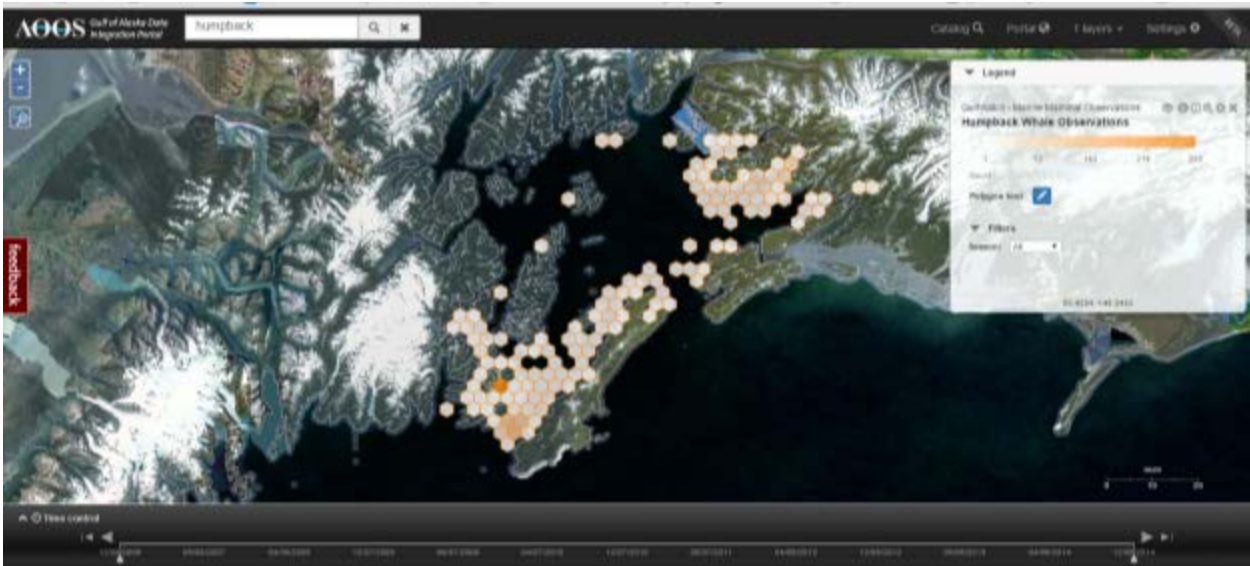
Figure 13. Screenshot of AOOS Gulf of Alaska Data Portal showing a hexed heat map of humpback whales observations in Prince William Sound. The darker the color, the greater the number of humpback whales were observed in that area. Using the time slider (at the bottom) or seasonal filter (in the right hand legend) the change in humpback whale distribution can be explored over time.

Additional data can be co-visualized with the humpback whale survey data to help infer changes in humpback whale distribution over time. As an example, the herring spawn survey data from the Alaska Department of Fish and Game (updated in the Workspace and portal through 2016 as part of this effort; Fig. 14) have been visualized for the entire time series from 1973 to 2016. The

