Assessing Risk to Arctic Subsistence Harvesting Areas from Marine Oil Spills

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Axiom DATA SCIENCE

AOOS Alaska Ocean Observing System

SRB&A

National Academy of Sciences

Project overview

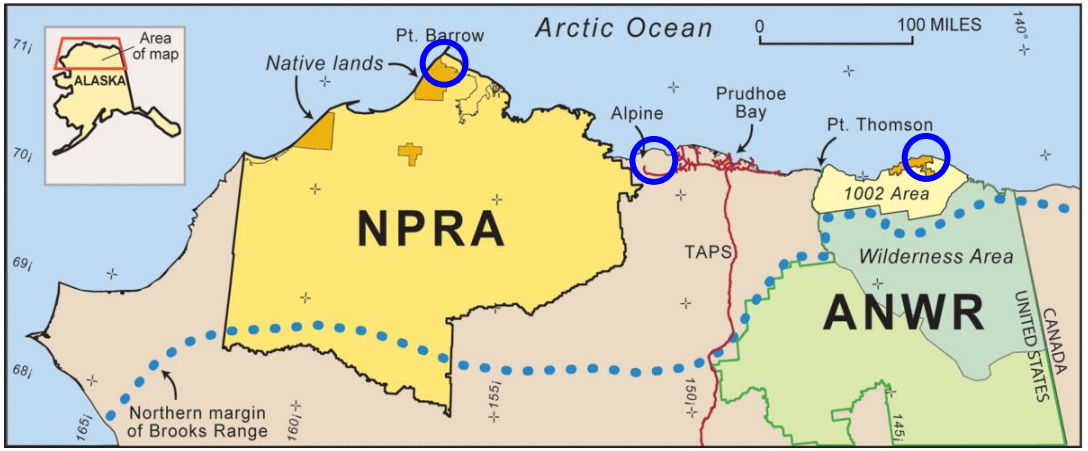
Funded by National Academy of Sciences, "Synthesis" Program

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

- Utqiagvik / Barrow
- Nuiqsut
- Kaktovik

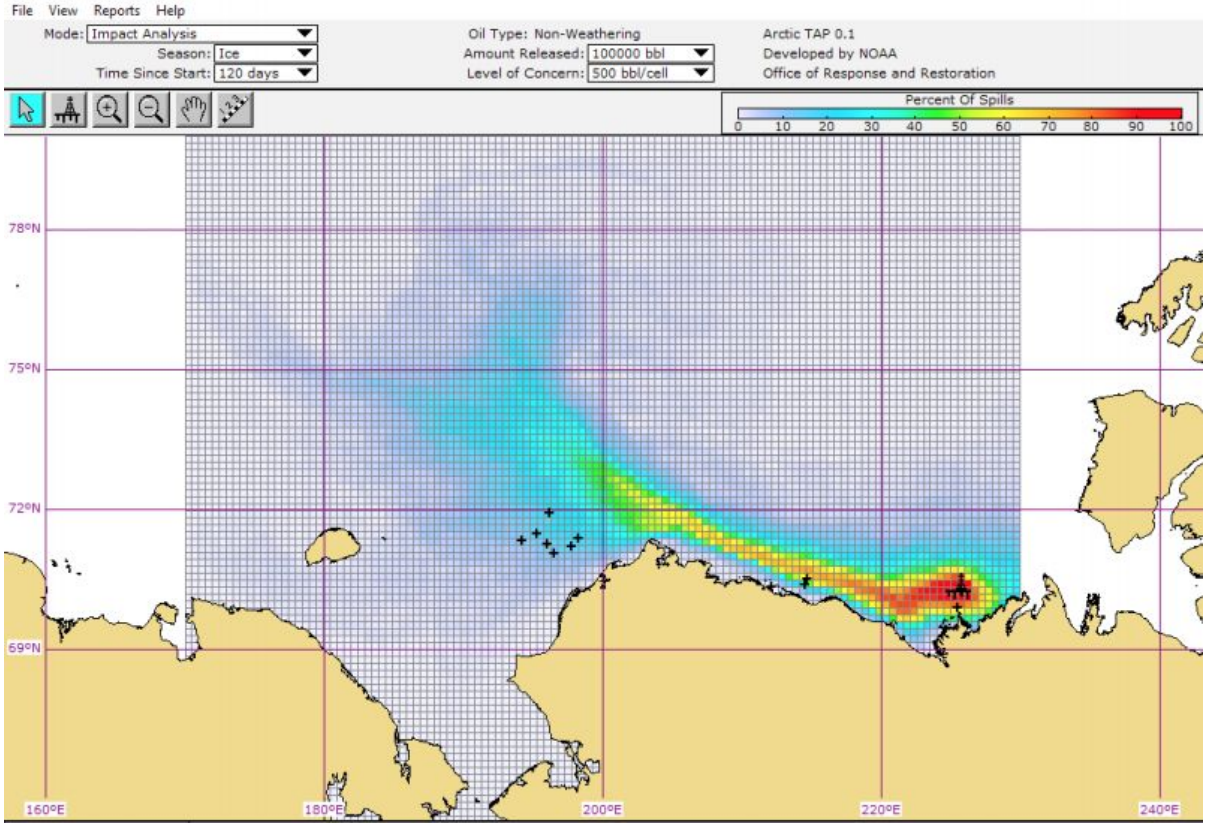
The method combines:

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

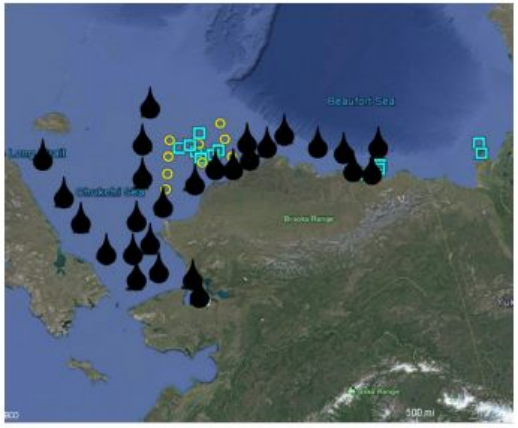


The analysis could be used in similar situations in the Gulf of Mexico or other regions with high potential for vessel accidents.

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.

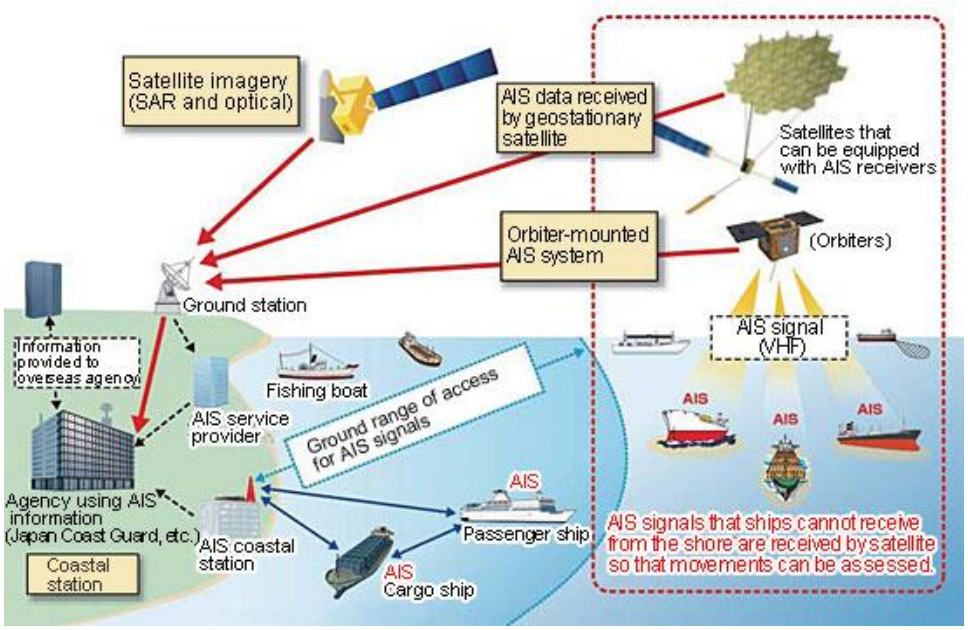
Trajectory Analysis Planner by the Office of Response and Restoration

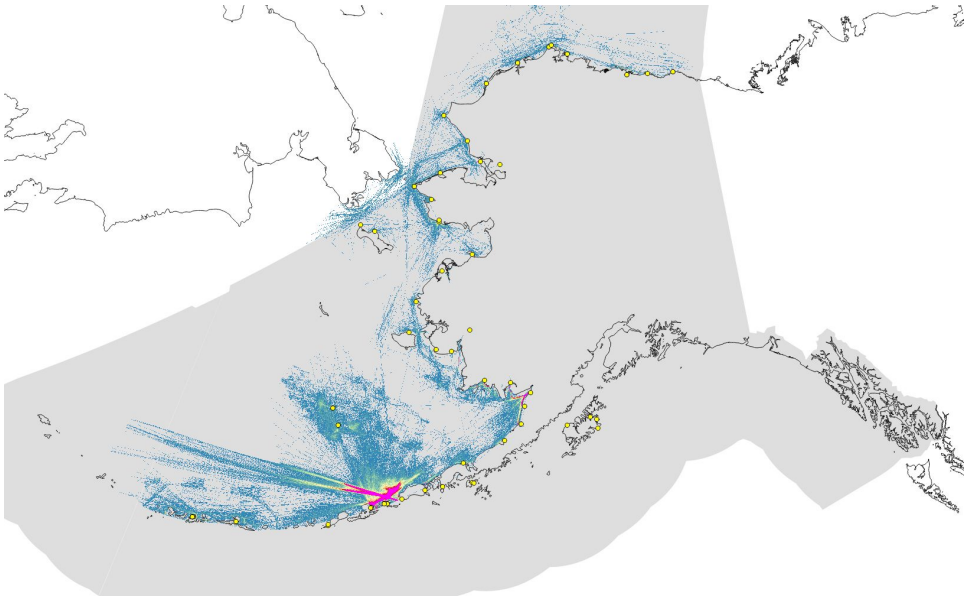
Ship Track Density - AIS

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:

