Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic

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### Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: Research Schedule and Milestones

<table>
<thead>
<tr>
<th>First year of Project Research</th>
<th>Progress</th>
<th>Why Not Reached</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>QTR 3</strong></td>
<td><strong>QTR 4</strong></td>
<td></td>
</tr>
<tr>
<td>Convene Steering committee meetings (teleconference, webinar)</td>
<td>X</td>
<td>Steering Committee established - Q2. Product scoping meeting introduced proto-type data queries, solicited feedback on product function, look, and capability – Q3. Webinar March 9, 2018 9:00 - 10:30.</td>
</tr>
<tr>
<td>Prepare and quality review AIS data</td>
<td>X</td>
<td>Completed quality review and correcton of Beaufort Sea and Bering Strait AIS Vessel Traffic in Q2-3. Completed the Bering Sea phase in Q3.</td>
</tr>
<tr>
<td>Optimize high-computer cluster workflow</td>
<td>X</td>
<td>High Performance Computing (HPC) optimized by integrating Alluxio as a data caching mechanism. Processing of all AIS data transformation steps (raw messages -&gt; clean pings -&gt; voyages -&gt; heatmaps) improved by 600%. Success!</td>
</tr>
<tr>
<td>Develop plan to transform AIS data into application ready NOAA-OCS Hydro Health Model format</td>
<td>X</td>
<td>Axiom staff worked with Patrick Keown of NOAA OCS on defining specific outputs to plug into hydrographic health model. Axiom staff transferred the 5-year vetted and processed MXAK AIS records to Patrick Keown of NOAA OCS ahead of schedule - Q4. Metric for success: Output produced from Hydro Health Model using the formatted AIS Data, and verified by NOAA-OCS as valid.</td>
</tr>
<tr>
<td>Implement cluster parallelization of U.S. Arctic EEZ AIS data to assess vessel density patterns</td>
<td>X</td>
<td>Data processing pipeline operationalized and applied to several large AIS data sets successfully (AK Marine Exchange, Danish AIS, OCS Archive and Marine Cadastre)</td>
</tr>
<tr>
<td>Current Year Metrics</td>
<td>Progress</td>
<td>Why NotReached</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
</tbody>
</table>
| Complete AIS data quality review and processing | Marine Exchange completed quality review and correction tables of Beaufort Sea and Bering Strait AIS Vessel Traffic in Q2, Bering Sea in Q3.  
  Metric: 100% AIS data reviewed and transferred to Axiom Data Science in Q3.                                                                                                           | NA            |
| Complete configured AIS data transfer      | All raw AIS data through 2017 transferred in Q2.  
All configured AIS data through 2017 transferred to Axiom Data Science by end of Q3.  
Evaluation and configuration of vetted data correction tables occurred in three regional phases. All data completed by end of Q3.  
Phase 1 – Barrow to Eastern Beaufort Sea (Q2);  
Phase 2 (Q2-3) – Bering Strait to Barrow (Q2-3)  
Phase 3 – North of Aleutians to Bering Strait (Q3).  
Metric: 100% data and the finalized AIS heatmap products vetted with Marine Exchange of Alaska prior to transfer of data files to NOAA OCS. | NA            |
| Complete optimization of the high-computer cluster workflow for high quantity data handling | Performance optimization completed with integration of Alluxio caching system into SPARK.  
Processing of all AIS data transformation steps (raw messages -> clean pings -> voyages -> heatmaps) improved by 600%.  
Metric: 100% MXAK 5-year dataset processed.                                                                                              | NA            |
<table>
<thead>
<tr>
<th>Current Year Metrics Year 1</th>
<th>Progress</th>
<th>Why Not Reached</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiate development of vessel density maps generated from the transferred AIS data</td>
<td>Several types of vessel density maps using the fully vetted MXAK AIS data presented to the Steering Committee during March 9, 2018 Webinar. &lt;br&gt;<strong>Metric:</strong> 100% draft products developed and presented to stakeholder steering committee. Data and products being integrated into the AOOs data portal/website tool, based on feedback, to be completed in Year 2 of project. An AIS projects webpage has been stood-up that allows access to vessel density maps and information on the AIS data, processing, workflow. <a href="http://ais.axds.co/">http://ais.axds.co/</a></td>
<td>NA</td>
</tr>
<tr>
<td>Document and curate AIS metadata throughout the project (in preparation for data archival);</td>
<td>All processes and workflow modifications are being tracked and documented. Final data transferred to NOAA OCS, Year 1 Q4 ahead of schedule. &lt;br&gt;<strong>Metric:</strong> 100% metadata completed by end of Q5 (Q2 Year 5) and ready for AOOs Data Portal.</td>
<td>NA</td>
</tr>
<tr>
<td>Develop technical documentation of data ingestion and prioritization processes utilized on the project to facilitate re-use and workflow scaling for other big-data analysis projects.</td>
<td>Members of the project team are currently maintaining an AIS projects website and authoring a technical whitepaper on data ingestion processes. These materials will be used to develop technical documentation for this project by Q2 of project Year 2. &lt;br&gt;<strong>Metric:</strong> 100% Completion of technical documentation to facility re-used and workflow scaling for other big-data projects. On Target, to be completed in Year 2 (Q4-5).</td>
<td>NA</td>
</tr>
</tbody>
</table>
Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: Steering Committee