herring spawn data can be displayed as either a plotted survey line or hexed heat map to represent the area where herring spawn activity has been observed. This dataset can be co-visualized (or 'stacked') together with humpback whale data to explore how distributions may coincide both spatially and temporarily with aggregations of spawning herring (Fig. 15). Additionally, the polygon tool can be applied to generate summary statistics of herring spawn and/or humpback whale observations within a user-defined area (Fig. 16).
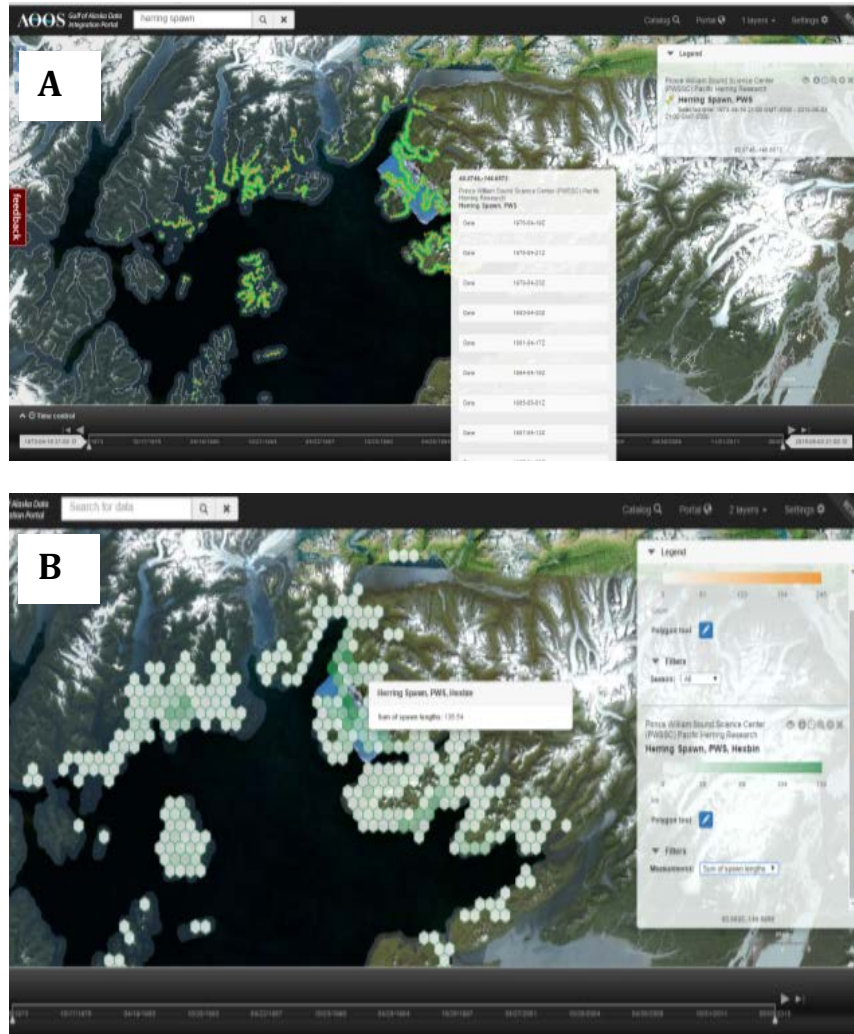
Figures 14a & b. Screenshots of AOOS Gulf of Alaska Data Portal showing two different graphical displays of herring spawn observations in Prince William Sound from surveys conducted 1973 to 2015. The upper figure (a) shows the length (km) of observed spawning area, whereas the heat map (b) show the sum of observed spawning lengths within a given area. The darker the color, the greater the length of total spawning activity that was observed in that area. Using the time slider (at the bottom of both figures), the change in herring spawn activity can also be explored over time.
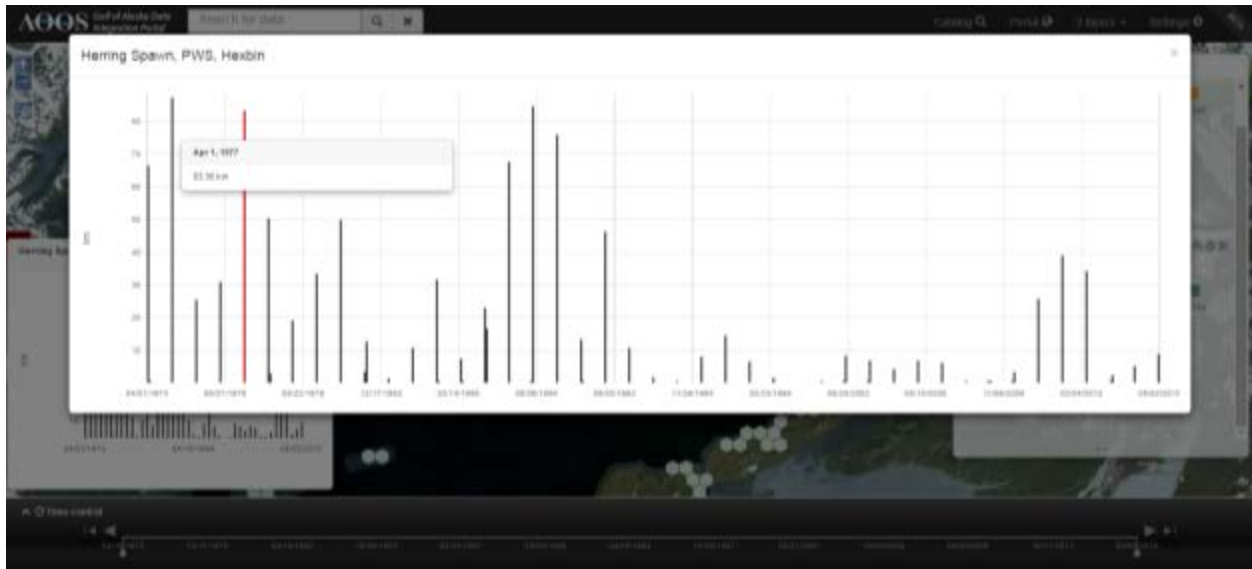
Figure 15. Screenshot of AOOS Gulf of Alaska Data Portal showing a polygon tool that automates summary statistics within user-defined spatial areas. A histogram of the length of herring spawn observed during aerial survey are shown over time from 1973 to 2015.