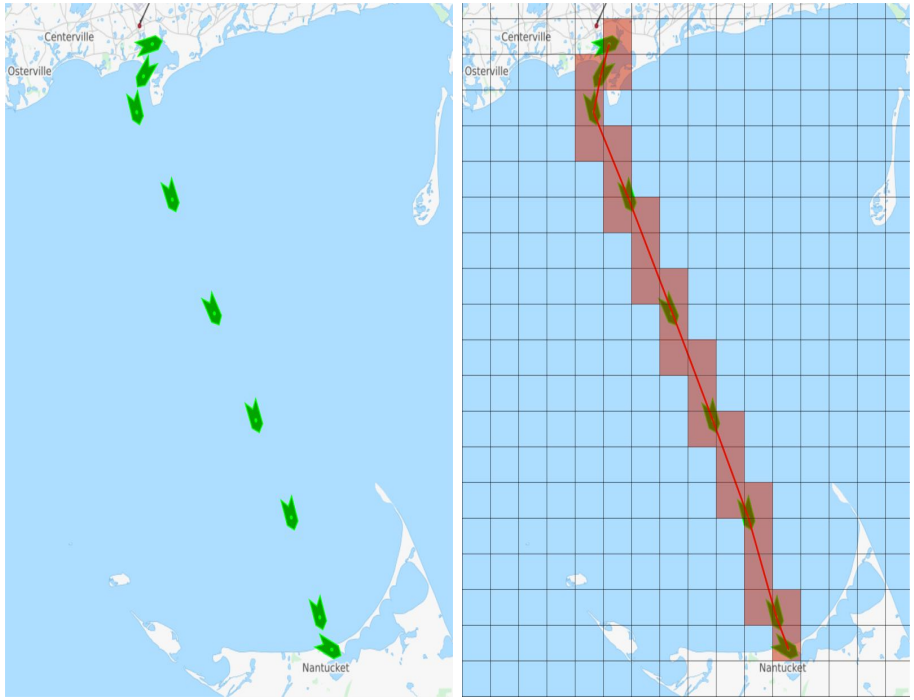
- US Coast Guard Terrestrial
  - Jan 2015 to Dec 2016
- US Coast Guard Satellite
  - Dec 2015 to June 2016
- Marine Cadastre Terrestrial
  - Jan 2009 to Dec 2014
- Marine Exchange of Alaska Terrestrial
  - Jan 2013 to Dec 2017

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



AOOS Alaska Ocean Observing System

ais

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

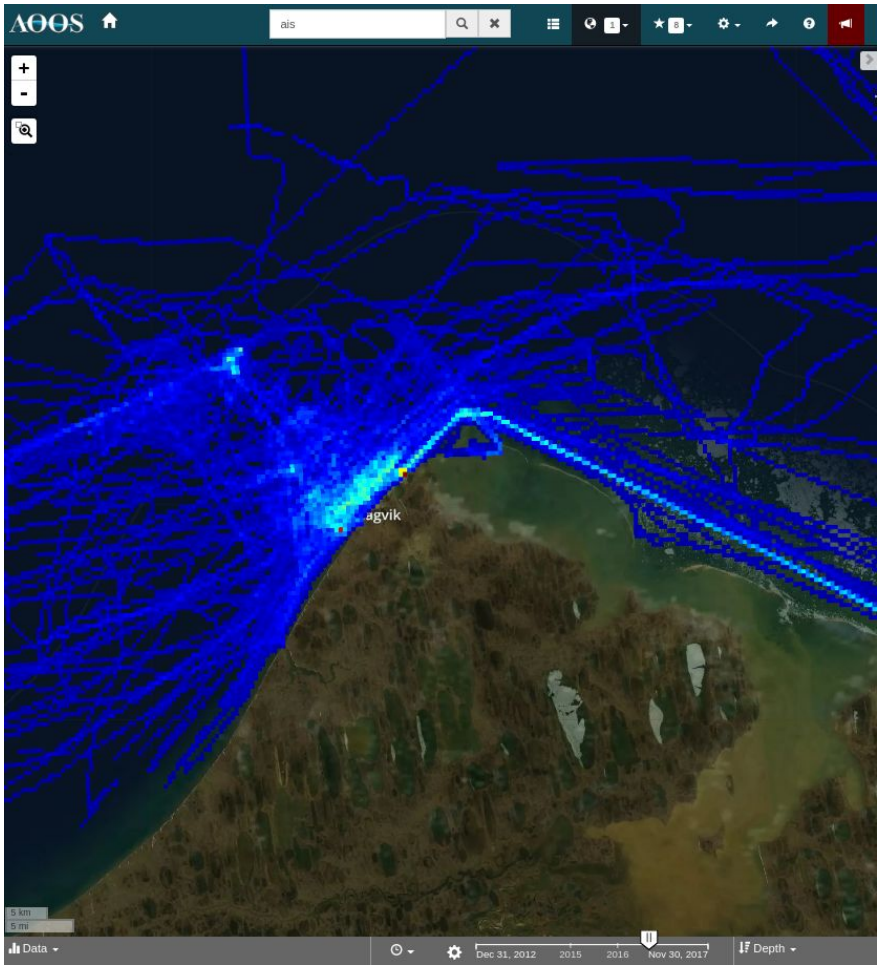
This dataset contains vessel traffic data within the United States Exclusive Economic Zone (US EEZ). Data were collected from onboard navigation safety devices that transmit and monitor the location and characteristics of large vessels that transited U.S waters. The dataset is composed of vessel traffic 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 UTC and covers 2017-10-01 00:00 to 2017-11-01 00:00.

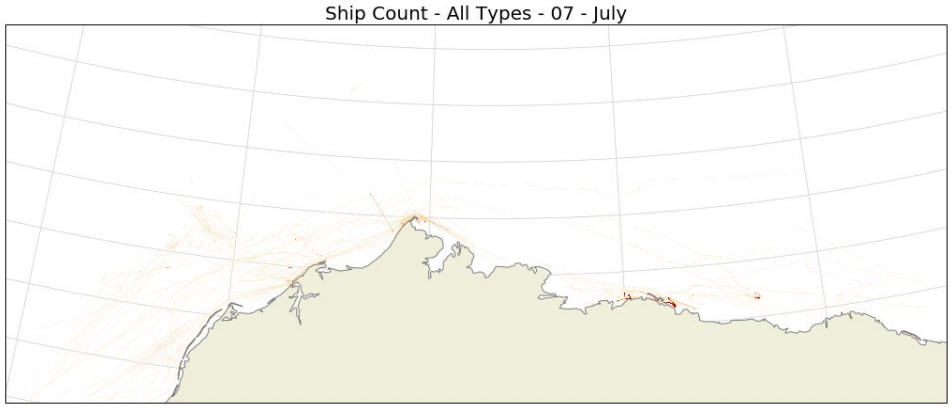
This project uses data from the Authoritative Vessel Identification Service (AVIS) provided by the US Coast Guard. This catalog was quality-checked by the Marine Exchange of Alaska for valid vessel categories for arctic-specific vessels. To simplify resulting data products, Vessel Service is grouped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

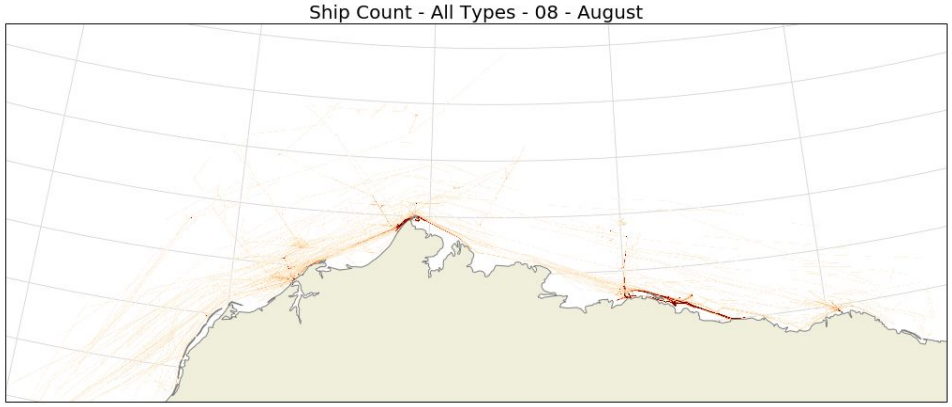
- Passenger
  - Passenger (Inspected and Uninspected)
  - Passenger Barge (Inspected and Uninspected)
- Tanker
  - Public Tankship/Barge
  - Tank Barge
  - Tank Ship
- Cargo
  - Freight Barge
  - Freight Ship
  - Industrial Vessel
  - Public Freight
- Other
  - Commercial Fishing Vessel
  - Fish Processing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

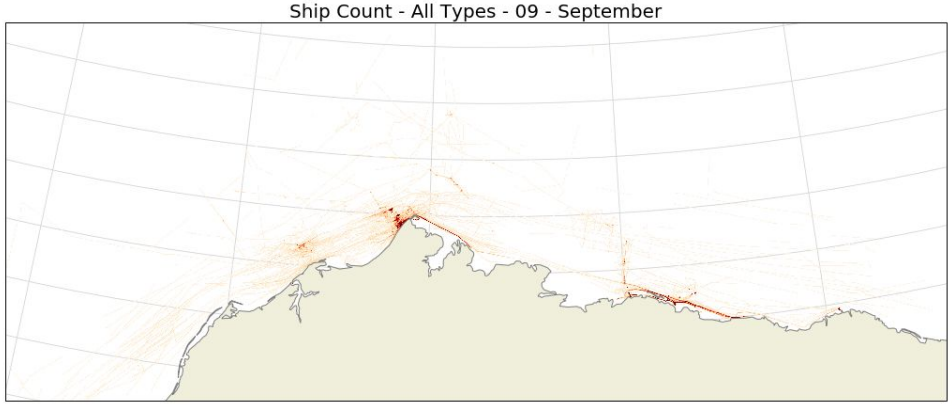
Metadata URL	http://ais.axds.co
Time span	Dec 31, 2012 15:00 (GMT-0900) - Nov 30, 2017 15:00 (GMT-0900)
Extent:	49.18°,158.05° x 73.26°,-146.29°



