2016-17 Freeze-Up and Break-Up Studies of the Alaskan Beaufort and Chukchi Seas

Progress Report No. 2 (Revision 1)
October 25, 2016 – March 13, 2017

Activities Undertaken

From October 25, 2016 through March 13, 2107, the following activities were undertaken under the contractual Scope of Work:

- ***Task 1. Planning and Administration***: Meteorological data and ice charts were obtained from publicly-available sources that included the National Ocean Service, Weather Underground, Iowa Environmental Mesonet, National Ice Center, and Canadian Ice Service. Planning was conducted and logistical arrangements were made for aerial reconnaissance missions initiated in late February to document the ice conditions at the end of freeze-up. In addition, planning was conducted for similar reconnaissance missions to be undertaken in late June or early July to document the ice conditions during break-up.

- ***Task 2. Satellite Imagery***: Twenty RADARSAT-2 images, consisting of ten of the Alaskan Beaufort Sea and ten of the Alaskan Chukchi Sea, were acquired from MacDonald, Dettweiler and Associates. The images were acquired on a semi-monthly basis starting in mid-October and continuing through the end of February. AVHRR images were downloaded from the National Weather Service website on a daily basis throughout this period, and MODIS images were downloaded from the NASA website on a daily basis from October 1st through November 9th and February 2nd through 28th (corresponding to the periods in which sufficient daylight was available for image acquisition).

- ***Task 3. Freeze-Up Reconnaissance Flights***: Four aerial reconnaissance missions were undertaken between February 23rd and March 1st. The missions, all of which were conducted with a fixed-wing aircraft, took place in the central and western portions of the Alaskan Beaufort Sea, and the nearshore and offshore portions of the Alaskan Chukchi Sea. Flying was precluded by poor visibility from February 24th through 26th, and by a mechanical problem with the aircraft on February 28th. The data acquired during the flights will be used to prepare drawings illustrating features of interest observed on the flight paths, including ice pile-ups, ridges, rubble fields, and significant leads.

- ***Task 5. Data Processing and Analysis***: Processing and analysis of the data acquired under Tasks 1 through 3 has been on-going since November 2016. The work has included estimating the dates of nearshore and basin-wide freeze-up, mapping the

Coastal Frontiers Corporation
882A Patriot Drive
Moorpark, CA 93021-3544
(818) 341-8133

seaward limit of the landfast ice zone, searching for multi-year ice in the ice charts and RADARSAT-2 images, predicting the thickness of undeformed first-year ice at the end of each month based on accumulated freezing-degree-days (FDD), and tabulating the characteristics of the ice pile-ups observed during the reconnaissance flights.

Key Findings: Beaufort Sea

- ***Air Temperatures:*** The air temperatures at Deadhorse Airport were exceptionally high by historical standards in October and November, and remained high throughout freeze-up. Over the course of the five-month study period (October through February), the average daily values exceeded the long-term average values for the 30-year period from 1981 through 2010 on 87 days (58% of the time) and dropped below on only 18 days (12% of the time). The number of accumulated FDD at the end of February (4,109) was the lowest recorded since the current series of freeze-up studies began in 2009-10.
- ***Winds and Storms:*** In sharp contrast to the past two years, westerly winds predominated during the five months from October through February, occurring 64% of the time. The storm population was more balanced, with seven easterlies and six westerlies (with a storm defined as an event during which the average daily wind speed exceeded 15 kt). The highest average monthly wind speed, 12 kt, occurred in January and February, while the highest average daily wind speed, 28 kt, and longest storm duration, seven days, were associated with a westerly event in early January.
- ***Ice Thickness:*** The thickness of undeformed first-year ice at the end of February, computed on the basis of accumulated FDD at Deadhorse Airport, was 117 cm - the lowest in the past eight years, and 9 cm less than the average during this period.
- ***Multi-Year Ice:*** Although the southern boundary of the multi-year pack ice advanced slowly to the south over the course of the five-month study period, it nevertheless remained well offshore. The minimum separation from the coast, 175 nm, occurred off Barter Island at the end of February.
- ***Beaufort Sea Reconnaissance Flights:*** Preliminary findings from the two flights conducted on February 23rd and 27th are summarized below:
  - *Landfast Ice:* Reflecting the predominance of westerly winds that preceded the first flight (Central Beaufort Sea), the landfast ice zone was found to be narrow and poorly-developed. Of particular note was the absence of landfast ice on Stamukhi Shoal, which typically serves as an anchor-point. As shown in Plate 1, ice had begun to ground on the shoal shortly before this flight, creating a compact rubble field up to 8 m high that had not yet stabilized the surrounding canopy. When the second flight (Western Beaufort Sea) was conducted on February 27th, following a two-day easterly storm, the landfast ice edge had moved offshore to another typical anchor-point, Weller Bank.
  - *Lagoon Ice:* As in past years, the ice in the lagoons behind the barrier islands was primarily flat and undeformed (Plate 2). Widely-scattered rubble with a typical height of 0.5 m was noted in some areas of Stefansson Sound.

