Exxon Valdez Oil Spill
Long-Term Monitoring Program (Gulf Watch Alaska) Final Report

Collaborative Data Management and Holistic Synthesis of Impacts and Recovery Status Associated with the *Exxon Valdez* Oil Spill

Exxon Valdez Oil Spill Trustee Council Project 16120120
Final Report

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Study History: This project conducted data management, recovery of historical data, and synthesis activities over a five-year period, and operated under projects from 2012-2016 (projects 12120120, 13120120, 14120120, 15120120, 16120120). The work was conducted in collaboration with other Long-Term Monitoring and Herring Research and Monitoring projects, including participants from the Alaska Ocean Observing System and from Axiom Data Sciences, and recovered data from over a hundred projects previously funded by the *Exxon Valdez* Oil Spill Trustee Council.

Abstract: Data collected prior to and in response to the *Exxon Valdez* oil spill are profoundly heterogeneous. They range from long-term, automated sensing of oceanographic and atmospheric conditions, to short-term, experimental, monitoring, and behavioral studies of biological components of the system, to socio-ecological studies of human-environmental interactions. The data collected in these studies includes data on population trends, behavior, physiology, and genetics of many species, as well as oceanographic and meteorological data at both regional and local scales. In this project, we built data management systems that allowed the rescue and preservation of 126 historical data sets spanning the 28-year period since the *Exxon Valdez* oil spill in 1989. Through interviews with original investigators, these historical data sets were recovered from projects funded over that time period by the *Exxon Valdez* Oil Spill Trustee Council, documented using detailed metadata describing their structure and contents, and preserved in the Gulf of Alaska Data Portal. In addition, two community-driven synthesis working groups were formed, one focusing on Gulf of Alaska dynamics, and the other on portfolio effects in the Gulf of Alaska. Each working group used historical and contemporary data to drive cross-disciplinary analysis of spill-impacted regions of the Gulf of Alaska.

Key words: Cook Inlet; data management; data rescue; DataONE; ecosystem; Gulf of Alaska; portfolio effects; Prince William Sound; socio-ecological systems; synthesis

Project Data: Data were recovered as described in this report from projects funded by the *Exxon Valdez* Oil Spill Trustee Council through a labor-intensive data salvage process. In the end, 126 data sets were recovered spanning a huge variety of disciplines, including lingering oil, oceanography, habitat, invertebrates, fish, mammals, birds, plankton, and socio-ecological interactions between people and the environment. A listing of the data recovered during the project is provided in Appendix 1. All data are archived in the Gulf of Alaska Data Portal (https://goa.nceas.ucsb.edu), with replicas in the DataONE federation (https://search.dataone.org), and the Alaska Ocean Observing System (http://portal.aoos.org/gulf-of-alaska.php). Each record within the archive provides a detailed and structured metadata record describing content, format, and structure of the data set, methods used to collect the data, contact information for custodians of the data sets, and terms of use for each data set.

Citation:

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. *Exxon Valdez* Oil Spill Long-Term Monitoring Program (Gulf Watch Alaska) Final Report (*Exxon Valdez* Oil Spill Trustee Council Project 16120120), *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska.

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EXECUTIVE SUMMARY

In this project, we built data management systems that allowed the rescue and preservation of 126 historical data sets spanning the 28-year period since the *Exxon Valdez* oil spill in 1989. Through interviews with original investigators, these historical data sets were recovered from projects funded over that time period by the *Exxon Valdez* Oil Spill Trustee Council, documented using detailed metadata describing their structure and contents, and preserved in the Gulf of Alaska Data portal. In addition, two community-driven synthesis working groups were formed, one focusing on Gulf of Alaska dynamics, and the other on portfolio effects in the Gulf of Alaska. Each working group used historical and contemporary data to drive cross-disciplinary analysis of spill-impacted regions of the Gulf of Alaska. The Gulf of Alaska dynamics group published one paper and has an additional six papers in review and preparation, while the portfolio effects group also published one paper and has an additional 12 papers in review or preparation.

INTRODUCTION

Data collected prior to and in response to the *Exxon Valdez* oil spill (EVOS) are profoundly heterogeneous. They range from long-term, automated sensing of oceanographic and atmospheric conditions, to short-term, experimental, monitoring, and behavioral studies of biological components of the system. The scientific data collected in these studies includes data on population trends, behavior, physiology, disease, and genetics of many species, as well as oceanographic and meteorological data at both regional and local scales. This diversity of data and data collection protocols substantially complicates data management by *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) long-term monitoring projects. In addition, investigators on both the long-term monitoring and herring population studies are affiliated with many different institutions and agencies, each currently collecting data from many sites within the spill region and managing it within the frameworks dispersed among these agencies. Any data management system will necessarily need to accommodate this heterogeneity and dispersion by preserving the original data and providing mechanisms to access, integrate, and analyze the data for crosscutting synthesis. Data management activities for oceanographic information 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 created collaboration between the National Center for Ecological Analysis and Synthesis (NCEAS), the Alaska Ocean Observing System (AOOS) and their partner Axiom Consulting, and the investigators of the pending long-term monitoring Gulf Watch Alaska (GWA) and Herring Research and Monitoring (HRM) programs. The collaboration augmented the expertise in data management and synthesis of these groups to maximize the efficiency of data collection and management for the GWA and HRM programs and expanded access to these data, collated additional historical data that are useful for synthesis from the EVOS-affected area, and conducted a broad-ranging synthesis of more than twenty years of EVOSTC-funded research data to generate a new knowledge of ecosystem impacts and recovery status for the spill affected area.

During the first two years of the project, NCEAS focused on facilitating data management and on recovering historical data from previous EVOSTC-funded projects to create the necessary data resources for synthesis; during years 3-5, NCEAS conducted a multi-year working group effort including GWA and HRM principal investigators (PIs) and other internationally renowned researchers to synthesize what is known about spill effects and recovery of ecosystems. These activities were interwoven with the complementary but distinct data management, technology development, and analysis activities previously proposed by Axiom and AOOS and which are referenced in the objectives below.

OBJECTIVES

The fundamental objectives of this proposal were to recover and archive historical data from EVOSTC-funded projects and conduct cross-cutting syntheses on the impacts of EVOS. The specific objectives were:

1) Provide data management oversight and services for project team data centric activities that include data structure optimization, metadata generation, and transfer of data between project teams (AOOS lead, with contributions from NCEAS).

2) Consolidate, standardize and provide access to study area data sets that are critical for retrospective analysis, synthesis and model development (AOOS and NCEAS).

3) Develop tools for user groups to access, analyze and visualize information produced or processed by the GWA and HRM program efforts (AOOS lead, with contributions from NCEAS).

4) Organize, integrate, analyze, and model the 20-year historical data from EVOSTC-funded projects and other monitoring in the spill area in preparation for synthesis under GWA and HRM programs and in NCEAS working groups (NCEAS lead with AOOS contributions).

5) Integrate all data, metadata and information products produced from this effort into the AOOS data management system for long-term storage and public use (AOOS lead).

6) Augment the AOOS/Integrated Ocean Observing System preservation and interoperability system with other data systems through integration of DataONE services (NCEAS lead).

7) Conduct additional broad synthesis activities on spill impacts and recovery as part of whole-ecosystem analysis through NCEAS working groups: NCEAS lead with AOOS and Prince William Sound Science Center (PWSSC) contributions.

METHODS

Historical Data Recovery

From 2012 to 2014, a team of one full-time and three part-time staff members was assigned to recover and archive data funded by EVOSTC targeting specifically those projects funded between 1989 and 2010. Project information was obtained from the projects page on the EVOSTC website, which includes varying levels of detail for each project, ranging from project title only to full bibliographic information and attached reports. We created a historic data manifest listing all EVOSTC-funded projects and some of the data sets associated with those projects. Salvaging efforts identified 419 relevant research project clusters funded by the EVOSTC since 1989, covering various time spans. Projects after 2002 were awarded with explicit terms and conditions from the EVOSTC requiring that data they collected be preserved and made publicly available. We tracked the progress of the data request and acquisition process for each project based on five stages: "emailed", "replied", "sent data", "published", and "unrecoverable".

Contact information was obtained through agency sites and Google searches based on the information we were able to gather from the EVOSTC site. If we were able to find contact information for the listed PI, an initial outreach email or phone call was made explaining the data recovery project, citing the data sharing requirements, and requesting data for the project in question. Projects for which outreach contact could be made were labeled "emailed" and were followed up numerous times if no reply was received. A reply to the outreach email would confirm that the contact information was correct and the project label would be promoted to "replied", regardless of level of cooperation expressed in the response. If the responder determined the data was unrecoverable, they were labeled as such and the reasons were recorded in our tracking system. Once we received data for a project, the label was changed to "data sent". If the data were clean and well documented enough and/or the contact was responsive enough to guide us through any necessary data edits and metadata creation, the data were published to the Gulf of Alaska Data Portal and the project was labeled "published".

