

# Assessing Risk to Arctic Subsistence Harvesting Areas from Marine Oil Spills

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Stephen R Braund and Associates



National  
Academy of  
Sciences

# Project overview

Funded by National Academy of Sciences, "Synthesis" Program

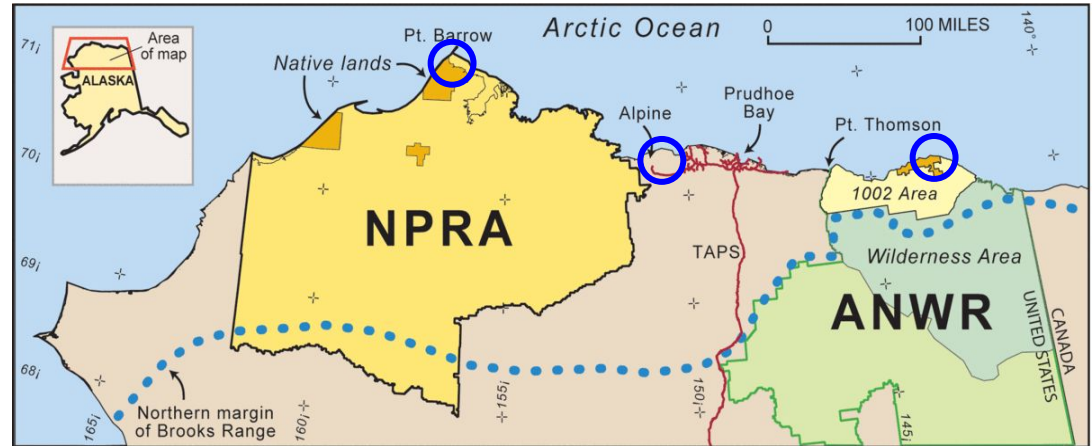
**Goal:** Develop analysis tool to assess risk from vessel-based marine oil spills to subsistence harvests in:

- Utqiagvik / Barrow
- Nuiqsut
- Kaktovik

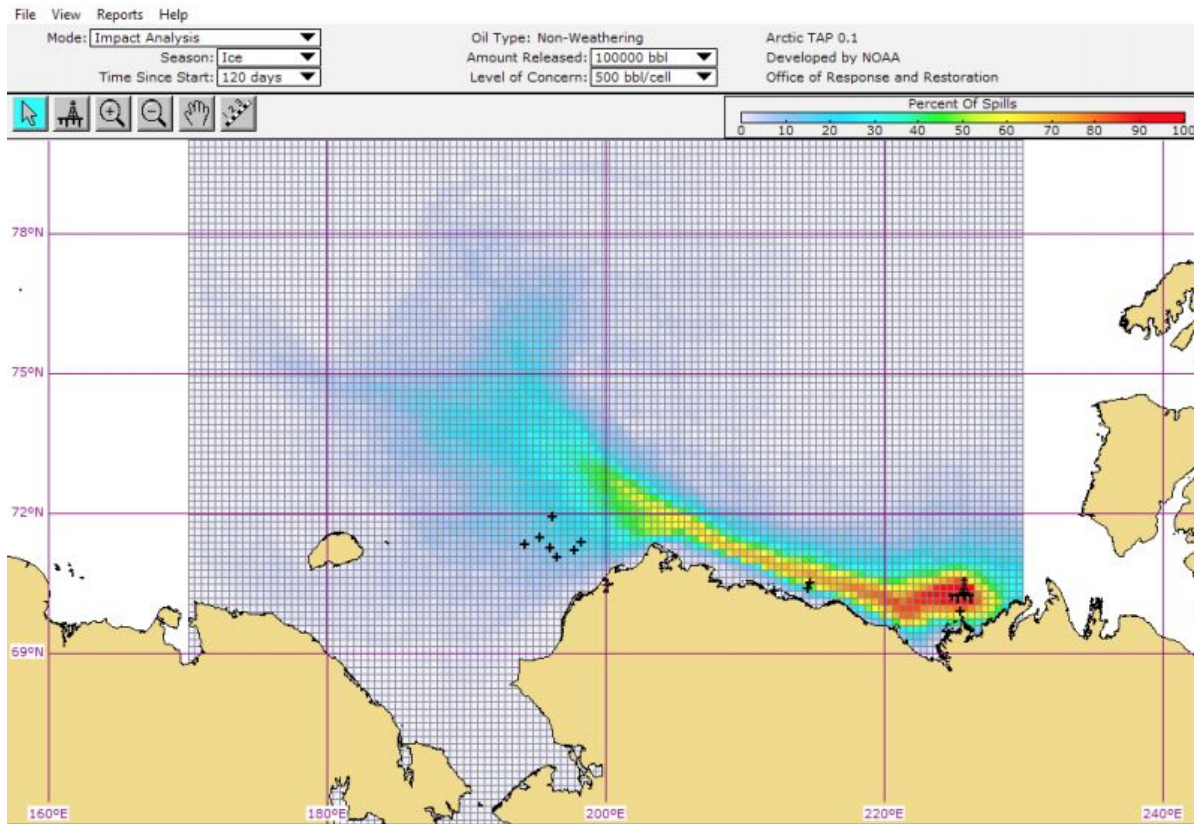
The method combines:

- Ship density from AIS
- Subsistence harvest data
- GNOME oil spill particle tracking

The analysis could be used in similar situations in the Gulf of Mexico or other regions with high potential for vessel accidents.



# Previous Work



48 sites were chosen to represent potential oil and gas activity, pipelines, fuel locations, and vessel traffic.



Start sites for spills in the Arctic TAP. The drilling platform sites are shown as blue squares, the pipeline sources as yellow circles, and the vessels as black droplets.

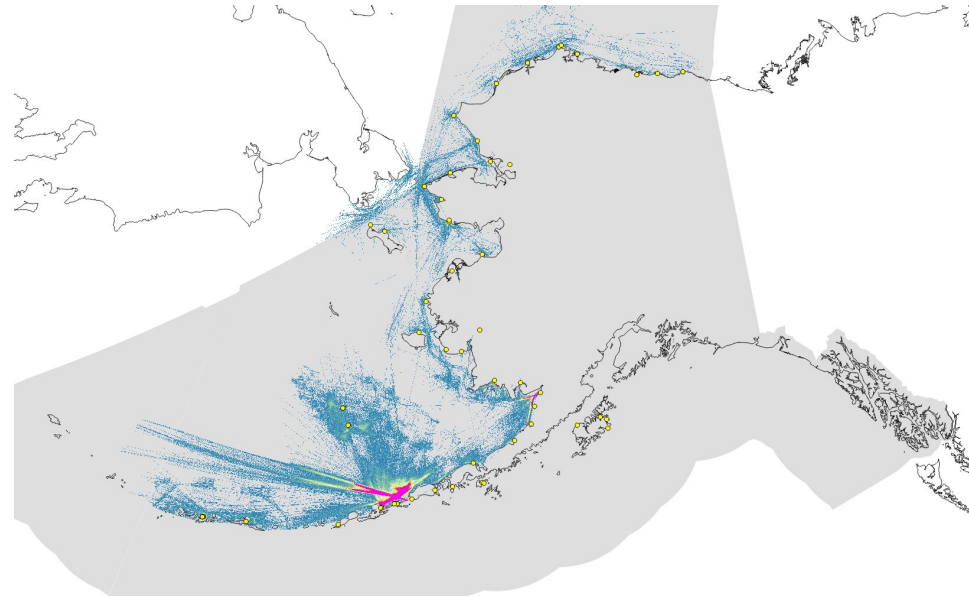
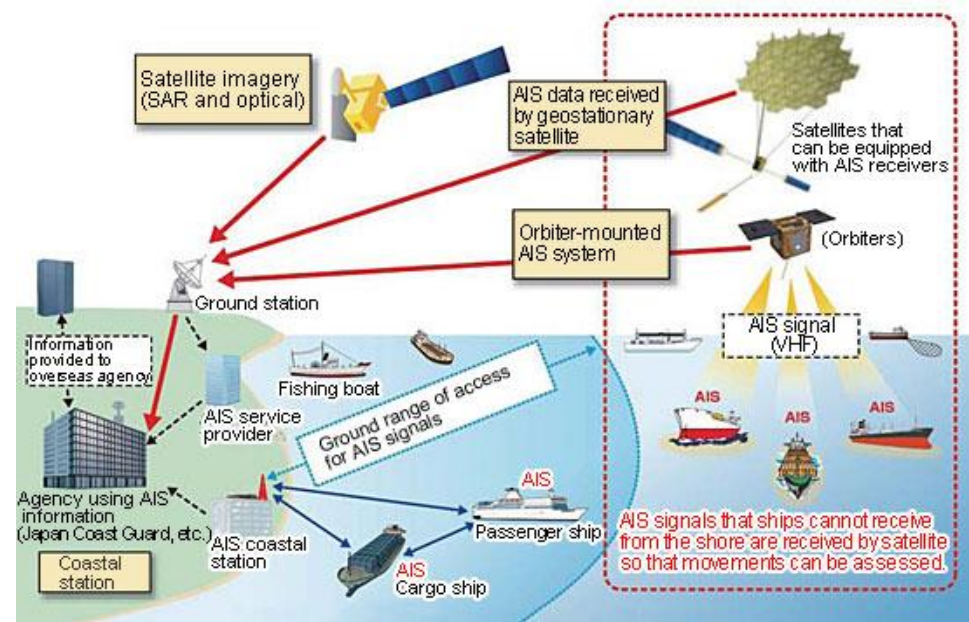
Trajectory Analysis Planner by the Office of Response and Restoration

# Ship Track Density - AIS

Automatic Identification System (AIS) is composed of ship-based transmitters and land or satellite-based receivers

- Required on all large vessels >300 gross tons
- Required on all US fishing boats over 65'

In AK, MXAK maintains 48 AIS receivers, 48 of which are in Arctic regions providing wide coverage of ship traffic.