Plate 1. Newly-Grounded Rubble with Heights to 8 m on Stamukhi Shoal (February 23, 2017)

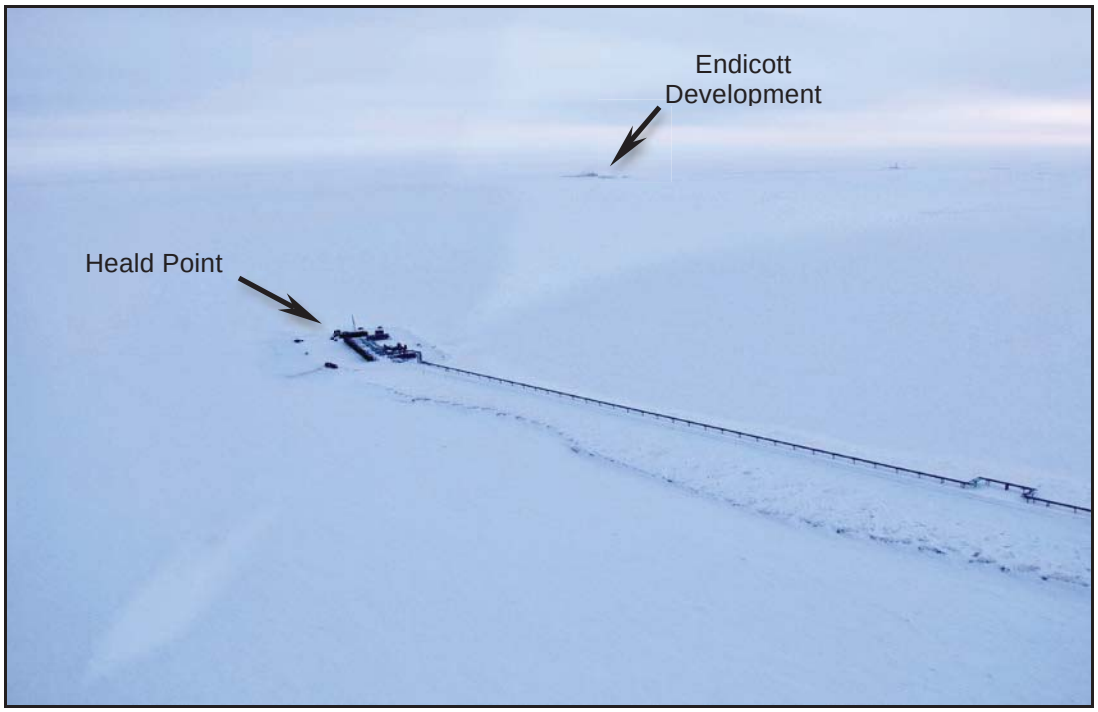

Plate 2. Undeformed Ice in Stefansson Sound between Heald Point and Endicott Development (February 23, 2017)

- *Old Ice:* Neither multi-year pack ice nor second-year ice composed of grounded rubble that had survived the 2016 melt season were observed during the flights.
- *Ice Pile-Ups:* Thirty-eight pile-ups were observed in the Central Beaufort Sea, consisting of one on the Oooguruk Offshore Drillsite (ODS), one on the Spy Island Drillsite (SID), one on Northstar Production Island and 35 on natural barrier islands and shoals (Plate 3). The heights, which ranged from 1 to 8 m above sea level, and the encroachment distances, which ranged from negligible to 12 m onto the subaerial beach, were unexceptional. Several of the pile-ups attained substantial lengths, however, including a maximum value of 5.9 km on a barrier island east of Point Brownlow.