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







Ship Track Density - AIS

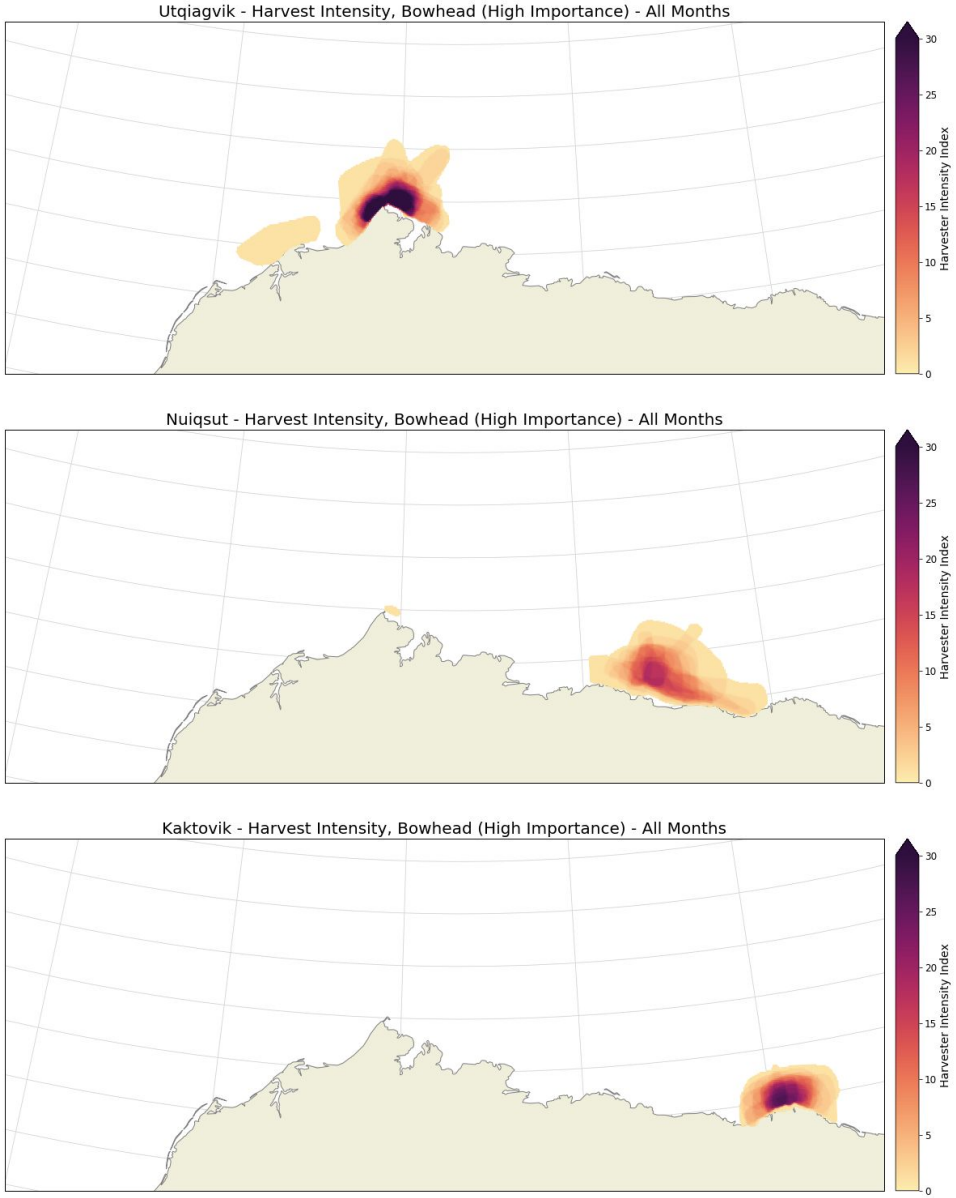
More information on this AIS data :
http://ais.axds.co/

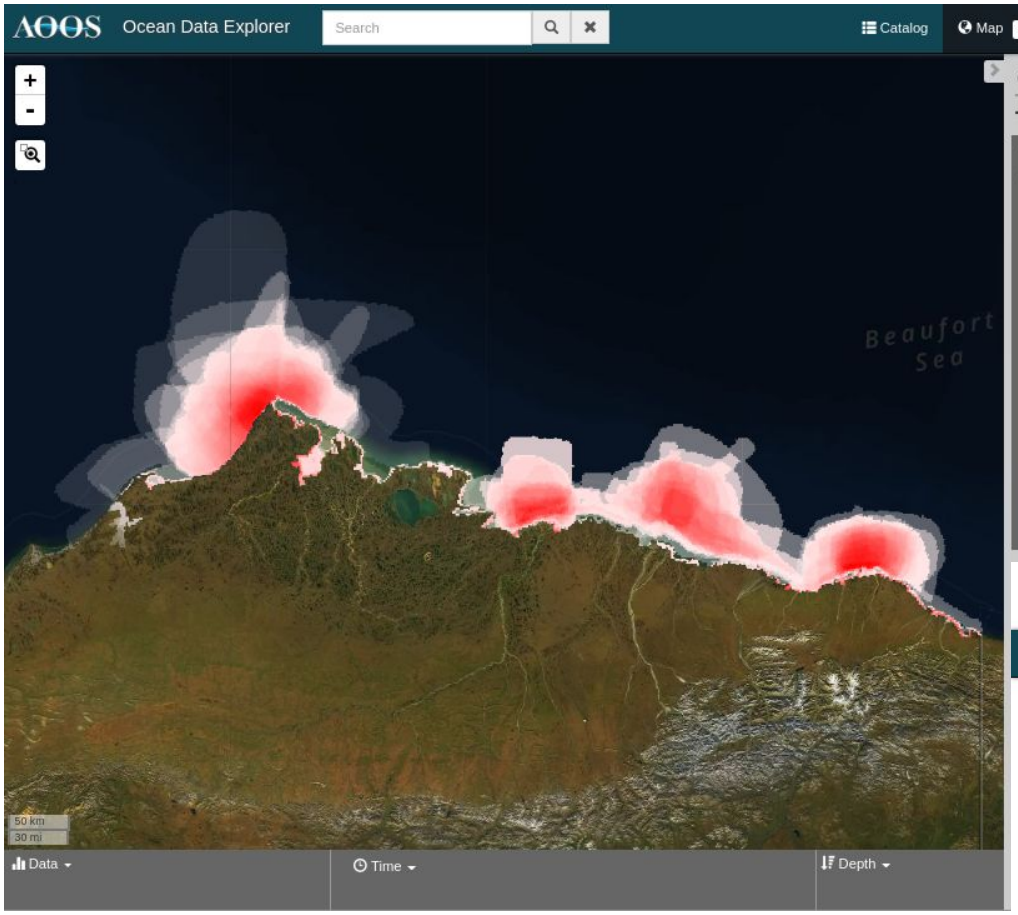
Explorable in the AOOS data portal:
portal.aoos.org

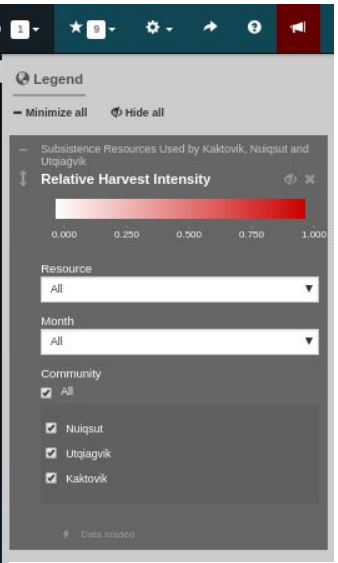
Subsistence Harvest Data

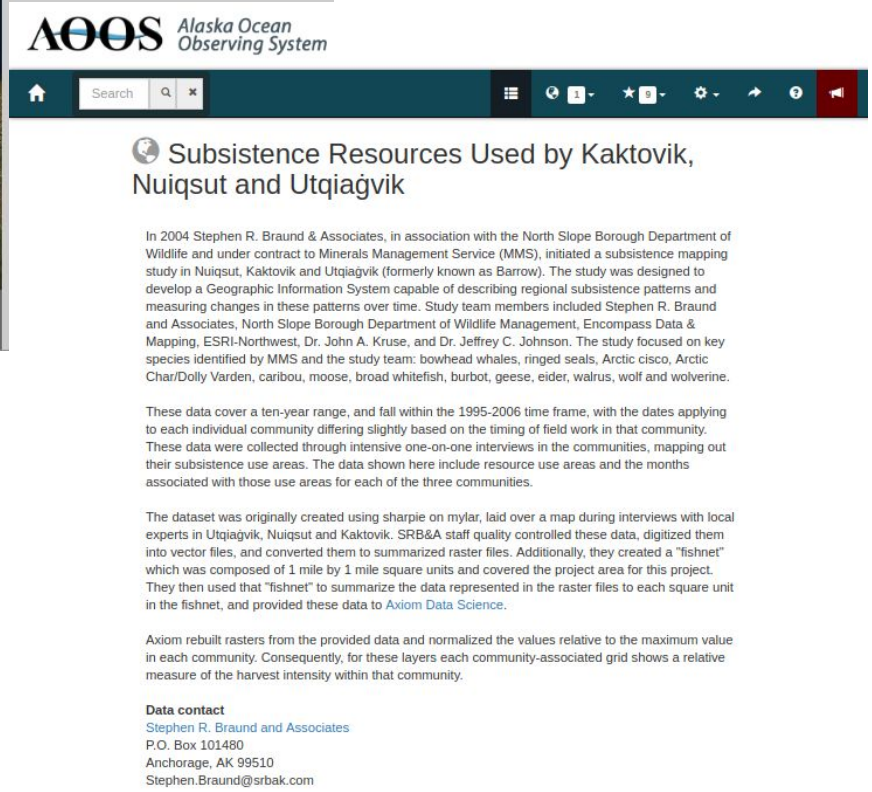
Harvester intensity index values provided by Stephen R. Braund & Associates:

