Environmental Studies Program: Ongoing Study

Field	Study Information
Title	Landfast Ice Climatology within the Arctic OCS (AK-19-03)
Administered by	Alaska Regional Office
BOEM Contact(s)	Caryn Smith, caryn.smith@boem.gov
Procurement Type(s)	Cooperative Agreement
Conducting Organization(s)	University of Alaska Fairbanks
Total BOEM Cost	$1,699,293
Performance Period	FY 2019–2023
Final Report Due	September 2023
Date Revised	September 20, 2022
Problem	Landfast ice is used as a platform for subsistence hunting and potentially for wintertime activities related to oil and gas exploration and development in the Beaufort Sea and Chukchi Sea. Understanding of the extent, stability, and seasonality of landfast ice is important for its safe use, but available data is quite old and conditions have been changing rapidly in recent years. Updated information about landfast ice extent and duration is also needed to validate coupled ice-ocean models used in BOEM's Oil Spill Risk Analysis (OSRA).
Intervention	This study will analyze landfast ice data interpreted by the National Weather Service (NWS) for the U.S. Arctic and produce improved estimates of minimum, mean, and maximum extents over time. Contributions of physical forcing mechanisms to changes in landfast ice will also be evaluated.
Comparison	The results will document changes in landfast ice cover over time.
Outcome	The analysis will document the role of physical forcing mechanisms on landfast ice extent and duration, offer information for validation of coupled ice-ocean circulation models, and improve understanding of the existing environment to support National Environmental Policy Act (NEPA) analyses.
Context	Beaufort Sea, Chukchi Sea

BOEM Information Need(s): Improved understanding of changes in landfast ice extent and stability is needed to provide context for interpretation of changing subsistence patterns and inform reviews and decision-making regarding oil and gas exploration and development plans involving on-ice activities. In addition, BOEM needs information about under ice circulation, including the influence of local freshwater river discharges, and the extent of landfast ice over time to validate coupled ice-ocean circulation models used to support OSRA.

Background: Offshore landfast ice can be used as a platform during potential winter oil and gas exploration or development, as well as subsistence activities. Ongoing environmental change in the Arctic has altered the extent, stability, and seasonality of the landfast ice along the U.S. Arctic coast and updated information is needed to facilitate planning and ensure the safety of on-ice activities. The

monthly minimum, mean, and maximum landfast ice extents along the Beaufort Sea coast were last quantified by Mahoney et al. (2012), but these data were collected up to 2008 and are more than 10 years old. Landfast ice extent is interpreted by the National Ice Center on a weekly basis (U.S. National Ice Center, 2018), whereas the NWS Alaska Sea Ice Program (ASIP) interprets landfast ice extent on the shelf areas surrounding Alaska on a daily basis (National Weather Service, 2018). The higher spatial and temporal resolution of these products will provide better understanding of ice stability and how storms and other physical processes influence landfast ice extent.

Documentation of the extent of landfast ice will also support validation of results from coupled ice-ocean circulation models used to support trajectory analyses for OSRA. In the Arctic, the oil-spill trajectory analysis must adequately represent how the movement of oil would be influenced by the presence of fixed, landfast ice.

Previous work by Weingartner and Kasper (2011) used idealized analytical and numerical models to examine the effects of spatially variable landfast ice cover on under-ice circulation. The results demonstrate that circulation under landfast ice cover is profoundly different from ice-free shelf circulation. Buoyancy forced experiments also showed that a landfast ice cover alters the behavior of a buoyant plume considerably, spreading it further offshore than in the ice free scenario. A recent publication by Weingartner et al. (2017) found similar results in their analysis of observations collected between 1999 and 2006 in Stefansson Sound. Results from this new study will provide additional context to these findings.

Objectives:

- Assess and document the landfast ice extent in the Beaufort Sea and Chukchi Sea at a higher temporal resolution and determine how it has changed over time.
- Evaluate how changes in landfast ice relate to local and regional changes in temperature, pressure, and major storms, as well as to global climate shifts.

