Thriving Communities 2
Final Report

Project Title: Synthesizing Ship Tracking Data, Oil Spill Model Results, and Subsistence Use Information into a Unique, Interactive Tool to Aid Research and Planning in Coastal Communities Bordering the Alaska Beaufort Sea
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I. PROJECT SUMMARY (from proposal)

This project will integrate data products describing vessel traffic patterns, estimated oil spill impacts, and subsistence use data from the communities of Barrow, Nuiqsut, and Kaktovik along the Beaufort Sea coast, and incorporate them into a unique tool for planners and subsistence community members. Spatial heat maps of vessel traffic density will be developed by analyzing Automated Identification System (AIS) data from the Marine Exchange of Alaska and NOAA to isolate marine vessel corridors experiencing the heaviest traffic. Investigators will run several hundred oil spill trajectory scenarios powered by ocean circulation and atmospheric wind models initialized at randomized locations and times coinciding with vessel traffic hotspots. Spill trajectory results will be summarized to produce a Spill impact density map for the Beaufort Sea. Subsistence-use patterns will be produced from aggregating individual subsistence mapping, harvest, and other socio-economic surveys from the Alaska Beaufort Sea communities of Barrow, Nuiqsut, and Kaktovik. These subsistence datasets have been previously unavailable, and include species descriptions, timing and area for targeted species, and other traditional ecological variables for each community. The subsistence mapping and species distribution data will be compared to the spill impact density maps to understand how different subsistence activities and their

relative timing could be impacted in the event of a spill. The data gathered and synthesized through this project will be publicly accessible through an interactive web-based mapping tool as a mechanism for increasing public, private sector, government, and community knowledge about possible spill effects to subsistence uses in the US Arctic.

II. PROJECT SUMMARY (from final report)

Coastal Arctic villages depend on the ocean for food and cultural identity. Decreasing sea ice has led to more ships of all types traveling off the north coast of Alaska and an increase in the risk of a marine oil spill that could affect a village's ability to hunt and fish and participate in cultural activities. This project aimed to determine which villages and resources have the higher risk of being affected by a future oil spill. To do this, the study team used previous data that surveyed harvesters from three Arctic Villages —Utqiaġvik, Nuiqsut, and Kaktovik —to find out when, where, and what they hunt and fish over a 10-year time period. Separately, the team used ship tracking data to make maps of ship traffic. The ship traffic maps were used to simulate 100,000 oil spill models, with each model tracking 1000 virtual oil "particles" for one week. The oil spill model results were combined with the hunting and fishing maps to determine which resources have a higher or lower risk of being affected by a ship-based oil spill. The results were put onto an interactive map online to be used as a tool for planning and decision support.

III. PROJECT RESULTS

Accomplishments

Customary and traditional uses of fish and wildlife are important to the economic and cultural livelihoods of Northern Alaska communities along the Beaufort Sea. Resources that Alaska Native communities depend on for subsistence purposes are already vulnerable to the effects of a changing climate. Shrinking sea ice cover in the Arctic has led to an increase in socioeconomic activity including offshore energy exploration and development and additional ship traffic. Sea ice coverage has decreased to the point that existing northern shipping lanes around the world are ice-free for longer periods and are projected to experience even more marine vessel traffic in the future. These changes increase the probability of accidents and potential for oil spills posing dangers to subsistence resources and the coastal environment. A spill in this region would be catastrophic to subsistence communities and difficult to respond to because of the Arctic's remoteness, harsh environmental conditions, and lack of sufficient facilities or ports for response. There are currently only three US marine ports on the Beaufort Sea —Utqiaġvik (formerly Barrow), Prudhoe Bay, and Bernard Harbor (near Kaktovik) — all of which Alaska's Institute of the North classifies as "very small" and, thus, insufficient to respond to major spills. A small cache of local spill response equipment is present in Utqiaġvik, but it is minimally outfitted for spill volumes of less than 5000 gallons of oil. A larger inventory of response equipment resides in Deadhorse, at Prudhoe Bay; however, that equipment is meant for spills from local oil and gas operations, not to be dispatched along the entire 400-mile coast from Utqiaġvik to Kaktovik.

Understanding and showing mapped subsistence activities in this region and the potential risk to those activities by oil spills is important to better inform the effects of vessel activity and oil exploration and to incorporate that information into decision-making processes.

This work had four main objectives: (Objective 1) Process, standardize and make openly-available data products that describe vessel traffic patterns, subsistence uses, and oil spill risk along the Beaufort Sea coast. (Objective 2) Summarize marine subsistence use patterns for the three Alaska Beaufort Sea communities of Utqiaġvik, Nuiqsut, and Kaktovik. (Objective 3) Understand the timing of various offshore subsistence activities and the potential relative impacts of offshore oil and gas operations. (Objective 4) Integrate data into an interactive map to be used as a tool to increase public knowledge and inform agency decision-making.