- 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

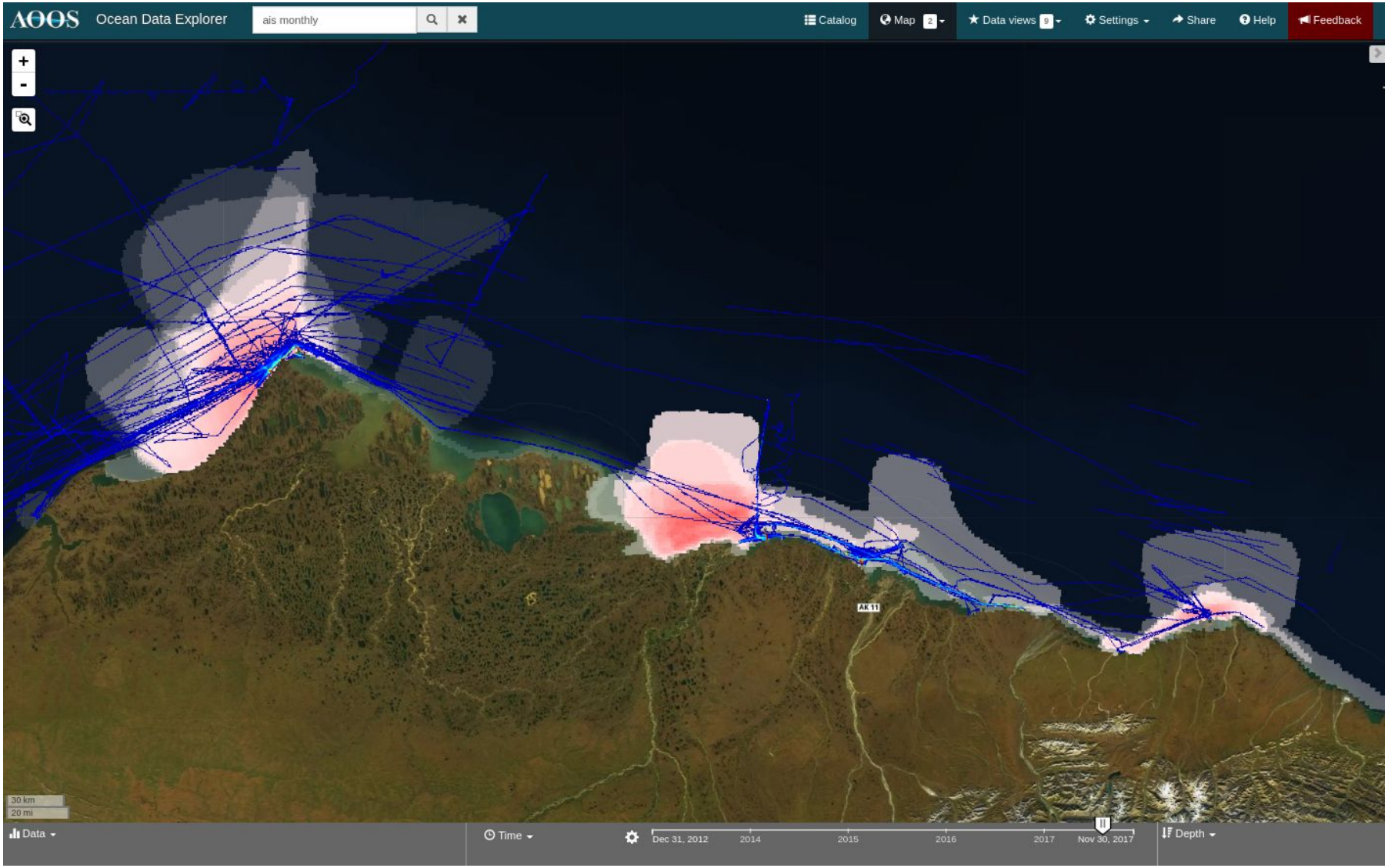




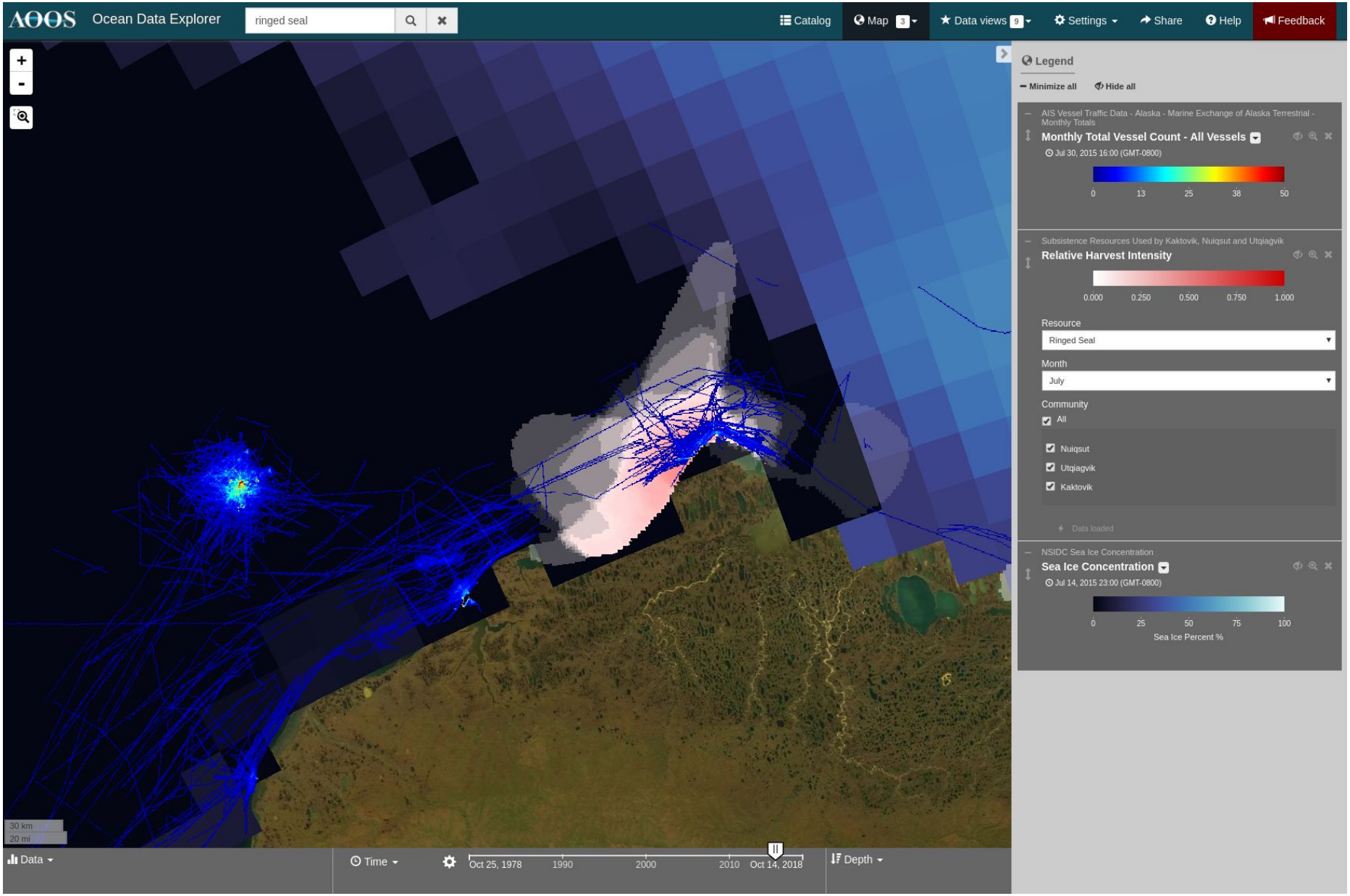




AOOS catalog entry for subsistence use areas mapped around Kaktovik, Nuiqsut and Utqiagvik provided by Stephen R. Braund & Associates



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

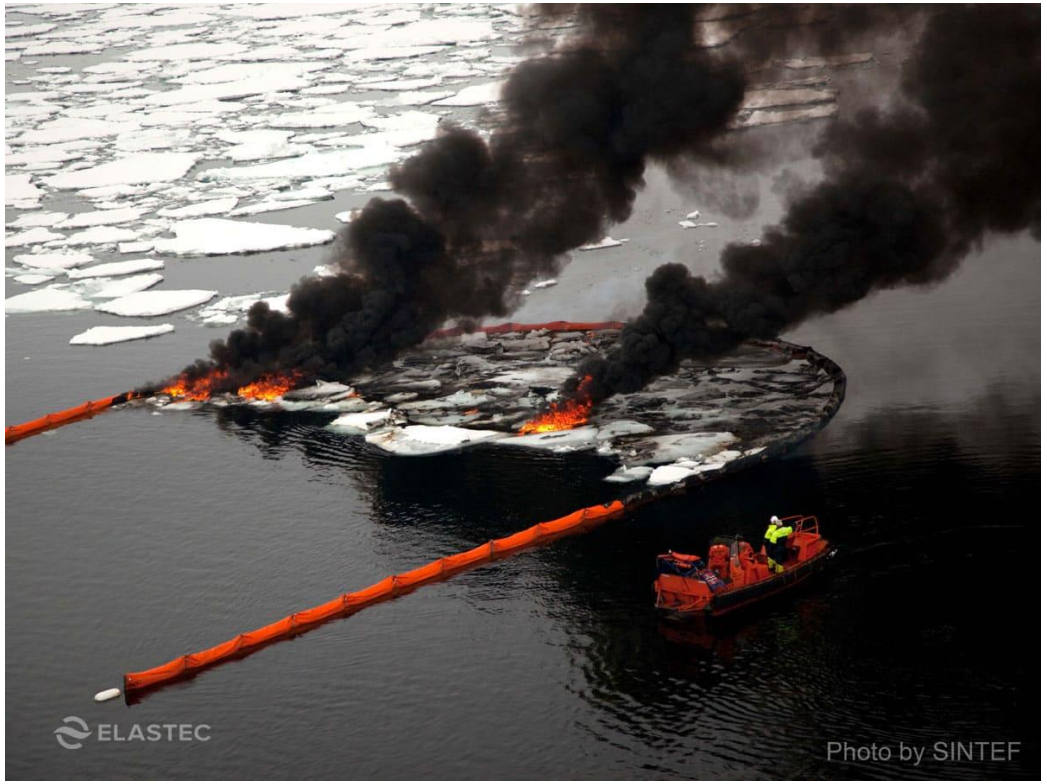


July 2015 ship track density, July harvest intensity of ringed seals near Utqiagvik, and sea ice concentration.

