Electronic Supplementary Material (ESI) for Environmental Science: Processes & Impacts.

Supplemental Information for:

Interannual, summer, and diel variability of CH_4 and CO_2 effluxes from Toolik Lake, Alaska, during the ice-free periods 2010–2015

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Echosounder survey for ebullition

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The echosounder survey was conducted over the course of 3 days during the warmest time of the Toolik summer, which is when you would expect to observe ebullition as methanogenesis and gas saturation are temperature dependent. The surveys were $\approx$ 34.5 km in length, which at an average depth of between 7 and 11 m depending on survey resulted in $\approx$ 34,800 m^2 (0.035 km^2) of area covered. Surveys were conducted at $\approx$ 1 knot and at a ping rate of 5 Hz in order to adequately resolve any small bubbles (see **?** and **?** for more echosounder ebullition survey specifics).

As seen in Figure S1, every potentially significant portion of Toolik was covered by the surveys, including regions as shallow as 1 m, although this falls close to the near-field zone of unreliable data for this particular echosounder (**?**). The majority of echograms show the presence of fish and plankton at multiple depths (Figs S2–S4). Except for one possible bubble in 11 m of water on 23 July (Fig. S5), no discernible bubbles were observed in any of the echograms. There were 20 instances on 23 July where acoustic signatures that could possibly be a bubble plume were observed (examples seen in Fig. S6). However, there were no other discernible bubbles near the plumes as is typically observed (see SI figures in **?** for an example). In addition, these features did not reach the air-water interface in the echogram, which would be expected in such shallow waters (between 1.5 and 4 m) if these were indeed bubble plumes. Nor did we observe any bubbles breaching the surface in these shallow locations, which is unfortunately the only way we could have confirmed that these were bubbles. Macrophytes can also appear as these features in shallow regions of lakes, although there are few macrophytes in Toolik.

In summary, we are aware that ebullition can be an important pathway for the gas losses from a lake, but our data cannot confirm that ebullition occurred or was important for degassing of Toolik Lake waters.

Table S1: *Ebullition survey sampling statistics*

Date	Color Color in Fig. S1	Length of survey (m)	Average surveyed depth (m)	Area surveyed (m^2)
19 July 2012	yellow	6,014	11	8,095
23 July 2012	red	18,573	7	15,775
24 July 2012	blue	9,905	8.5	10,953
Total	34,492		—	34,823