To meet these objectives, we did the following:

Objective 1. Process, standardize, and make openly-available data products that describe vessel traffic patterns, subsistence uses, and oil spill risk along the Beaufort Sea coast.

Marine AIS vessel and subsistence data were aggregated, standardized, and ingested into the AOOS interoperability data system. Analyses of vessel density patterns were conducted and visualized with subsistence use data for three Alaska Beaufort Sea communities. These preliminary data products were reviewed by the project team and optimizations identified before their use in the oil spill trajectory analysis.

Funding from the Arctic Domain Awareness Center, for a separate project using AIS data to develop bathymetric survey priorities, helped with the initial aggregation and quality control of AIS data. AIS data from the continental US and Alaska were received from the Alaska Marine Exchange and NOAA in raw, NMEA AIS message format. These data totaled 16.2 TB of uncompressed data containing over 159 billion AIS messages. The AIS messages were decoded, converted to CSV files, and then loaded into an Apache GeoSpark cluster for transformation and analysis. Apache Spark is a horizontally scalable, parallel processing stack built upon a suite of high-performance open-source technologies that store, process and provide access to the data. Raw AIS messages were ingested into our scalable parallel, distributed file system based on GlusterFS and run through a series of cleanup and analyses stages on the computing cluster. The first stage parsed the raw AIS messages, filtered out invalid data, and merged the messages with a Vessel Identification System (VIS) catalog data to provide ship metadata (such as vessel draft or service type) and voyages. This phase reduced the data to approximately 9 million vessel voyages.

To produce vessel traffic summaries for this work, we cropped the vessel voyage catalog to the US Arctic region, which resulted in a catalog of ~31,000 vessel voyages undertaken between 2013 and 2017 in the Beaufort Sea region. The catalog of vector voyages was split by month and ship type and then rasterized into 500-meter grids. The outputs were a variety of heat map raster grids representing spatial and temporal vessel traffic trends and density footprints in the Beaufort Sea region. The vessel traffic raster grids were then used to inform the spill locations selected for oil spill simulations.

Subsistence harvest data and the results of the oil spill risk analysis were also ingested into the AOOS data system and made publicly available through the Ocean Data Explorer; they are described below in the results of Objectives 2 and 3, respectively.

Through the Ocean Data Explorer, the ship traffic data, subsistence use maps, and oil spill risk results are made accessible through web interoperability systems including web mapping services (WMS) and web feature services (WFS), which serve image tiles to the public over the internet. Individual tiles can also be downloaded as mapped PNG files. In addition, the AIS traffic data and oil spill risk results can be downloaded from the catalog as shapefiles and/or CSVs, or from the metadata page as georeferenced rasters (geoTIFFs).

Objective 2. Summarize subsistence harvest patterns for Alaska Beaufort Sea communities.

SRB&A inventoried and compiled subsistence information from multiple studies for the three Alaska Beaufort Sea communities of Utqiaġvik, Nuiqsut, and Kaktovik. For the data used for this project, SRB&A, in association with the North Slope Borough Department of Wildlife and under contract to Minerals Management Service (MMS), initiated a subsistence mapping study in 2002 focused on the communities of Utqiaġvik, Nuiqsut, and Kaktovik. The study was designed to develop a Geographic Information System capable of describing regional subsistence patterns and measuring changes in these patterns over time. Study team members included Stephen R. Braund and Associates, North Slope Borough Department of Wildlife Management, Encompass Data & Mapping, ESRI-Northwest, Dr. John A. Kruse, and Dr. Jeffrey C. Johnson. The study focused on key species and/or resources identified by MMS (now the Bureau of Ocean Energy Management [BOEM]) and the study team: bowhead whales, ringed seals, Arctic cisco, Arctic Char/Dolly Varden, caribou, moose, broad whitefish, burbot, geese, eider, walrus, wolf, and wolverine.

SRB&A compiled the results of these studies and provided them for this project. The mapped harvest areas cover a ten-year range, and fall within the 1995-2006 time frame, with the dates applying to each individual community differing slightly based on the timing of field work in that community. The data were collected through one-on-one interviews in the communities, mapping active harvesters' subsistence use areas. The data include subsistence use areas by resource harvested and the months associated with those use areas for each of the three communities.

After compiling the subsistence information for this project, SRB&A created a subsistence analysis area, defined as the intersection of the U.S. domain of the Chukchi and Beaufort seas with subsistence use area data from the three subsistence study communities. In order to overlay the subsistence use area data with the other project variables (e.g., ship traffic and oil spill trajectories), SRB&A created unique analysis units using the ArcGIS “Create Fishnet” tool, which creates a feature class containing a net of square units. For this project, SRB&A set each unit as a 1mi x 1mi square; SRB&A termed each individual square as a “subsistence analysis unit.”