Figure 16. Screenshot of AOOS Gulf of Alaska Data Portal co-visualizing (or 'stacking') different data layers to allow for exploration of possible relationships. The length of observed herring spawn is shown along the coast in a green and orange dashed line The number of humpback whales observed during surveys are shown in orange dots. The larger the dot and the darker the color, the greater the number of humpback whales observed in that area. Using the time slider (at the bottom), the change in humpback distribution relative to herring spawn activity can be explored over time and area.

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Available in the Gulf of Alaska data portal are hundreds of additional datasets that allow for simplified, visual integration. As additional data is added from the HRM and GWA programs, the portal will continue to provide researchers with a streamlined visual environment for data selection, filtering, and exploration from multiple sources (including environmental, atmospheric, and numeric models). This tool allows rapid discovery of interesting findings to support (or deny) initial study hypotheses, inform further experimentation and experimental design, and generate additional hypotheses or "hot spots" related to drivers of environmental change in Prince William Sound.

DataONE

In January 2017, Axiom Data Science became a Member Node in the DataONE federation. The Member Node is named the Research Workspace, which is the next generation version of the Ocean Workspace that will be launched with expanded data sharing capabilities in summer 2017. The goals for becoming a DataONE Member Node were to ease the requirement of providing EVOSTC funded datasets to a data archive center by simplifying the upload of content, generation of metadata and archive submission processes for the PI; while simultaneously providing transparency of program data management and archiving to the data managers, program leads, and funders. The technical pathway developed during the HRM program includes tools for metadata generation, archive package creation, and ingestion into the Member Node. Enhancements planned to be developed and implemented during the upcoming 5-year HRM funding cycle include automated QA steps and completeness checks for metadata content, customized metadata entry forms based on data types and programmatic requirements, and tools for reading in xml-formatted metadata from other standards, e.g. FGDC CSDGM or EML.

As the data creators, it was the responsibility of the PIs to make the final decisions about which data would be made publicly available and what level of quality control was required for the data. As the data management personnel and managers of the DataONE Member Node, it was the responsibility of Axiom staff to verify that PIs delivered all of the data that they had agreed was to be made publicly available, to provide any assistance necessary to the PIs to help them generate quality metadata for their data, and to augment the Workspace to send data to a DataONE member repository for long-term preservation. Submissions of HRM data to the DataONE Member Node was a collaborative effort dependent upon the responsibilities of both the data management team at Axiom and HRM PIs. After PIs uploaded final, QC'ed versions of their datasets into the Ocean Workspace, data management personnel first reviewed data file content to verify that all expect data had been delivered, and then reviewed metadata generated by the PI for quality and completeness. Data management personnel then sent metadata review notes back to PIs documenting any further needs of the metadata for each dataset uploaded. After PIs had addressed the needs of their metadata, data management personnel reviewed the final metadata and initiated the automated submission feature through the Workspace.

A list of the datasets archive in the DataONE repository and replicated in the Gulf of Alaska

Member Node are listed in Appendix 2. Further these datasets are discoverable through DataONE Search (https://search.dataone.org), which is the default software for search and discovery of data and metadata within DataONE. At the time of writing, DataONE provides access to nearly 1 million Earth observation dataset and 300,0000 metadata files totaling nearly 30TB of data.

