Marine Shipping Vulnerability Analyses using Automatic Identification System (AIS) Data

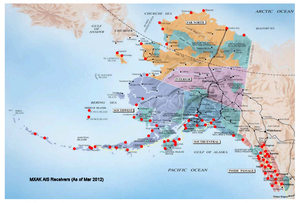
MARTIN ROBARDS (WCS), BRITTA SCHROEDER (UAF),
MICHAEL LINDGREN (UAF-SNAP), AARON POE, and DOUGLAS BURN (ABSI LCC)

Introduction

Maritime transport has increased throughout the Arctic and is predicted to continue to do so as a result of multiple factors, including continued loss of summer sea ice, global economic patterns, and Arctic resource extraction. To effectively respond to the conservation risks associated with vessel traffic supporting Alaskan and global needs requires: a) documentation of traffic patterns and trends; b) understanding of risks; and c) consideration of viable policy options for addressing risks. Here, we describe two interdisciplinary research projects that map Automatic Identification System (AIS) data into a format that can inform measures to promote the safety of bowhead and gray whales, and indigenous food security.

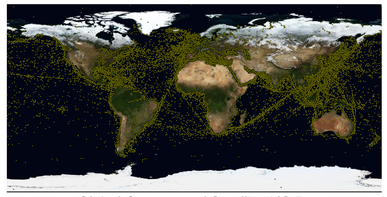
Materials and methods

We use terrestrial AIS receiver data (provided by Marine Exchange of Alaska) to investigate traffic patterns in Bering and Anadyr Straits, including potential interaction with marine mammals.



We overlay AIS information with data from TEK, ecological studies, and tagging efforts for bowhead and gray whales to assess potential times and areas for higher risk of vessel strikes.

For the broader Bering Sea, we use satellite AIS data (provided by ExactEarth) to identify areas at risk due to proximity of ships to land (reducing response window) and distance from emergency response (increasing response time).



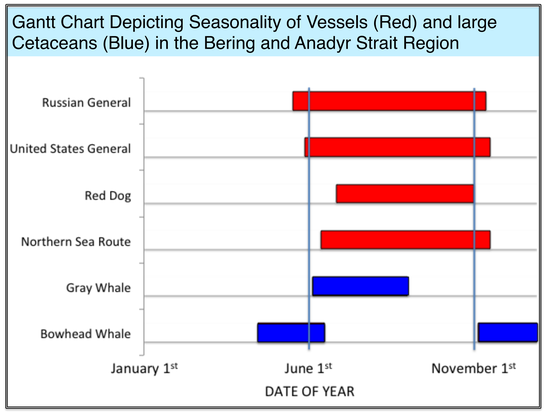
Global Coverage of Satellite AIS Data

Vagaries and errors in self-reported data across millions of data points compromise the full value of AIS data as a research tool. However, we overcame some of these limitations by linking data from other trusted sources such as the IHS Register of Ships, and through R-scripts parsing out unique combinations over multiple fields. This was facilitated by use of the UAF Super Computer which allowed manipulation of such large data.

Preliminary Results

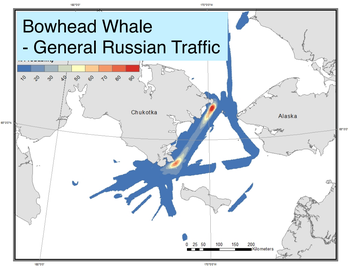
Bering Strait Analysis using Land-Based AIS Data

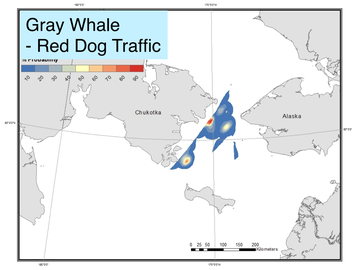
Gantt Chart Depicting Seasonality of Vessels (Red) and large Cetaceans (Blue) in the Bering and Anadyr Strait Region



Currently, bowhead whales are largely separated from vessels in Bering and Anadyr Straits by time (see Gantt chart – vessel routes in red, large cetaceans in blue). Bowheads migrate through this region in spring (April to June), and fall (November through December). However, as vessel operators continue to expand windows of operation, care should be taken in areas of potential interaction with bowhead whales (discussed below). In contrast, grey whales summer along the Chukotka Peninsula and are likely vulnerable to interactions with ship traffic during their entire summer season (discussed below).