SRB&A provided Axiom with a dataset that included a metric for harvester intensity, which was based on the average (mean) number of harvesters reporting use in a subsistence analysis unit during the 1995-2006 time period. Axiom converted these to relative harvester intensity (0-1) based on each community's maximum harvester intensity. This step was necessary to a) normalize results so that one community's harvesters were not prioritized over another purely because it has more people, and b) protect the anonymity of individual subsistence users who harvested in isolated areas (e.g., on the fringes of the subsistence use areas where individual harvesters could be identified by their location).

In addition to harvester intensity, SRB&A also provided a relative "resource importance" index of each resource. These "low", "moderate", and "high" importance categories are specific to each community, but are used as a weighting factor in assessing overall risk to a community's subsistence resources. Resource importance describes the relative importance of a subsistence resource as measured by percentage of total harvest (Material Importance) and the percentage of households attempting to harvest and receive resources (Cultural Importance). Measures of material and cultural importance are established through the use of quantitative measures derived from available data. While all subsistence activities and resources are of high importance to a community, the importance of individual resources relative to one another varies according to material and cultural measures used in this analysis.

The ranges for Material Importance were developed based on the fact that all resource categories contribute to a cumulative 100 percent of harvest. Because many subsistence communities rely on a diverse resource base from which they harvest, it is not unusual for the top contributing resource categories to only contribute in the teens to lower 20 percent of harvest. The ranges for Material Importance below in Table 1 reflect the nature of subsistence harvests across an often-diverse resource base where few resource categories represent this relatively high percentage of the total community harvest and allow for all study communities to have a high, moderate, and low resources.

Table 1. List of Quantitative Measures for Material Importance

Material Importance	High (H)	Moderate (M)	Low (L)
% of Total Harvest (in pounds)	H >20%	20%> M >2%	L <2%

The ranges for Cultural Importance below in Table 2 are specific to each community's unique behavior of attempting to harvest and receiving. This community-centric approach, where every community's ranges are defined based on that community's unique set of data, takes into account cultural variation between communities and between the ways certain resources are harvested. Whereas, a community's harvest (Material Importance) will always total 100 percent, the cultural measures of importance are unique to each community and may exhibit a wide range of variation depending on the community's cultural and environmental setting (e.g., proximity to urban areas, regulatory restrictions, proximity to resources). For each variable by community, a range is determined by subtracting the lowest percentage of households within each variable (e.g., attempting to harvest) from the highest percentage of the same variable (e.g., 100-40=60). That range (e.g., 60) is then divided into thirds in order to determine the high, moderate, and low ranges (e.g., Low = 40-60; Moderate = 60-80; High = 80-100).

As an example, in one community, the range of households trying to harvest different resources may be 20-50 percent, whereas in a second community it may be as high as 40-100 percent. Reasons for these differences may include work commitments, geographic and climatic restraints, urban disruption, or regulatory environment which limit or facilitate the opportunities for attempting to harvest. A community-centric approach takes into account the unique community range in both examples above, standardizing the high range to 40-50 percent for the first community and 80-100 percent for the second community. Table 2 shows how the above measures are used to categorize each resource as "high," "moderate," or "low" for cultural importance.

Table 2. List of Quantitative Measures for Cultural Importance*

Cultural Importance - Equal Thirds Based on Community Range | High (H) | Moderate (M) | Low (L)
% of Households Attempting Harvest | Top Third | Middle Third | Bottom Third
% of Households Receiving | Top Third | Middle Third | Bottom Third
** Cultural Importance Example – If 40-100% of households attempt to harvest various resource categories then using the community thirds threshold method (100-40=60 divided by 3 resulting in each category being 20) as follows: High=80-100 / Moderate=60-80 / Low=40-60

For the final determination of a resource as a high, moderate, or low resource of importance, the top value from the three variables of percent of total harvest, percent of households attempting to harvest, or percent of households receiving is selected. For example, bearded seal may represent 15 percent of total harvest (moderate), top third percent of households attempting to harvest (high), and bottom third percent of households in receiving (low). The final selection ranks bearded seal overall as a resource of high importance in this example due to the cultural importance of participation/attempting to harvest ranking in the top third.

This resource importance analysis, while reflecting one method of quantitatively measuring the importance of subsistence resources, does not take into account a multitude of factors for which quantitative data do not exist (e.g., spirituality, ethics and values, ideologies, identities, celebration and ceremonies). Rankings of resources under high, moderate, and low importance should be viewed only in terms of the indicators presented here and not in terms of overall importance. Subsistence harvesters in the study communities routinely view all of the resources they harvest during their seasonal cycle of availability as important to their community and/or individual health and cultural identity.

Objective 3. Understand the timing of various offshore subsistence activities and the potential relative impacts of offshore oil and gas operations.