Alaska AIS receiver locations with sample heatmap

# AIS Datasets

Available datasets:

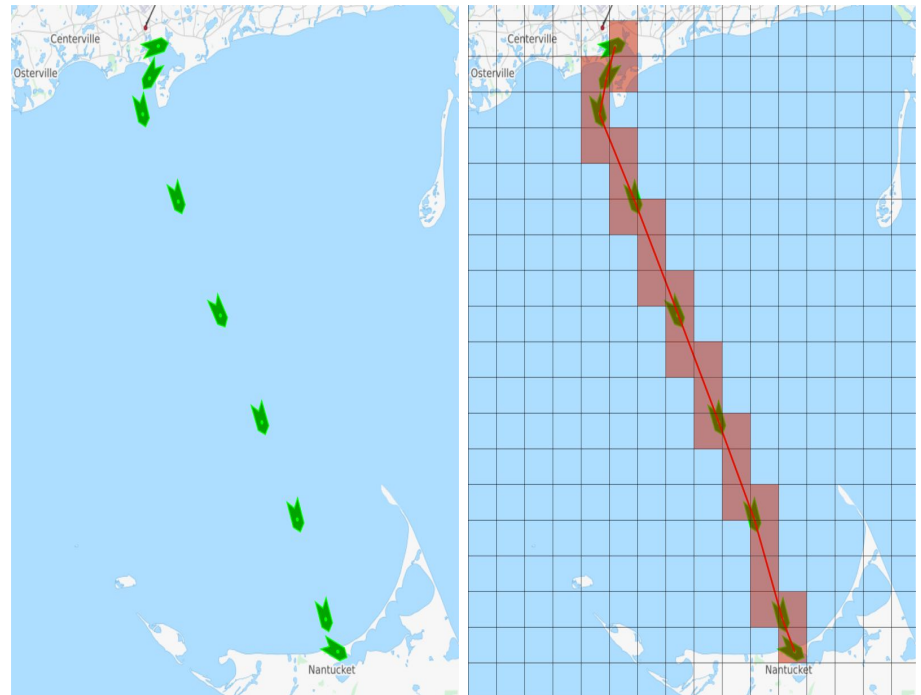
- US Coast Guard Terrestrial
  - Jan 2015 to Dec 2016
- US Coast Guard Satellite
  - Dec 2015 to June 2016
- Marine Cadastre Terrestrial
  - Jan 2009 to Dec 2014
- Marine Exchange of Alaska Terrestrial
  - Jan 2013 to Dec 2017

For Arctic purposes, the Marine Exchange dataset provides the largest spatial and temporal coverage

Find more at: <http://ais.axds.co/>

Vessel data processing:

1. Raw messages turned into vessel pings
2. Vessel pings into vessel voyages
3. Filter voyages into ship type
4. Generate vessel traffic heatmaps



## AIS Vessel Traffic Data - Alaska - Marine Exchange of Alaska Terrestrial - Monthly Totals

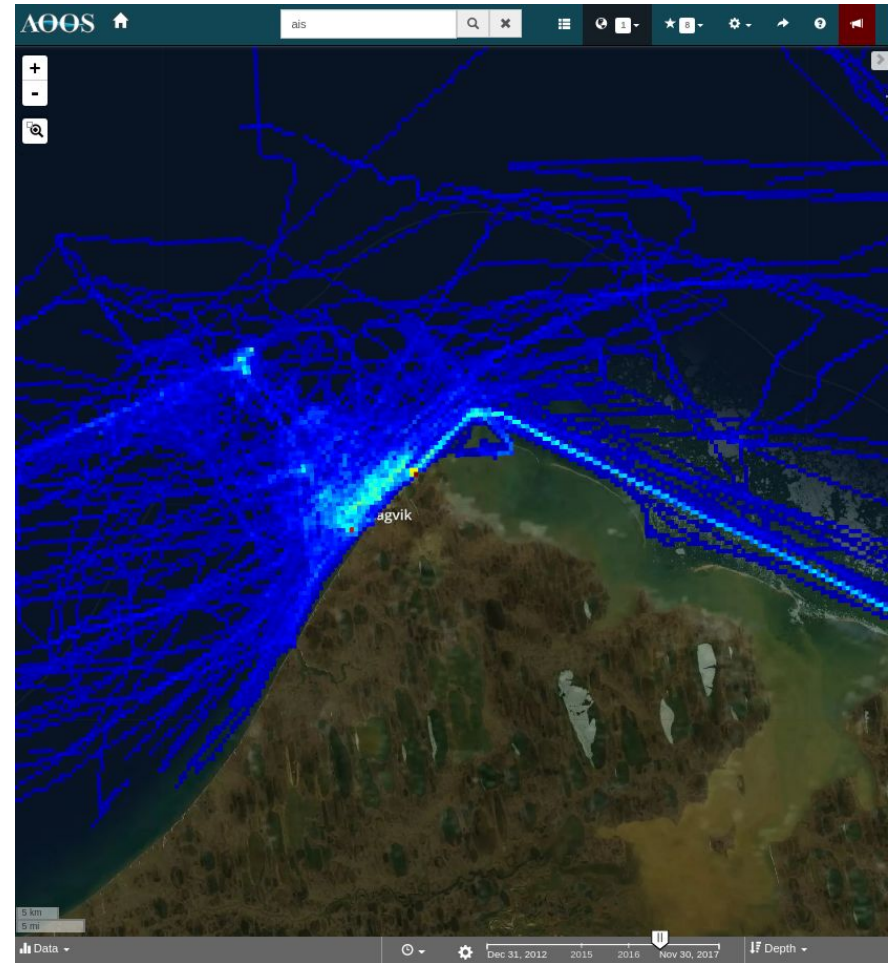
This dataset contains vessel traffic data within the United States Exclusive Economic Zone (US EEZ). Data were collected from onboard navigation safety devices that transmit and monitor the location and characteristics of large vessels that transited U.S. waters. The dataset is composed of vessel traffic heatmap grids that are segmented by region, vessel type, month, and year, and describe aggregate traffic information extracted from the raw AIS data. The grids are 500 meter resolution and in an Albers Equal Area projection.

Data is given as monthly totals, and the timestamp for each raster indicates the beginning of the month. For example, the monthly total for October 2017 is timestamped at 2017-10-01 00:00 and covers 2017-10-01 00:00 to 2017-11-01 00:00.

This project uses data from the Authoritative Vessel Identification Service (AVIS) provided by the US Coast Guard. This catalog was quality-checked by the Marine Exchange of Alaska for valid vessel categories for arctic-specific vessels. To simplify resulting data products, Vessel Service is grouped into four broad categories: Passenger, Tanker, Cargo, and Other. For more information, see <http://ais.axds.co/#vessel-catalog>.

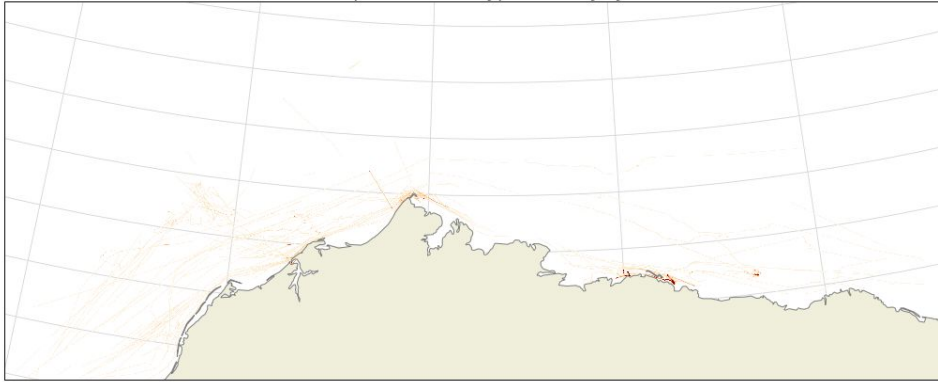
- Passenger
  - Passenger (Inspected and Uninspected)
  - Passenger Barge (Inspected and Uninspected)
- Tanker
  - Public Tankship/Barge
  - Tank Barge
  - Tank Ship
- Cargo
  - Freight Barge
  - Freight Ship
  - Industrial Vessel
  - Public Freight
- Other
  - Commercial Fishing Vessel
  - Fish Processing Vessel
  - Mobile Offshore Drilling Unit
  - Offshore Supply Vessel
  - Oil Recovery
  - Public Vessel
  - Recreational
  - Research Vessel
  - SAR Aircraft
  - School Ship
  - Towing Vessel
  - NON-VESSEL
  - Unclassified

<b>Metadata URL</b>	<a href="http://ais.axds.co">http://ais.axds.co</a>
<b>Time span</b>	Dec 31, 2012 15:00 (GMT-0900) - Nov 30, 2017 15:00 (GMT-0900)
<b>Extent</b>	49.18°, 158.05° x 73.26°, -146.29°