CONCLUSIONS

This project provided data management support to the EVOSTC-funded HRM program to ensure efficient organization, consolidation, and documentation of data collected for use by the study team as well for future use by a larger community. Concurrently, it provided tools for visualizing physical and biological datasets produced from the HRM projects, which can then be integrated and displayed alongside historical spill-related and other environmental dataset from the Gulf of Alaska region. This work coordinated and shares costs with several existing data management projects that are parallel in scope to the data management needs of the HRM program, and it leverages cyberinfrastructure and existing data management capacities of both the AOOS and Axiom Data Science technologies. The project supported data submission and organization, metadata generation, and data transfer among study teams through the EVOS HRM program Workspace instance. Axiom data managers, analysts, and domain experts quality reviewed metadata and data structure formats produced from the HRM projects and advise PIs in best practices for short-term and long-term data formats as well as metadata authoring. Through data and metadata submission tracking and engagement with PIs, Axiom helped to ensure that the HRM projects meet their data sharing deliverables. Axiom software engineers also developed and provide web-based tools to facilitate data discovery and visual exploration of some HRM project datasets, which included the ability to search and filter datasets by space, time, parameter, taxonomy, and keyword. Last, to ensure the long-term preservation of HRM project data final datasets and products were archived in the DataONE data repository where they can be discovered, accessed, and re-used for retrospective analyses of the recovery of the spill-affected ecosystem.

LITERATURE CITED

Jones M. B., R Blake, J. Couture, and C. Ward. 2018. Collaborative Data Management and Holistic Synthesis of Impacts and Recovery Status Associated with the *Exxon Valdez* Oil Spill. Final Report (*Exxon Valdez* Oil Spill Trustee Council Program 16120120). *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

Appendix 1. The responsibilities for each of the Herring Research and Monitoring program roles across the various steps in the data life cycle.

Lifecycle Step	HRM Project PIs	HRM Program Management Team	Axiom Data Science	NCEAS	EVOSTC
Data	*PI/agency responsibility; established sampling protocols for each component.*	*Review & maintain sampling Standard Operating Procedures (SOPs). Coordinate, with Science Coordinating Committee, consistency in sampling across the program.*	*Store current Standard Operating Procedures within Ocean Research Workspace.*	*Meet objectives focused on historic data salvage*	*Fund data collection projects and programs. Establish basic requirements: quality data, well documented, publicly accessible, archived.*
QA/QC	*PI responsibility based on agency or entity requirements. Documentation of instrument calibration & data QA/QC procedures to be included in sampling SOPs & project metadata.*	*Review QA/QC documentation before accepting data. Limited QA/QC performed on metadata to ensure it has required information (e.g. date, time, location, etc.) and data fields are appropriately documented (e.g. units in column headers).*	*Working with HRM program coordinator, specific datasets are aggregated together and reviewed for problems to prepare for synthesis efforts. Ensure QA/QC of metadata prior to archive..*	*For historical data, limited QA/QC (e.g., columns, domain, units) is performed and provided in metadata documentation to ensure it has required information. If original PIs are unavailable then any issues are simply noted in metadata.*	*Establish clear requirements for program and coordinate on agency data standards.*
Metadata	*PI responsibility to provide metadata according to agency and team standards.*	*Works w/PIs & data team to develop requirements. Assists PIs & reviews project level and file level metadata files.*	*Metadata can be created through the Workspace using the ISO suite of protocols with taxonomic extensions (ITIS). Provide technical assistance and training for PIs to author metadata*	*For historical data projects, NCEAS to research data and provide metadata as available to reconstruct the data set. Metadata are extracted from reports, papers,*	*Coordinate on agency metadata requirements and standards.*

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			following best practice. Quality review metadata prior to archive.	*and other available materials. Metadata are provided in EML format using tools developed at NCEAS (web entry, and Morpho entry).*	
Internal data access and staging	*Post data on Ocean Research Workspace as soon as possible, but no later than 1 year after collection.*	*Keeps records of data availability. Assists PIs in posting data on Ocean Research Workspace. Coordinates with Axiom/AOOS and NCEAS on user requirements for Workspace.*	*Provide Workspace as internal staging area for use by team. Work w/team to develop additional functionality for team use. Workspace is highly leveraged tool that is password protected.*	*Use Redmine ticket system to track the lengthy process of finding, acquiring, and processing historical data. As data are processed, they are inserted as private objects into the GoA Member Node, and then made public as the documentation is completed.*	
Data security	*n/a*	*n/a*	*Data are archived on AOOS server in Anchorage & at mirror site in Portland OR. Data also archived on the Axiom Member Node, replicated to DataONE, and a copy is made on the AOOS data servers. DataONE checks validity of content through rolling audit.*	*Historical data are archived on the NCEAS GoA Member Node, replicated to DataONE, and a copy is made on the AOOS data servers. DataONE checks validity of content through rolling audit.*	*Provide requirements, if any, for agency data archive.*
Data analysis,	*Produce data*	*Coordinates with PIs,*	*Provides team*	*Historical data*	

