SEA ICE OUTLOOK 2016 Report contribution: Perspectives relating to icebreaker shipping in areas of land-fast ice

1. Souness, C.[a]

1b. [a]Affiliation: Department of Geosciences, University of Edinburgh, Edinburgh, Scotland
Additional contributions: Prof. Peter Nienow(as 'a')

2. The primary author of this work is not in the employ of 'a' and therefore should be considered a 'citizen scientist'.

3. It is our preference that this document be taken as a stand-alone contribution, representing only a brief treatment of ongoing research. We plan to submit separate contributions for future consideration.

4. Executive summary:

Icebreaker passages through areas of seasonal land-fast ice (for purposes of base re-supply, research support, tourism, coastal patrol and others) comprise part of an upward-trending pattern of shipping volumes in Arctic waters (e.g. Stewart et al., 2007; Ho, 2010). We propose that, in light of this upsurge in marine traffic, accounting for icebreaker routings could be beneficial when forecasting the nature and extent of sea ice in certain areas. The frequency and object of icebreaker movements can affect ice stability, specifically that of land-fast ice. We have observed that whilst conservatively routed icebreaking vessels (which adhere to straight, linear courses through areas of inter-island land-fast ice) appear to have a minimal (although observable) impact upon that fast-ice's propensity for accelerated breakup, icebreaker routing of a more circuitous nature (where vessels execute broad turns and exploratory loops in frozen waterways) appear to encourage the onset of seasonal fast ice disintegration.

With advance knowledge of icebreaker shipping schedules, and a record of these sailing's object, the impact of icebreaker passages might be considered and accounted for in projections of local fast ice stability and thus also drift ice extent. The link between icebreaker maneuvering patterns and temporal variability in fast ice longevity has however unfortunately received little or no scrutiny from the research community thus far. We propose that more attention be paid to this issue, as a fuller understanding of how icebreaker transits affect fast ice on a local scale could not only improve the fidelity of regional outlook projections but also help inform codes of best practice in ship routing and maneuvering which might reduce any undue effects that icebreaking - regardless of its purpose - has on what is already a fragile and threatened ecosystem (e.g. Screen and Simmonds, 2010; Stroeve et al., 2008; Johannessen et al., 2004).

5. This submission is heuristic in nature:

Methods:

The qualitative observations related in this document represent only part of a larger, ongoing study based, at present, upon three summer seasons' work aboard an icebreaker in the Franz Josef Land (FJL) archipelago, Russian Federation. These field observations are augmented by satellite imagery collected by the Operational Land Imager (OLI) sensor mounted on the Landsat 8 platform. We focus here on the 2015 summer season, specifically on observations made at two case study sites within the FJL archipelago: Booth Sound (81□ 04' N, 56□ 08' E) and Collinson Fjord (80□ 50' N, 58□ 11' E).

Knowledge of ship routings gathered whilst in the field permitted the post-season collection and inspection of relevant satellite imagery, enabling us to visually appraise the timing and manner in which areas of fast ice broke apart following icebreaker transits of the named study sites (above) and how breakup appeared to relate to the shape of paths cut by the vessel.

6. 'Dataset':

Summary of observations:

In 2015 the named study sites were still entirely occupied by unbroken, contiguous fast ice into mid-June. This ice was navigated by icebreaker for the first time that year on June 12th. In Booth Sound the ship cut a linear path (from west to east) executing only one major deviation (Fig. 1a) where the icebreaker performed three consecutive course alterations, drawing a 'V'-like shape in an otherwise linear track. In Collinson Fjord the ship's movements were more extravagant, describing numerous broad loops and 'figure-eights' in the expansive fast ice east of the fjord (Fig. 2) before assuming a more straight-forward, linear course as the vessel exited the fjord via its southwestern end.

The icebreaker in question re-visited both sites 12 days later, on June 24th. This enabled field observations of change at the two sites, informing later satellite image acquisition.

During the time elapsed between June 12th and June 24th the fast ice occupying both waterways had remained broadly stable in those areas where the ship's course of June 12th had been linear (Figures 1 and 2). However, where maneuvers had been performed (namely the 'V' in Booth Sound and the broad 'loops' in Collinson Fjord) visible breakup of variable severity had occurred.