Methods: Researchers will compile a time-series of landfast ice data for the Beaufort Sea and Chukchi Sea from interpreted sea ice data available from the NWS Alaska Sea Ice Program from 2008 through 2021. Results will be analyzed to produce a climatology that includes daily, weekly, monthly minimum, mean, and maximum landfast ice extent and to evaluate the changes in landfast ice over time. Sea Ice Mass Balance Buoys and Acoustic Doppler Current Profilers (est. 4–5) will measure thermodynamics, temperature, salinity, ice thickness, and ice velocities, mostly beneath the landfast portion of the sea ice. Researchers will use these data to examine the physical forces that drive changes in seasonal and interannual landfast ice extents, including large breakout events. Local and traditional knowledge from coastal communities along the Beaufort and Chukchi Sea will be used to identify conditions associated with freeze-up, formation of landfast ice, major breakouts linked to storm events and changes in subsistence harvest.

Specific Research Question(s):

1. How has landfast ice extent in the Beaufort Sea and Chukchi Sea changed over time?
2. How has the stability and seasonal duration of landfast ice in the U.S. Arctic been altered in recent decades and what can be inferred about its use as a platform for on-ice activities, including subsistence hunting and oil and gas exploration and development?

3. How is landfast ice affected by physical forcing, including the winter and springtime under-ice circulation in the central Beaufort Sea, freshwater discharges from rivers in the area, variations in hydrography, and storms? Is this relationship changing over time?

Current Status: Ongoing, fieldwork and data analysis underway.

Publications Completed:

Einhorn A. and Mahoney, A. 2023. Interferometric analysis of landfast sea ice breakouts occurring along the Alaska Outer Continental Shelf. Alaska Marine Science Symposium. January 23–27, 2023. Abstract and Poster. 1 p.

Hedstrom, K., Hallberg. R., Danielson. S., Curchitser, E., Mahoney, A. 2022. Arctic ice-ocean circulation modeling: recent improvements and applications. Ocean Sciences Meeting. 24 February – 4 March 2022. Virtual Event. Abstract and Oral Session. 1 p.

Hedstrom, K., Hallberg. R., Danielson. S., Curchitser, E., Mahoney, A., Adcroft, A., Drenkard, L., Ross, A., Stock. C. 2023. Arctic ice-ocean circulation modeling: recent improvements and applications. Alaska Marine Science Symposium. January 23–27, 2023. Abstract and Poster. 1 p.

Hedstrom, K., Mahoney, A., Danielson, S., Curchitser, E., Hallberg, R. 2022. Arctic ice-ocean circulation modeling: recent improvements and applications. Alaska Marine Science Symposium. January 24–27, 2022. Virtual Symposium. Abstract and Poster. 1 p.

Jones, J., Mahoney, A., Bieniek, P., Hedstrom, K., Einhorn, A., Danielson, S. 2022. Toward forecasting landfast sea ice. Alaska Marine Science Symposium. January 24–27, 2022. Virtual Symposium. Abstract and Poster. 1 p.

Mahoney, A., Einhorn, E. 2022 Toward an updated climatology of landfast sea ice for the Alaska Outer Continental Shelf. Alaska Marine Science Symposium. January 24–27, 2022. Virtual Symposium. Abstract and Poster. 1 p.

Affiliated WWW Sites: http://www.boem.gov/akstudies/

References:

Mahoney, A., Eicken, H., Shapiro, L., Gens, R., Heinrichs, T., Meyer, F., and Gaylord, A., 2012. *Mapping and characterization of recurring spring leads and landfast ice in the Beaufort and Chukchi Seas*, OCS Study BOEM 2012-067. University of Alaska Coastal Marine Institute, Fairbanks, Alaska. https://espis.boem.gov/final%20reports/5226.pdf

National Weather Service, 2018. Webpage: https://www.weather.gov/afc/ice (accessed May 8, 2018)

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Weingartner, T., Danielson, S. L., Potter, R. A., Trefry, J. H., Mahoney, A., Savoie, M., Irvine, C., and Sousa, L., 2017. Circulation and water properties in the landfast ice zone of the Alaskan Beaufort Sea, Continental Shelf Research 148:185-198.

Weingartner, T. and Kasper, J. L., 2011. Idealized modeling of circulation under landfast ice, OCS Study BOEMRE 2011-056. University of Alaska Coastal Marine Institute, Fairbanks, Alaska. https://espis.boem.gov/final%20reports/5163.pdf