synthesis & visualization	*analyses, synthesis documents and data visualizations from project data.*	*AOOS, Axiom and NCEAS to produce synthesis and visualization products and reports.*	*with full access to all data for potential applications. Provide team access to all ancillary AOOS data & tools. Provide time series animations & syntheses on request from science team & outreach team.*	*are made publicly available via the GoA Member Node, and can be accessed from the web, analytical environments like R, and workflow systems like Kepler and VisTrails.*	
Data discovery (search function)	*Ensures that data are complete, QA/QCd & have complete metadata records.*	*Determines when data & metadata are ready to be published to public AOOS portal.*	*Incorporates data & metadata into AOOS GoA data search catalog w/additional HRM & historical EVOSTC tags. Data are also searchable in the DataONE archive..*	*Historical data are listed on the AOOS GoA data portal, and are searchable on the DataONE portal as well as the KNB.*	
Public data delivery	*Reviews published data on data portal for accuracy.*	*Reviews published data on data portal for accuracy. Keeps track of program data delivery status.*	*When data meet all above requirements, publish data & metadata into the AOOS Gulf of Alaska portal, the Axiom DataONE member node, and DataONE replica servers.*	*Historical data and metadata can be downloaded from AOOS GoA Data Portal, the GoA DataONE member node, and DataONE replica servers.*	*Public data access is required.*
Long-term archive			*AOOS data system is being used for long-term storage. Further, an automated delivery to the DataONE*	*Provide linkages to DataONE to replicate data across diverse institutions to protect against funding and policy failures.*	*Long-term archiving required by trustee agencies.*

			Member Node. Provide linkages to DataONE to replicate data across diverse institutions to protect against funding and policy failures. Data have 3 replicas nationally, GoA porta, Axiom Member Node, DataONE.	*Historical data have 3 replicas nationally.*

Appendix 2. Datasets generated by EVOSTC Herring Research and Monitoring programs from 2012 to 2016 that are stored in the AOOS Workspace, and made publicly available in the Gulf of Alaska Data Portal and replicated in the DataONE archive for long-term preservation.

Project Name	PI	Project #	Resource Information	
PWS Herring Research and Monitoring	Pegau	12120111, 13120111, 14120111, 15120111, 16120111	Metadata title:	Prince William Sound Herring Program in the Gulf of Alaska Exxon Valdez Oil Spill Affected Area
			Dataset content:	file inventory
			Years:	2012-2016
			AOOS metadata ID:	58c81b8c2ab79c00077c0593
			Workspace storage:	https://workspace.aoos.org/campaign/2558424/evos-herring-program/metadata
			DataONE archive:	https://doi.org/10.24431/axds/0a8f3bd2-5329-432c-b71e-94171373854d
Acoustic consistency: intensive surveys of juvenile herring	Rand	12120111-G, 13120111-G, 16120111-G	Metadata title:	Intensive Acoustic Surveys of Juvenile Herring, Prince William Sound, 2013-2014, EVOS Herring Program
			Dataset content:	raw & processed acoustic files; herring biomass summary
			Years:	2013-14
			AOOS metadata ID:	58b5c3f62ab79c0008dd33f4
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283128/folder/212904/raw-acoustic-data-2013-2014
			DataONE archive:	https://doi.org/10.24431/rw1k1u
Acoustic consistency: intensive surveys of juvenile herring	Rand	12120111-F, 13120111-F, 14120111-F, 15120111-F, 16120111-F	Metadata title:	Acoustic Juvenile Herring Abundance Data, Prince William Sound, 2012-2015, EVOS Herring Program
			Dataset content:	raw & processed acoustic files; herring biomass summary
			Years:	2007-2016 (raw); 2012-2015 (processed)
			AOOS metadata ID:	58b8d50a2ab79c0008dd3401
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283121/files
			DataONE archive:	https://doi.org/10.24431/rw1k1v
ADFG Surveys: aerial survey, biomass age sex length, spawn	Moffit	16160111T	Metadata title:	Aerial survey observations of Pacific herring (Clupea pallasii) school distribution and estimates of school biomass in the Prince William Sound Management Area, Alaska, 1974–2007.
			Dataset content:	aerial biomass observation data
			Years:	1973-2016
			AOOS metadata ID:	58c844cc2ab79c00077c0594
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283281/folder/263247/aerial-herring-biomass-observations,-1973-2016
			DataONE archive:	n/a
ADFG Surveys: aerial survey, biomass age sex length, spawn	Moffit	16160111T	Metadata title:	Documentation of Pacific herring (Clupea pallasii) milt from aerial surveys in the Prince William Sound Management Area, Alaska, 1973–2016.
			Dataset content:	aerial spawn observation data
			Years:	1973-2016
			AOOS metadata ID:	58c85fcc2ab79c00077c0597

