Navigability Indicators for the Northwest Passage and the Northern Sea Route

Introduction

National Climate Assessment (NCA). The U.S. NCA [Melillo et al., 2014] acts as a national climate snapshot or status report. Climate “indicators” for the NCA are meant to provide a clear and concise way of quantifying the status and trends of various elements of the climate system and their biological significance.

Northwest Passage (NWP) and Northern Sea Route (NSR). The NWP and NSR are sea routes across portions of the Arctic Ocean that connect the Atlantic and Pacific Oceans. The NWP passes through the Canadian Arctic Archipelago, and the NSR passes north of Russia.

Navigability indicators. We are in the process of constructing navigability indicators for the NWP and NSR that indicate the percentage of the route’s length that is free enough of sea ice to allow the passage of a ship. The navigability indicators change daily as sea ice conditions change.

Arctic marine mammals. All seven of the marine mammal species that live in the Arctic year-round (beluga, narwhal, bowhead whale, ringed seal, bearded seal, walrus, and polar bear) occupy portions of both the NWP and the NSR. We are in the process of identifying and mapping key areas of their habitat that intersect the routes of the NWP and NSR, to see which species might be impacted by increased shipping and industrial development as Arctic sea ice continues to decline.

Methods

Sea-ice data. We use daily sea-ice concentration products derived from the Advanced Scanning Microwave Radiometer for the Earth Observing System (AMSR-E) on NASA’s Aqua satellite, obtained from the Centre for Marine and Atmospheric Sciences (ZMAW) in Hamburg, Germany [Spreen et al., 2008]. Data are mapped to a polar stereographic grid with 0.25-km grid size, and are available from June 2002 to October 2011. AMSR-2 and other data will be used to extend results beyond 2011.

Navigability indicators. We outline the routes of the NWP and NSR on a base map using ArcGIS, extract the sea-ice data from within the route boundaries, and calculate the navigability indicators from the time series of sea-ice data within the routes.

Arctic marine mammals. Data on home ranges of Arctic marine mammals have been gleaned from more than 100 peer-reviewed journal articles. We focus on June–October, the most likely months for shipping activity through the NWP and NSR.

Results

Navigability indicators. We illustrate the method for one particular route of the NWP (Fig. 1) with sea ice shown for August 15, 2009. The sea-ice concentration as a function of distance along the route (Fig. 2) shows that the route is blocked in Viscount Melville Sound. The percentage of the route that is open from June–October, 2002–2011, is shown in Fig. 3.

Arctic marine mammals. Home ranges of bowhead whales, belugas, and narwhals in September are shown in Figs. 4, 5, 6, along with routes of the NWP. Table 1 lists specific populations and abundance estimates.

2017 AMS Theme: Observations Lead the Way

At the request of AMS we include the following:

1. Observations that are needed to benefit future research
   - High resolution daily sea-ice data with complete Arctic coverage; surveys and tracking of Arctic marine mammal populations; ship tracks.
2. Instruments that are needed to make these observations
   - Satellite instruments like AMSR-2 or better; long-lasting telemetry devices for Arctic marine mammals; open database of ship tracks.
3. The greatest observational needs for this discipline in general
   - Surveys and tracking of Arctic marine mammals.

References


Acknowledgements

This work is funded by the NASA program Climate Indicators and Data Products for Future National Climate Assessments, grant NNX16AG33G, PI: H. Stern.