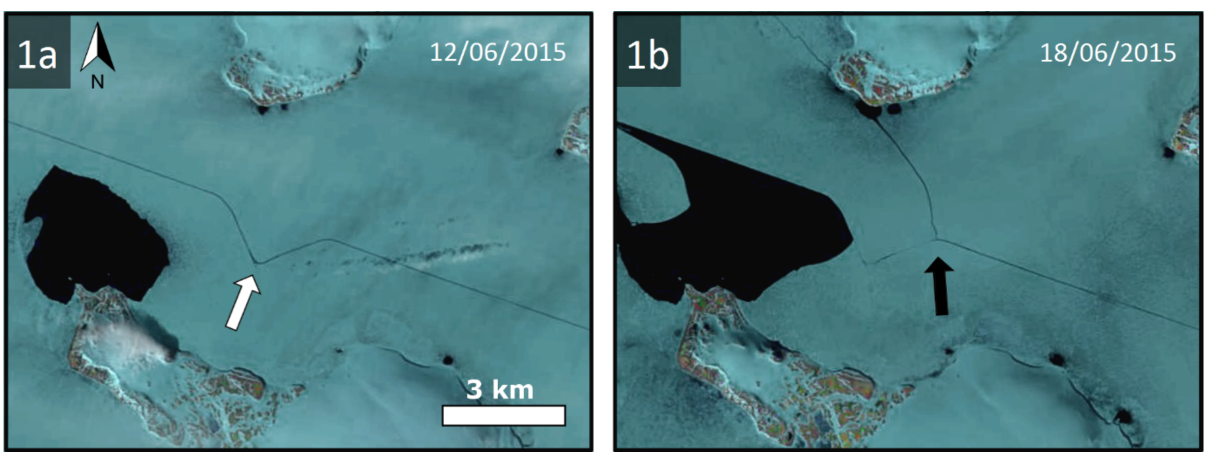

Fig. 1: Satellite imagery of Booth Sound taken by the Landsat 8 'Operational Land Imager' (OLI) on June 12th (1a) and June 18th (1b). The icebreaker's track is clearly visible in both frames. The 'V'-shaped series of turns is highlighted by a white arrow in 1a whilst in 1b a black arrow denotes the open fracture which seems to stem from the 'V' structure's eastern vertex. The large ice slab which has been cut away can also clearly be seen in 1b, drifting westwards and out of the frame.

In Booth Sound a large piece of ice (> 5 km^2 in area) was cut free on the western flank of the 'V', whilst a long fracture can be seen to have formed at the vertex of one turn (Fig. 1b), extending more than 7 km to the NNW of the cut channel. In Collinson Fjord all of the fast ice contained within and to the ice-peripheral side of the 'loops' had broken away and become mobile drift ice (Fig. 2), this 'breakup' visibly conforming to the lines of the icebreaker's track of June 12th.