			Workspace storage:	https://workspace.aoos.org/group/3503/project/283281/folder/2532168/aerial-herring-spawn-observations,-1973-2016
			DataONE archive:	n/a
ADFG Surveys: aerial survey, biomass age sex length, spawn	Moffit	16160111T	Metadata title:	Survey_Routes_1997_2016_WGS84
			Dataset content:	aerial survey route data
			Years:	1973-2016
			AOOS metadata ID:	58c860ec2ab79c00077c0598
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283281/folder/263241/aerial-herring-survey-routes,-1999-2016
			DataONE archive:	n/a
ADFG Surveys: aerial survey, biomass age sex length, spawn	Moffit		Metadata title:	Prince William Sound, ADF&G Pacific Herring Fishery Monitoring- Bird Observations: Birds_2008_2016_WGS84
			Dataset content:	aerial survey marine bird observations
			Years:	2008-2016
			AOOS metadata ID:	58c8618f2ab79c00077c0599
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283281/folder/2532169/aerial-survey-marine-bird-observations,-2008-2016
			DataONE archive:	n/a
ADFG Surveys: aerial survey, biomass age sex length, spawn	Moffit		Metadata title:	Prince William Sound, ADF&G Pacific Herring Fishery Monitoring- Marine Mammal Observations: MarineMammals_2008_2016_WGS84_11-15-2016
			Dataset content:	aerial survey marine mammal observations
			Years:	2008-2016
			AOOS metadata ID:	58c862832ab79c00077c059a
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283281/folder/263252/aerial-survey-marine-mammal-observations,-2008-2016
			DataONE archive:	n/a
ADFG Surveys: aerial survey, biomass age sex length, spawn	Moffit		Metadata title:	Prince William Sound, ADF&G Pacific Herring Fishery Monitoring- Sea Lion Observations: Sealions_2008_2016_WGS84_11-15-2016
			Dataset content:	aerial survey sea lion observations
			Years:	2008-2016
			AOOS metadata ID:	58c863402ab79c00077c059b
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283281/folder/2532234/aerial-survey-sea-lion-observations,-2008-2016
			DataONE archive:	n/a
ADFG Surveys: aerial survey, biomass age sex length, spawn	Moffit	12120111N	Metadata title:	Scales as growth history records for Pacific herring in Prince William Sound
			Dataset content:	scale measurement data and scale image library
			Years:	1982-2016
			AOOS metadata ID:	58c8641f2ab79c00077c059d
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283281/folder/2460185/scale-measurement-data,-1982-2016
			DataONE archive:	n/a
Adult biomass surveys	Rand	12120111-E, 36120111-E,	Metadata title:	Adult Herring Biomass Survey Data, Prince William Sound, 2012-2016, EVOS Herring Program