Also of interest were the reasons data were not recovered. To quantify these responses we categorized the projects into: "no contact information", "data lost", "non-digital data", "unwilling to share", and "requested additional funding". Data are only labeled data lost if our contact confirmed that they were so. Similarly, the non-digital data, unwilling to share and requested additional funding cases are only labeled as such for projects where data requests were rejected for these confirmed reasons. Non-digital data is deemed "unrecoverable" here since our project lacked the resources to convert or store such data. Where possible, we have since digitized these data and published in the archive.

Data archiving efforts spanned an initial intensive two year period with follow-ups in the subsequent three years of the project, and included three data coordinators who trained and supervised six student interns over the time period.

Recovered data were documented using the Morpho metadata editor to produce structured metadata in Ecological Metadata Language format (EML), and archived on a Gulf of Alaska Data Portal (https://goa.nceas.ucsb.edu) as well as at replica sites in the DataONE network (https://search.dataone.org) and at the AOOS data portal (http://portal.aoos.org/gulf-of-alaska.php).

Synthesis Working Groups

Requests for proposals were advertised, submissions were reviewed, and two working groups were selected to conduct synthetic analyses of the Gulf of Alaska (GOA) ecosystems based on the 28 years of data collected since EVOS. These same steps were taken to recruit two postdoctoral researchers to participate in the working groups and conduct further analyses of the GOA systems. All of these efforts commenced in 2015. The selected working groups looked at social-ecological relationships in the GOA and the effects of diversity on the stability of the GOA ecosystem. These projects were entitled "Understanding Changes in the Coastal Gulf of Alaska Social-Ecological System: Analysis of Past Dynamics to Improve Prediction of Future Response to Natural and Anthropogenic Change" (henceforth "Gulf of Alaska Dynamics"; PIs Okey, Klinger, and Ruzicka) and "Applying Portfolio Effects to the Gulf of Alaska Ecosystem: Did Multi-scale Diversity Buffer Against the *Exxon Valdez* Oil Spill" (henceforth "Portfolio Effects"; PIs Marshall, Beaudreau, Brenner, Hunsicker, Ward, Shelton), respectively. Both groups held organizational meetings in late 2014 and work began in early in 2015.

The Gulf of Alaska Dynamics working group and the Portfolio Effects working group each held two working group meetings in 2015 and two in 2016 at NCEAS in Santa Barbara, CA to further their synthesis goals. The two postdocs associated with these groups (Blake and Ward) also started just before FY15, and worked concurrently with the synthesis working groups. Both groups used collaborative methods to collate, clean, integrate, and analyze historical data associated with the spill-affected regions in Alaska and to generate novel insights into the impacts and recovery of the oil spill and its relationship to other ecological and environmental factors.

Staff at NCEAS supported the work of these two working groups by promoting the synthesis opportunity, reviewing proposals, and managing all logistics associated with working group activities. This included handling travel logistics and reimbursements for 195 person visits by the researchers to NCEAS for meetings, providing conference facilities, breakout spaces, and meeting organization services, and providing and supporting an excellent computing and networking environment for performing analysis and visualization activities both during working group meetings and while the researchers were performing analyses between meetings.

RESULTS

Historical Data Recovery

During the first two-year phase of historical data recovery, we documented and published data from 94 of the 419 data sets that we identified from historical EVOSTC funding, which represents 27% of the project clusters that published at least one data set (Fig. 1). During the initial recovery period, we corresponded with PIs for an additional 168 projects, but had not yet received data from them, got no response regarding 62 data sets, and classified 76 data sets as unrecoverable. The main obstacle to recovering data sets was lack of responsiveness of investigators in providing data (or responding at all), and lack of information on the files that were sent. Specifically, this included files without column headers, folders of hundreds of files without explanation of the contents, duplicate data sets being sent with small, unexplained differences making it difficult to determine what should be published, lack of units and acronym definitions, outdated file formats that must be converted, and files with graphs and embedded comments. It has also been difficult to confirm that we received all of a project's data due to the lack of information provided, and many PIs are unable to describe their historical data to us.

Data sets that 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.

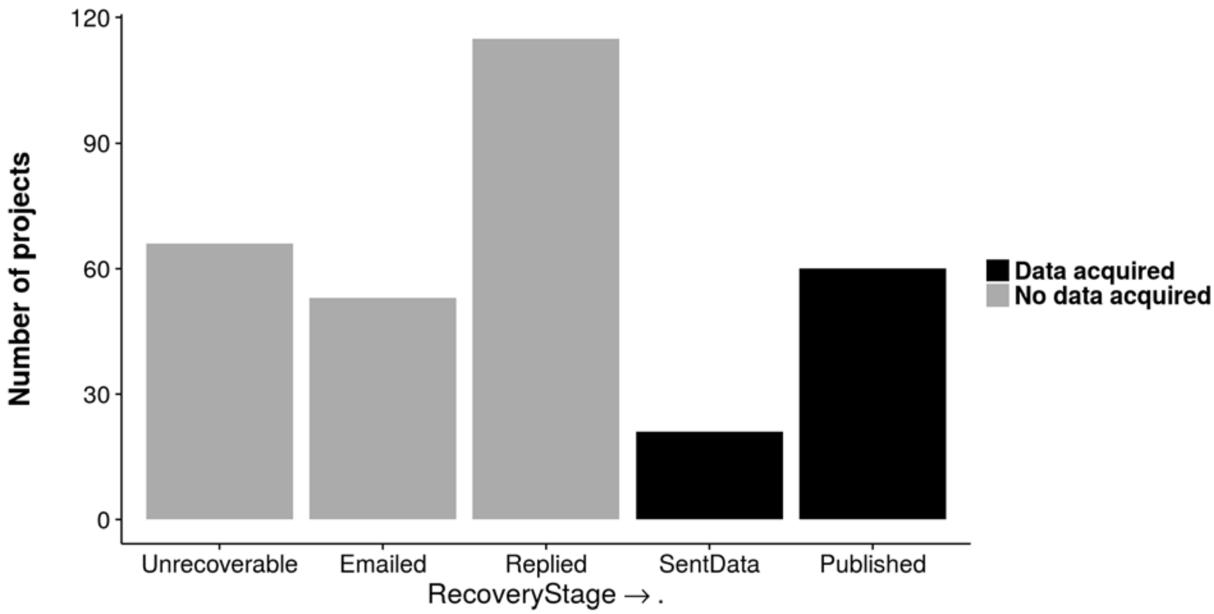

Figure 1. Initial data acquisition success for data in the intensive 2-year recovery period, reflecting an initial success rate of 27%, which eventually grew to 30% with additional effort over the project.

During subsequent recovery efforts over the following three years, we continued to identify critical data sets and attempted to locate additional people and sources of information about data set disposition. These efforts results in an additional 32 data sets for which we received and documented data, bringing the cumulative total to 126 recovered data sets (30% of the 419 projects).

After completing this process, we classified reasons why data were not recovered (Fig. 2), which clearly showed that communication breakdowns were the primary obstacle to obtaining data, either because we never were able to obtain effective contact information, or, when contact was established initially, researchers stopped communicating with us before their data were fully recovered. In a much smaller number of cases, the data were confirmed to be lost, or too laborious to digitize. The final two categories, 'unwilling to share' and 'requested funding', represent cases where investigators refused to share their data, which is effectively the case for all of the 'communication lost' cases as well. It is important to note that prior to 2002, EVOSTC terms and conditions did not require PIs to make data publicly available.