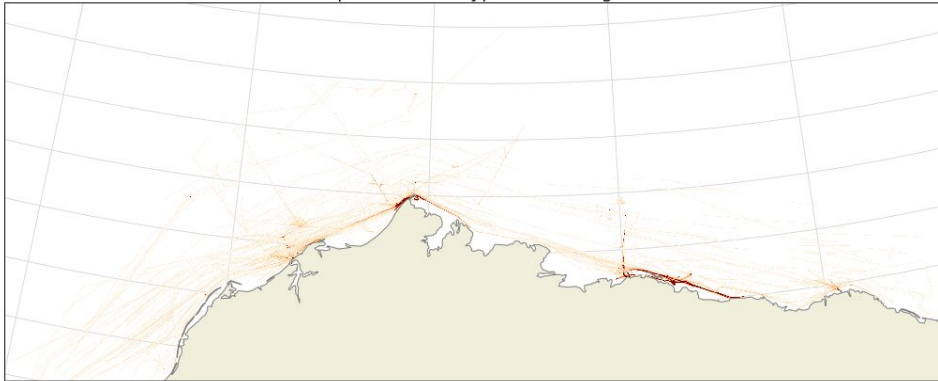


**AOOS Catalog Entry for Marine Exchange AIS Data (all vessels, August 2016)**

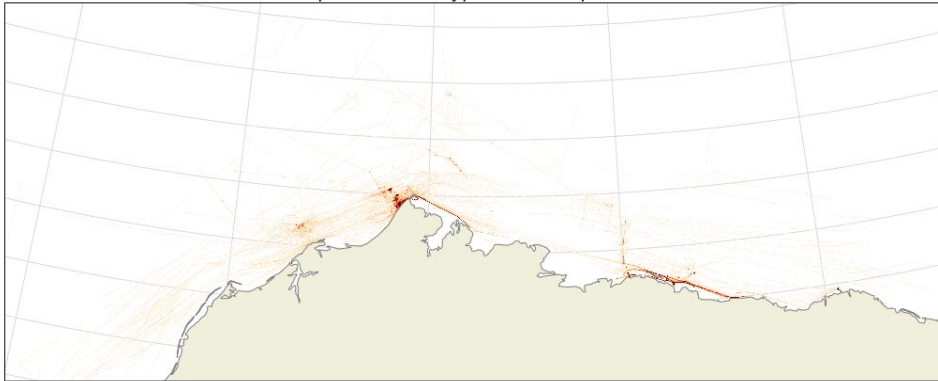
Ship Count - All Types - 07 - July



Ship Count - All Types - 08 - August



Ship Count - All Types - 09 - September



# Ship Track Density - AIS

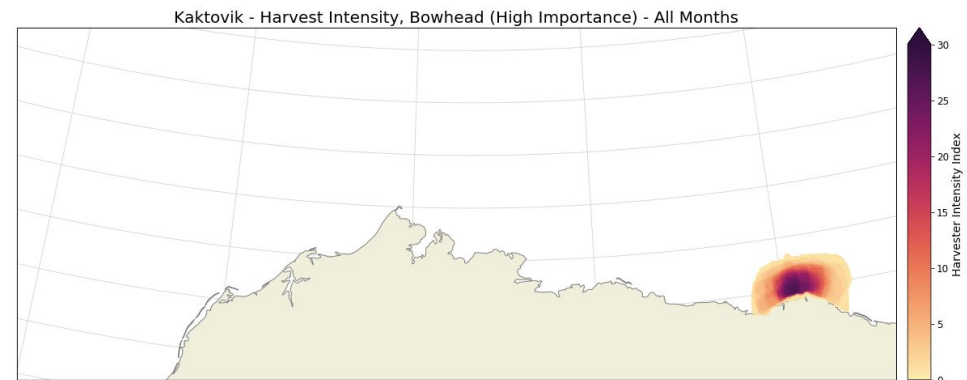
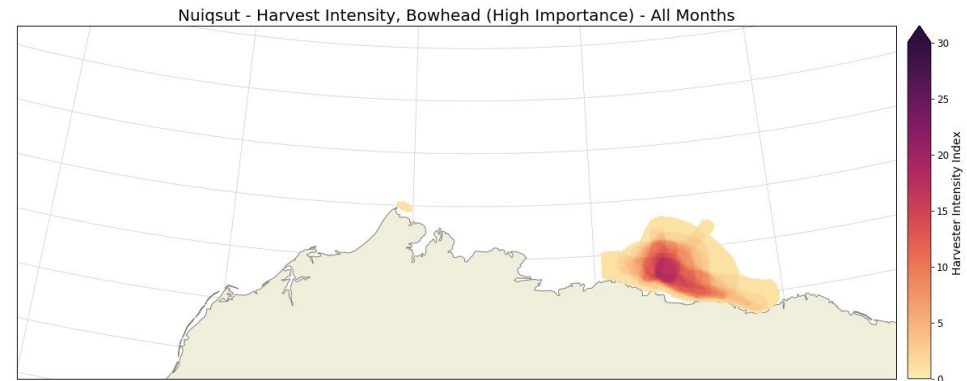
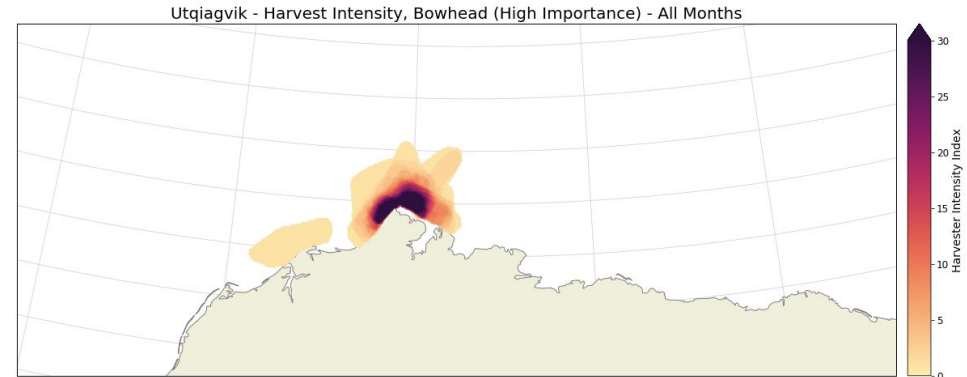
More information on this AIS data :  
<http://ais.axds.co/>

Explorable in the AOOS data portal:  
[portal.aos.org](http://portal.aos.org)

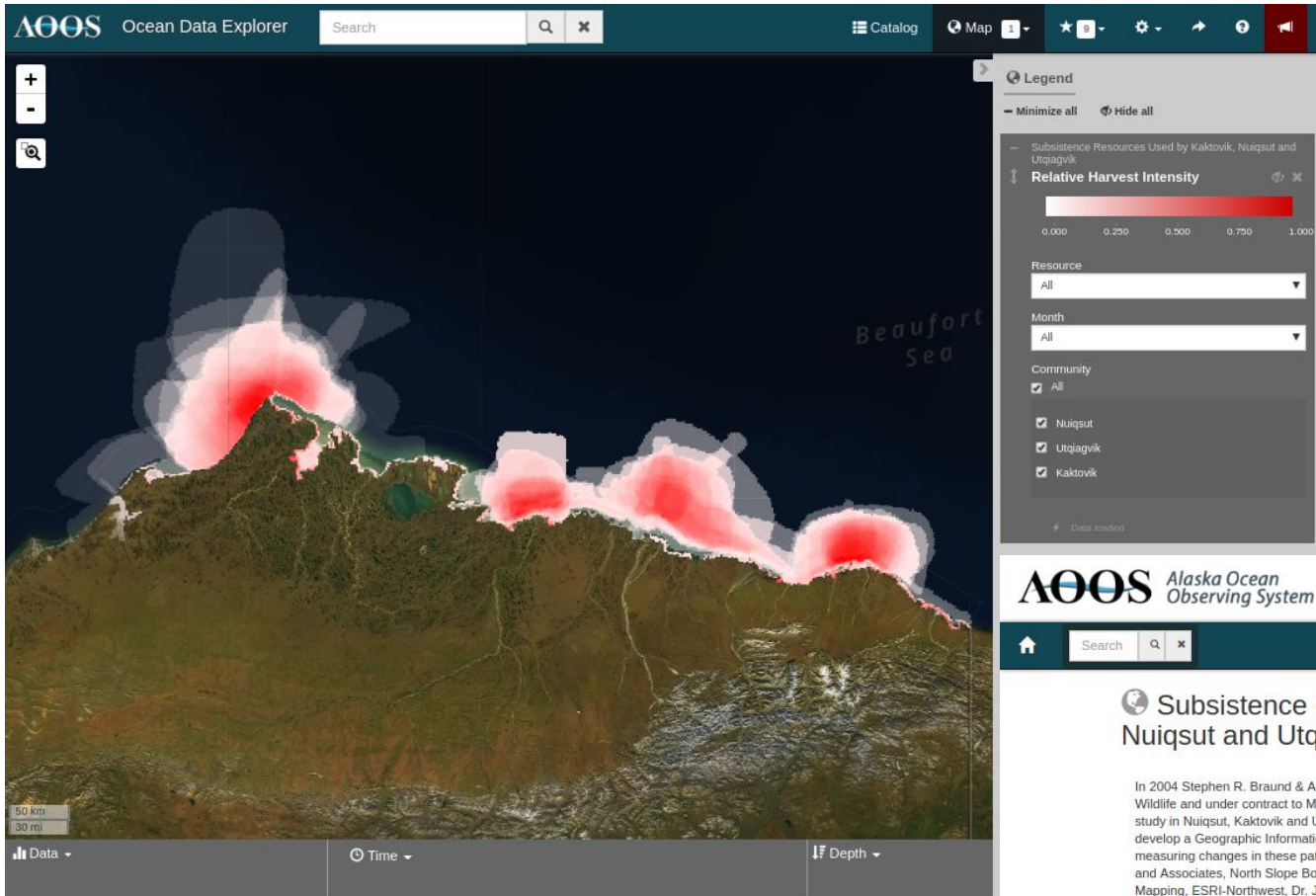
# Subsistence Harvest Data

Harvester intensity index values provided by Stephen R. Braund & Associates:

- Surveys by SRB&A conducted from 1995-2006, funded by Mineral Management Service
- One-on-one interviews conducted in Utqiagvik, Nuiqsut, and Kaktovik
- Local experts drew areas on maps, which were then digitized, aggregated, anonymized, and summarized to protect individual hunters' data
- SRB&A produced harvest areas by resource, month, and relative importance to community







## AOS catalog entry for subsistence use areas mapped around Kaktovik, Nuiqsut and Utqiagvik provided by Stephen R. Braund & Associates

### Subsistence Resources Used by Kaktovik, Nuiqsut and Utqiagvik

In 2004 Stephen R. Braund & Associates, in association with the North Slope Borough Department of Wildlife and under contract to Minerals Management Service (MMS), initiated a subsistence mapping study in Nuiqsut, Kaktovik and Utqiagvik (formerly known as Barrow). 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 identified by MMS 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.

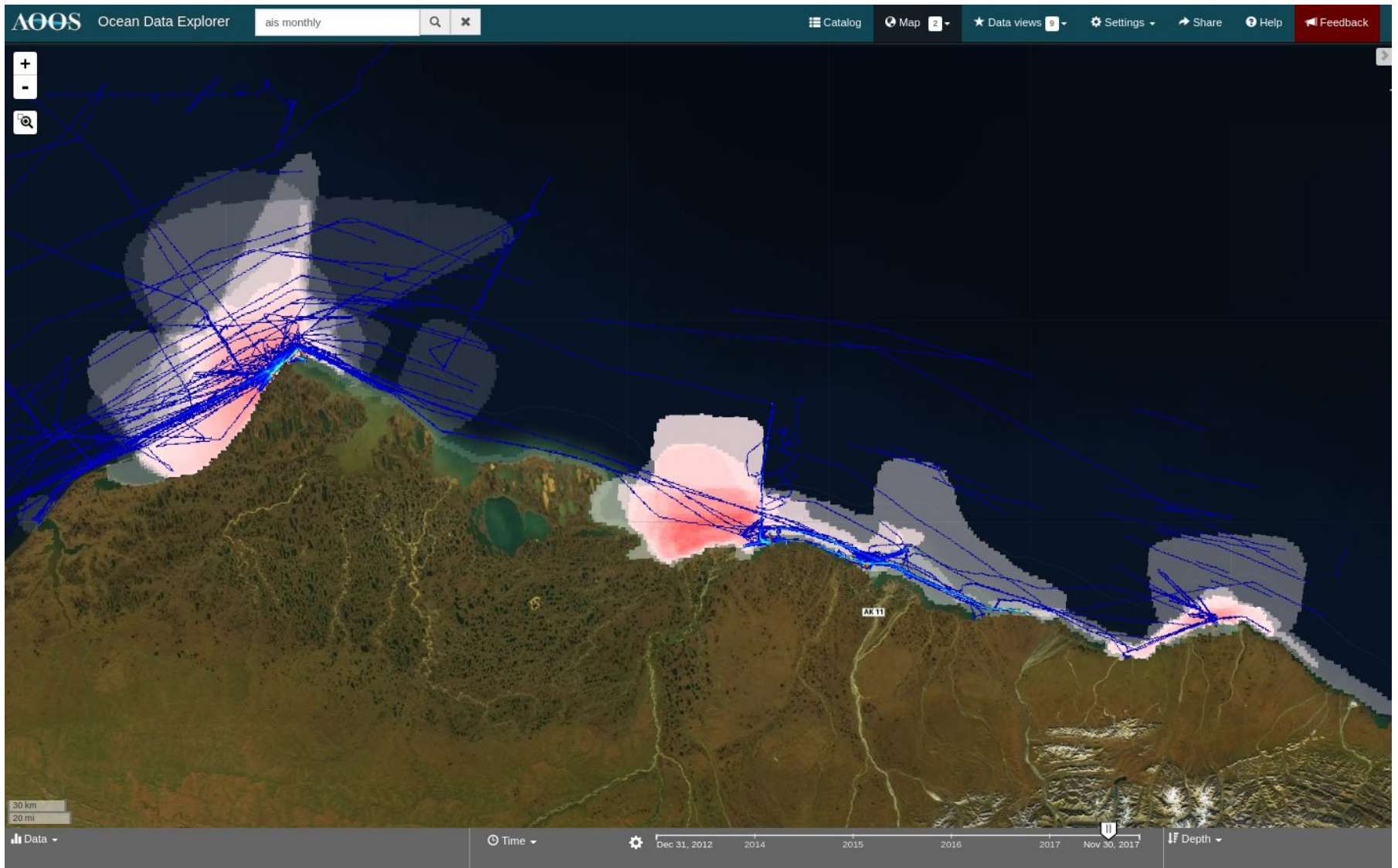
These data cover a ten-year range, and fall within the 1995-2006 time frame, with the dates applying to each individual community differing slightly based on the timing of field work in that community. These data were collected through intensive one-on-one interviews in the communities, mapping out their subsistence use areas. The data shown here include resource use areas and the months associated with those use areas for each of the three communities.