- The project Steering Committee members:
  - Dr. Jon Berkson (USCG HQ and Project Champion)
  - Lt. Bart Buesseler (NOAA AK Region, Navigation Manager)
  - Patrick Keown, NOAA OCS Geospatial Data Manager
  - Paul Webb, USCG D17 (AK) (CIV)
  - Randy “Church” Kee, Maj Gen, USAF (Ret), Executive Director ADAC
  - Dr. Guillermo Auad, BOEM

- Additional stakeholders invited to participate:
  - Lt. Matt Forney, OMAO/DOD/Interagency Liaison, OCS, NOAA
  - Frank Parker, USCG Office of Nav. Systems
  - John Hauman, NGA (National Geospatial-Intelligence Agency)
Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: Steering Committee Webinar 09 Mar 18

- Steering committee (SC) webinar held March 9, 2018, 9:00 – 10:30am
  - Provided information about the project, background, motivation, goals and data demonstrations
  - Solicited input to advise on content of data visualization products, and invite suggestions for implementation features (e.g., search queries) for the web-based visualizations and data layering.
- Others outside of the SC participated and provided feedback
- A few of the attending stakeholders have already accessed and utilized formatted data outputs developed as part of this project.
  - Leland Snyder, NOAA Chart geographer and AIS data user;
  - Christina Fandel, Office of Coast Survey (OCS), NOAA used AIS data during implementation of the Hydro Health Model during winter of 2017-18.
• Significant outcome is being able to process these large data sets and make them available for use in a consistent and useable format.
  • All different AIS data sources have inconsistent data formats and are riddled with errors.
  • End-user on their own has to perform substantial pre-processing to get data into consistent and useable structures, which takes a very long time.
  • Having the capability to download data that are well documented (including any QC performed on the data) and consistently formatted in addition to having a set of uniform tools to handle the data, for example, with plotting or data transfer, is providing a beneficial service to the overall AIS data user community.
• Having data that are vetted and corrected to contain more complete records, as the 5-year record of Marine Exchange data on this project, is providing more information (e.g., information needed to compute under keel depth) than un-vetted data sets (e.g., the Marine Cadastre data only has 20-30% information required for computing under keel depth).
  • Note, other sources of AIS data displayed on the AIS Projects website have only had minor automated QC applied, and therefore, contain errors not identified by the automated processes.
Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: AIS Projects Website

AIS Vessel Traffic Data Products

The Automatic Identification System (AIS) is a system of shipboard transmitters and land-based and satellite-based receivers that allow vessel locations to be broadcast and recorded. AIS operates in the VHF frequency and has the capability of transmitting information in real time which provides major benefits in collision avoidance, vessel tracking, fleet planning and management. In addition to the real time benefits of AIS, historic AIS information is used by Hydrographic organizations to look at trends in traffic routes to assist in hydrographic survey and nautical chart planning.

Data Downloads

For a description of each dataset, see Available Datasets below.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Year</th>
<th>Region</th>
<th>Ship Type</th>
<th>Format</th>
<th>Download</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine Exchange Terrestrial</td>
<td>2017</td>
<td>US EEZ Alaska</td>
<td>All Ships</td>
<td>Heatmap</td>
<td>GeoTIFF, Metadata</td>
</tr>
<tr>
<td>Preliminary Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine Exchange Terrestrial</td>
<td>2017</td>
<td>US EEZ Alaska</td>
<td>Passenger Ships</td>
<td>Heatmap</td>
<td>GeoTIFF, Metadata</td>
</tr>
<tr>
<td>Preliminary Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
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Results, data sets and documentation available via a project webpage accessible at [http://ais.axds.co/](http://ais.axds.co/)
Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: Sample of heat map showing passenger vessels between 2013 and 2016.