To determine which subsistence activities would most likely be impacted from a potential spill, this work used a combination of the ship traffic density maps, oil spill model results, and the subsistence use area data. To do this, we conducted an Oil Spill Risk Assessment (OSRA) following the ISO-compliant IT-OSRA methodology (Sepp-Neves 2015, Sepp-Neves 2016). This methodology was selected because it incorporates the likelihood of a vessel being present in a given location (AIS data) and social value for a region (subsistence use data) with results from oil spill simulations to derive a risk assessment. The steps to complete the OSRA are the following:

OSRA Step 1. Create Particle Release Grid. The IT-OSRA methodology begins with a particle release grid, which is a list of predefined locations where vessels have previously traveled. The AIS data products consisted of vessel traffic density on a 500 m square grid, which would have required more than a million oil spill simulations - a substantial computational task. To strike a balance between taking advantage high-resolution AIS data and computational efficiency, the AIS data were re-gridded onto a 10 km square grid, and this grid was used throughout the oil spill portion of the synthesis.

OSRA Step 2. Conduct Oil Spill Simulations.
Axiom Data Science ran over 100,000 oil spill trajectory scenarios in the Beaufort Sea coastal study area.

The spill model results were summarized to produce a spill impact density map and relative risk assessment for subsistence use areas.

Oil spills were simulated using PyGnome, a Python implementation of the General NOAA Operational Modeling Environment (GNOME), the oil spill modeling tool used by the NOAA Office of Response and Restoration. The GNOME model takes into account ocean currents, surface winds, and oil weathering to move virtual particles from their release point in a path defined by the environmental variables. For this work, oil spill simulations were forced by the Navy's Hybrid Coordinate Ocean Model (HYCOM) for ocean currents, temperature, and salinity, and NCEP NCAR Reanalysis model results were used for surface winds. Each spill simulation tracked 1000 particles to simulate the release of 1000 bbl of marine diesel subject to weathering via evaporation, dispersion, and emulsification.

The location and release time of oil spill simulations were derived from the AIS data. Vessels types were grouped into ten archetypes, which were then used to seed oil spills and organize the results. For each archetype, a simulated oil spill was released from each point in the particle release grid where a vessel had been present in the past. Oil spill simulations were started on a weekly basis for each month where vessels were present in the AIS data to capture the variability in oceanic and atmospheric conditions across seasons.

OSRA Step 3. Calculate Oil Spill Risk Assessment (OSRA). The risk, R, to a specific subsistence region, S, is a combination of the hazard posed to the region from an oil spill, H, and the social value attributed to the region derived from subsistence use data, I.

$$Rs = Hs \cdot Is$$

The social value of the area S, Is, is a combination of the subsistence use data, Has,i, and the importance of the resource i, V, to each community. Each resource, I, was independently weighted by the communities as either low (1/3), medium (2/3), or high (1).

$$Is = Has,i \cdot Vi$$

The hazard score for the region S is a combination of three terms: the probability of a vessel being at location r from the particle release grid, (Pt)r, the probability of an oil spill affecting the subsistence region, S, (Pb)S, and a concentration index, Cs. The concentration index is the mean concentration of oil within the region for each month divided by the maximum mean concentration within the region.

$$HS = (Pt)r \cdot (Pb)s \cdot (Cs)$$

This produced a heat map describing the calculated risk for each community by month, resource, and vessel type. The results for this analysis were normalized by the maximum monthly risk integrated over a year observed by a single community. This allowed for comparison of risk between different months, resources, vessel types, and communities, as well as inferring the contribution of each to the total risk.

Objective 4. Integrate data into an interactive map to increase public knowledge and inform agency decision-making.

Over many years of experience Axiom Data Science, in partnership with AOOS, has developed a framework for collating, managing, analyzing and sharing a variety of environmental data types. This framework was leveraged to publish the results of this project to web-based interactive maps to aid in agency decision support.

A major result of this work, the Arctic Oil Spill Risk Assessment Data Portal (https://arctic-osra.aoos.org/) allows users to browse, search, visualize, layer, and/or download the AIS data, the OSRA results, and the data products that were used to drive the oil spill models. The subsistence data are also served through the system, but downloads are restricted to anonymized harvester intensity maps. Data catalog entries succinctly describe each data product and provide metadata, spatial and temporal resolutions, processing steps, and usage notes and constraints. The catalog entries will also provide, when applicable, download links which provide access to the data through multiple formats including WMS, WFS, THREDDS, or CSV depending on the data type. Each dataset is listed as a separate, mappable layer that can be loaded into an interactive, web-based map. The map is built on HTML5 and JavaScript allowing for features such as time controls, roll-overs to get relative data values, interactive graphs, and user customizations including selection of units, colormaps, and color scales. Multiple layers produced in this project can be simultaneously loaded onto the map, allowing users to frame and highlight results suited to their own interest or purview including federal or state agency representatives, researchers, and the local community. A tutorial on how to use the data portal is linked from the Arctic Oil Spill Risk Assessment Data Portal, or at this link: https://files.axds.co/portals/114/files/Arctic-Oil-Spill-Risk-Assessment-Tutorial.pdf

Stakeholder input during the process
The project team had originally proposed developing a Project Steering Committee to guide development of the risk assessment tool. However, after initial discussions with potential committee members, including the North Slope Borough (NSB), the Bureau of Ocean Energy Management (BOEM), and NOAA's Office of Response and Restoration, the team decided to devote Year 1 of the project to aggregating, synthesizing and ingesting the datasets and models that were to be used in developing the final tool and data products.