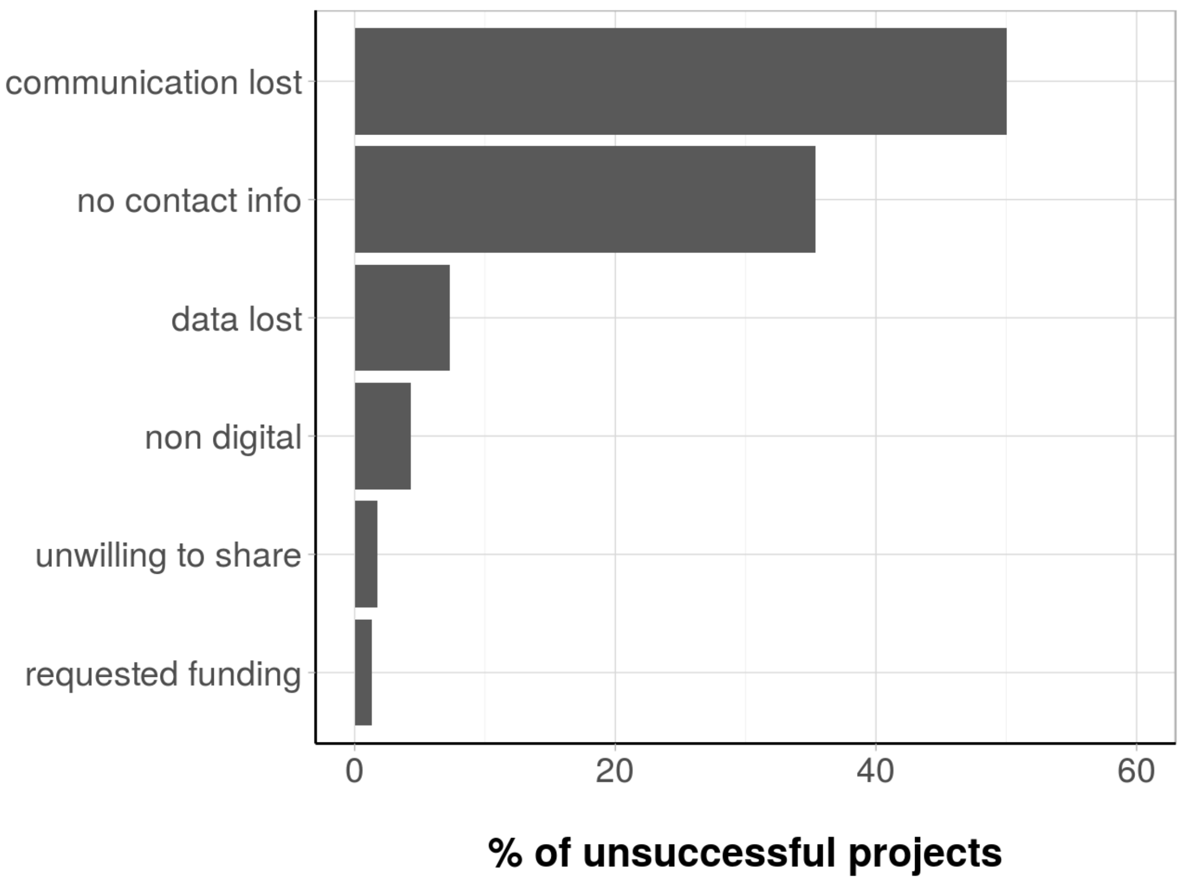

Figure 2. Categorized reasons for unrecovered data from projects. While specific data loss was rare, the authors interpret lack of communication as an unwillingness or inability to share data.

All data recovered during this effort were published with documentation in the Gulf of Alaska Data Portal (https://goa.nceas.ucsb.edu), which is a data repository that we established for the purposes of this project using the Metacat data repository system (Fig. 3).

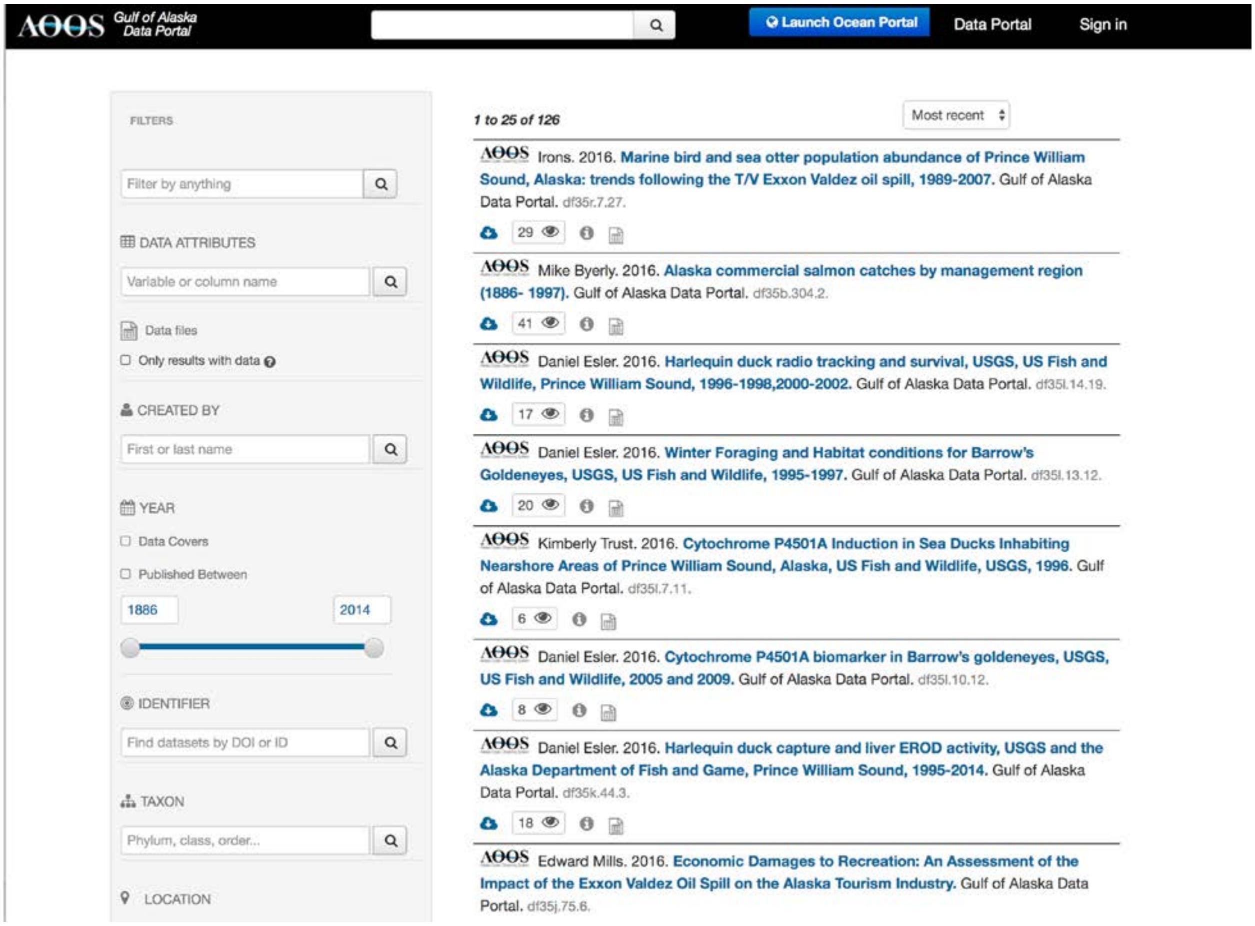

Figure 3. Gulf of Alaska Data Portal screen capture showing the data listing and search filters that were designed and deployed during the project (https://goa.nceas.ucsb.edu).

This repository allowed us to replicate the data sets to the DataONE federation of repositories to ensure their long-term preservation (Fig. 4), in addition to the copy that we deposited with the AOOS. The Metacat-housed copy of the data were accessible through a machine accessible programming interface, which allowed these data to be automatically ingested into analyses using R statistical language during analysis for synthesis activities.

During late 2016, we began preparation of a manuscript describing these data recovery efforts and lessons learned in the process, which we plan to submit for publication in mid-2017.

Figure 4. Replication of data to the DataONE Network. The Gulf of Alaska Data Metacat server is located in Santa Barbara, California. Data were automatically replicated to the Knowledge Network for Biocomplexity (KNB) repository in Santa Barbara, the University of New Mexico (UNM) data repository, and the Oak Ridge National Laboratory (ORNL) repository. In addition, a copy of the historical data and metadata were manually copied to the AOOS data system, headquartered in Anchorage, Alaska.

Synthesis Working Groups

Synthesis groups convened in 2016 and met four times in person at NCEAS in Santa Barbara, CA to collate and analyze data, collaborate on research, and write manuscripts. The members of the two working groups are shown in Tables 1 and 2.

Table 1. Participants in the Gulf of Alaska Dynamics working group

Name	**Institution**
Cameron Ainsworth	University of South Florida
Edward Allison	University of Washington
Natalie Ban	University of Victoria
Rachael Blake	University of California, Santa Barbara
Jessica Couture	University of California, Santa Barbara
Thomas Dean	Coastal Resources Associates Inc.
Sarah Gaichas	National Oceanic and Atmospheric Administration (NOAA)
Amber Himes-Cornell	National Oceanic and Atmospheric Administration (NOAA)
Kristin Hoelting	Colorado State University
Stephen Kasperski	National Oceanic and Atmospheric Administration (NOAA)
Teresa Klinger	University of Washington
Zachary Koehn	National Oceanic and Atmospheric Administration (NOAA)
Conor Maguire	University of Washington
Daniel Monson	US Department of the Interior
Thomas Okey	University of Victoria
Carlos Ormond	Simon Fraser University
James Ruzicka	Oregon State University
Samantha Siedlecki	University of Washington
Colette Ward	University of California, Santa Barbara
J. Timothy Wootton	University of Chicago
Stephani Zador	National Oceanic and Atmospheric Administration (NOAA)