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

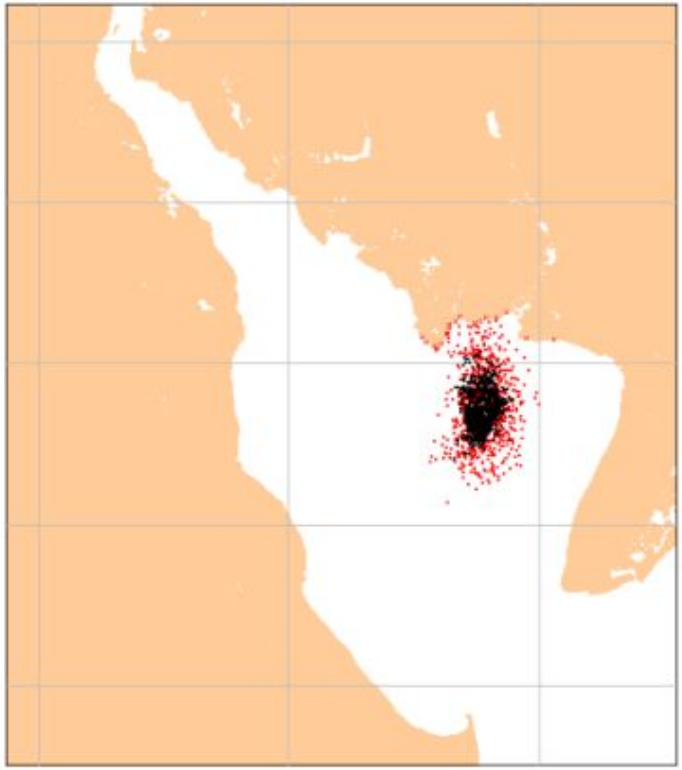
Oil Spill Modeling - GNOME

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

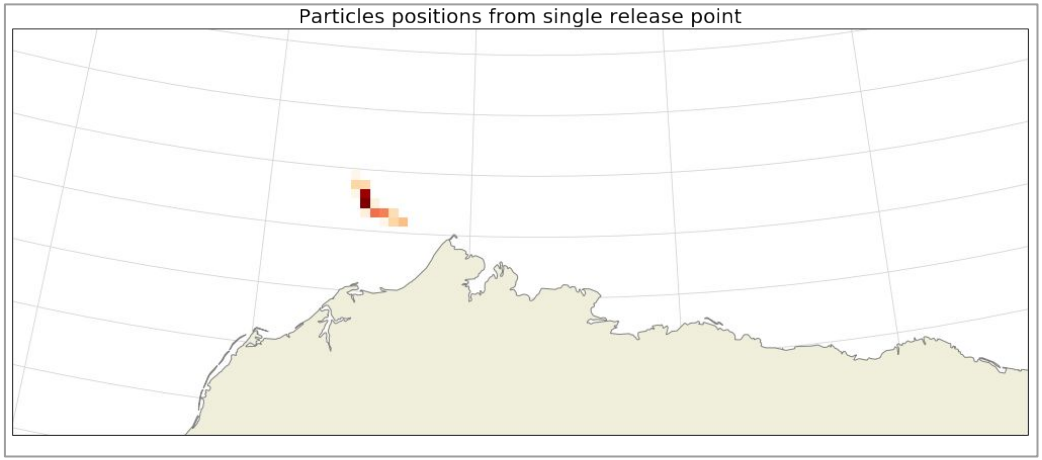
- Predicts oil spill spreading based on wind and ocean currents
- Incorporates inherent uncertainty
- Includes weathering terms

AOOS/Axiom runs the GNOME model with:

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

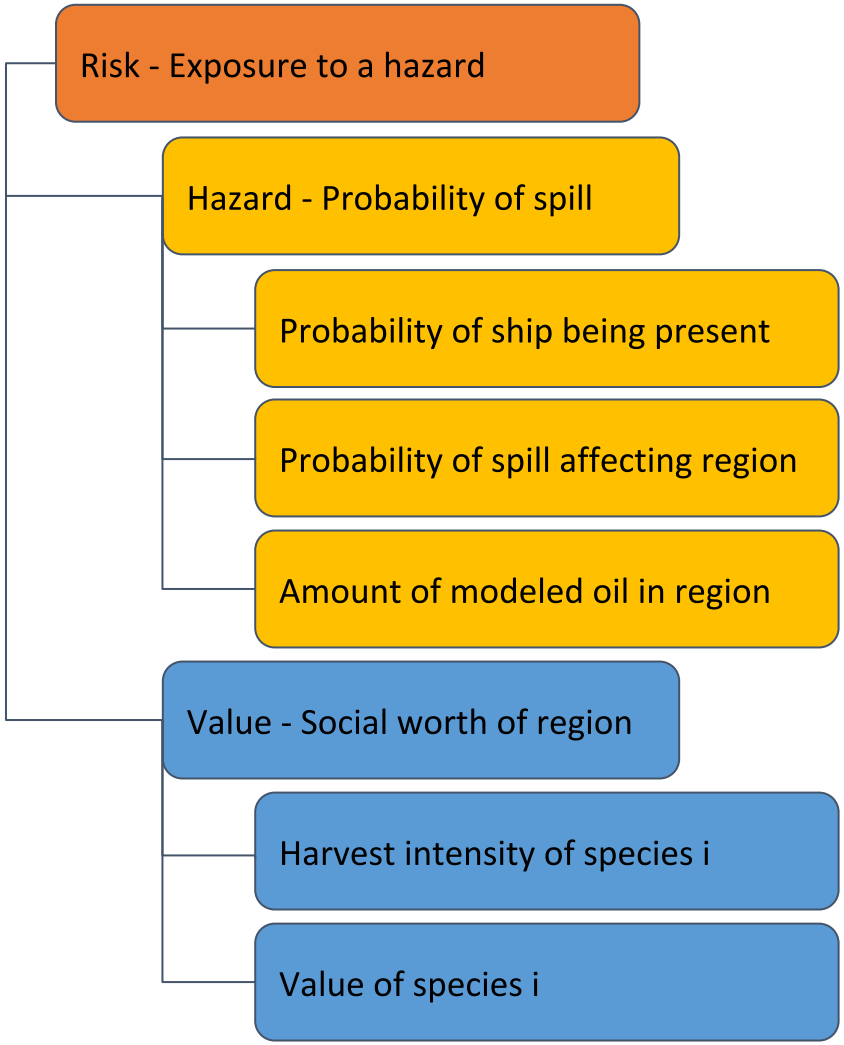


Example GNOME particle tracking



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

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

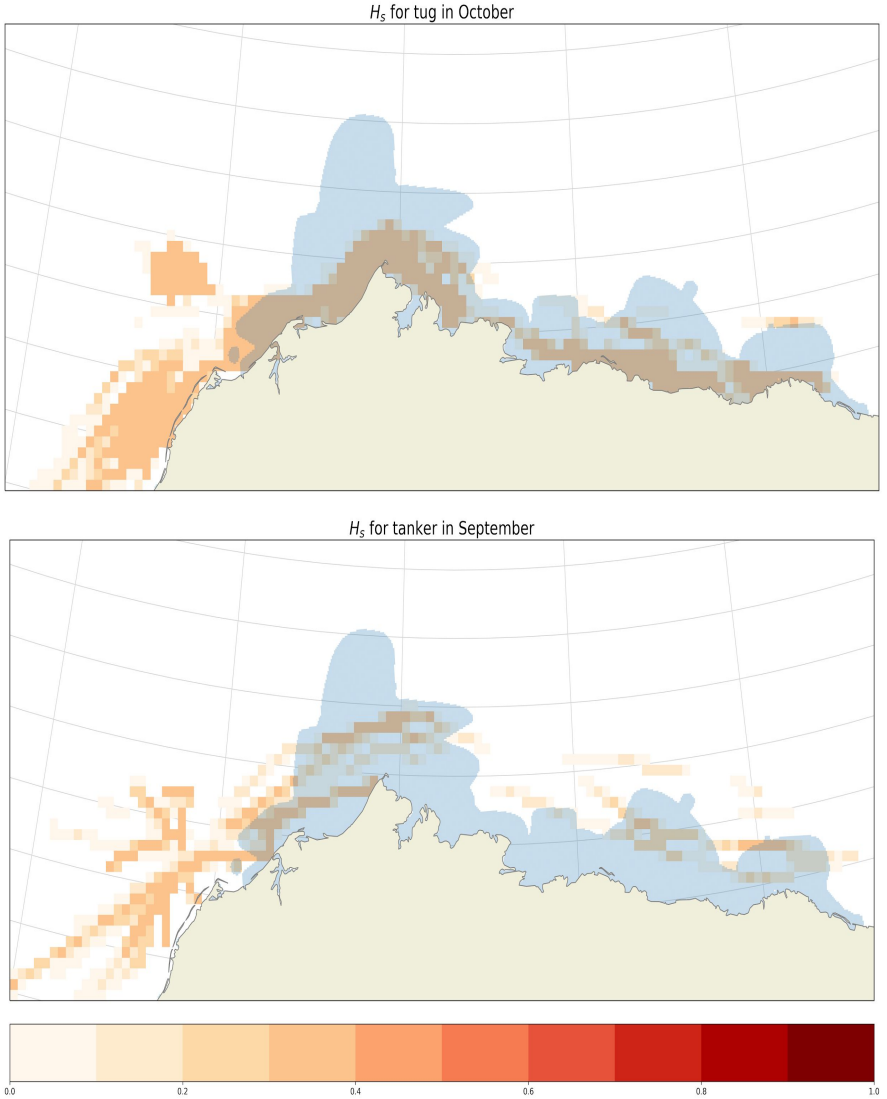
$Ha_{s,i}$

V_i

Method: Calculating hazard index

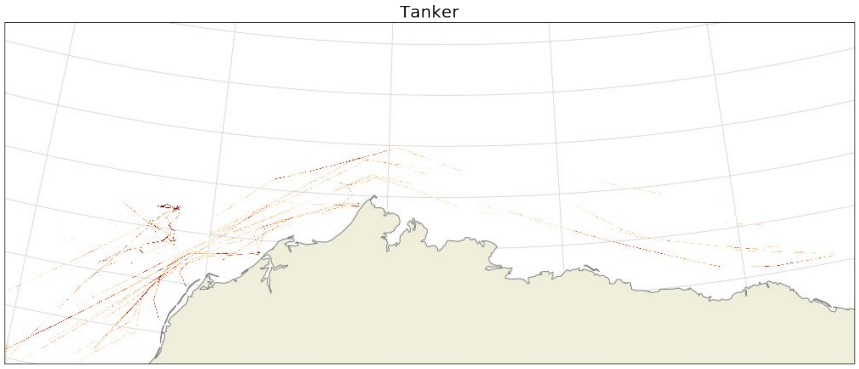
$$H_s = (P_t)_r \cdot (P_b)_s \cdot C_s$$