A meeting was then held in August 2018 to review the results of these activities and demonstrate potential options for the final tool. The feedback session was attended by representatives from BOEM's Alaska Regional Office, the Coast Guard's spill response section, NOAA's Office of Response and Restoration including Alaska Scientific Support Coordinator and Alaska Regional Coordinator, and the North Slope Borough Wildlife Department's Senior Wildlife Biologist. The group reviewed all of the data layers and their metadata to be used in the tool and provided insights on how best to display and explain various aspects of the tool. Some issues raised by the group included:
- Although the subsistence harvest areas reflect a decade of data, having more current subsistence data would make the tool even more useful, especially to show changes in trends over time.
- AIS data do not include all vessels in the region: military vessels can mask their AIS, and small crafts don't use AIS.

- Oil spill trajectory modeling depends on the accuracy of the underlying circulation model, which is getting better for the Arctic, but still needs improvement.
- The tool shows the potential risk to harvest "activities", not necessarily the species themselves, although this is inferred. Group participants thought there was still significant value in this.
- Management agencies think the tool will have value in planning and response actions. The NSB senior biologist thought the borough might use the tool for planning and educational purposes but struggled to see how the smaller communities would use it themselves. He recommended the study team follow up with communities after the project ends with more in-depth discussion and training.

Implications

This work produced an increased understanding of potential risks associated with vessel traffic and oil spill scenarios for Beaufort Sea coastal communities. This was achieved through the synthesis of existing datasets and modeling tools into new data and information products that describe quantitatively and categorically the potential risks of vessel traffic, including traffic related to offshore oil and gas activities, in the Beaufort Sea to the subsistence harvesters in the three communities of Utqiaġvik, Kaktovik, and Nuiqsut.

For the project team, we built expertise and the cyberinfrastructure required to run, manage, and store the outputs from nearly 100,000 oil spill scenarios in the Arctic region. This new capacity for oil spill scenario planning will be especially valuable in the future as the changing environment leads to decreasing sea ice throughout the year (which will alter Arctic ocean surface currents that drive spill movement) and new maritime traffic patterns (seeding new spills). This work also positions the project team to assist in oil spill planning scenarios in other parts of the U.S. that experience offshore oil and gas activities and subsistence, recreational or commercial activities, including the Gulf of Mexico.

The project has implications for the research of others in that this project produced multiple new, open data products that are now available for use. Though the original subsistence harvester data cannot be shared because it is considered proprietary to the individual data providers (Alaska Native subsistence users), the normalized maps produced by this work are open-source and of high interest to other users and oil spill planning groups based in Alaska. The AIS data summaries are sought after by the U.S. Coast Guard and are being used in multiple other research studies, including a program through the Arctic Domain Awareness Center prioritizing the locations for new bathymetric surveys to avoid bottom-contact accidents.

The Arctic oil spill risk assessment tool is of special interest to organizations concerned with the increased potential of oil spills in the Arctic. These include members of Alaska's Regional Response Team (www.alaskarrt.org), including the Coast Guard, oil spill response and cleanup contractors, conservation non-profits, NOAA's Office of Response and Restoration, and the Alaska Department of Environmental Conservation, the state agency in charge of preventing spills of oil and hazardous substances, preparing for when a spill occurs and responding rapidly to protect human health and the environment.

Understanding the risks of vessel-based oil spills in Arctic regions has profound implications for Alaska Natives. Small changes in the timing and locations of vessel traffic lanes based on the risk analysis completed by this research could have the ability to protect the lives and livelihoods of villages that

depend heavily on the marine environment for food and cultural survival. This potential benefit was noted by participants during a presentation on this work to the Arctic Waterways Safety Committee in October 2018.

The analysis completed here, if extended to other regions of Alaska with updated subsistence and AIS data, as well as other regions outside Alaska with offshore oil and gas activities and extensive vessel traffic, has the ability to provide insights to other areas of concern including commercial and recreational fishing areas, marine protected areas and protected habitats (e.g., sea bird or walrus concentrations), or other areas of human use and potential conflicts.