Table 2. Participants in the Portfolio Effect working group

Name	Institution
Milo Adkison	University of Alaska, Fairbanks
Sean Anderson	University of Washington
Anne Beaudreau	University of Alaska, Fairbanks
Rachael Blake	University of California, Santa Barbara
Richard Brenner	Alaska Department of Fish and Game
Jessica Couture	University of California, Santa Barbara
Sherri Dressel	Alaska Department of Fish and Game
Janet Duffy-Anderson	National Oceanic and Atmospheric Administration (NOAA)
Alan Haynie	NOAA, Alaska Fisheries Science Center
Anne Hollowed	NOAA, National Marine Fisheries Service (NMFS)
Mary Hunsicker	National Oceanic and Atmospheric Administration (NOAA)
Mike Litzow	Farallon Institute for Advanced Ecosystem Research
Kristin Marshall	University of Washington
Jonathan Moore	Simon Fraser University
Tammy Neher	National Oceanic and Atmospheric Administration (NOAA)
Jeep Rice	Retired, National Oceanic and Atmospheric Administration (NOAA)
Andrew Shelton	National Oceanic and Atmospheric Administration (NOAA)
Jennifer Shriver	Alaska Department of Fish and Game
Colette Ward	University of California, Santa Barbara
Eric Ward	National Oceanic and Atmospheric Administration (NOAA)
Jordan Watson	University of Alaska, Fairbanks
Benjamin Williams	University of Alaska, Fairbanks

Gulf of Alaska Dynamics Synthesis Working Group

This working group is examining the effects of stressors on the resilience of social-ecological systems of the GOA, with focus on food webs, fisheries, pollutants, and nearshore habitats. This working group has actively been working on the following synthesis publications:

1) Linking ecosystem processes to communities of practice through commercially fished species in the Gulf of Alaska. 2017. S. G. Zador, S. K. Gaichas, S. Kasperski, C. L. Ward, R. E. Blake, N. C. Ban, A. Himes-Cornell, J.Z. Koehn. ICES Journal of Marine Science. DOI: 10.1093/icesjms/fsx054

Marine ecosystems are complex, and there is increasing recognition that environmental, ecological, and human systems are linked inextricably in coastal regions. The purpose of this paper was to integrate environmental, ecological, and human dimensions information important for fisheries management into a common analytical framework to examine the linkages between these traditionally separate subject areas. We focused on synthesis of linkages between the GOA marine ecosystem and human communities of practice defined by different fisheries sectors. Our specific objective was to document the individual linkages among environmental, ecological, and human dimensions variables in conceptual models, then build qualitative network models to perform simulation analyses to test how bottom-up and top-down perturbations might propagate through these linkages. We found that it is both possible and beneficial to integrate environmental, ecological, and human dimensions information important for fisheries into a common framework. First, the conceptual models allowed us to synthesize information across a broad array of data types, representing disciplines such as ecology and economics that are more commonly investigated separately, often with distinct methods. Second, the qualitative network analysis demonstrated how ecological signals can propagate to human communities, as well as how fishery management measures may influence the system, depending on the focal species and community of practice. Third, we found that incorporating multi-species interactions changed outcomes because considering qualitative impacts of perturbations on the combined multispecies system reversed some of the ecological and human outcomes relative to single species analyses. Overall, we demonstrated the value of linking information from the natural and social sciences to better understand complex social-ecological systems, and the value of incorporating ecosystem-level processes into a traditionally single species management framework. We advocate for conceptual and qualitative network modelling as efficient foundational steps to inform ecosystem-based fisheries management.

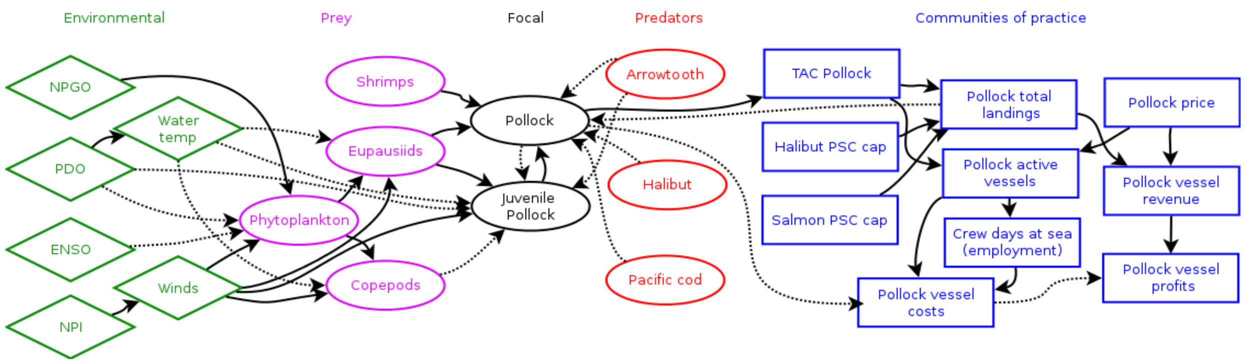

Figure 5. Conceptual model of the social-ecological system for pollock, showing linkages between environmental factors (green diamonds), prey (pink ovals), predators (red ovals), and communities of practice factors (blue rectangles).

2) Factors affecting disaster preparedness, response and recovery in the context of the Community Capitals Framework. A. Himes-Cornell, C. Ormond, K. Hoelting, N. C. Ban, J. Z. Koehn, E. Allison, E. C. Larson, D. H. Monson, H. Huntington, T. Okey. Anticipated submission to Ocean and Coastal Management in June 2017.

Disaster research often focuses on how and why communities are affected by a single, discrete extreme event. This article uses the Community Capitals Framework to understand how community capitals influence a community's preparedness, response to and recovery from a disaster. We used the GOA as a case study, where two major disturbances affected six communities: the 1964 Good Friday Earthquake (natural disaster) and the 1989 *Exxon Valdez* oil spill (technological disaster). We found that while the presence of relatively rich natural capitals commonly contributed more resources to pre-disaster planning and over long-term recovery, restriction of access immediately following disasters was to the significant detriment of many communities. Communities with strong political, social, and financial capitals pre-disaster tended to fare better immediately following disasters, and also contributed to longer-term processes of transformation or recovery. However, the technological disaster seriously undermined these capitals in some communities.

3) Comparing the roles of Pacific halibut and arrowtooth flounder within the Gulf of Alaska ecosystem and fishing economy. J. Ruzicka, S. Zador, A. Himes-Cornell, S. Kasperski. In preparation, expected submission to Fisheries Oceanography in July 2017.

The fishing industry along the western GOA coast directly employs over 28,000 people and produces processed fish with a wholesale value of $950 million. Groundfish represent almost one-third of the total wholesale value of processed GOA seafood. The most highly valued groundfish, for both quality and price, is Pacific halibut (*Hippoglossus stenolepis*), but the most abundant is the arrowtooth flounder (*Atheresthes stomias*). Pacific halibut are highly valued because of the high quality of their flesh and their large size. In contrast, arrowtooth flounder are not a valued fish because their flesh degrades upon heating. Both are high trophic level fish but because of differences in their relative abundances and diet preferences, they play different roles in the GOA ecosystem. In this study, we compare the ecological and economic roles of Pacific halibut and arrowtooth flounder within the GOA ecosystem and fishing economy. Using analyses with an end-to-end ecosystem model for the western and central GOA, we quantify the importance of both species to the ecosystem in terms of energy demand upon lower trophic levels and energy contribution to higher trophic levels. We find that the ecosystem is much more sensitive to reductions in arrowtooth abundance than in increased halibut abundance, with the greatest ecological effects upon mid- and upper trophic level competitors but effects upon few direct predators. Halibut have larger impacts upon fisheries than upon other groups within the ecosystem, negatively impacting fisheries that target pollock, Pacific cod, and crabs. Arrowtooth flounder more strongly impact the ecosystem than fisheries, but the impact of reduced arrowtooth abundance upon fisheries is still substantial. All fishery gear groups benefitted from decreased arrowtooth abundance, including the flatfish trawl gear group which targets arrowtooth along with other flatfish.

4) *Large-scale environmental variability and changes in coastal Gulf of Alaska food web structure*. J. Ruzicka, S. Siedelecki, T. Okey, A. Himes-Cornell, T. Klinger, T. Dean, T. Wootton, S. Kasperski. In preparation, expected submission to Journal of Marine Science in spring 2018.

Over the past three decades, both the community composition and seasonal oceanographic conditions on the GOA shelf have varied. Using an intermediate complexity end-to-end ecosystem model of the western GOA shelf, retrospective National Oceanographic and Atmospheric Administration (NOAA) buoy time-series data of wind and current conditions, and annual surveys of the plankton and fish community, we are comparing energy flow patterns throughout the pelagic and benthic food webs. Our goals are first, to build a mechanistic understanding of ecosystem dynamics, and second, to characterize ecosystem sensitivity to anthropogenic perturbation (e.g., fishing pressure and catastrophic events such as oil spills) in the face of the natural interannual variability of seasonal climate drivers.

5) *Associations between Mussel Abundance and Environmental Drivers in the Gulf of Alaska.* R. Blake, T. Dean, T. Klinger, D. H. Monson, S. Siedlecki, T. Wootton. In preparation, expected submission to PLoS One in 2017.

Drivers of nearshore benthic organisms remain difficult to identify, yet for important species such as mussels in the GOA, it is critical to understand what drives abundance. Mussels provide an important ecosystem service by filtering large quantities of water daily. They also make up a large proportion of the diet of sea stars, sea otters, oystercatchers, and other nearshore invertebrates and vertebrates. This study examines environmental drivers at three scales, from local to regional, to determine which factors most influence mussel abundance.