- 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

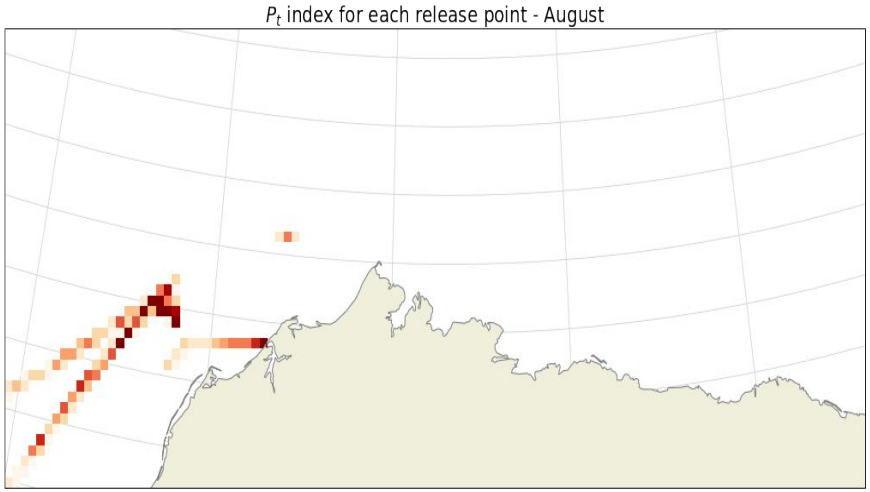


Method: Calculating Pt

Tanker positions from AIS



Probability of tanker at location

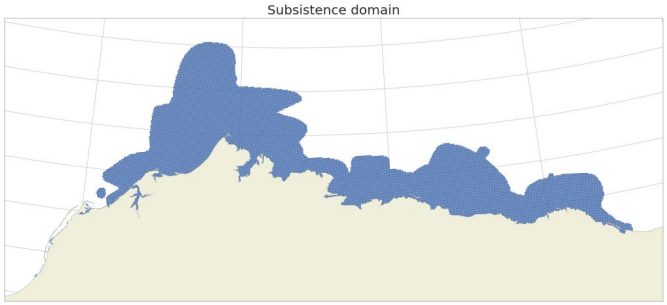


- Regrid AIS positions for each ship type into 10 km x 10 km grid
- Calculate probability of ship type present in each grid cell per month
- Oil spill simulations released from each of these points

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

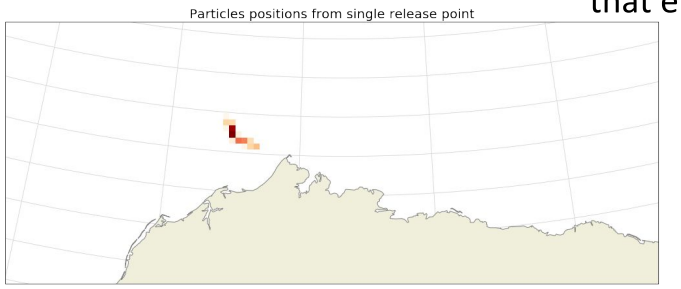
Method: Calculating Pb

Subsistence domain



$(P_b)_s$

Oil spill simulations

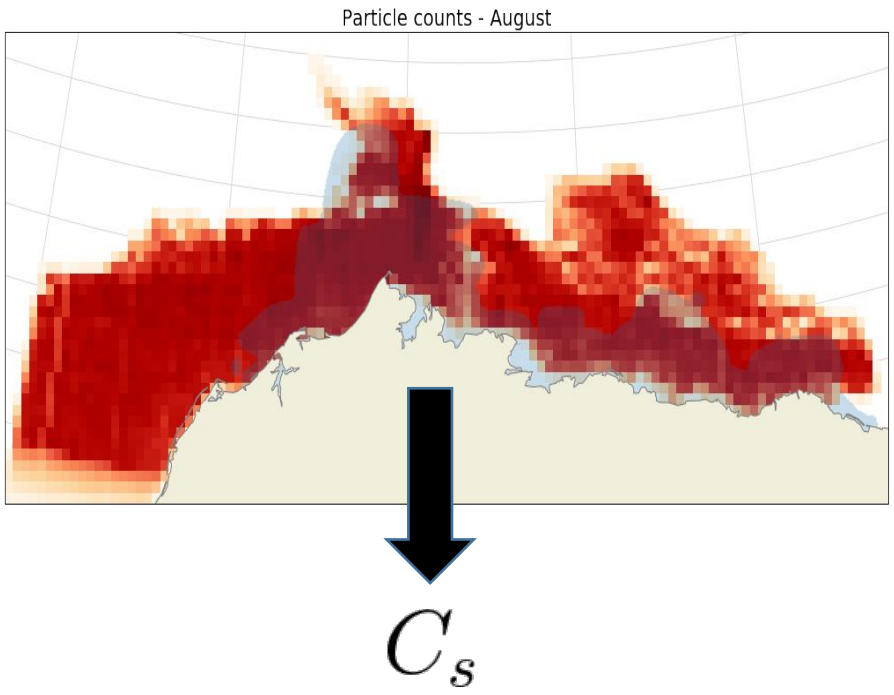


Percent of oil spill simulations that enter subsistence region

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

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

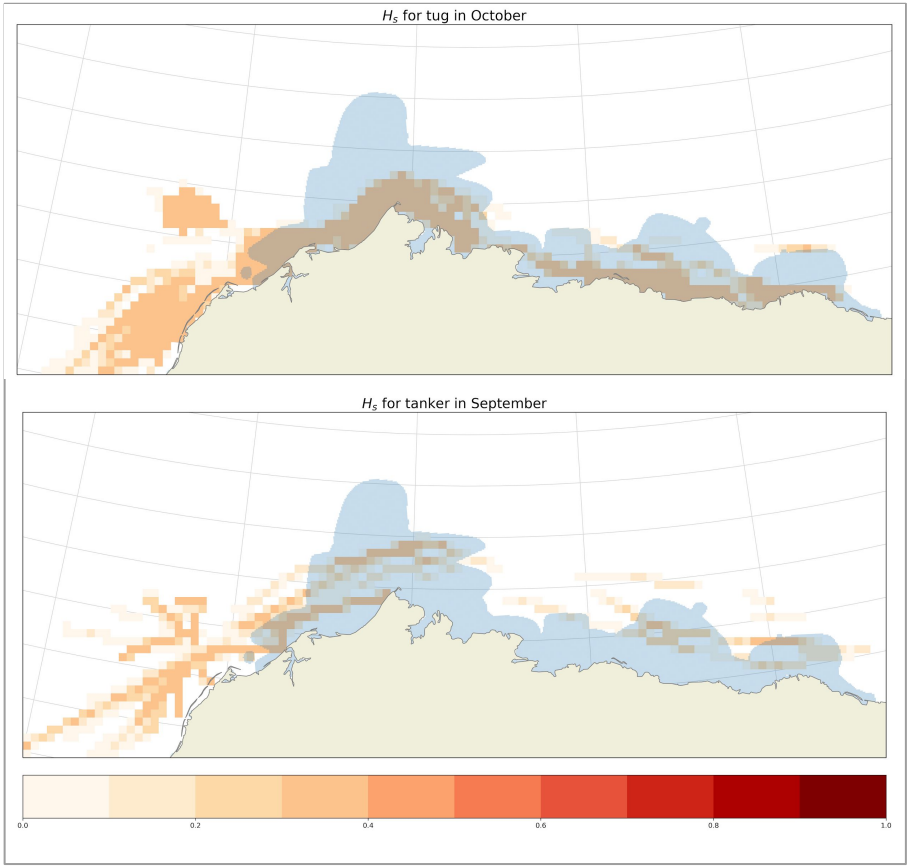
Method: Calculating Cs



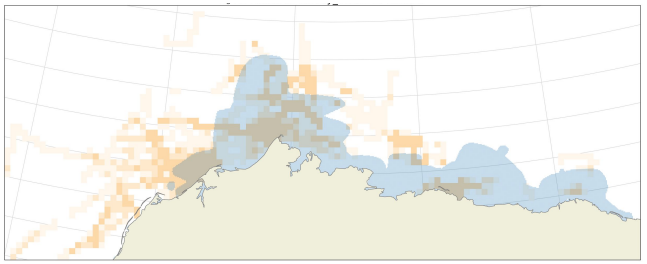
- A - Calculate maximum number of particles within a single cell for subsistence domain
- B - Calculate particles within each cell in domain
- Cs = B/A

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

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

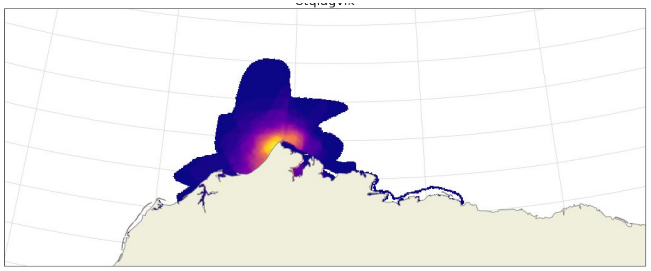


Example: Hazard indexes from Tugs in October and Tankers in September



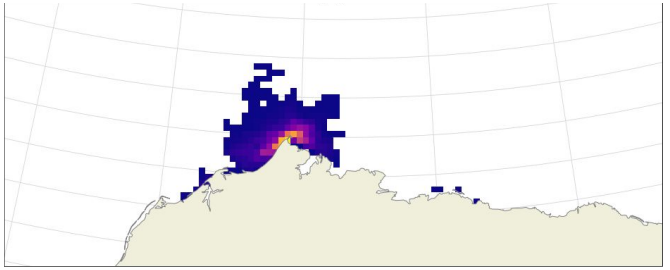
Calculated hazard (probability of spill based on ship tracks)