Plate 3. 5-m High Pile-Up that Encroached 12 m onto North Shore of Duchess Island (February 23, 2017)

Key Findings: Chukchi Sea

- ***Air Temperatures:*** The average daily air temperatures at Barrow Airport, like those at Deadhorse, remained high throughout freeze-up. The deviations from normal were especially large in October and November, when the average daily values exceeded the long-term averages (1981 through 2010) on 31 and 25 days, respectively. Over the course of the five-month study period (October through February), the average daily values exceeded the long-term averages on 101 days (67% of the time) and dropped below on only 7 days (5% of the time). The 3,263 FDD that had accumulated at the end of February represented the lowest total in the past eight years.

- ***Winds and Storms:*** Easterlies outnumbered westerlies from October through December, but westerlies predominated in January and February. Over the entire duration of the five-month study period, easterlies prevailed 61% of the time. This frequency ties that in 2013-14 as the lowest in the past eight years. The storm population consisted of eight easterlies and six westerlies. The highest average monthly wind speed, 12 kt, occurred in October and January; the highest average daily wind speed, 27 kt, and longest storm duration, nine days, were associated with a westerly event that began in late December and ended in early January.
- ***Ice Thickness:*** Based on the 3,263 FDD that had accumulated at Barrow Airport, the computed thickness of undeformed first-year ice at the end of February was only 103 cm. This value is nearly ten percent lower than the prior minimum of 114 cm recorded during the eight freeze-up periods that began in 2009-10.
- ***Multi-Year Ice***: Multi-year ice remained absent from the Alaskan Chukchi Sea throughout the five-month study period.
- ***Chukchi Sea Reconnaissance Flights:*** Preliminary findings from the flights conducted on February 27th and March 1st are summarized below:
  - *Landfast Ice:* In contrast to the Beaufort, where westerly winds tend to dislodge the landfast ice, they promote the development of such ice in the Chukchi by pushing the pack ice against the coast. The relatively high frequency of westerlies in 2016-17 produced a continuous strip of landfast ice that stretched from Point Lay to Barrow on March 1st. The width of the strip varied substantially, from more than 10 km between Point Lay and Icy Cape to less than one kilometer off Point Belcher. The strip was anchored by grounded ridges and rubble with typical heights of 2 to 5 m. The landfast ice zone off Barrow is shown in Plate 4.
  - *Lagoon Ice:* The ice in the protected waters of Kasegaluk Lagoon, the Kuk River Entrance, and Peard Bay was flat and undeformed (Plate 5).
  - *Ice Pile-Ups:* Sixty-three ice pile-ups were observed between Point Lay and Barrow, but their dimensions were modest by historical standards. The heights ranged from 1 to 5 m, the encroachment distances from negligible to 10 m, and the alongshore lengths from 50 m to 4 km. A representative example is included in Plate 5.
  - *Flaw Lead*: Reflecting the strong easterly storm that precluded flying from February 24th through 26th, a wide flaw lead was evident on February 27th and March 1st. The lead was open on the 27th (Plate 4), whereas extensive refreezing was observed on the 1st in response to light westerly winds (Plate 6).
  - *Katie's Floeberg:* As in three of the past eight years, Katie's Floeberg had not formed at the time of the February reconnaissance flight. This finding is consistent with the absence of deep-keeled multi-year ice, which tends to initiate the formation of the floeberg when it runs aground on Hanna Shoal.