6) *Can oil spills shift marine ecosystems to alternate stable states? Preliminary simulations with an Ecopath model of Prince William Sound, Alaska.* T. A. Okey. In preparation, expected submission to PLoS One in 2017.

Simulations of an earthquake and an oil spill, using a trophic mass-balance model of the Prince William Sound ecosystem, indicate different scenarios of long-term impacts—some showing eventual recovery and others showing a shift to alternate stable states. The dynamic simulation routine Ecosim was used to indicate relative biomass (i.e., population) trajectories of biotic ecosystem components in response to these simulated disturbances. Direct mortalities are specified for various ecosystem components, based on empirical data on impacts of EVOS, a 40 million litre spill that occurred in Prince William Sound in 1989. Biomasses of other biotic components in the food web were subsequently indicated to vary over time based on specified rates of interactions (i.e., energy flow) among components. Simulations indicate that (1) Prince William Sound can recover relatively quickly from a large earthquake, such as the 1964 Good Friday earthquake that triggered tsunamis and changed elevations, because in general, only lower trophic level components were impacted to varying extents in different areas; (2) Oil spills that impact mostly higher trophic levels (based on documented impacts of the EVOS) can have more severe impacts in which system recovery is slower; and (3) Oil spills that have more broad impacts (affecting both high and low trophic levels) can lead to 'alternate stable states' from which recovery may not occur, and which the EVOS possibly caused. Trophic forces are explicitly considered in the Ecopath model and Ecosim simulations, while physical forces are implicit in the model and simulation scenarios. The mass-balanced trophic model of Prince William Sound was constructed by a broad collaboration of experts on various components of the system. The simulations presented in this analysis were verified qualitatively by observed recovery trajectories of various ecosystem components. A general conclusion is that the resilience of biological communities to disturbance may depend on the breadth of impacts across trophic levels.

7) Simulating effects of the Exxon Valdez Oil Spill on the Prince William Sound ecosystem in the context of changing fisheries and climate. T. Okey, Ainsworth, S. Kasperski, S. Seidlecki, J. Ruzicka, T. Dean, J. Bodkin, and possibly T. Klinger, A. Himes-Cornell, and Pauly. In preparation, with anticipated submission to Marine Pollution Bulletin in 2017.

For more than 25 years, the Prince William Sound ecosystem has been influenced by EVOS, by fishery effects, and by environmental variability and change. Each of these categories of drivers have characteristically different effects on the biological community of the Prince William Sound ecosystem. For instance, EVOS impacts were most dramatic and most persistent in the nearshore benthic food web; Pacific Decadal Oscillation changes had greatest impacts on pelagic food web; and fisheries impacts vary across habitats. We have attempted to reconstruct past ecosystem changes in the Prince William Sound marine ecosystem by driving the Prince William Sound model with empirically-estimated and taxonomically-specific responses to oil and the changes in catches of all fisheries, and comparing functional group trajectories to measured time-series of functional group changes over 25 years, calibrating the model behavior by fitting to those time series, and comparing resulting production anomalies to independent time series of production. The process also calibrated the model, increasing its skill, for use in future explorations of management and policy.

8) *Variation in mussel abundance in the Gulf of Alaska in response to physical and biological factors*. T. Klinger, R. Blake, S. Siedlecki, T. Wootton, D. Monson, T. Dean, and J. Ruzicka. In preparation.

Applying Portfolio Effects to the Gulf of Alaska Synthesis Working Group

This working group sought to assess the relationship between biodiversity and stability of ecological populations and communities, as well as harvest of marine species, in the GOA. This group has 12 research papers underway:

1) Spatio-temporal models reveal subtle changes to demersal communities following the Exxon Valdez oil spill. 2017. A. O. Shelton, M. E. Hunsicker, E. J. Ward, B. Feist, R. Blake, C. L. Ward, B. C. Williams, J. T. Duffy-Anderson, A. B. Hollowed, A. C. Haynie. ICES Journal of Marine Science fsx079. DOI: [10.1093/icesjms/fsx079](https://doi.org/10.1093/icesjms/fsx079).

Toxic pollutants such as crude oil have direct negative effects for a wide array of marine life. While mortality from acute exposure to oil is obvious, sub-lethal consequences of exposure to petroleum derivatives for growth and reproduction are less evident and sub-lethal effects in fish populations are obscured by natural environmental variation, fishing, and measurement error. We use fisheries independent surveys in the GOA to examine the consequences of EVOS for demersal fish. We delineate areas across a range of exposure to EVOS and use spatio-temporal models to quantify the abundance of 53 species-groups over 31 years. We compare multiple community metrics for demersal fish in EVOS and control areas. We find that areas more exposed to EVOS have more negative trends in total groundfish biomass than non-EVOS areas, and that this change is driven primarily by reductions in the abundance of the apex predator guild (Fig. 6). We show no signature of increased variability or increased levels of synchrony within EVOS areas. Our analysis supports mild consequences of EVOS for groundfish communities, but suggests that long time-series and assessments of changes at the community level may reveal sub-lethal effects in marine communities.

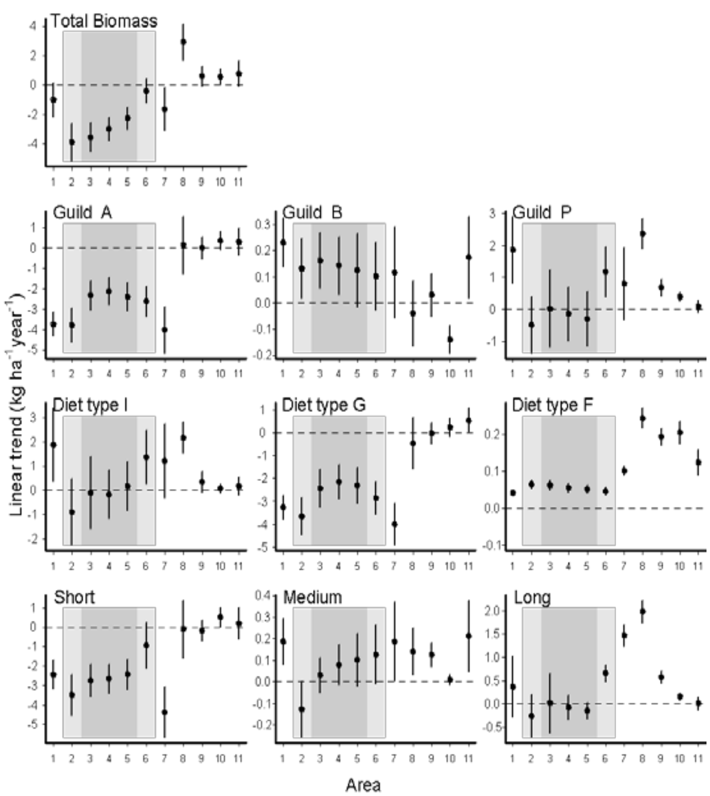

Figure 6. Estimated linear trend for the 11 groundfish regions. Areas hypothesized to be most affected by EVOS are shaded darkly, the marginal areas of EVOS exposure have lighter shading, and unexposed areas are not shaded. Each row shows the community broken up based on guild, diet category, or recruitment interval. Note that the values of the y-axis vary among panels.

2) Environmental heterogeneity and conserved community architecture drive spatial patterns of diversity across the Gulf of Alaska large marine ecosystem. R. E. Blake, C. L. Ward, M. E. Hunsicker, A. O. Shelton, A. Hollowed, A. In preparation, anticipated submission to Ecology in 2017.

The mechanisms structuring patterns of diversity and community composition can be difficult to identify, and much of our knowledge stems from study of local ecological systems. Two candidate mechanisms include dispersal and environmental heterogeneity, which structure communities at local and larger scales by fostering species coexistence and niche partitioning, respectively. It is important to understand these patterns and their drivers at larger scales, especially in the face of climate and other perturbations. The GOA has complex topography, climate-driven variability, and a well-studied groundfish community, making it an ideal study system. We examined patterns of diversity and community composition in the groundfish community across 14 sites in the GOA using geostatistically modeled groundfish abundance and biomass from the Alaska Fisheries Science Center trawl survey data (1984 – 2015). We found that species richness, and alpha, beta, and functional diversity varied little both within and between study areas, and were conserved across the central GOA (Fig. 7). Conversely, community composition varied significantly along a longitudinal gradient, with distinct groups of species in individual study areas. These differences in community composition were driven by rare and lower-density species, while high-density species remained the same. Thus, community structure was conserved despite variation in species identities. Overall, environmental heterogeneity and community structure control groundfish diversity across the GOA large marine ecosystem.