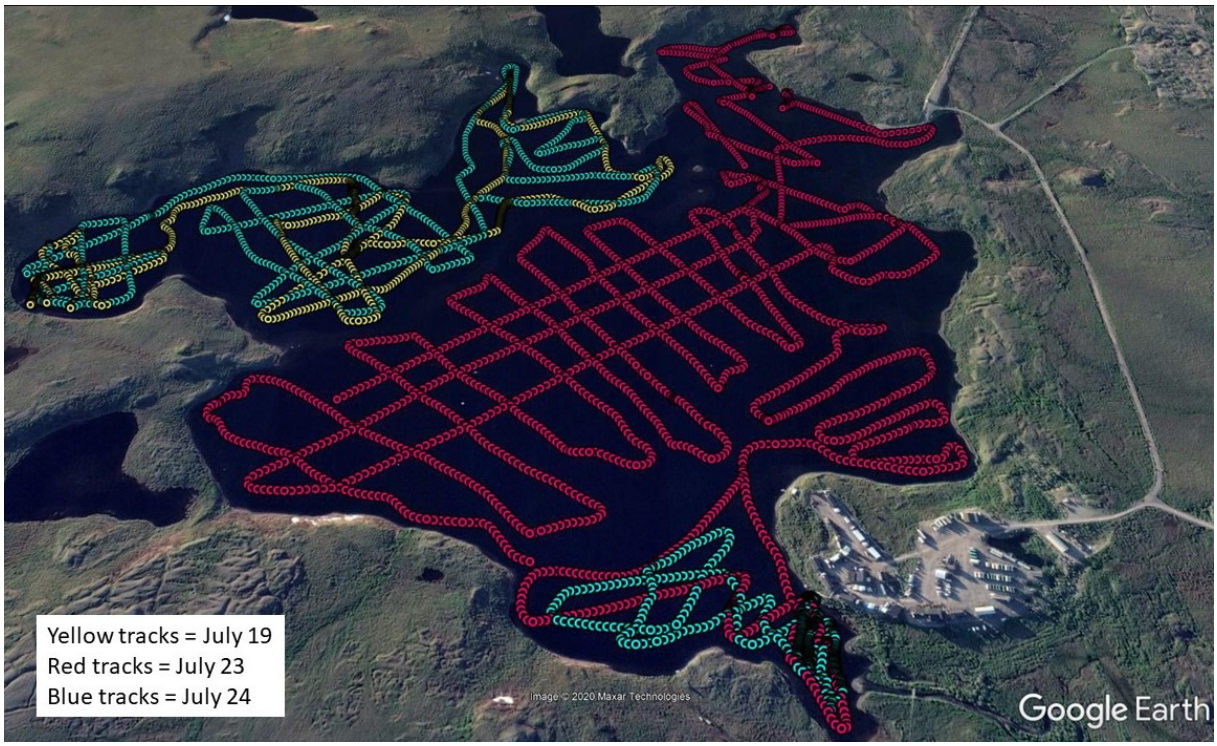

Figure S1: *Sonar tracks for 3 surveys conducted on 19 July 2012 (yellow tracks), 23 July 2012 (red tracks) and 24 July 2012 (blue tracks). Background aerial image from Google Earth.*

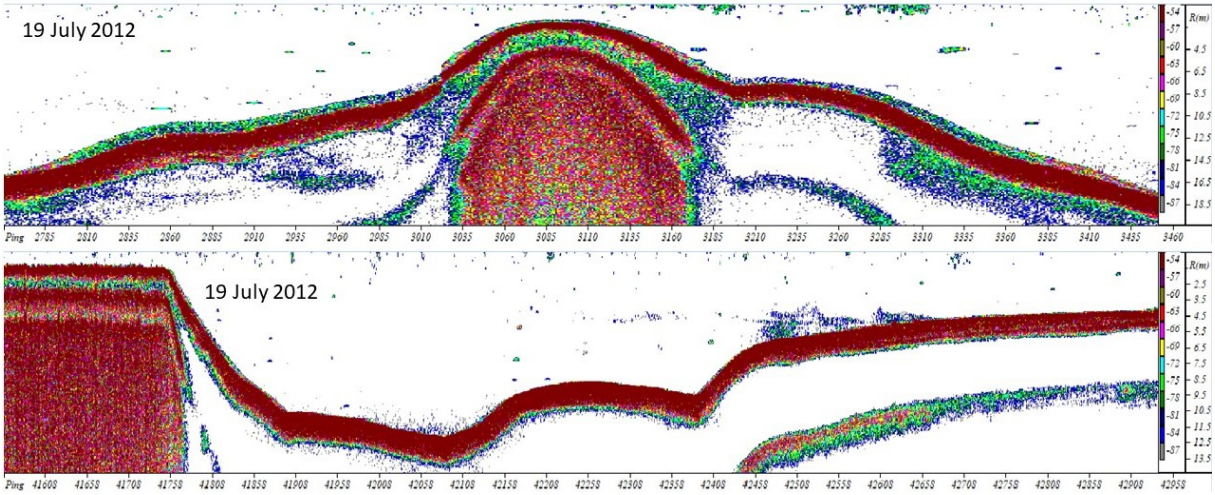

Figure S2: *Echogram examples from 19 July 2012. Threshold set to –90 dB in order to see all objects as small as plankton.*