Passenger ships including those inspected and uninspected vessels, and passenger barges (e.g., Ferries).
Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: Planned Research Outcomes – Year 1

Primary Outcomes:

• Application-ready, gridded files describing AIS vessel densities for use in the NOAA-OCS Hydrographic Health Model
  • Status: Complete!
    • Gridded files provide the extracted AIS information needed for decision makers and stakeholders in the U.S. Arctic area;
    • They also provide patterns of historical as well as emerging vessel traffic patterns.
    • Results included formatted inputs to the Hydrographic Health Model whilst making those inputs readily accessible for other applications.

• A dedicated interactive project data portal/website within the Alaska Ocean Observing System (AOOS) Arctic Data Portal will provide public access to the underlying data and will include instruction and resources used for visualization on project webpage/data portal.
Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: Planned Research Outcomes – Year 1

Secondary Outcomes:

- Improved efficiency in vetting, processing and analyzing AIS data that can be used for new research and AIS data applications.
- Use lessons learned from vetted data corrections to improve automated processes for future QC implementations on AIS data.
- Improved access to the types of AIS data most useful to stakeholders, and the capability to make this information public and visually accessible to those who need or would like access to it.
  - Standard AIS data are not available in consistent and useful formats to most end-users and the public. This project optimized a process to take these large datasets and provide outputs in a consistent, application-ready format, regardless of the source.
  - Data and visualizations will be made available to the public through the public AOOS website and via links on primary stakeholder websites.
- Expanded compute capacity nationwide for AIS data handling for similar projects.
- This project will inform the USCG where the AIS system needs improvement, which could be used to guide USCG efforts at implementation processes and requirements.
Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: Planned Research Outcomes – Year 1

• Key Stakeholder Engagement In Program Year 1 (Q1-4)
  • Steering Committee was interviewed and formed Q2.
  • A Steering Committee webinar was held March 9, 2018 to provide information about the project, provide data demonstrations, and to solicit input from the steering committee and other stakeholders attending the webinar.

• Key External Presentations to Stakeholders In Program Year 1 (Q1-4):
  • Jessica Austin, Axiom Data Science February 15, 2018. American Geophysical Union (AGU) Ocean Science Meeting 2018, Portland, Oregon February 11-16, 2018: Session: Big Data for a Big Ocean - Progress on Tools, Technology, and Services III. Presentation Title: Developing Big-Data Infrastructure for Analyzing AIS Vessel Tracking Data on a Global Scale
  • Carol Janzen, IPCoMM (Indigenous People’s Council for Marine Mammals) Meeting April 11, 2018. Title: Using Ship Tracking Data for Decision Making
Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: Planned Research Outcomes – Year 2

• By the end of the project in Year 2, final data products to be transferred:
  • NOAA-OCS for application in their Hydrographic Health Model (Completed during Year 1).
  • Other applications identified through interactions with assigned USCG Project Champion(s), project Steering Committee and USCG Project Advocates. (In process)
  • Public project website/portal hosted by AOOS. (In process)

• The investment in this foundational project will be leveraged to:
  • Improve efficiency in vetting, processing and analyzing AIS data that can be used for new research.
  • Improve access to the types of AIS data most useful to stakeholders, and make this information visually accessible to those who need it.
  • Expand capacity nationwide for AIS data handling for similar projects.
  • Help identify where the AIS system needs improvement, which could be used to guide USCG efforts at implementation processes and requirements.

• **Knowledge Product** - we (and others via documentation) will be able to apply the techniques pioneered in this project to other big data challenges with different types of data.
Using Vessel Tracking Data to Prioritize Bathymetric Surveying in a Rapidly Changing Arctic: Transition Plans and Pathways

• By end of Year 2 – Q6, final data products will have been transferred in the form of geo-spatial gridded density files to NOAA-OCS.

• The Alaska Ocean Observing System (AOOS), being a regional association of the NOAA funded Integrated Ocean Observing System (IOOS), will act as the additional transition target for the raw data.
  • AOOS has processing capacity required to operate on large data set and implement the HPC methodology by way of an AOOS web-based visualization and plotting tool.
  • The plotting capable portal will also be accessible through links to the AOOS portal on the DHS S&T HSUP and USCG websites and other interested party websites.
  • Final data products will be accessible on the AOOS Data System via the dedicated project website/data portal.

• All software components produced by this project are built-off of open source software and are portable to other data processing facilities.
  • The AOOS web-based user tool processes raw AIS data within an HPC environment.
  • Methodology can be transitioned to any facility that maintains the necessary compute capacity to support the analysis workload. The source code developed during this project can also be provided as a deliverable or mechanism for technology transfer. *See Note Below*

• Researchers expect to achieve TRL 7/8 for project-developed information products and software applications.