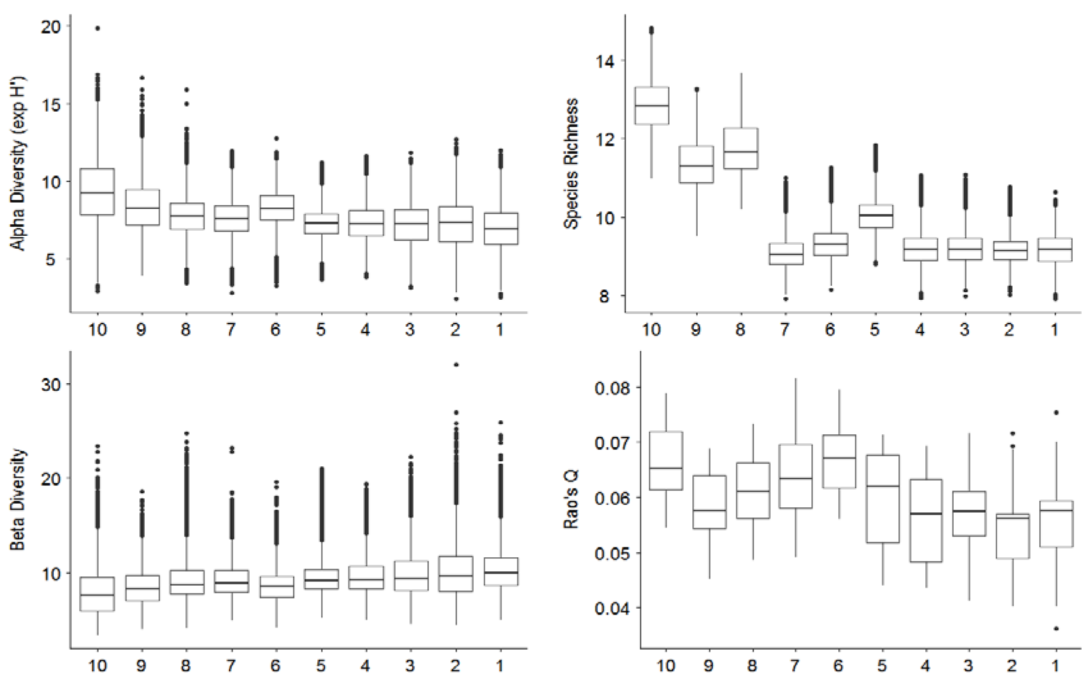

Figure 7. Diversity metrics of the groundfish community (Y axes) across 10 areas of homogeneous depth (X axes) in the Central Gulf of Alaska showing very little variation except a slight difference in species richness.

3) From local to regional: spatial scaling of long-term diversity and stability in the Gulf of Alaska groundfish community. C. L. Ward, R. E. Blake, M. E. Hunsicker, A. O. Shelton, A. B. Hollowed, and O. L. Petchey. Anticipated submission to Proceedings of the Royal Society of London B: Biological Sciences in 2017.

The mechanisms underlying the relationship between diversity and stability are well understood at the scale of local communities but remain largely unexplored empirically regarding their scaling from local to regional levels. Here we evaluate spatial scaling of diversity and stability in the groundfish community across 10 discrete local patches in the GOA large marine ecosystem, using data from NOAA's long term benthic trawl survey (1984-2015). We document greater aggregate community stability at the regional than the local level, and evaluate the relative influence thereon of (i) processes at the local scale (asynchrony between species in local communities and mean species variability) and (ii) processes at the between-patch (beta) scale (asynchrony between local communities and spatial turnover in community composition).

4) Evaluating signals of oil spill impacts, climate, and species interactions in Pacific herring and Pacific salmon populations in Prince William Sound and Copper River, Alaska. 2017. E.J. Ward, M. Adkinson, J. Couture, S. C. Dressel, M. A. Litzow, S. Moffitt, T. Hoem Neher, J. Trochta, and R. Brenner. PLoSONE. DOI: 10.1371/journal.pone.0172898.

EVOS occurred in March 1989 in Prince William Sound, Alaska, and was one of the worst environmental disasters on record in the United States. Despite long-term data collection over the nearly three decades since the spill, tremendous uncertainty remains as to how significantly the spill affected fishery resources. Pacific herring (*Clupea pallasii*) and some wild Pacific salmon populations (*Oncorhynchus* spp.) in Prince William Sound declined in the early 1990s, and have not returned to the population sizes observed in the 1980s. Discerning if, or how much of, this decline resulted from the oil spill has been difficult because a number of other physical and ecological drivers are confounded temporally with the spill; some of these drivers include environmental variability or alternating climate regimes, increased production of hatchery salmon in the region, and increases in populations of potential predators, like humpback whales. Using data pre- and post-spill, we applied time-series methods to evaluate support for whether and how herring and salmon productivity has been affected by each of five drivers: (1) density dependence, or increasing population growth rate at decreasing population density (2) the EVOS event, (3) changing environmental conditions, (4) interspecific competition on juvenile fish, and (5) predation and competition from adult fish or, in the case of herring, humpback whales. Our results showed support for intraspecific density-dependent effects in herring, sockeye, and Chinook salmon, with little overall support for an oil spill effect. Of the salmon species, the largest non-EVOS driver was the negative impact of adult pink salmon returns on sockeye salmon productivity. Herring productivity was most strongly affected by changing environmental conditions; specifically, freshwater discharge into Prince William Sound was linked to a series of recruitment failures—before, during, and after EVOS. These results highlight the need to better understand long terms impacts of pink salmon on food webs, as well as the interactions between nearshore species and freshwater inputs, particularly as they relate to climate change and increasing water temperatures.

5) Long term trends in ichthyoplankton assemblage structure, biodiversity, and community synchrony in the Gulf of Alaska and their relationships to climate. K. Marshall, K., and J. Duffy-Anderson. Anticipated submission to Ecology in 2017.

This work (i) assesses species richness, shannon diversity, synchrony, and dynamic factor analysis trends over time, and (ii) evaluates whether trends may be explained by environmental drivers and spawning stock biomass.

6) Benefits and risks of diversification for individual fishers. 2017. S.A. Anderson, E.J. Ward, A.O. Shelton, M.D. Adkison, A.H. Beaudreau, R.E. Brenner, A.C. Haynie, J.C. Shriver, J.T. Watson, and B.C. Williams. Proceedings of the National Academy of Sciences. DOI: https://doi.org/10.1073/pnas.1702506114

Individuals relying on the extraction of natural resources for their livelihood — fishers, farmers, miners, and loggers, among others — face high levels of income variability driven by a mix of environmental, biological, management, and economic dynamics. A key component to managing these industries is identifying how regulatory actions and individual behavior affect income variability and, by extension, economic stability and the sustainable use of natural resources. For commercial fisheries, communities and vessels fishing a greater diversity of species have less revenue variability than those fishing a lower diversity. However, it is unclear if these benefits extend to the actions of individual fishers and how year-to-year changes in diversification affect revenue and revenue variability. Here, we identify three axes by which fishers in Alaska, one of the world's most productive fishing regions, can diversify fishing activities. We show that, despite increasing specialization over the last 30 years, fishing permits with higher species diversity reduces individual revenue variability and fishing an additional permit is associated with higher revenue and lower variability (Fig. 8). However, increasing species diversity within the constraints of existing permits has a fishery-dependent effect on revenue and is usually (93% probability) associated with increased revenue uncertainty the following year. Our results demonstrate that the most effective option for individuals to decrease revenue variability is to purchase permits to participate in additional or more diverse fisheries. However, this option is expensive, often limited by regulations such as catch share programs, and consequently unavailable to many individuals. With increasing environmental variability in a changing climate, it will be particularly important that individuals relying on natural resources for their livelihood have effective strategies to reduce income variability.

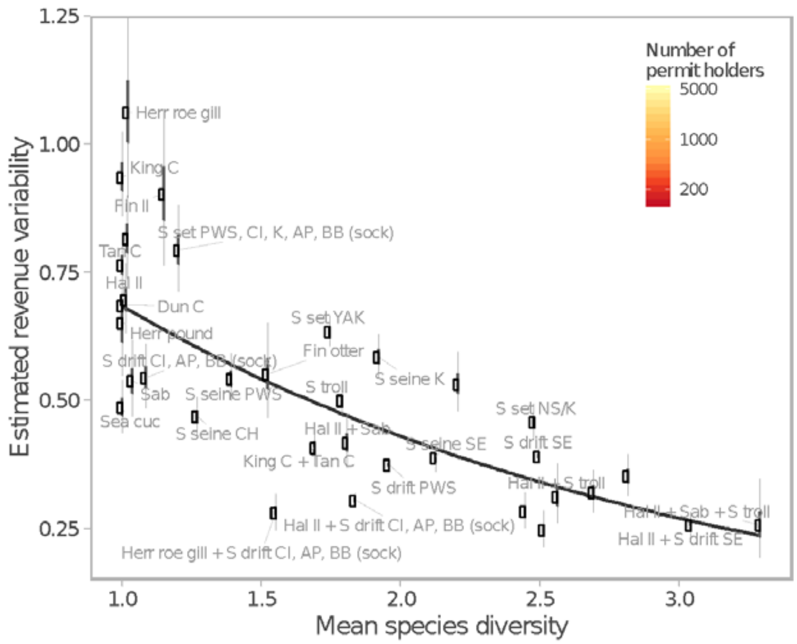

Figure 8. Revenue variability versus permit strategies. Individuals who fish permits and permit combinations (permit strategies) with higher species diversity have lower expected revenue variability. On the y-axis, dots, thick lines, and thin lines represent posterior medians, 50%, and 95% credible intervals for the 34 most common permit strategies. Thick black line, and dark and light grey shaded regions indicate median, 50%, and 95% credible intervals of strategy-level regression built into the hierarchical model. Estimated variability represents expected standard deviation for a permit holder who does not change species diversity or days fished from year-to-year.