+



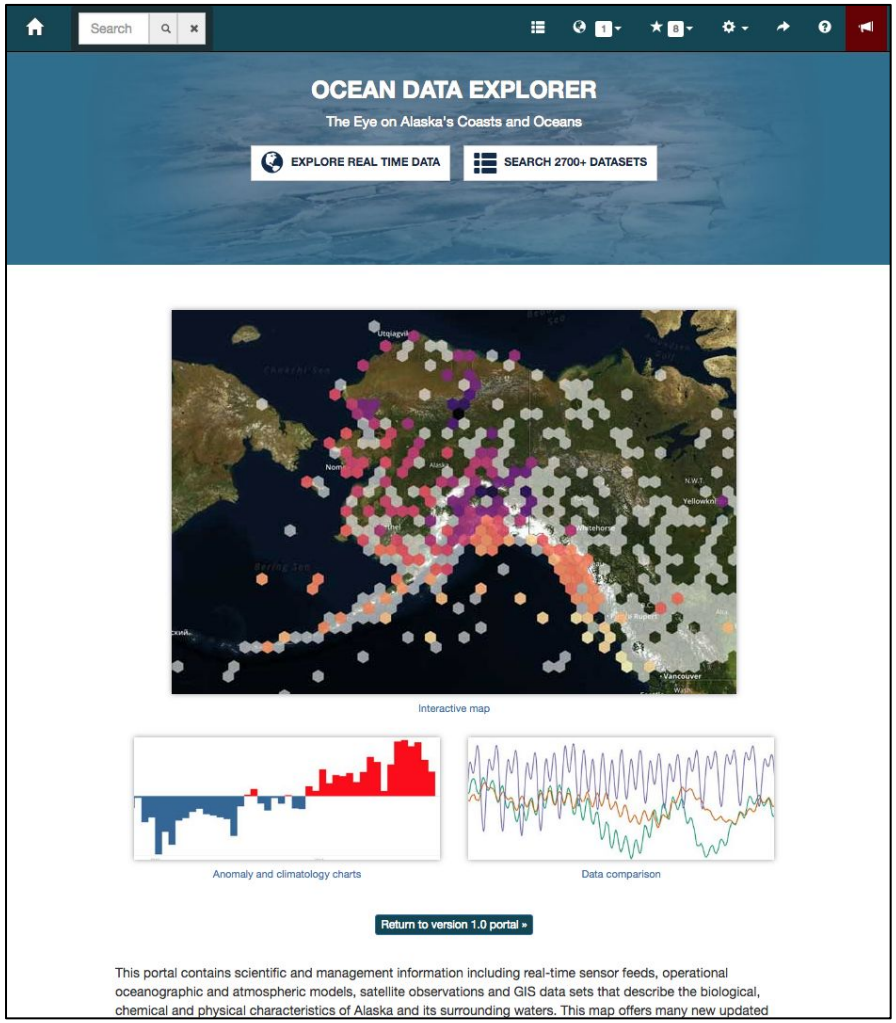
Social value (subsistence use areas)

=

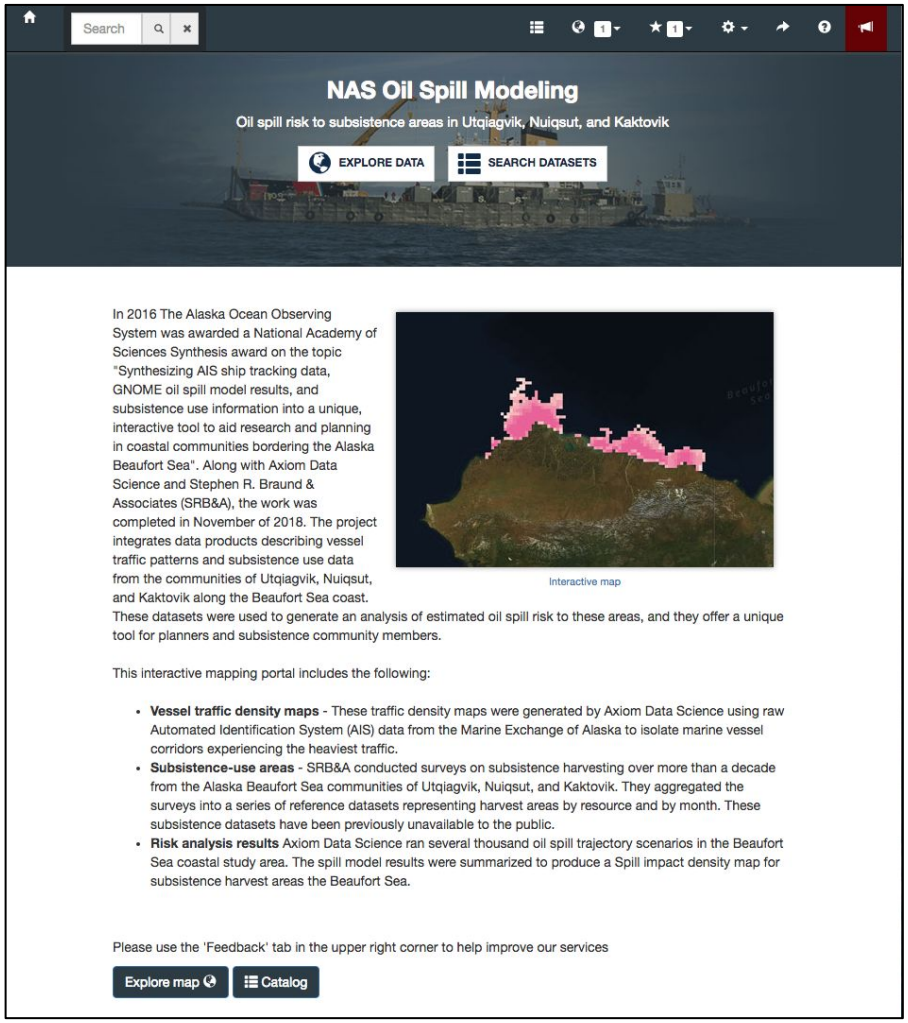


Calculated risk to the resource

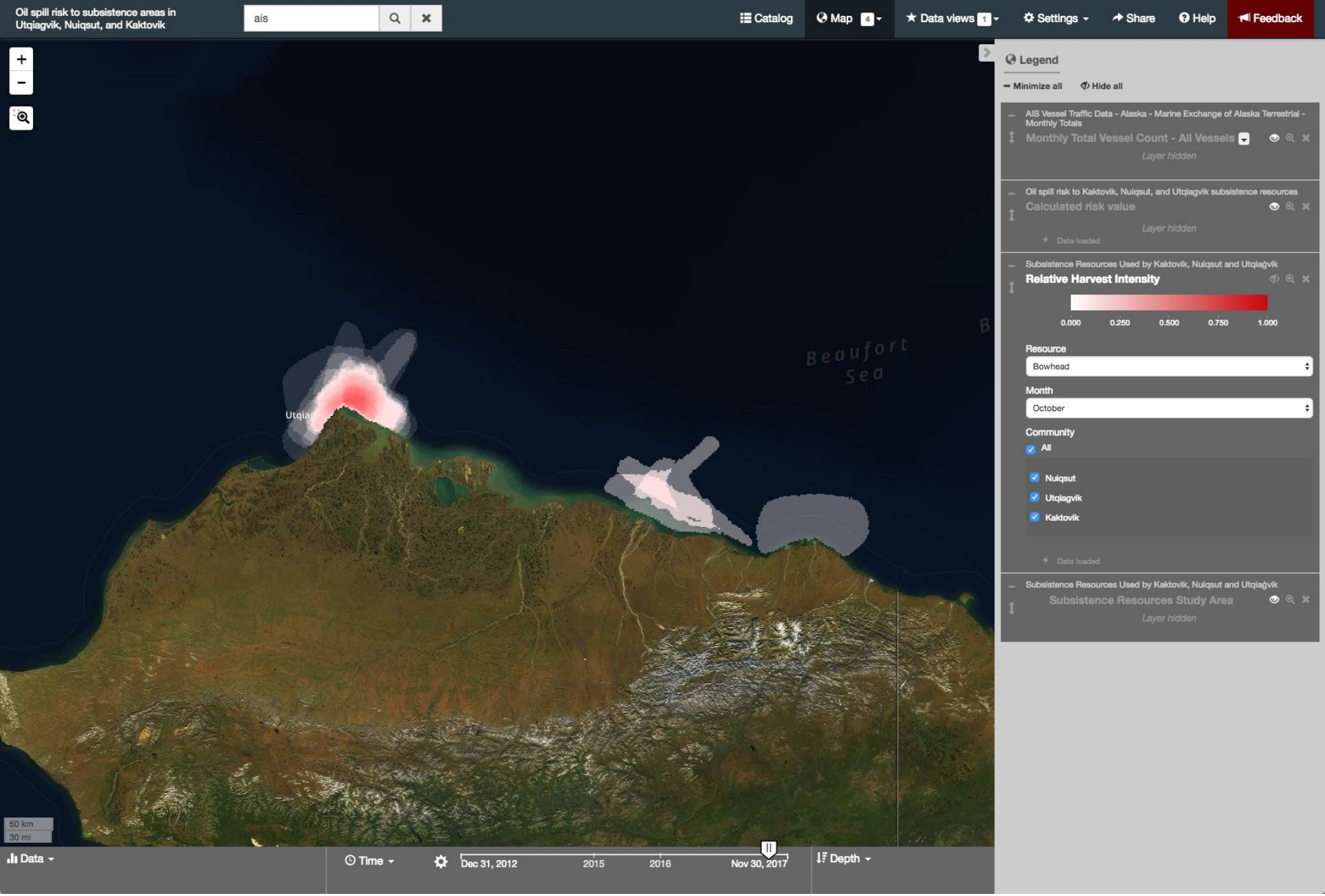
Results: AOOS portal and dedicated portal