The dataset was originally created using sharpie on mylar, laid over a map during interviews with local experts in Utqiagvik, Nuiqsut and Kaktovik. SRB&A staff quality controlled these data, digitized them into vector files, and converted them to summarized raster files. Additionally, they created a "fishnet" which was composed of 1 mile by 1 mile square units and covered the project area for this project. They then used that "fishnet" to summarize the data represented in the raster files to each square unit in the fishnet, and provided these data to [Axiom Data Science](#).

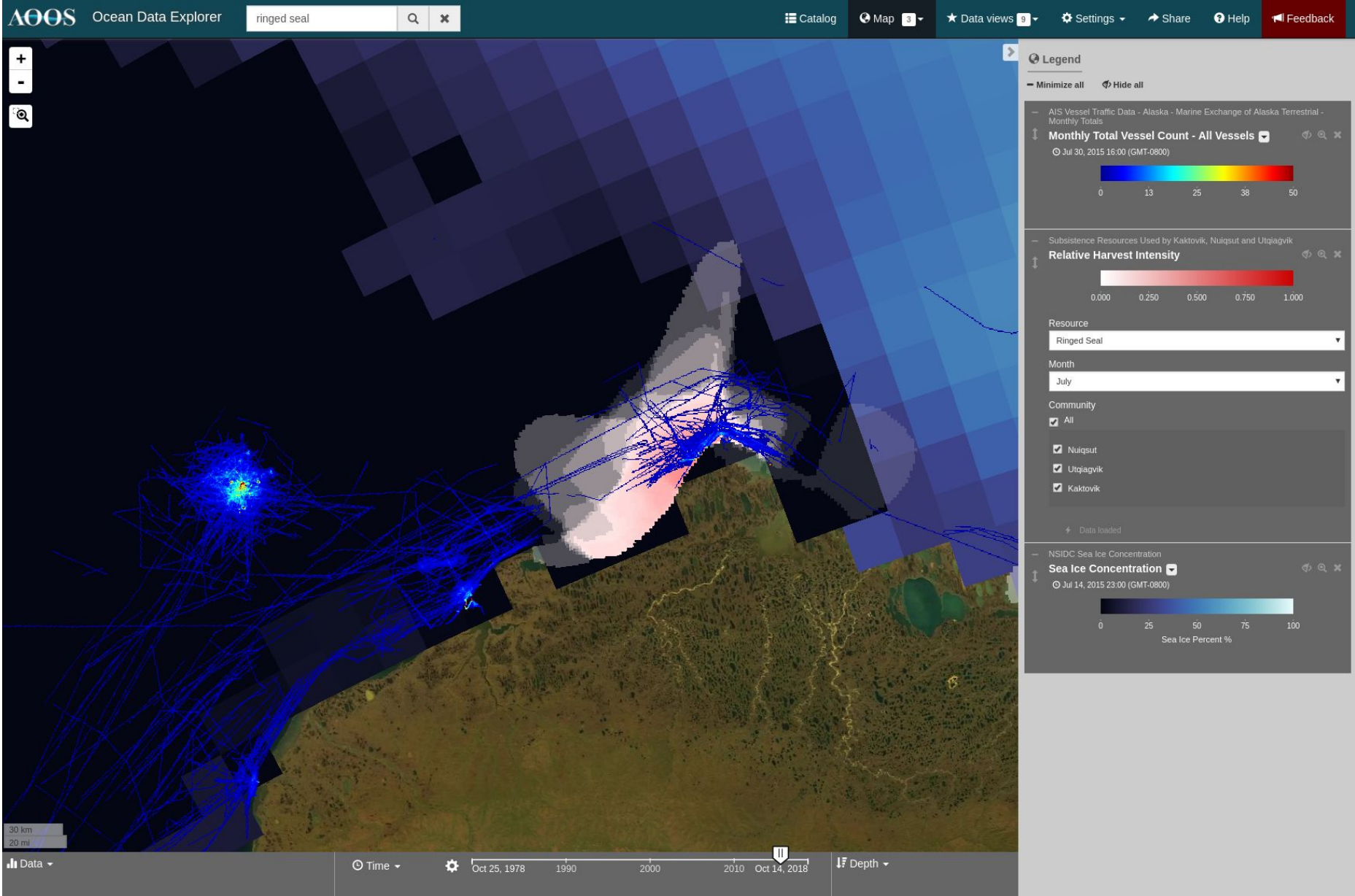
Axiom rebuilt rasters from the provided data and normalized the values relative to the maximum value in each community. Consequently, for these layers each community-associated grid shows a relative measure of the harvest intensity within that community.

#### Data contact

Stephen R. Braund and Associates  
 P.O. Box 101480  
 Anchorage, AK 99510  
[Stephen.Braund@srbak.com](mailto:Stephen.Braund@srbak.com)



In addition to the tool, the data layers can be viewed using the AOS Ocean Data Explorer Interactive map - AIS data from August 2017 along with August subsistence use areas.



July 2015 ship track density, July harvest intensity of ringed seals near Utqiagvik, and sea ice concentration.

# Oil Spill Risk Assessment

Method developed by Sepp-Neves et al. (2015, 2016, 2018) attempts to answer:

1. Which areas are more likely to be affected by a spill?
2. Which areas are at more risk if there is a spill?
3. How does the spatial distribution of risk change over time?



American Fireboom testing by Elastec

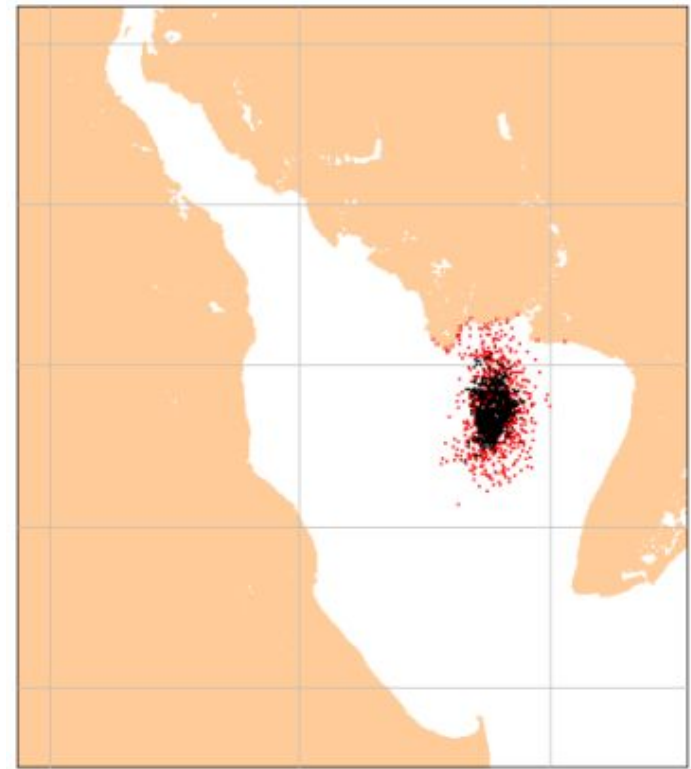
# Oil Spill Modeling - GNOME

Oil spill modeling tool of the NOAA's Office of Response and Restoration Emergency Response Division ([source](#))

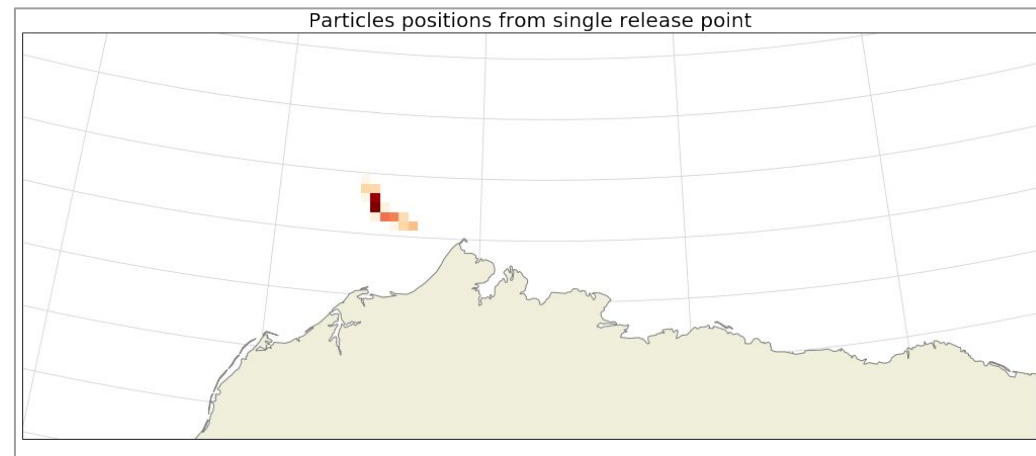
- Predicts oil spill spreading based on wind and ocean currents
- Incorporates inherent uncertainty
- Includes weathering terms

AOOS/Axiom runs the GNOME model with:

- Navy HYCOM results to forecast ocean currents
- GFS model to forecast winds

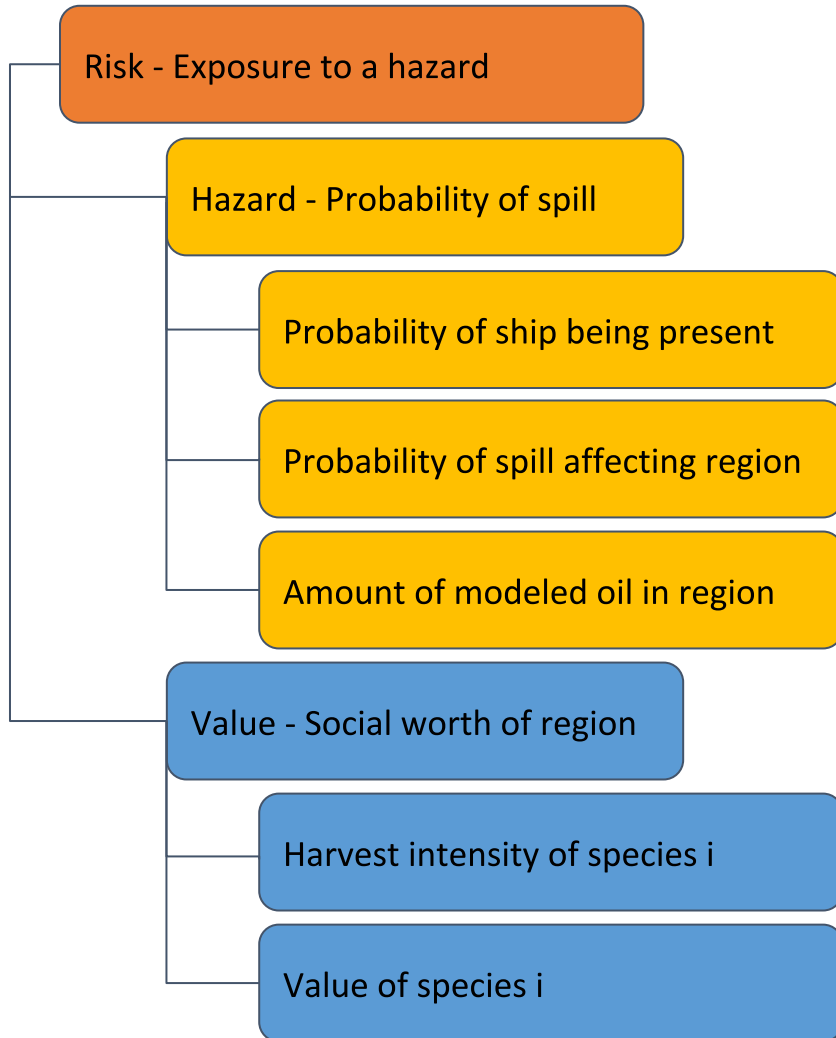


Example GNOME particle tracking



Example GNOME particle tracking from single point

# Method: Overview



$$R_s = H_s \cdot I_s$$

$$H_s = (P_t)_r \cdot (P_b)_s \cdot C_s$$

$$P_t$$

$$P_b$$

$$C_s$$

$$I_s = Ha_{s,i} \cdot V_i$$

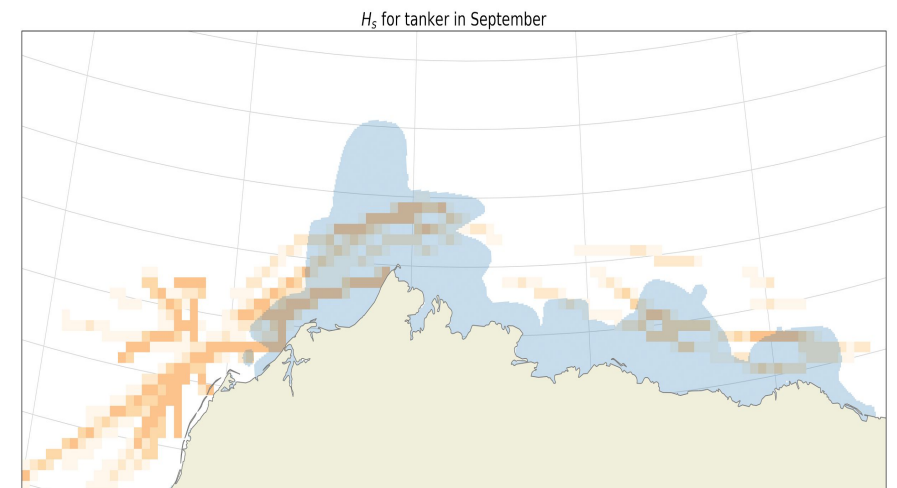
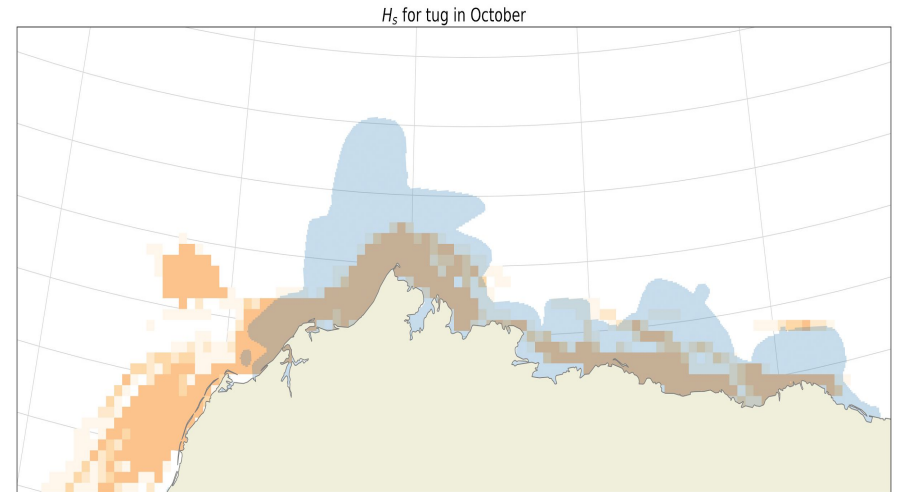
$$Ha_{s,i}$$

$$V_i$$

# Method: Calculating hazard index

$$H_s = (P_t)_r \cdot (P_b)_s \cdot C_s$$

- Calculate hazard index for top 10 ship types based on AIS data
- Calculate hazard index for each ship type for each month that the ships were present
- Results in map of relative hazard

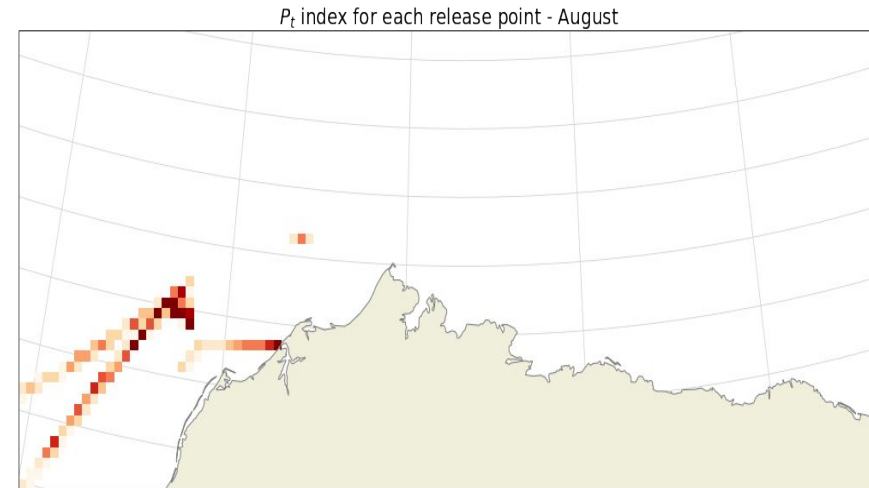
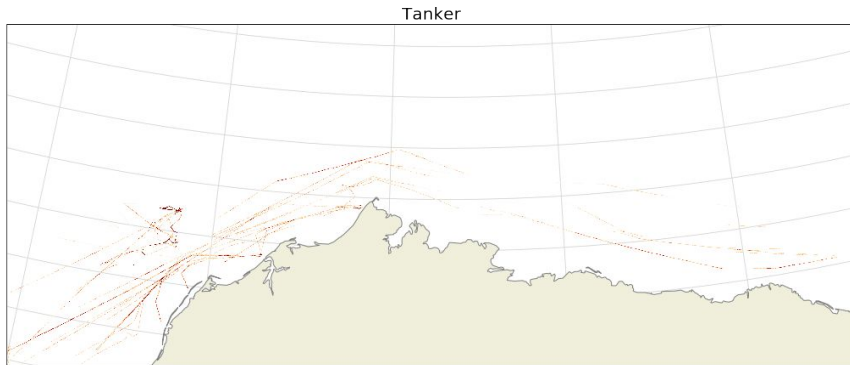


# Method: Calculating $P_t$

Tanker positions from AIS



Probability of tanker at location



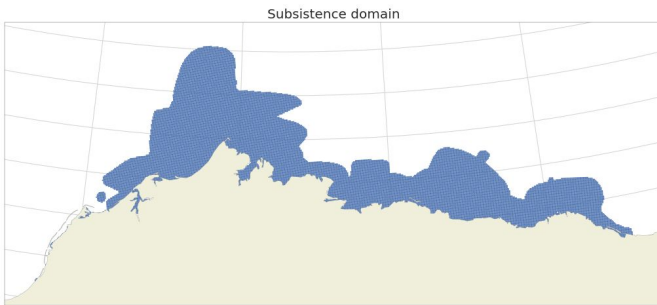
- Regrid AIS positions for each ship type into 10 km x 10 km grid
- Calculate probability of ship type present in each grid cell per month
- Oil spill simulations released from each of these points

$$H_s = (P_t)_r \cdot (P_b)_s \cdot C_s$$

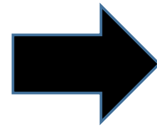


# Method: Calculating $P_b$

Subsistence domain



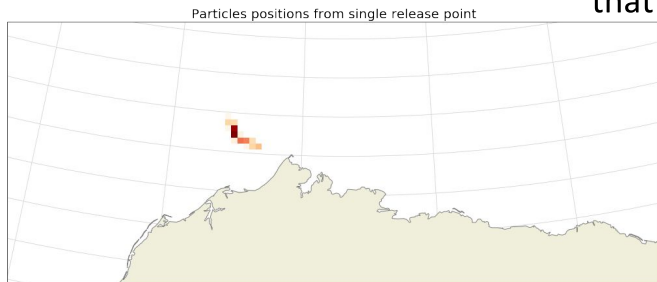
- For each oil spill, check if results intersect with subsistence region
- Calculate percent of oil spill simulations intersect