Line densities of ship traffic were overlaid with published bowhead (Citta et al., 2012) and gray whale (Heide-Jørgensen et al., 2012) telemetry data in order to produce graphics depicting areas of **potential spatial interaction** between whales and vessels on specific routes **where timing overlaps**.

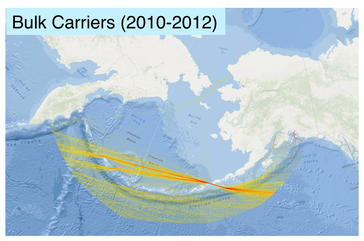


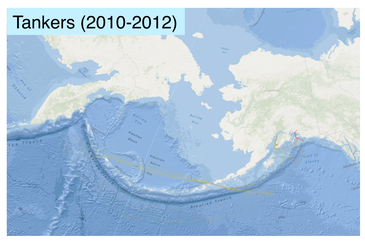


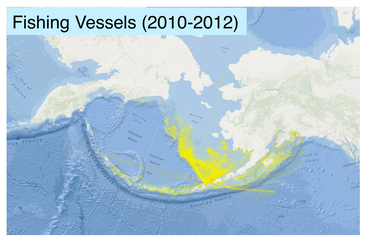
As examples, the left figure depicts the areas of most likely interaction for vessels on general Russian traffic routes with bowhead whales. The right figure depicts areas of most likely interaction between Red Dog traffic and gray whales. We emphasize the relatively small datasets for tagging data (<0.5% of estimated population) so these should be regarded as putative, rather than conclusive.

Aleutian Island Analysis using Satellite AIS Data

We parsed satellite AIS data for different vessel types and plotted shipping routes as a first step in establishing specific vessel patterns. Results clearly demonstrate the prevalence of bulk transporters (left graphic) as compared to tankers (middle graphic); the concentrated use of the Aleutians, but dispersed use of the shelf break and Bristol Bay by fishing vessels; and the use of multiple passes, including either side of Attu, Amukta, Amchitka and Unimak passes.







Conclusions

Both terrestrial and satellite-based AIS data provide an invaluable data source for objective scientific analysis of vessel traffic routes, but involve unique, and sometimes considerable challenges and uncertainties. Even for small areas and time periods, data files can involve millions of records and require significant efforts for ensuring data quality in research applications.

Our data depicts the timing of whale presence as evidenced by indigenous harvests. By extension, our results also reflect concerns regarding the threats presented by shipping to both marine mammals and subsistence hunters. Continued efforts to encourage reporting of vessels in these areas and for speeds less than 12 knots would be expected to mitigate most threats. While our focus here has been on strike risks to large cetaceans, much work is still needed on the chronic and acute affects of disturbance by ships and their noise on all marine mammals.

With respect to the Aleutian Chain, next steps will be to establish seasonality of routings for the different vessel types and overlay this data with oceanographic data to assess areas of greater vulnerability of landfall for stricken vessels or spilled products.

Subsistence Hunting Skiff in May off Gambell, Alaska (Photo: Robards)

Literature

Citta, J., L. Quakenbush, J. George, R. Small, M. Heide-Jørgensen, H. Brower, B. Adams, and L. Brower. 2012. Winter movements of bowhead whales (*Balaena mysticetus*) in the Bering Sea. Arctic 65(1): 13-34.

Heide-Jørgensen, M., K. Laidre, D. Litovka, M.Villum Jensen, J. Grebmeier, and B. Sirenko. 2012. Identifying gray whale (*Eschrichtius robustus*) foraging grounds along the Chukotka Peninsula, Russia, using satellite telemetry. Polar Biology 35: 1035-1045.

Acknowledgments

Ground-based AIS data from Marine Exchange of Alaska. We appreciate the help of Ed Page and his staff. ExactEarth provided Satellite-based data. Tim Robertson (Nuka Research) kindly provided additional vessel MMSI data. Funding was generously provided by ABSI-LCC and Flora Family Foundation.

Further information

Martin Robards: mrobards@wcs.org

Marine Exchange of Alaska: www.mxak.org

International Maritime Organization: http://www.imo.org/OurWork/Safety/Navigation/Pages/AIS.aspx