Unexpected Results

N/A

Project Relevance

The following audiences would be most interested in the results of this project:

- Researchers
- Community Leaders
- Local Government Officials
- State Government Officials
- Federal Government Officials
- Non-Profit Private Sector
- For-Profit Private Sector

Oil spill planning and response in Alaska is mandated at all levels of government and garners intense community interest, especially after the devastating impacts of the 1989 Exxon Valdez Oil Spill. As sea ice decreases in the Arctic and marine vessel traffic increases, the potential for oil spills of various sizes also increases. Government officials, community leaders, tribes, and industry all want to avoid oil spills, and minimize the impacts of those that do occur, especially to critical fish and wildlife species and the Alaska Native subsistence users who rely on them. The research community would be interested in these results because they are increasingly being asked to conduct scientific research (physical, biological and socio-economic) to help decision makers respond to the impacts of climate change. Social scientists are playing a more important role in broad, integrated ecosystem research projects with actionable outcomes and products. Environmental nongovernmental organizations are watchful of the potential cumulative impacts of climate change and increased human activities on sensitive Arctic species and habitats.

Education and Training

Number of students, postdoctoral scholars, or educational components involved in the project:

- Undergraduate students: 0
- Graduate students: 0
- Postdoctoral scholars: 0
- Other educational components: 6

We presented this work at four venues with a diverse set of adults. We also provided two educational workshops for potential users. These presentations and workshops are described in more detail in the Communications, outreach, and dissemination section.

IV. DATA AND INFORMATION PRODUCTS

This project produced data and information products of the following types:

- Data
- Information Products
- Websites or data portals
- Curricula for education and training

DATA

Data Management Report:
See attached Data Management Report.

Relationships between Data Sets:
This project was a synthesis of marine vessel traffic data, subsistence data, and risk results produced by an oil spill analysis. The marine vessel traffic data were ingested and managed through a separate, externally-funded project so are not listed in the data reporting table. However, the results are made available through the AOOS Data Assembly Center, the Ocean Data Explorer and the Oil Spill Risk Assessment tool. Subsistence data include two GIS-style groups of layers that describe the bounds of the area studied and the relative harvester intensity within the surveyed area. The latter includes many sublayers that show the harvester intensity over the entire period, per month, per community, and per subsistence resource. The oil spill risk layers (calculated risk value) is a derived product of the complete analysis and summarizes the risk by intersecting the results of the oil spill models (driven by ship traffic) with the relative harvester intensity layers. Therefore, each sublayer of relative harvester intensity has a corresponding risk layer (e.g., risk to Bowhead Whale Use Areas in July).

Additional Documentation Produced to Describe Data:
We produced a website information product, "Data Products Explanation Page with Methodology and Acknowledgements," which describes in detail the OSRA methodology and the process used to generate the risk assessment results. It also includes download links for the OSRA results as geoTIFFs along with preview images.

Other Activities to Make Data Discoverable:
All results from this project are stored in a dedicated project data portal (Arctic Oil Spill Risk Assessment Portal), the AOOS Ocean Data Explorer, as well as in the AOOS Data Assembly Center (DAC). Data can be found in the Arctic Oil Spill Risk Assessment Portal or the Ocean Data Explorer by browsing the catalog or using keyword search terms. The ship traffic data and risk results are available through web interoperability systems and as PNG images, web mapping services, web feature services, shapefiles, and CSVs. The original tif files from the risk analysis are made available upon request. Images of the subsistence harvester intensity data are available for download (as PNGs) and through web mapping services as tiled images.

The AOOS DAC is a federally certified data center established and maintained with funding by NOAA, and meeting federal standards and protocols for data management, quality control and access. All data within the DAC are made available through the federal archive, the National Center for Environmental Information, as well as through DataONE (Data Observation Network for Earth), a National Science Foundation initiative to increase access to data across multiple member repositories, The AOOS DAC provides access to one of the largest collections of ocean and coastal data in Alaska.

Sensitive, Confidential, or Proprietary Data:
Subsistence harvester intensity data are sensitive, confidential, and proprietary due to confidential agreements with individual harvesters in the study communities. Therefore, the subsistence harvester intensity information is only available for download as images or by viewing them through the AOOS portal developed for this project.

INFORMATION PRODUCTS

Information Products Report:
See attached Information Products Report.

Citations for Project Publications, Reports and Monographs, and Workshop and Conference Proceedings:
N/A

Websites and Data Portals:
Arctic Oil Spill Risk Assessment Data Portal (interactive mapping application) - http://arctic-osra.aoos.org
Data Products Explanation Page with Methodology and Acknowledgements (metadata) - https://osra.axds.co/
Arctic Oil Spill Risk Assessment Products (project information) - https://aoos.org/ais-oil-spill-support/

AOOS will maintain the project websites and data portal indefinitely.

Additional Documentation Produced to Describe Information Products:
Arctic Oil Spill Risk Assessment Data Portal Tutorial
Arctic Oil Spill Risk Assessment Overview - https://files.axds.co/portals/114/files/Arctic-Oil-Spill-Risk-Assessment-Products-Overview.pdf

Other Activities to Make Information Products Accessible and Discoverable:
The NAS project is described on a project page available on the Alaska Ocean Observing System home page. The project page provides links to the Arctic Oil Spill Risk Assessment Data Portal, a tutorial describing how to use the new OSRA tool (downloadable PDF), an overview of the project (downloadable PDF), and an informational website explaining the data products along with the methodology used to produce them.