$(P_b)_s$

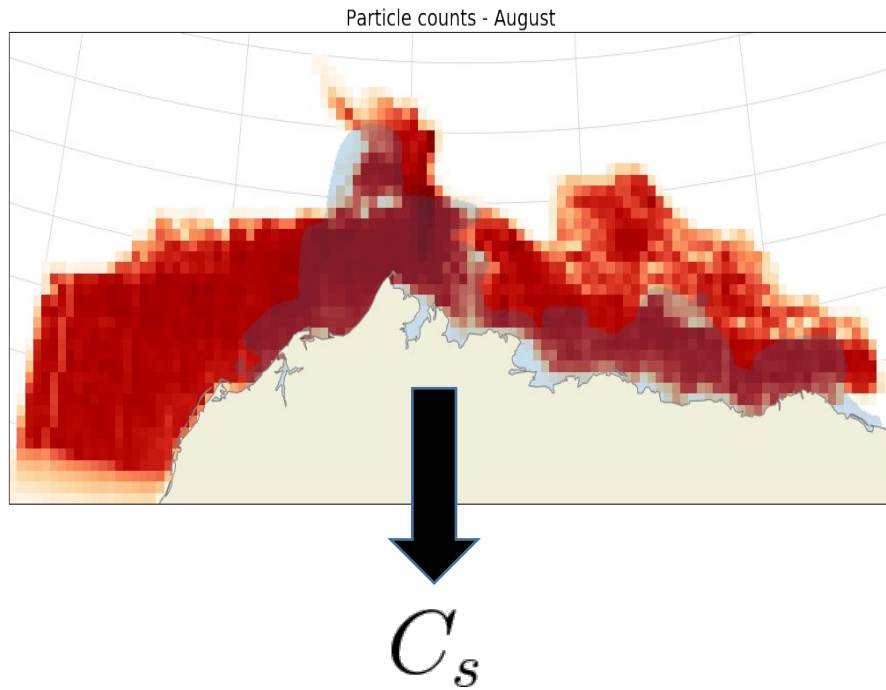
Oil spill simulations

Percent of oil spill simulations  
that enter subsistence region



$$H_s = (P_t)_r \cdot (P_b)_s \cdot C_s$$

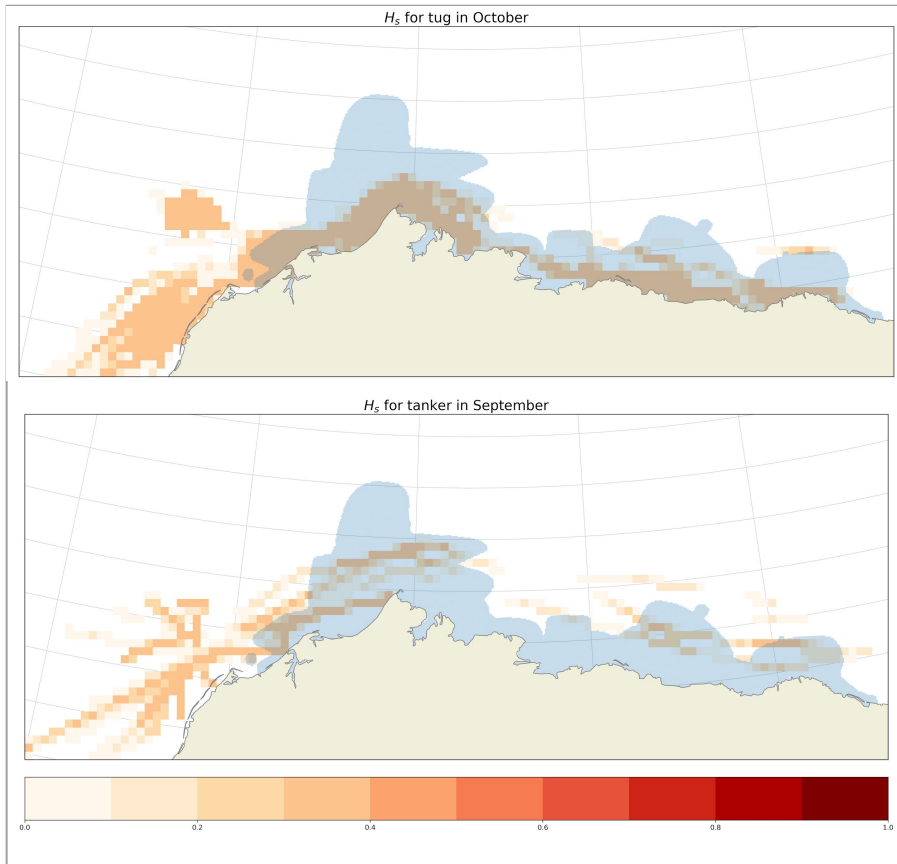
# Method: Calculating $C_s$



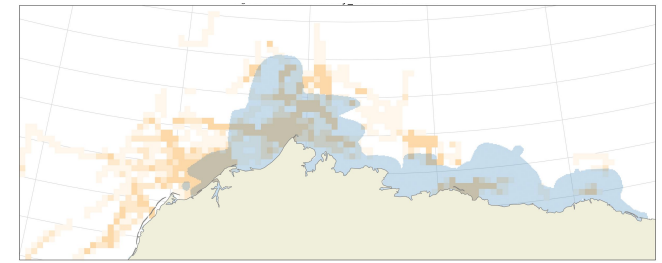
- A - Calculate maximum number of particles within a single cell for subsistence domain
- B - Calculate particles within each cell in domain
- $C_s = B/A$

$$H_s = (P_t)_r \cdot (P_b)_s \cdot C_s$$

# Hazard (AIS) x Social Value (subsistence) = Calculated Risk

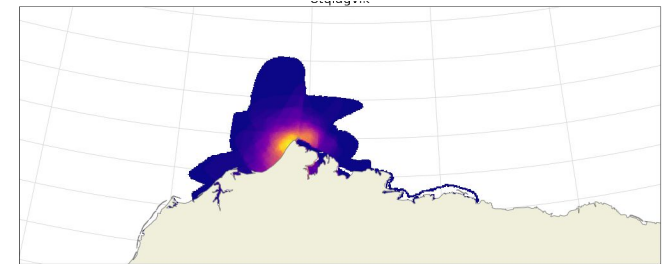


Example: Hazard indexes from Tugs in October and Tankers in September



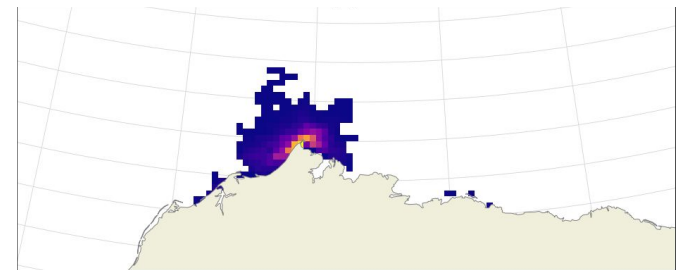
Calculated hazard (probability of spill based on ship tracks)

+



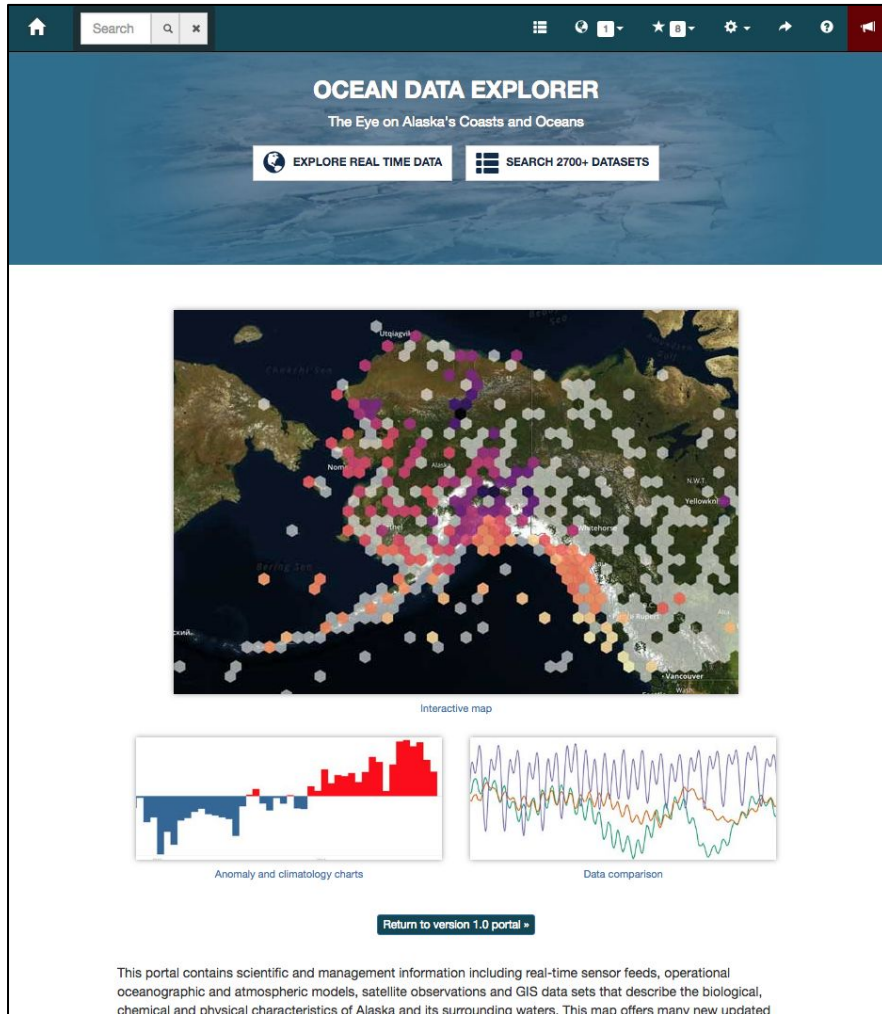
Social value (subsistence use areas)