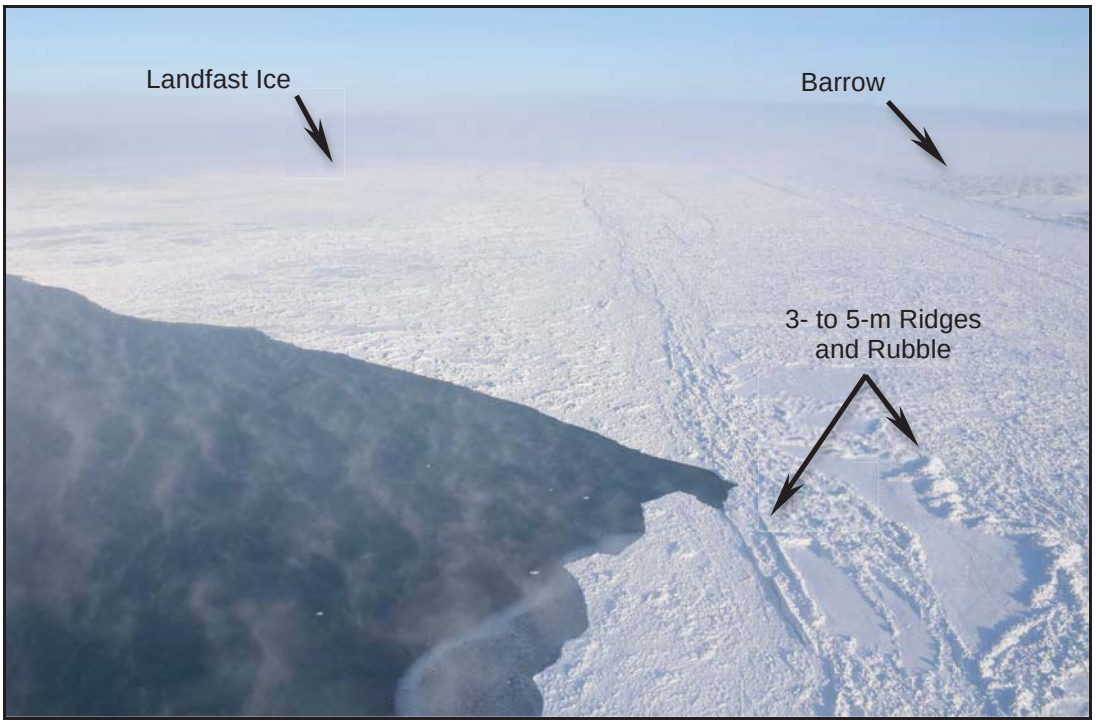

Plate 4. Landfast Ice and Open Flaw Lead off Barrow (February 27, 2017)

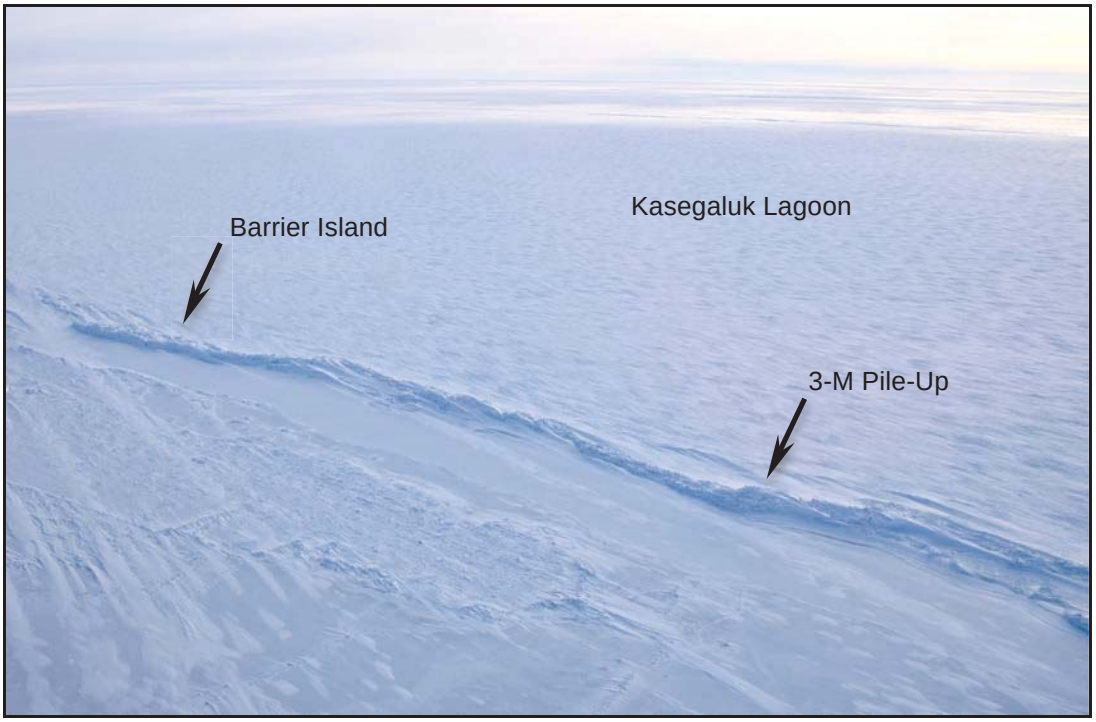

Plate 5. Undeformed Ice in Kasegaluk Lagoon along with 3-m Pile-Up that Encroached 10 m onto Barrier Island 25 km East of Icy Cape (March 1, 2017)