Confidential, Proprietary, Specially Licensed Information Products:
N/A

V. PUBLIC INTEREST AND COMMUNICATIONS

Most Unique or Innovative Aspect of the Project

This project modeled and tracked more than 100,000 virtual oil spills across hundreds of square miles throughout a year as they spread into areas that people depend on for food and their cultural identity. Only one group (known to us) has undertaken oil spill planning in this way, and this is the first time that we know of that oil spill modeling results were combined with subsistence use information.

Most Exciting or Surprising Thing Learned During the Project

The mapped areas of subsistence use for Utqiaġvik, Nuiqsut, and Kaktovik are now accessible on an interactive map along with the other results of this study.

Most Important Outcome or Benefit of Project

This project applies an ISO-standard risk assessment to resource harvest areas on the US Arctic coast and shows that subsistence use areas need to be protected to ensure the subsistence and cultural continuity of the Beaufort Sea communities. The results can be used by villages, natural resource managers, local and federal government planners, and resource development companies (e.g., commercial fishing or oil) to minimize risk to areas commonly used by subsistence harvesters. The techniques and infrastructure we developed for this project could be used to assess the potential risk of oil spills to other well-defined spatial regions of interest such as marine mammal habitat, commercial fishing areas, etc.

Communications, Outreach, and Dissemination Activities of Project

Public Presentations

April 12, 2018 – Indigenous Peoples' Council for Marine Mammals, Anchorage

Staff briefed IPCoMM on the project at their spring board meeting. IPCoMM is a statewide coalition of Tribal marine mammal commissions, councils and other Native organizations formed for the purpose of identifying and addressing marine mammal issues of common concern. About 25 people attended and asked to see the final tool when finished. An additional briefing is planned for spring 2019.

October 17, 2018 - Alaska Eskimo Whaling Commission, Anchorage

The team briefed the AEWC at its fall meeting. The members of the commission are the registered whaling captains and their crew members of the 11 whaling communities of the Arctic Alaska coast. The AEWC mission is to safeguard the bowhead whale and its habitat, defend the Aboriginal Subsistence Whaling Rights of the members, and preserve the cultural and traditional values of these communities. Members were very interested in the tool, but it was clear that one-on-one interaction would be most beneficial.

October 18, 2018 - Arctic Waterways Safety Committee, Anchorage

The team briefed the safety committee during its fall board meeting. This organization brings together local marine interests in the Alaskan Arctic in a single forum to act collectively on behalf of those interests to develop best practices to ensure a safe, efficient, and predictable operating environment for all current and future users of the waterways. Members include local governments, marine pilots, tribes and recreation, tourism and other private sector interests. The members were supportive of the tool,

but more in-depth training would be needed for each individual organization that is represented on the committee.

October 30, 2018 - Alaska Regional Response Team, Anchorage
This presentation on the tool and datasets generated a lot of interest from community members, state and federal officials, the Coast Guard, oil spill contractors, and conservation non-profits. Several of the organizations present, including the Alaska Department of Environmental Conservation and NOAA's Office of Response and Restoration, expressed strong interest in the tool and data products. The ARRT is an advisory board to the Federal On Scene Coordinator, and provides federal, state and local governmental agencies with means to participate in response to pollution incidents. The Alaska Department of Environmental Conservation showed particular interest in future use of the tool. Additional outreach and training is planned for ARRT member agencies and organizations.

November 9, 2018 - Stakeholder Briefing and Demonstration, Anchorage
The NAS project results were included in a briefing conducted by AOOS on a collaborative project funded by the Arctic Domain Awareness Center: AIS PAC – AIS for Prioritizing Arctic Charting. The workshop was also held by webinar for remote attendance. The two-hour intensive session allowed participants to use the AOOS Ocean Data Explorer and the Arctic Oil Spill Risk Assessment portal to explore the datasets and information products developed by this project. The seven participants included NOAA Coast Survey's Alaska Regional Navigation Manager, as well as Coast Guard representatives.

November 15, 2018 – Stakeholder Briefing and Demonstration, Juneau, AK
The Juneau workshop, held at the offices of the Marine Exchange of Alaska, was similar in format to the Anchorage workshop, with about 10 people participating, including National Marine Fisheries staff as well as Coast Guard District 17 staff.

The following are comments compiled by the Coast Guard attendees following the November demonstrations:

- "The ability of the AOOS data portal to make data, visualizations, and products available through their web-based tool is very useful to District 17 users. We also appreciate the data being exportable in a format that we can then upload it into a GIS program of our choice (e.g. GoogleEarth, ArcMap, etc.). The ability to display and download AIS vessel traffic data, parsed by general categories (cargo, passenger, tanker, etc.) is very useful for planning the placement of resources such as cutters, aircraft, and people, etc. This can inform short-term tactical planning as well as long-term strategic planning, including the homeporting of cutters that haven't even been built yet. This type of data and the analysis it enables is required to support multiple Coast Guard mission areas, including search and rescue, pollution and oil spill response, mass rescue, marine safety, and living marine resource law enforcement."