=



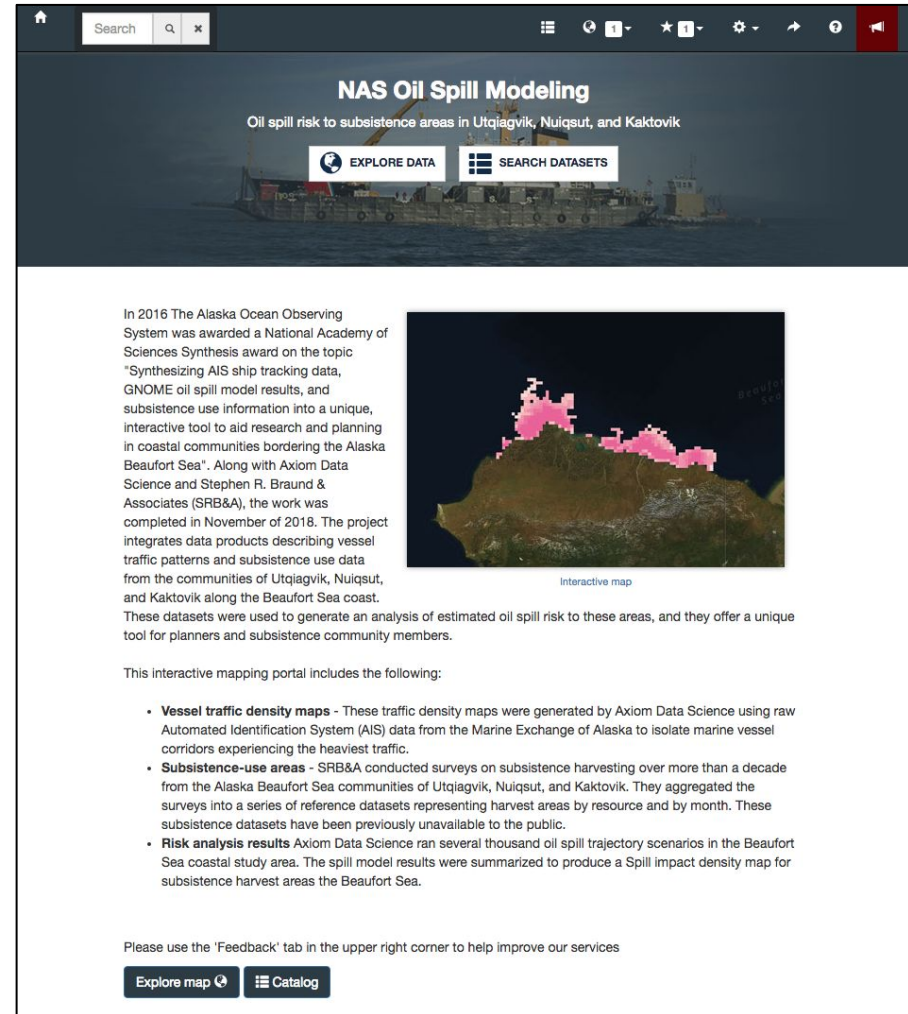
Calculated risk to the resource

# Results: A00S portal and dedicated portal



The screenshot shows the 'OCEAN DATA EXPLORER' portal. The header features a search bar and navigation icons. Below the header, the title 'OCEAN DATA EXPLORER' is displayed with the subtitle 'The Eye on Alaska's Coasts and Oceans'. Two main buttons are visible: 'EXPLORE REAL TIME DATA' and 'SEARCH 2700+ DATASETS'. The main content area features a large map of Alaska and the Beaufort Sea, overlaid with numerous colored hexagonal markers representing data points. Below the map are two smaller charts: 'Anomaly and climatology charts' (a bar chart) and 'Data comparison' (a line graph). A 'Return to version 1.0 portal >' button is located at the bottom of the main content area. A footer paragraph states: 'This portal contains scientific and management information including real-time sensor feeds, operational oceanographic and atmospheric models, satellite observations and GIS data sets that describe the biological, chemical and physical characteristics of Alaska and its surrounding waters. This map offers many new updated'.

portal.aos.org

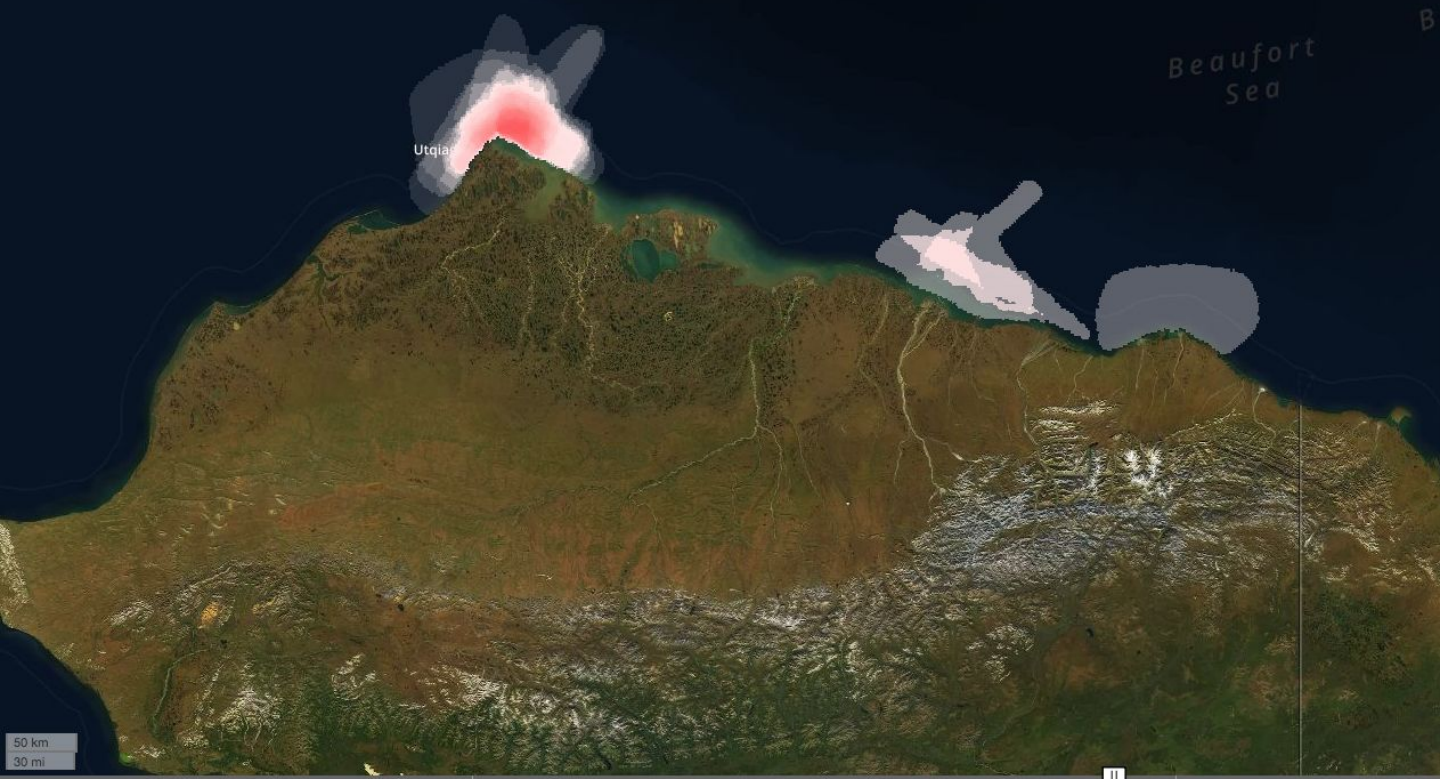


The screenshot shows the 'NAS Oil Spill Modeling' portal. The header features a search bar and navigation icons. Below the header, the title 'NAS Oil Spill Modeling' is displayed with the subtitle 'Oil spill risk to subsistence areas in Utqiagvik, Nuiqsut, and Kaktovik'. Two main buttons are visible: 'EXPLORE DATA' and 'SEARCH DATASETS'. The main content area features a map of the Beaufort Sea coast with pink shaded areas representing oil spill risk. To the left of the map is a text block: 'In 2016 The Alaska Ocean Observing System was awarded a National Academy of Sciences Synthesis award on the topic "Synthesizing AIS ship tracking data, GNOME 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". Along with Axiom Data Science and Stephen R. Braund & Associates (SRB&A), the work was completed in November of 2018. The project integrates data products describing vessel traffic patterns and subsistence use data from the communities of Utqiagvik, Nuiqsut, and Kaktovik along the Beaufort Sea coast. These datasets were used to generate an analysis of estimated oil spill risk to these areas, and they offer a unique tool for planners and subsistence community members.' Below the text is a smaller version of the map labeled 'Interactive map'. Below the map is a list of features: 'This interactive mapping portal includes the following: 

- **Vessel traffic density maps** - These traffic density maps were generated by Axiom Data Science using raw Automated Identification System (AIS) data from the Marine Exchange of Alaska to isolate marine vessel corridors experiencing the heaviest traffic.
- **Subsistence-use areas** - SRB&A conducted surveys on subsistence harvesting over more than a decade from the Alaska Beaufort Sea communities of Utqiagvik, Nuiqsut, and Kaktovik. They aggregated the surveys into a series of reference datasets representing harvest areas by resource and by month. These subsistence datasets have been previously unavailable to the public.
- **Risk analysis results** Axiom Data Science ran several thousand oil spill trajectory scenarios in the Beaufort Sea coastal study area. The spill model results were summarized to produce a Spill impact density map for subsistence harvest areas the Beaufort Sea.

' At the bottom, there is a 'Please use the 'Feedback' tab in the upper right corner to help improve our services' message and two buttons: 'Explore map >' and 'Catalog >'.