		14120111-E, 15120111-E, 16120111-E	Dataset content:	raw & processed acoustic files; herring biomass summary
			Years:	2000-2016 (raw); 2012-2016 (processed)
			AOOS metadata ID:	589bc7cab3cb1f0008806b51
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283087/files
			DataONE archive:	Project deadline extended until fall 2017
Aerial surveys of juvenile herring	Pegau	16120111-O/ 10100132-F	Metadata title:	Aerial surveys of juvenile herring, Prince William Sound, 2010-2016, EVOS Herring Program
			Dataset content:	raw & processed aerial; survey files; age 1 index summary
			Years:	2010-2016
			AOOS metadata ID:	58b8d2ba2ab79c0008dd3400
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283080/files
			DataONE archive:	https://doi.org/10.24431/rw1k111
Age at first spawn	Vollenweider & Heintz	12120111J	Metadata title:	Age at First Spawn for Herring in Prince William Sound, 2012-2015, EVOS Herring Program
			Dataset content:	histological analysis, scale growth measurements, fish age, and biological characteristics of the fish
			Years:	2012-2016
			AOOS metadata ID:	283160
			Workspace storage:	https://workspace.aoos.org/project/283156/files
			DataONE archive:	https://doi.org/10.24431/rw1k115
Fatty acid analysis as evidence for winter migration of age-0 herring	Heintz	12120111-I, 13120111-I	Metadata title:	Fatty Acid Analysis as Evidence for Winter Migration of Age-0 Herring in Prince William Sound, 2010-2012, EVOS Herring Program
			Dataset content:	fatty acid, growth, energy, RNA/DNA, diet data
			Years:	2010-2012
			AOOS metadata ID:	5898fc11b3cb1f000824db3a
			Workspace storage:	https://workspace.aoos.org/group/3503/project/282637/files
			DataONE archive:	https://doi.org/10.24431/rw1k110
Fish predation on juvenile herring	Bishop	10100132-G	Metadata title:	Fish Predation on Juvenile Herring in Prince William Sound, Alaska, 2009-2012, EVOS Herring Program
			Dataset content:	fish catch and prey data
			Years:	2009-2012
			AOOS metadata ID:	589e2806b3cb1f0008806b5c
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283074/files
			DataONE archive:	https://doi.org/10.24431/rw1k1z
Genetic stock structure of herring in PWS	Wildes & Guyon	16120111-P	Metadata title:	Genetic Stock Structure of Herring in Prince William Sound, 2012-2015, EVOS Herring Program
			Dataset content:	fish genetics data
			Years:	2012-2015
			AOOS metadata ID:	589a0eadb3cb1f000824db46

			Workspace storage:	https://workspace.aoos.org/group/3503/project/283164/files
			DataONE archive:	https://doi.org/10.24431/rw1k114
Growth and energy in overwintering herring	Heintz	10100132-D	Metadata title:	Growth and Energy of Overwintering Herring in Prince William Sound, 2009-2012, EVOS Herring Program
			Dataset content:	fatty acid, growth, energy, RNA/DNA, diet data
			Years:	2009-2015
			AOOS metadata ID:	5898d70a30c49e0007fcef8e
			Workspace storage:	https://workspace.aoos.org/group/3503/project/282615/files
			DataONE archive:	https://doi.org/10.24431/rw1k1y
Herring capture	Bishop	12120111-A, 13120111-A, 14120111-A, 15120111-A, 16120111-A	Metadata title:	Validation of acoustic surveys for Pacific herring, 2010-2016: EVOS Herring Program
			Dataset content:	fish morphometrics; gear deployment log; master cruise list
			Years:	2009-2015
			AOOS metadata ID:	589a221fb3cb1f000824db47
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283136/files
			DataONE archive:	https://doi.org/10.24431/rw1k1a
Herring disease program	Hershberger	12120111-K, 14120111-K, 15120111-K, 16120111-K; 070819	Metadata title:	Herring Infections Prevalence Data, 2007-2016, EVOS Herring Program
			Dataset content:	disease prevalence summary; raw lab files
			Years:	2007-2016
			AOOS metadata ID:	58a21314b3cb1f0008806b5e
			Workspace storage:	https://workspace.aoos.org/group/3503/project/282905/files
			DataONE archive:	https://doi.org/10.24431/rw1k11
Juvenile herring intensive condition monitoring	Gorman & Kline	12120111-M, 13120111-M	Metadata title:	High Temporal and Spatial Resolution Study of Herring Condition in Prince William Sound, Energetics Data, Prince William Sound, 2011-2012, EVOS Herring Program
			Dataset content:	age-0 herring morphology and energetic condition data
			Years:	2011-2012
			AOOS metadata ID:	589a6aefb3cb1f000824db48
			Workspace storage:	https://workspace.aoos.org/group/3503/project/282629/files
			DataONE archive:	https://doi.org/10.24431/rw1k17
Juvenile herring intensive condition monitoring	Heintz & Gorman	12120111-M, 13120111-M	Metadata title:	High Temporal and Spatial Resolution Study of Herring Condition in Prince William Sound, Growth and Diet Data, 2011-2012: EVOS Herring Program
			Dataset content:	data related to seasonal changes in growth, energy stores, and diet of young-of-the-year (YOY) herring in PWS
			Years:	2011-2012
			AOOS metadata ID:	310998
			Workspace storage:	https://workspace.aoos.org/project/310992/folders/310998/metadata
			DataONE archive:	https://doi.org/10.24431/rw1k16
Juvenile herring condition	Heintz & Gorman,	12120111-L, 14120111-L,	Metadata title:	Juvenile Herring Condition Monitoring, Energetics Data, Prince William Sound, 2005-2016, EVOS Herring Program