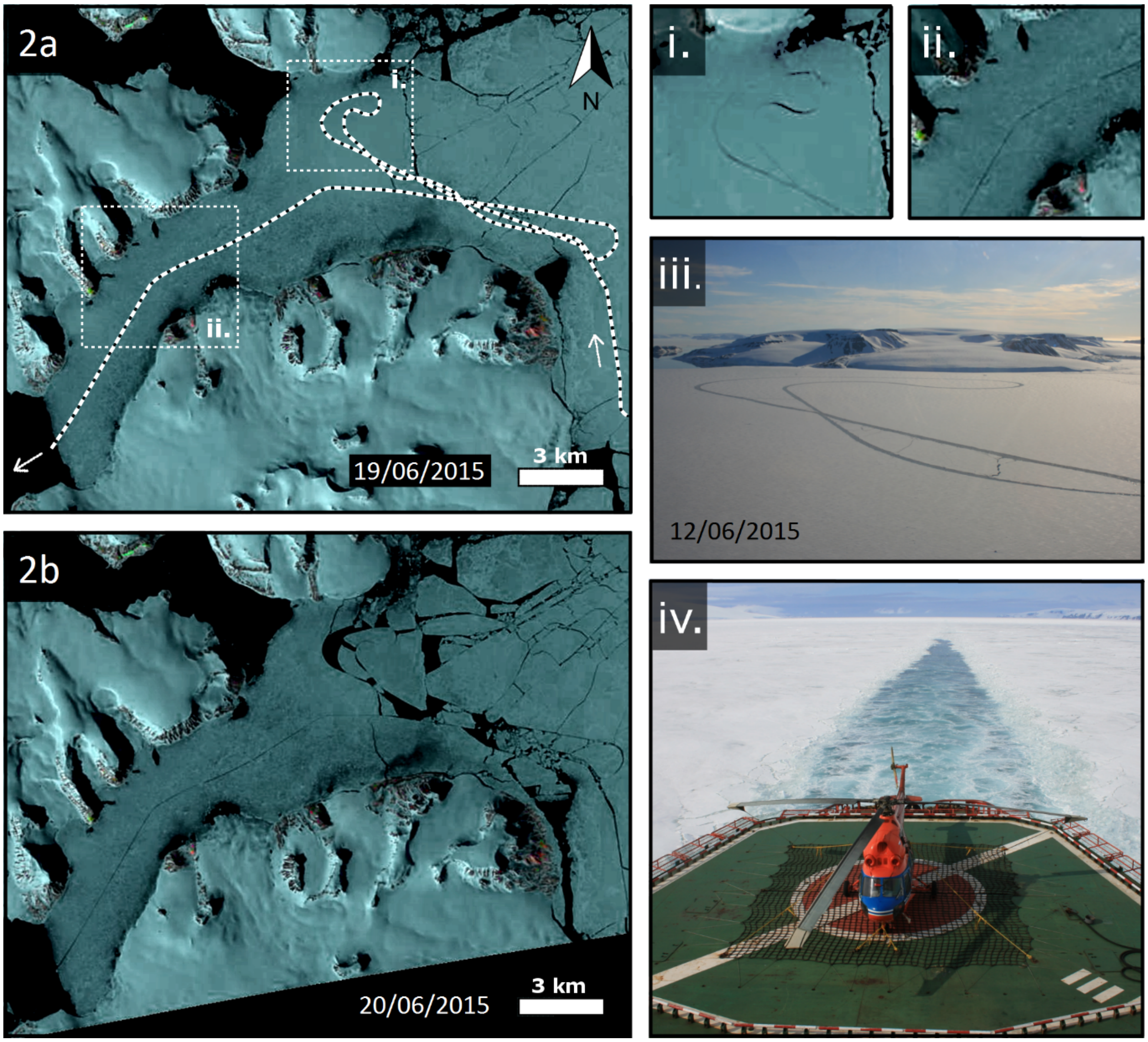

Fig. 2: OLI imagery of Collinson Fjord taken on June 19thth (2a) and June 20th (2b). The track taken by the icebreaker is highlighted by a dashed line in 2a, with details of both parts of the 'loop' section and the linear section shown at 'i.' and 'ii.' Respectively. 'iii.' shows an aerial photograph taken of the 'loop' track area taken on June 12th at the time of initial icebreaking ('iv.'). In frame 2b the area of fast ice previously cut in a looped fashion on June 12th (iii.) can be seen to have broken up completely and begun to drift eastwards.

7. ‘Prediction’:

   These observations represent only a small part of a larger ‘dataset’ from waterways around the FJL archipelago during 2014, 2015 and 2016. However, as stated in the executive summary, we propose on the basis of these and other observations that icebreaker transits can have a potentially significant effect on fast ice stability in coastal and inter-island seaways. Fore-knowledge of icebreaker shipping schedules could help contribute to the production of more informed forecasts of ice stability and extent in areas where shipping of this kind is frequent.

   The magnitude of the effect icebreakers exert on coastal fast ice may vary considerably with the manner in which an icebreaker is maneuvered. Linear courses undertaken through areas of enclosed fast ice (e.g. in fjords or inter-island sounds) appear to have markedly less impact on ice breakup patterns than courses characterized by numerous turns, loops or ‘figure eights’. Thus, we propose that in the interests of protecting the already fragile fast ice ecosystem more research into this relationship is needed so as to inform a ‘code of best practice’ for icebreaker operation, particularly in the field of tourism, this being a sector of economic growth in the Polar Regions.

8. Uncertainty:

   Although this ‘model’ is both qualitative and heuristic, and therefore can be attributed no numerical ‘uncertainty’, it should be noted that the material presented here represents only a small component of a larger study which in itself is restricted to studies undertaken in a single archipelago and during only a three year window. More work is needed.

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