7) Salmon portfolios. E. Ward, E., et al. Anticipated submission to Proceedings of the Royal Society of London B: Biological Sciences in 2017.

This work will assess the diversification over time of salmon catch portfolios among Pink and Chum salmon. We find that benefits of diversification are declining - on average, boom/bust cycles are more profitable, but income variability is much greater. Most fishers are now focusing on fewer species. This paper is in preliminary stages and will be developed during 2017.

8) Historical patterns and drivers of diversification in Gulf of Alaska fisheries. Beaudreau, A. et al. Anticipated submission to Fish and Fisheries in 2017.

Policy, economic, and environmental pressures can influence fishing behavior and fishers' long-term strategies regarding participation in a fishery. Maintaining a diversity of fishing strategies may, in turn, act as a buffer against future changes. This work examines historical patterns and drivers of diversification in Alaskan fisheries, including shifts in the portfolio of harvested species and permit types used by fishers. The manuscript evaluates five case studies examining fishery- and community-level responses to multiple drivers, including species declines, the *Exxon Valdez* oil spill, market factors, limited entry, and rationalization. Overall, this work documents evidence for reduced participation and increasing specialization in Alaskan commercial fisheries.

9) Twenty-five years after the Exxon Valdez oil spill: a synthesis of climatic, anthropogenic, and ecological drivers of Gulf of Alaska communities. K. Marshall, and all working group members. Anticipated submission to Frontiers in Ecology and the Environment in 2017.

The portfolio effects working group prepared this manuscript that synthesizes the group's work over the life of the grant. Understanding how ecosystems respond to environmental variability and large perturbations is a central problem in marine ecosystems. EVOS was an extremely large perturbation to the GOA ecosystem. However, because species and populations differ in the timing and magnitude of their responses to perturbations, the long-term effects of the oil spill may be difficult to detect in areas other than nearshore environments. Multiple scales of diversity in the ecosystem may also have protected its structure and functioning from long-term impacts. This work synthesizes time-series from the GOA ecosystem and fisheries and used novel statistical methods to: 1) build an understanding of the temporal and spatial scales of variation in biomass, recruitment, and diversity for herring, salmon, and groundfish in the GOA, 2) investigate the roles of climate, ecological interactions, socioeconomic factors, and fishery management in explaining variation in ecosystem components, and 3) examine the role of diversity in stabilizing the temporal dynamics of plankton and focal fish species, and the catch portfolios of individual commercial fishermen in the GOA pre- and post-oil spill. Overall, we find that climate, economic, and management shifts had more discernable and long-term impacts on fish population and fishery dynamics than the oil spill. Our synthesis improves understanding of the role of multiple sources of variability in structuring GOA communities and advances methods in spatiotemporal modeling.

Finally, the portfolio effects group has planned three additional manuscripts that are still in the early preparation phase. One of these will be led by A. Haynie on the relationship between the EVOS and the individual fishing quota system. Another led by R. Brenner will focus on the relationships between salmon and herring in Prince William Sound and the GOA. And a final manuscript to be led by E. Ward will focus on relationships between groundfish and salmon.

The group has presented summaries of this work at eight conferences, as listed in the Other References section.

DISCUSSION

Our results show that, despite significant effort at recovery, data are hard to preserve. Data that are left undocumented and unpreserved for long periods are unlikely to be accessible for future scientific studies, even if the data are critical to retrospective analysis. That only 30% of the data collected following EVOS were recoverable with a significant rescue investment is consistent with other studies that show the difficulty in retroactively rescuing data. For example, Vines et al. (2014) showed that, on average, the odds of data availability dropped 17% per year, and Roche et al. (2015) showed that 64% of ecology and evolution data are inaccessible or unusable even from journals that enforce strong mandates for public data. Environmental data are particularly valuable for synthesis (Carpenter et al. 2009), in part because the data are irreplaceable for establishing baseline conditions when evaluating large scale disturbance events and global change. Although researchers recognize the value of data for synthesis, and although they are in principle committed to sharing and archiving their data, in practice pragmatic constraints on researcher time have traditionally prevented them from effectively documenting and sharing their data. Our results showing limited data recovery demonstrates the significant opportunity costs that arise when researchers lack the proper incentives to preserve their data. In the case of EVOSTC-funded projects, those funded prior to 2002 operated under a regime in which data sharing was not explicitly required, which was a lost opportunity to promote data preservation. After 2002, the explicit requirement for projects to share data provided a strong signal that preservation of data was expected and valued, and this in turn made collation of those data easier after-the fact.

Even in the absence of complete data preservation, synthesis is still possible through laborious data acquisition and cleaning, and exploitation of personal networks. While data may not be readily accessible through repositories, the same publication incentive that causes researchers to avoid spending their time on public data sharing can cause them to provide data to a personal colleague who will include them on a publication. In the two synthesis groups conducted here, both groups were able to obtain valuable data that was used in effective cross-cutting analysis, but the vast majority of the time spent undertaking the synthesis was used for obtaining, cleaning, and integrating data from obscure corners of the research world. Two full time postdocs, a full time data coordinator, and a team of data interns were all involved in collating data for synthesis. While the groups succeeded, they did so inefficiently and at great personal investment. Had all the data they sought been preserved initially after collection, analysis and modeling could have been started a year or more earlier than was possible. Thus, synthesis would be far more efficient and broader in scope if data were preserved and documented when collected. Furthermore, it may have been possible to conduct synthesis work at a greater temporal scale, had it been possible to recover more data. This would be good for researchers that want to re-use their own data, good for science because it enables others to build on prior findings, and good for funders that want to maximize the value of their research funding investment. Improvements in the efficiency of data sharing would directly lead to increased impacts of science on society.

CONCLUSIONS

Historical data are critical for retrospective analysis of long-term ecological and environmental phenomena, and yet they are rarely preserved. Despite the significance and magnitude of EVOS and the well-funded, concerted effort to monitor recovery and impacts, and although post-2002 EVOSTC research funds were awarded to PIs conditional on data sharing, data are still extremely difficult to find for the 28 years since the event. Improving this situation requires a wholesale culture shift by researchers whose incentives are largely driven by academic publication and agency promotion. Until such a shift occurs, synthesis activities such as those conducted here will continue to require long periods to acquire, clean, and integrate data, and must accept that significant amounts of historical data will be lost or unusable for retrospective research. Future groups that wish to preserve the legacy of scientific work in response to events such as the *Exxon Valdez* oil spill will need to provide strong mandates for data preservation at the time of collection, systems for verification and peer review of data as they are collected, and long-term funding to data repositories and curators to ensure data are not lost through inadvertent lapses in infrastructure.

ACKNOWLEDGEMENTS

We are grateful to the many researchers who generously gave their time to help document and preserve the valuable historical data stemming from the *Exxon Valdez* oil spill. We also thank Sarah Clark, Emma Freeman, Gavin McDonald, and Jesse Goldstein for their work on interviewing researchers and carefully documenting data for preservation. We thank Axiom Data Science, and in particular, Rob Bochenek and Ross Martin, for their assistance and insights into the archival process for historical data. And we thank the *Exxon Valdez* Oil Spill Trustee Council for funding this project and for their foresight in promoting data preservation and sharing through their program policies and mandates. The findings and conclusions presented by the authors are their own and do not necessarily reflect the views or position of the *Exxon Valdez* Oil Spill Trustee Council.

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Presentations by Working Group Members

Beaudreau, A., E. Ward, R. Brenner, J. Watson, A. O. Shelton, J. Shriver, B. Williams, and A. Haynie. 2017. Historical patterns and drivers of diversification in Gulf of Alaska fisheries. Society for Applied Anthropology Meeting, Santa Fe, NM. Oral Presentation.

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Blake, R. E., C. L. Ward, M. Hunsicker, A. Shelton , **A. B. Hollowed**, and A. Haynie. 2017. Environmental heterogeneity and conserved community architecture drive spatial patterns of diversity across the Gulf of Alaska large marine ecosystem. Alaska Marine Science Symposium, Anchorage, AK. Poster.

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Ward, C. L., R. E. Blake, M. Hunsicker, A. O. Shelton, A. Hollowed, E. Harvey, and O. L. Petchey. 2017. From local to regional: spatial scaling of long-term diversity and stability in the Gulf of Alaska groundfish community. Canadian Conference for Fisheries Research, Montreal, Canada. Oral Presentation.