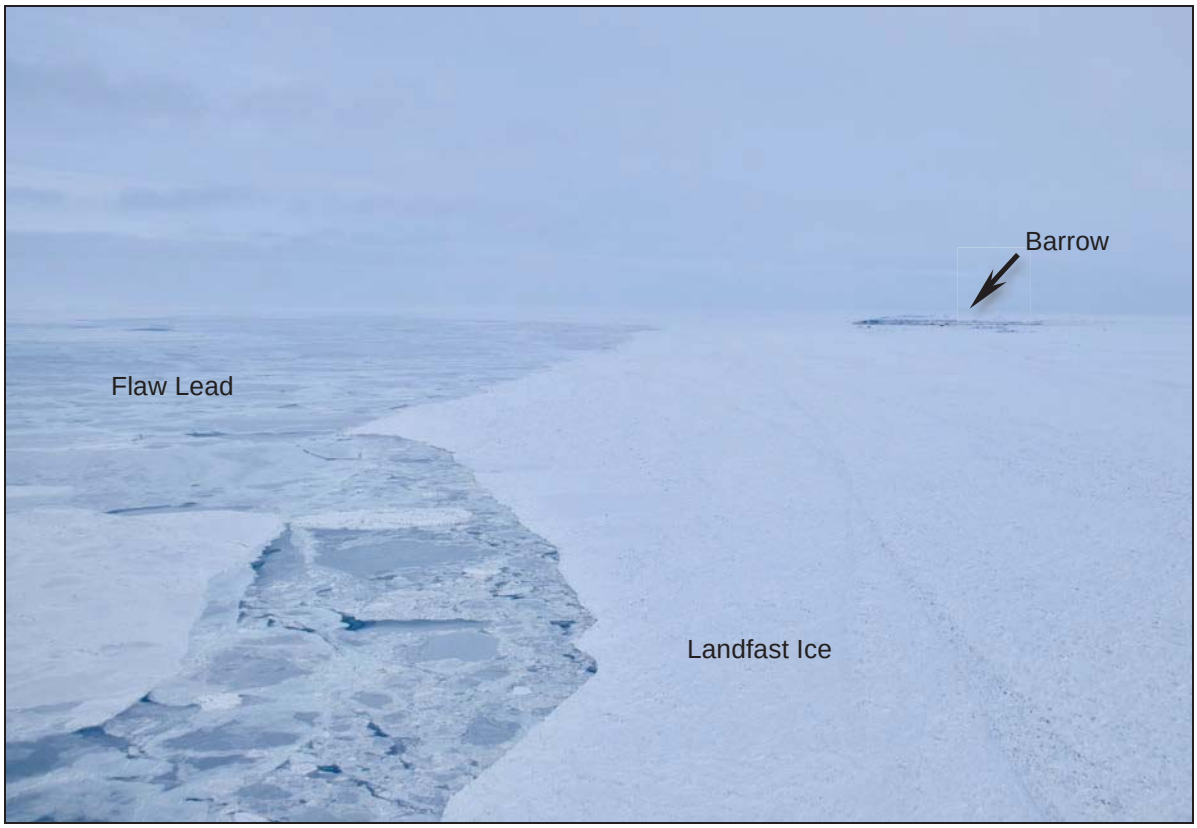

Plate 7. Landfast Ice and Refreezing Flaw Lead off Barrow (March 1, 2017)

Activities Planned

- Continue the analysis of the data acquired during freeze-up pertaining to meteorological conditions, ice movement, the landfast ice zone, and the Chukchi Sea flaw lead.
- Continue the acquisition of air temperature data through the end of the 2016-17 winter season to support the computation of the maximum thickness attained by undeformed first-year ice.
- Analyze the data obtained during the freeze-up reconnaissance flights, including correlating the photos and videos with the flight paths.
- Initiate preparation of the freeze-up draft report.
- Initiate the acquisition of meteorological data, ice charts, and satellite imagery in mid-May, to document the progress of break-up.
- Continue making logistical arrangements for the break-up reconnaissance flights to be conducted in late June or early July.

Percent Completion

Contract Amount = $623,930.00

Invoice No.	Period Covered	Work Completed Each Period		Work Completed to Date	
		% of Total	$	% of Total	$
4096	9/21-10/24/16	25.24	$157,482.50	25.24	$157,482.50
4160	10/25/16-3/13/17	24.76	$154,482.50	50.00	$311,965.00