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monitoring	Kline	15120111-L, 16120111-L	Dataset content:	energetics data
			Years:	2005-2016
			AOOS metadata ID:	33867
			Workspace storage:	https://workspace.aoos.org/project/282629/folder/33867/pwssc-final-energetics-data_2005-2016
			DataONE archive:	https://doi.org/10.24431/rw1k13
Juvenile herring condition monitoring	Heintz & Gorman	12120111-L, 14120111-L, 15120111-L, 16120111-L	Metadata title:	Juvenile Herring Condition Monitoring in Prince William Sound, Growth and Diet Data, 2012-2016, EVOS Herring Program
			Dataset content:	growth, energy, RNA/DNA, diet data
			Years:	2012-2016
			AOOS metadata ID:	589bbe2ab3cb1f0008806b4f
			Workspace storage:	https://workspace.aoos.org/project/282629/folder/310989/growth-and-diet-data_final,-2012-2016
			DataONE archive:	https://doi.org/10.24431/rw1k15
Meta-analysis of global herring population dynamics	Branch, Trochta	12120111-Q, 14120111-Q, and 16120111-Q	Metadata title:	Meta-analysis of Global Herring Population Dynamics, 1974 to 2011, EVOS Herring Program
			Dataset content:	global herring biomass summaries
			Years:	n/a
			AOOS metadata ID:	58a368c0b3cb1f0008806b63
			Workspace storage:	https://workspace.aoos.org/group/3503/project/1622014/files
			DataONE archive:	https://doi.org/10.24431/rw1k1i
Meta-analysis of global herring population dynamics	Branch	12120111-Q, 14120111-Q, and 16120111-Q	Metadata title:	Using Bayesian Age-Structured-Analysis (ASA) Model for Herring Population Dynamics in Prince William Sound, EVOS Herring Program
			Dataset content:	ASA model codebase, input and output data files
			Years:	n/a
			AOOS metadata ID:	589e1176b3cb1f0008806b5a
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283170/files
			DataONE archive:	https://doi.org/10.24431/rw1k1t
Non-lethal sampling of juvenile herring	Boswell	12120111D	Metadata title:	Non-lethal Sampling: In-Situ Estimation of Juvenile Herring Sizes in Prince William Sound, 2013-2014, EVOS Herring Program
			Dataset content:	ROV video files; herring measurement data\
			Years:	2013-2014
			AOOS metadata ID:	589b94c4b3cb1f0008806b4c
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283142/files
			DataONE archive:	n/a
Physical oceanographic charateristics of nursery habitats	Gay	10100132-E	Metadata title:	Physical Oceanographic Characteristics of Herring Nursery Habitats in Prince William Sound, 2010-2012: EVOS Herring Program
			Dataset content:	moored and cast CTD; thermistor data
			Years:	2010-2012
			AOOS metadata ID:	5898fb2cb3cb1f000824db39

			Workspace storage:	https://workspace.aoos.org/group/3503/project/283108/files
			DataONE archive:	https://doi.org/10.24431/rw1k116
Plankton & ocean observations in PWS	Campbell	10100132-A	Metadata title:	Oceanographic Conditions in Prince William Sound, CTD, Chlorophyll-a, and Zooplankton Data: 2010-2012, EVOS Herring Program
			Dataset content:	Chl-a, CTD data, zooplankton data
			Years:	2010-2012
			AOOS metadata ID:	58af9b432ab79c0008dd33ec
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283115/files
			DataONE archive:	https://doi.org/10.24431/rw1k14
Tracking seasonal movements of adult Pacific herring in PWS	Bishop	12120111-B, 13120111-B, 14120111-B	Metadata title:	Tracking Seasonal Movements of Adult Pacific Herring in Prince William Sound, 2012-2014, EVOS Herring Program
			Dataset content:	herring telemetry tag log and detection data
			Years:	2012-2013
			AOOS metadata ID:	5898e410b3cb1f000824db34
			Workspace storage:	https://workspace.aoos.org/group/3503/project/283150/files
			DataONE archive:	https://doi.org/10.24431/rw1k1x