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APPENDIX 1: Recovered Data Sets

Recovered historical data sets (126) from *Exxon Valdez* Oil Spill Trustee Council-funded projects.

Title	Creators	Identifier
1:1,000,000-Scale State Boundaries of the United States	The National Atlas of the United States of America, USGS	df35d.430.2
A biological inventory of intertidal and shallow subtidal communities in Prince William Sound, Kachemak Bay and Kodiak Island, Alaska: 2003 - 2004	Brenda Konar, Katrin Iken	df35d.138.11
Acoustic surveys to determine biomass and distribution of forage species in Prince William Sound, Alaska: 1995 - 1998	Lewis Haldorson, Thomas Shirley, Kenneth Coyle, Richard Thorne	doi:10.5063/F1D798BS
Aerial Surveys of Harbor Seals in Prince William Sound, Alaska: 1989 - 2001	Kathryn Frost, Sara Iverson, Lloyd Lowry, Mike Simpkins, Jay Ver Hoef	doi:10.5063/F1057CVK
Age-Sex-Length-Weight data for pacific herring in Prince William Sound, Alaska (1973-2014)	Steve Moffitt, Richard Brenner	df35b.273.7
Alaska commercial salmon catches by management region (1886- 1997)	Mike Byerly	df35b.304.2
Algal Size and Density Data Prince William Sound, Alaska (1990, 1991, 1993, 1998)	Thomas Dean	df35b.168.10
Anadromous Water Catalog (AWC) data for lower stream points in Prince William Sound districts 221-229, Alaska Department of Fish and Game 2013	Steve Moffitt	df35k.41.2
Annual photographic survey summaries of killer whales in Alaska: 1984 - 2012	Craig Matkin, Eva Saulitis, Graeme Ellis	df35d.136.17
Assessing prey of pink salmon fry from zooplankton net catch data in Prince William Sound, Alaska: 2001	Richard Thorne, Gary Thomas	doi:10.5063/F18G8HM2

Title	Creators	Identifier
Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches In Prince William Sound, 2000	Dennis Lees, William Driskell	df35c.9.25
Average monthly temperatures at select NOAA NBDC tide stations throughout Alaska: 1922-2010	National Buoy Data Center	df35a.34.9
Behavior and Feeding Summaries for Killer Whales in Alaska: 2003 - 2012	Craig Matkin, Eva Saulitis, Graeme Ellis	df35d.408.7
Biological Survey of Deep Subtidal (>20m) Marine Sediment Resources in Lower Kenai Peninsula and near Kodiak Island, Alaska: 1989 - 1991	Howard Feder	doi:10.5063/F1KW5CX7
Biophysical Observations Aboard Alaska Marine Highway System Ferry: Tustumena, Gulf of Alaska (2004-2008)	Edward D. Cokelet	df35b.8.26
Biopsy Summaries for Killer Whales in Alaska: 1994 - 2012	Craig Matkin, Eva Saulitis, Graeme Ellis	df35d.402.7
Breeding Ecology of Harlequin Ducks, Alaska Department of Fish and Game, Eastern Prince William Sound, 1991-1993	David Crowley, Samuel Patten\, Jr.	df35k.3.19
Chinook salmon release program in Crab Bay, Evans Island, Alaska: 1994-1997	Howard Ferren, Jeff Milton, David Reggiani	df35a.43.9
Common Murre Population Monitoring in the Chiswell Islands, AK, 1989-2001	David Roseneau, Arthur Kettle, G. Vernon Byrd	df35j.29.11
Common Murre Restoration Monitoring in the Barren Islands, AK, 1993-1994	David Roseneau, Arthur Kettle, G. Vernon Byrd	df35j.14.15
Continuous plankton recorder zooplankton and phytoplankton data, North Pacific Ocean: 1997, 2000-2009, 2012	Sonia Batten, David Welch	df35d.195.12
Cutthroat trout and Dolly Varden char inventory in Prince William Sound, Alaska: 1997	Merlyn Schelske, Ken Hodges, David Schmid	doi:10.5063/F1NP22CR

Title	Creators	Identifier
Cytochrome P4501A biomarker in Barrow's goldeneyes, USGS, US Fish and Wildlife, 2005 and 2009	Daniel Esler	df35l.10.12
Cytochrome P4501A Induction in Sea Ducks Inhabiting Nearshore Areas of Prince William Sound, Alaska, US Fish and Wildlife, USGS, 1996	Kimberly Trust	df35l.7.11
Disease assays conducted on harbor seal blood serum in Prince William Sound, Alaska: 1975 - 2001	Kathryn Frost, Sara Iverson, Lloyd Lowry, Mike Simpkins, Jay Ver Hoef	doi:10.5063/F1QJ7F7N
East Amatuli Island Remote Video Link Project - 1999	Michael O'Meara, Arthur Kettle	doi:10.5063/F1G44N67
Ecological effects to benthic infauna from lingering oil in Prince William Sound, Alaska: 2004 [unformatted data]	Betsy Day	df35d.231.5
Ecology and demographics of Pacific sand lance in Lower Cook Inlet, Alaska: 1997 - 1999	Martin Robards, John Piatt	doi:10.5063/F1F769G5
Economic Damages to Recreation: Alaska Sport Fishing in the Aftermath of the *Exxon Valdez* Oil Spill	Edward Mills	df35j.63.21
Economic Damages to Recreation: An Assessment of the Impact of the *Exxon Valdez* Oil Spill on the Alaska Tourism Industry	Edward Mills	df35j.75.6
Eelgrass Density and Flower Data at Oiled and Control Sites, Prince William Sound, Alaska (1990,1991,1993,1995)	Dr. Stephen Jewett	df35b.146.7
Effects of EVOS on abundances and reproduction of Murre colonies, near PWS, coastal Kenai and Alaska Peninsulas, and Kodiak Island (1989-1991).	David Nysewander	df35i.24.34

Title	Creators	Identifier
Egg and larval mortality data between oiled and non-oiled areas of Prince William Sound, Alaska following the *Exxon Valdez* Oil Spill in 1989	Evelyn Brown, Michael McGurk	doi:10.5063/F1VD6WC9
Estimating forage fish distribution and abundance using aerial surveys in Prince William Sound, Alaska: 1995 - 1999	Brenda Norcross, Gary Borstad, Evelyn Brown, Stephanie Moreland	doi:10.5063/F15H7D6G
Evaluating Harlequin Duck Population Recovery: CYP1A Monitoring and Population Data (2006, 2007, 2009)	Dan Esler	doi:10.5063/F1X63JTD
Evaluation of Alaska Harbor Seal (Phoca vitulina) population surveys: A simulation study (1995-1996)	Dr. Milo Adkison	df35b.10.8
Factors affecting recovery of pigeon guillemot populations in Prince William Sound, Alaska 1995 - 2000 [Unformatted Data]	Lindsey Hayes, Gregory Golet, Kathy Kuletz, David Duffy, David Irons, Daniel Roby, Ted Spencer	df35d.248.5
Fatty acid signatures for harbor seals and their prey in and around Prince William Sound, Alaska	Kathryn Frost, Sara Iverson, Lloyd Lowry, Mike Simpkins, Jay Ver Hoef	doi:10.5063/F1TB14T4
Fish Density in Subtidal Communities of Prince William Sound, Alaska (1990, 1991, 1993, 1995)	Thomas Dean, Stephen Jewett	df35b.175.3
Forage fish diet in Prince William Sound, Alaska: 1994 - 1996	Molly Sturdevant	doi:10.5063/F1V985ZZ
GAK1 Mooring Timeseries data, Seward, Alaska (1970-2012)	Thomas J. (Tom) Weingartner, Thomas C. Royer	df35b.21.6
Genetic discrimination of herring populations in Prince William Sound, Alaska: 1994-1998	Jeffrey Olsen, Paul Bentzen, Jonathan Wright, Jim Seeb, Lisa Seeb, Susan Merkouris	df35a.38.7
Geographic Extent, Temporal Persistence and Mapping of Floating Oil from the *Exxon Valdez* Oil Spill: 1989	Marshal Kendziorek	doi:10.5063/F10Z715D
Geographical Information System database of the availability of historical	Jim Bodkin, Tom Dean, Kim Kloecker, Heather Coletti	df35d.457.8

Title	Creators	Identifier
data in the nearshore zone of the Gulf of Alaska		
GIS maps of habitat protection and acquisition in Alaska: 1993 - 2004	EVOS Restoration Office Habitat Acquisition Work Group	df35d.266.5
GIS tracks for killer whale encounters in Alaska: 1984 - 2013	Craig Matkin, Eva Saulitis, Graeme Ellis	df35d.462.4
Habitat protection and acquisition support for the *Exxon Valdez* Oil Spill Trustee Council in Alaska: 1993 - 2004	EVOS Restoration Office Habitat Acquisition Work Group	df35d.333.3
Harbor seal monitoring in southern Kenai Peninsula fjords, Alaska: 1979 - 2007	Anne Hoover-Miller, Caroline Jezierski, Shannon Atkinson	doi:10.5063/F1KS6PHX
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