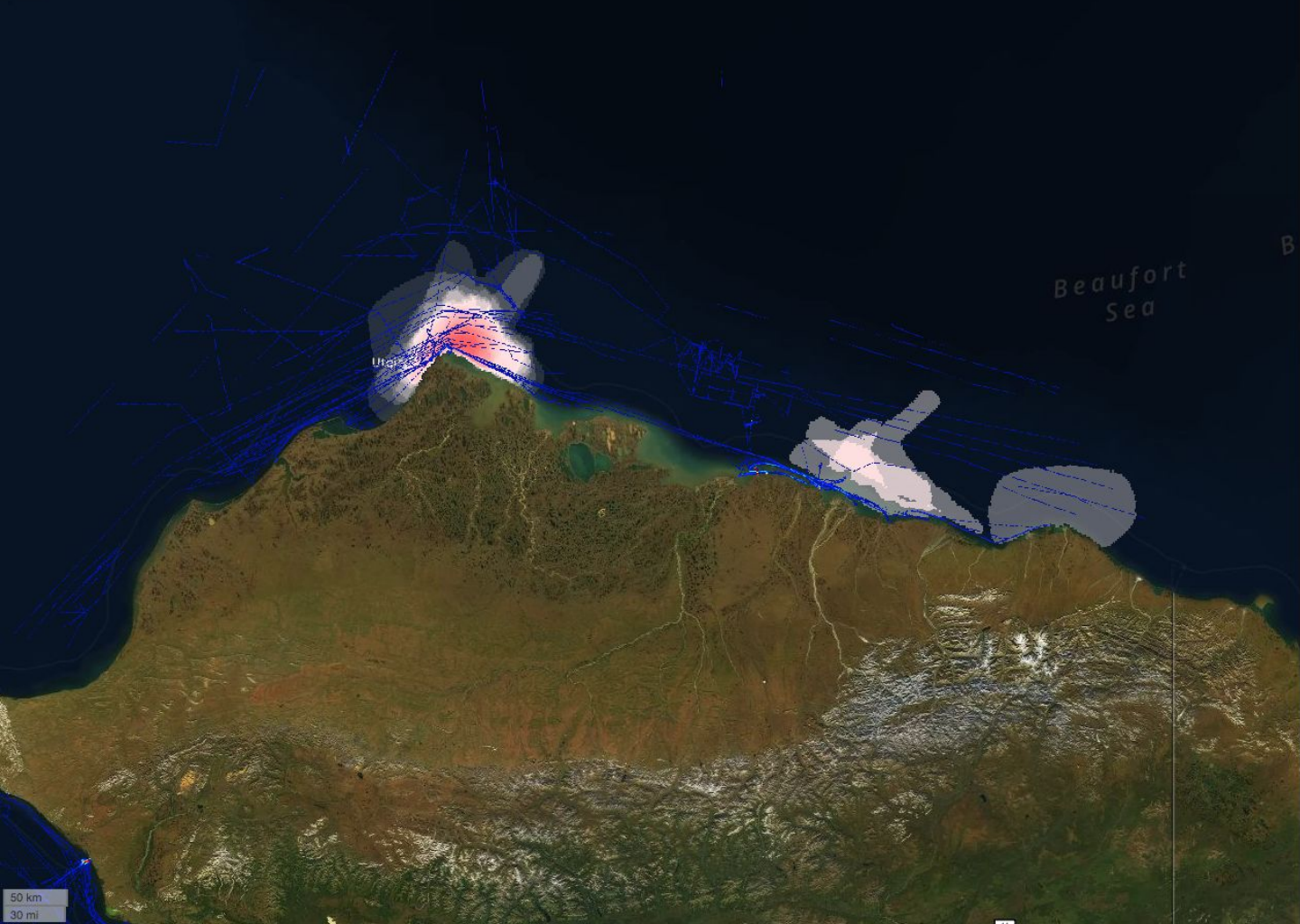
portal.aos.org/?portal\_id=114



**Legend**

- Minimize all Hide all
- AIS Vessel Traffic Data - Alaska - Marine Exchange of Alaska Terrestrial - Monthly Totals
  - Monthly Total Vessel Count - All Vessels
    - Layer hidden
- Oil spill risk to Kaktovik, Nuiqsut, and Utqiagvik subsistence resources
  - Calculated risk value
    - Layer hidden
    - Data loaded
- Subsistence Resources Used by Kaktovik, Nuiqsut and Utqiagvik
  - Relative Harvest Intensity**
    - 0.000 0.250 0.500 0.750 1.000
    - Resource: Bowhead
    - Month: October
    - Community:
      - All
      - Nuiqsut
      - Utqiagvik
      - Kaktovik
    - Data loaded
  - Subsistence Resources Used by Kaktovik, Nuiqsut and Utqiagvik
    - Subsistence Resources Study Area
      - Layer hidden

Subsistence for bowhead in October



**Legend**

Minimize all Hide all

AIS Vessel Traffic Data - Alaska - Marine Exchange of Alaska Terrestrial - Monthly Totals

**Monthly Total Vessel Count - All Vessels**

Aug 30, 2017 16:00 (GMT-0800)

0 13 25 38 50

Oil spill risk to Kaktovik, Nuiqsut, and Utqiagvik subsistence resources

Calculated risk value

Layer hidden

Data loaded

Subsistence Resources Used by Kaktovik, Nuiqsut and Utqiagvik

**Relative Harvest Intensity**

0.000 0.250 0.500 0.750 1.000

Resource

Bowhead

Month

October

Community

All

Nuiqsut

Utqiagvik

Kaktovik

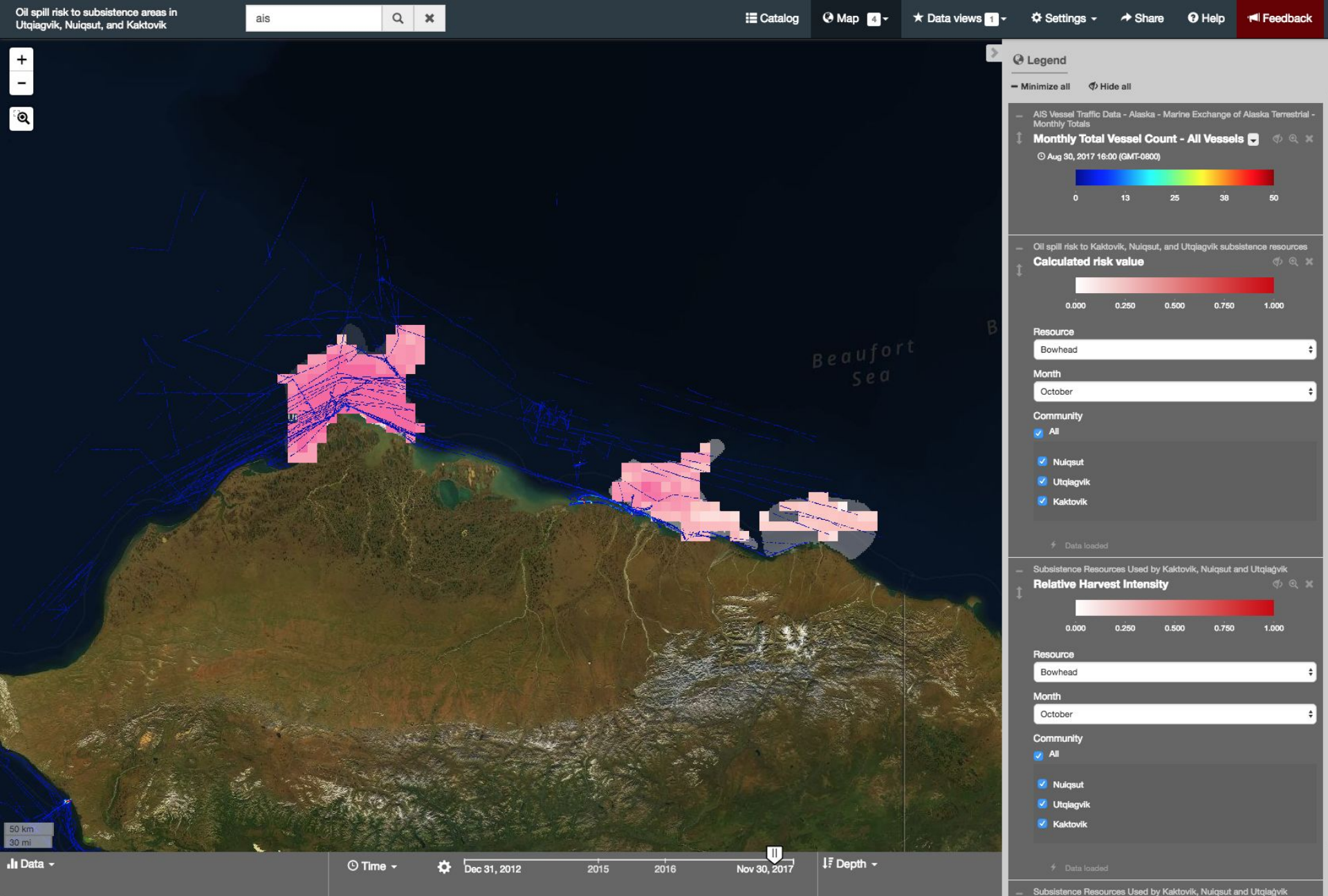
Data loaded

Subsistence Resources Used by Kaktovik, Nuiqsut and Utqiagvik

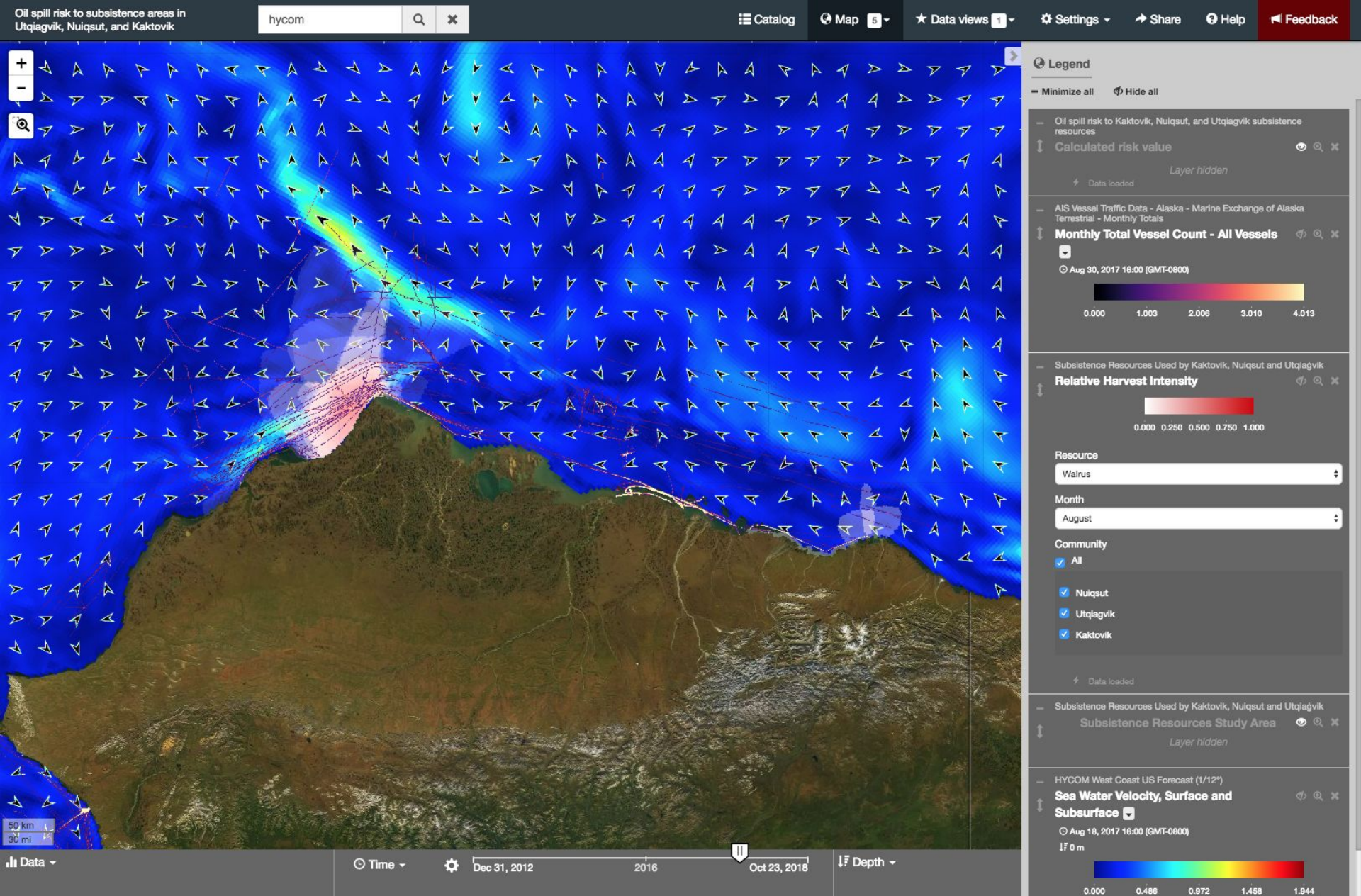
Subsistence Resources Study Area

Layer hidden

With AIS tracks (all vessel types) from October, 2017



With risk analysis - intersection of use and where modeled particles end up



Add HYCOM to see along shore currents that protect Kaktovik (and hurt Utqiagvik) from modeled oil



Find the tool online  
**<http://arctic-osra.aos.org>**

[Link](#)