Environmental Studies Program: Ongoing Study

Field	Study Information
Title	Ice Impacts on the Resonance, Convergence, and Friction of Tidal Transport (Tide-Ice ReCon) (AK-24-03-01)
Administered by	Alaska Regional Office
BOEM Contact(s)	Sean Burril (sean.burril@boem.gov)
Procurement Type(s)	Cooperative Agreement
Conducting Organization(s)	University of Alaska Coastal Marine Institute
Total BOEM Cost	$151,834 plus Joint Funding ($146,834)
Performance Period	FY 2024–2026
Final Report Due	September 2026
Date Revised	May 5, 2025
Problem	Existing tidal models of Cook Inlet do not include ice. BOEM requires a better understanding of transport friction, convergence, and resonance properties of Cook Inlet to determine if there is statistically significant seasonal change, and how much of that change can be explained by ice cover to improve modeling estimates used for National Environmental Policy Act Assessments.
Intervention	This study will use current, tide, and sea ice observations along with idealized models to refine modeling algorithms in order to examine how friction increases or decreases the convergence and resonance properties of Cook Inlet, including seasonal sea ice.
Comparison	The results of this study can be compared with field measurements and oceanographic models.
Outcome	The study will provide analytical equations to use in refining tidal forcing in oceanographic models.
Context	Cook Inlet Planning Area

BOEM Information Need(s): Improved understanding of tidal dynamics, including interaction with sea ice, in Cook Inlet, Alaska is needed to inform environmental reviews and decision-making regarding energy exploration and development plans and provide context for interpretation of seasonal variability of sea ice and tide interactions. In addition, updated information about tidal dynamics is useful to validate coupled ice-ocean circulation models used to support oil-spill risk analysis, better understand pathways of potential oil spills, and improve tidal models to better estimate tidal resource energy.

Background: Transport and the fate of materials in Cook Inlet is primarily driven by tidal currents through erosion, mixing/circulation, and deposition These processes can be enhanced by the presence of sea ice and sea ice-tide interactions (Mulherin et al. 2001; Neumeier and Wang, 2015). The best circulation and transport models of Cook Inlet are calibrated or validated using NOAA tidal harmonics (e.g., Danielson et al., 2016; Oey et al., 2007; Shi et al., 2020; Wang and Yang, 2020), which are

calculated based on an entire tidal epoch (i.e., 18.6 years) and do not differentiate between seasons or ice conditions.

Seasonal sea ice cover affects hydrodynamics by increasing friction, which, in the ocean decreases peak water levels by attenuating tides, but in rivers increases water levels (Brenner et al., 2021, Prowse and Beltaos, 2002). In coastal basins, sea ice is commonly modeled to attenuate tides, however, the presence of ice is attributed to amplifying estuarine tidal currents in the Hudson and Nelson rivers (Georges 2012; Wang et al., 2012). In resonant basins, observed ice effects are frequency dependent and noted for maintaining ice-free polynyas (Johnson et al., 1986; Polyakov and Martin, 2000), but lack a clear mechanistic explanation that may also affect transport and flood drivers. To resolve how ice affects transport in Cook Inlet, the interaction of friction, resonance, and convergence must be understood with and without ice.

Objective(s): The overarching goal is to better understand how ice affects tides and the residual transport in Cook Inlet.

- Characterize the seasonal variability of tidal amplitudes and phases across Cook Inlet.
- Identify how different drivers or parameters affect seasonal tidal variability and the relative resonance and convergence in Cook Inlet, focusing on the sea ice concentration, seaward extent, and ice morphologies.
- Decompose the along estuary subtidal transport of suspended particulate matter (e.g., weathered oil particulates) into the five commonly used components under various ice scenarios and identify new ice related terms.
- Identify and derive analytical equations for use in numerical models and refine their algorithms, specifically those relating the effects of ice friction and geometry changes on the amplitudes and phases of tidal water levels and currents.

Methods: Researchers will analyze tidal timeseries using traditional and non-stationary harmonics and compare the open water results to those with varying sea-ice extents and concentrations. Researchers will conduct idealized modeling to investigate resonance and convergence effects with and without ice. Researchers will decompose tidal transport terms by analyzing model results under varying conditions of ice coverage and ice morphology. Finally, researchers will derive analytical equations from after tuning physical parameters in the idealized model. A final report shall document the key findings.

Specific Research Question(s):

1. How does friction increase or decrease the convergence and resonance properties of Cook Inlet?
2. How does ice affect tidal amplitude and the tidal currents in Cook Inlet?
3. What is the future approach that BOEM should adopt to improve tidal modeling efforts within Cook Inlet?

Current Status: Ongoing, data analysis underway.

Publications Completed:

Dykstra SL, Schuttelaars H, Gomez E, Pontbriand M. 2025. Ice impacts on the resonance, convergence, and friction of tidal transport (Tide-Ice ReCon). In: Alaska Marine Science Symposium; January 27–31, 2025; Anchorage, Alaska. Anchorage (AK): North Pacific Research Board. p. 165. https://online.flippingbook.com/view/858551675/172/.

Pontbriand M , Schuttelaars H, Talke S, Dykstra SL. 2025. Tidal changes and variability in Cook Inlet. In: Alaska Marine Science Symposium; January 27–31, 2025; Anchorage, Alaska. Anchorage (AK): North Pacific Research Board. p. 168. https://online.flippingbook.com/view/858551675/174/

Schuttelaars H, Dykstra SL. 2025. Ice impacts on the tidal and subtidal water motion: A 2DV modeling study. In: Alaska Marine Science Symposium; January 27–31, 2025; Anchorage, Alaska. Anchorage (AK): North Pacific Research Board. p. 164. https://online.flippingbook.com/view/858551675/171/.

Affiliated WWW Sites: N/A

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Shi L, Lanerolle L, Chen Y, Cao, Patchen R, Zhang A, Myers EP. 2020. NOS Cook Inlet operational forecast system: model development and hindcast skill assessment. Silver Spring (MD): National Oceanic

and Atmospheric Administration, Coast Survey Development Laboratory. 77 p. Report No.: NOAA Technical Report NOS CS 40.

Wang R, McCullough GK, Gunn GG, Hochheim KP, Dorostkar A, Sydor K, Barber DG. 2012. An observational study of ice effects on Nelson River estuarine variability, Hudson Bay, Canada. Continental Shelf Research. 47: 68–77. https://doi.org/10.1016/j.csr.2012.06.014

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