- "It is helpful that the data itself is described in detail, with extensive documentation. This enables us to understand the characteristics of the data we are using."

- "Data layering is very useful- especially given the diversity of the data available (to include subsistence hunting areas). This really helps to increase overall maritime domain awareness."

- "Axiom's ability to leverage cluster computing infrastructure and applications far surpasses the resources we have at D17 to handle AIS data; as a result, the AOOS data portal can display data in a much more efficient and robust manner than we can using our own Coast Guard enterprise resources."

- "We would definitely use this tool if it continues to ingest recent AIS data (doesn't stop at 2017)."

Website – Project Page on www.aoos.org

Newsletters – Stories included in Fall 2016 AOOS e-News and Winter 2019 AOOS Update. These are circulated to a 500-person listserv. Status of project was reported frequently in the Executive Director Monthly Update, which is circulated to about 70 people, including the AOOS board, key partners and collaborators, and the national IOOS Program Office.

Annual Impact Report – The project was included in the 2017 AOOS Impact Report and will be highlighted in the 2018 Impact Report (to be published in March 2019).

Data Report

DataType	DigitalResourceType	Title	FileName	Creators	PointofContact	PublicationYear	RepositoryName	DOIorPersistentURL	Keywords	Publications
Geospatial	image or visual data	maps	multiple	Austin, Jessica	.com	n/a	DataONE			doi: 55.1097/science.4567
Social/Cultural	Geospatial (vector, raster, or gridded)	Resources Used by Kaktovik, Nuiqsut and Utqiaġvik: Subsistence Resources Study Area		Stephen R. Braund and Associates and Axiom Data Science	Stephen R. Braund and Associates srba@alaska.net 907-276-8222	2018	Alaska Ocean Observing System	https://arctic-osra.aoos.org/#module-metadata/c2bacbd5-d323-4069-a09a-262ce6ebaf7c	socioeconomic, subsistence, arctic, harvest	
Social/Cultural	Geospatial (vector, raster, or gridded)	Resources Used by Kaktovik, Nuiqsut and Utqiaġvik: Relative Harvest Intensity		Stephen R. Braund and Associates and Axiom Data Science	Stephen R. Braund and Associates srba@alaska.net 907-276-8222	2018	Alaska Ocean Observing System	https://arctic-osra.aoos.org/#module-metadata/c2bacbd5-d323-4069-a09a-262ce6ebaf7c	socioeconomic, subsistence, arctic, harvest	
Earth and Environmental Sciences	Geospatial (vector, raster, or gridded)	Oil spill risk to Kaktovik, Nuiqsut, and Utqiagvik subsistence resources: Calculated risk value		Jesse Lopez (Axiom Data Science)	Jesse Lopez jesse@axiomdatascience.com	2018	Alaska Ocean Observing System	https://arctic-osra.aoos.org/#module-metadata/58bee87b-617b-4819-bdde-d04c849b6519	socioeconomic, subsistence, arctic, harvest, oil spill modeling, risk assessment	

Information Products Report

InfoProductType	DigitalResourceType	Title	FileName	Creators	PublicationYear	Publisher	RepositoryName	DOIorPersistentURL	DatasetReference
Website or Data Portals	Web Based Resource	Arctic Oil Spill Risk Assessment Data Portal		Axiom Data Science	2018	Alaska Ocean Observing System	Alaska Ocean Observing System	http://arctic-osra.aoos.org/	
Curricula (for education or training)	Web Based Resource	Arctic Oil Spill Risk Assessment Data Portal Tutorial	Arctic-Oil-Spill-Risk-Assessment-Tutorial.pdf	Will Koeppen (Axiom Data Science)	2018	Alaska Ocean Observing System	Alaska Ocean Observing System	https://files.axds.co/portals/114/files/Arctic-Oil-Spill-Risk-Assessment-Tutorial.pdf	
Curricula (for education or training)	Web Based Resource	Arctic Oil Spill Risk Assessment Overview	Arctic-Oil-Spill-Risk-Assessment-Products-Overview.pdf	Will Koeppen (Axiom Data Science)	2018	Alaska Ocean Observing System	Alaska Ocean Observing System	https://files.axds.co/portals/114/files/Arctic-Oil-Spill-Risk-Assessment-Products-Overview.pdf	
Website or Data Portals	Web Based Resource	Data Products Explanation Page with Methodology and Acknowledgements		Jesse Lopez (Axiom Data Science)	2018	Axiom Data Science	Axiom Data Science	https://osra.axds.co/	
Website or Data Portals	Web Based Resource	Arctic Oil Spill Risk Assessment Products		Molly McCammon	2018	Alaska Ocean Observing System	Alaska Ocean Observing System	https://aoos.org/ais-oil-spill-support/	