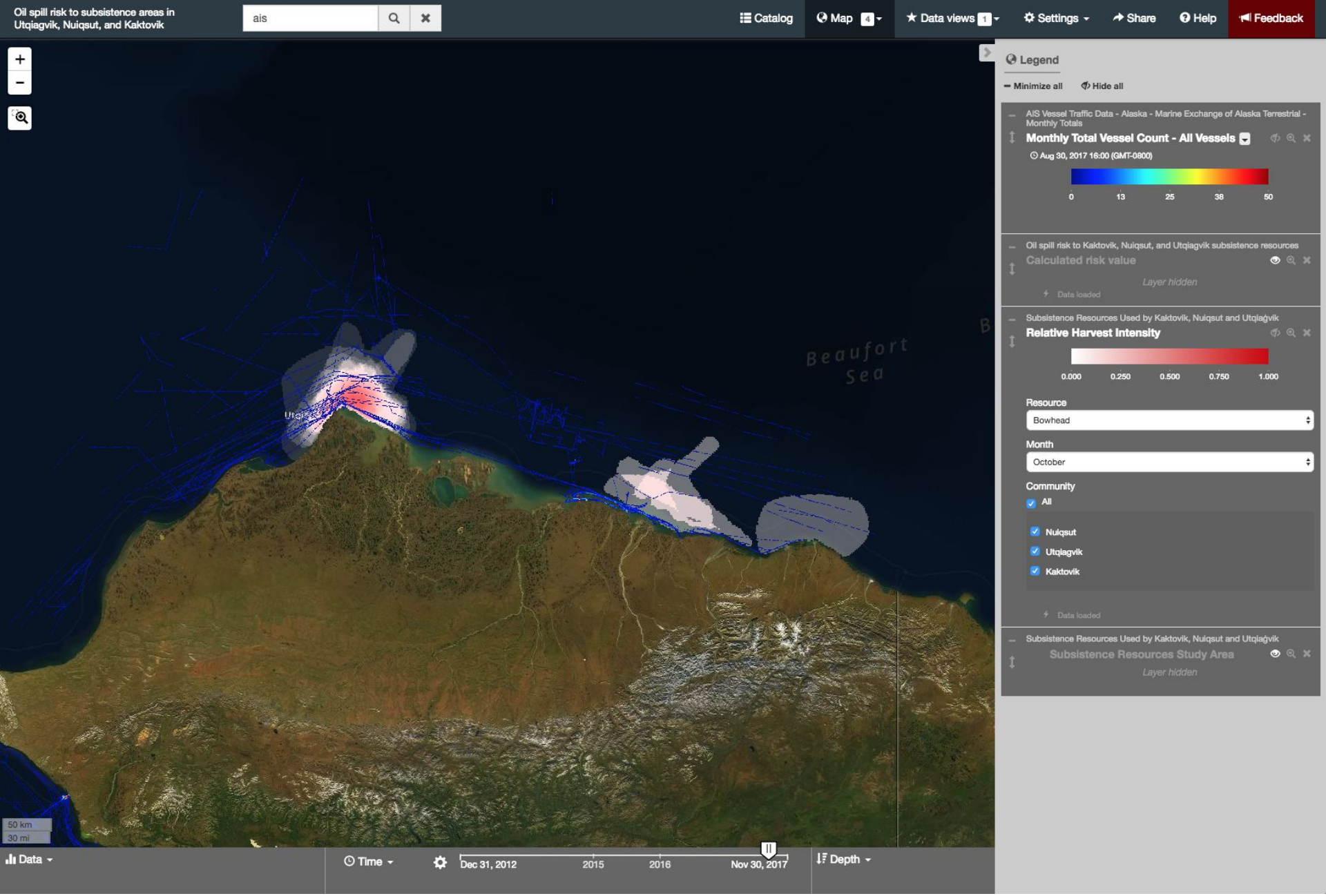
portal.aoos.org



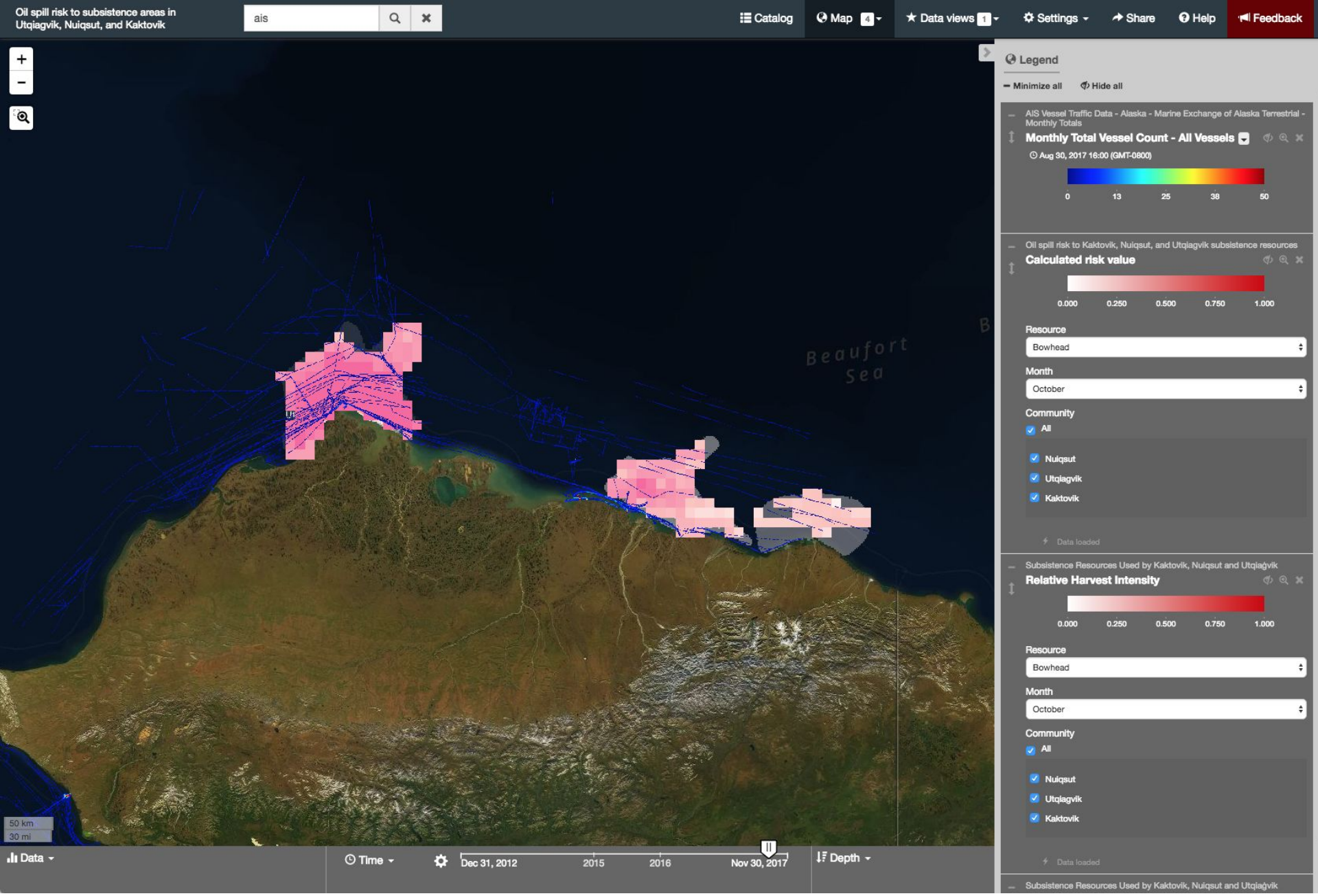
portal.aoos.org/?portal_id=114



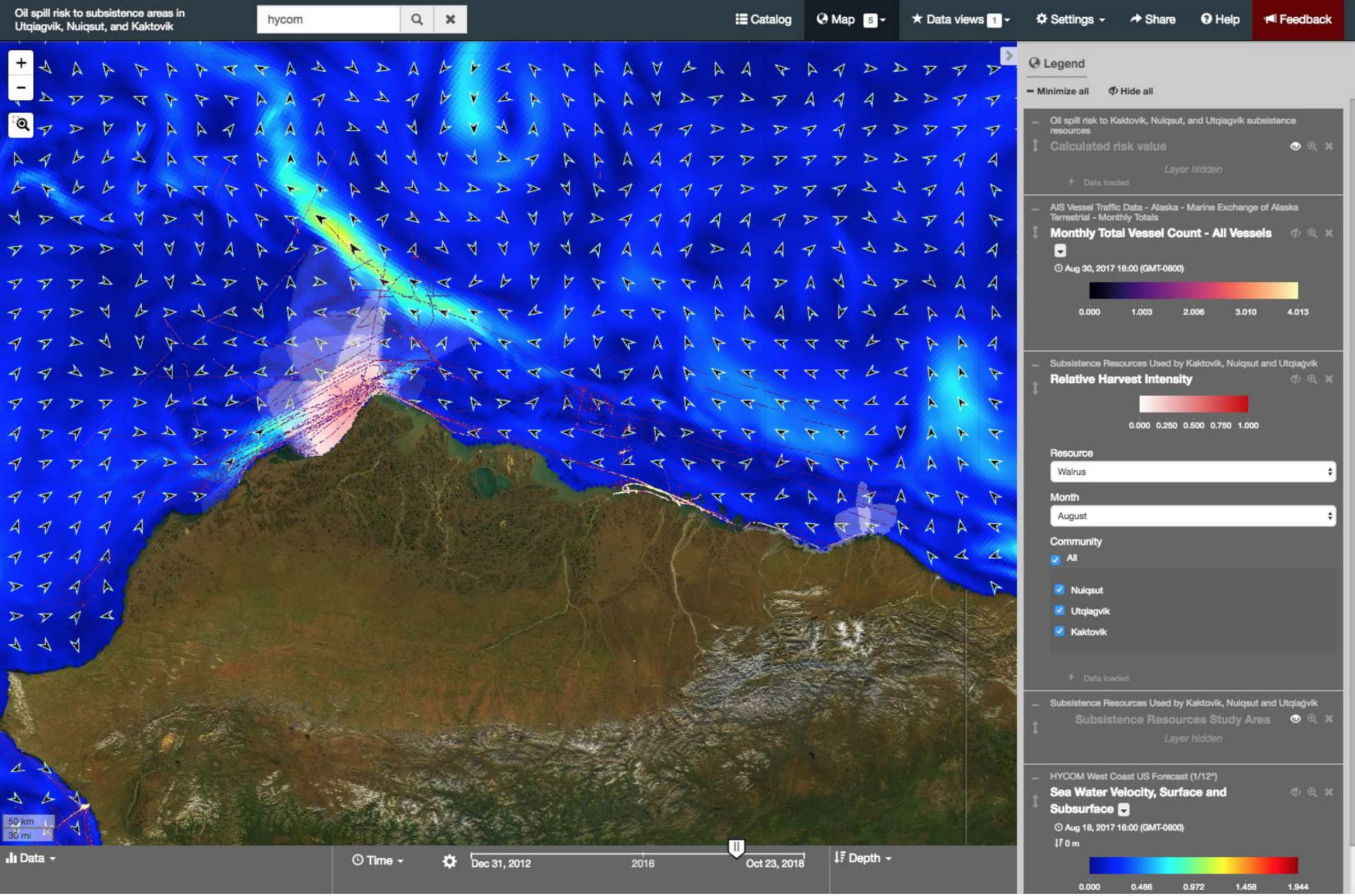
Subsistence for bowhead in October



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.aoos.org

Link