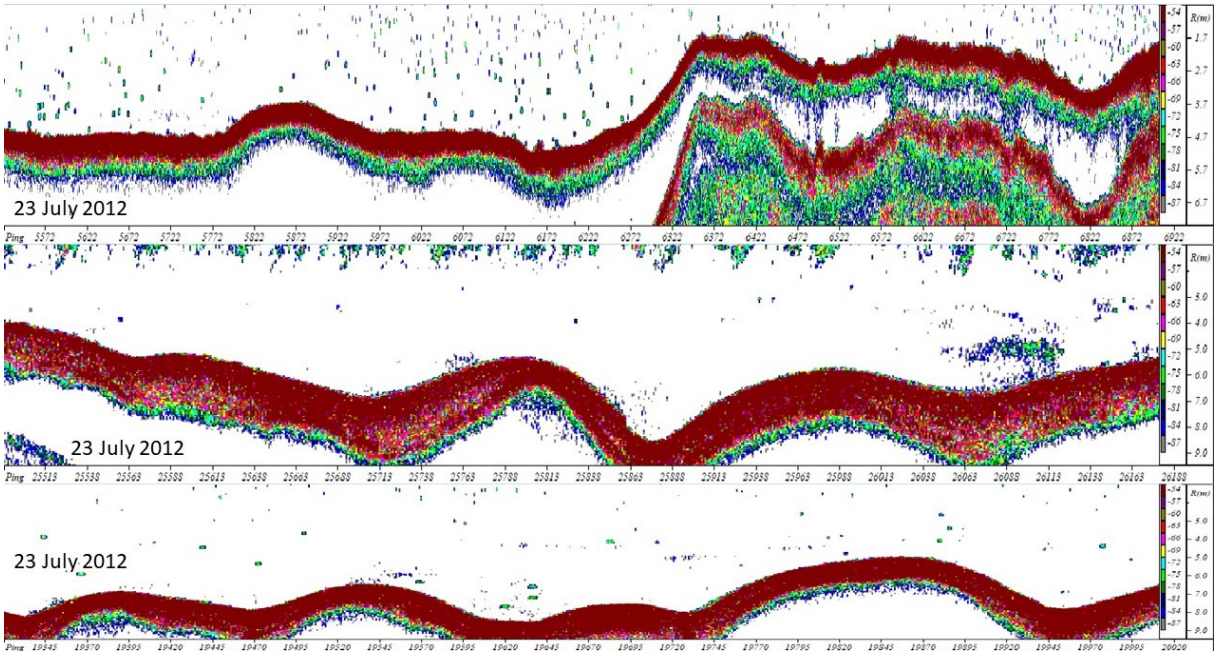

Figure S3: *Echogram examples from 23 July 2012. Threshold set to –90 dB in order to see all objects as small as plankton.*

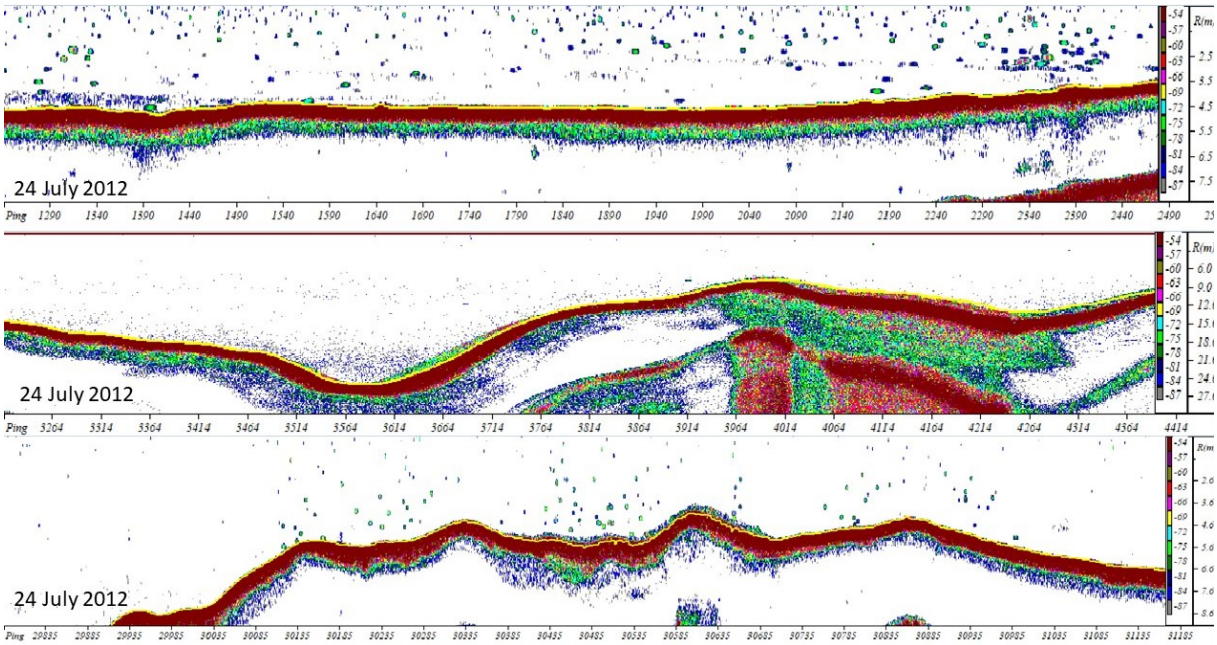

Figure S4: *Echogram examples from 24 July 2012. Threshold set to –90 dB in order to see all objects as small as plankton.*

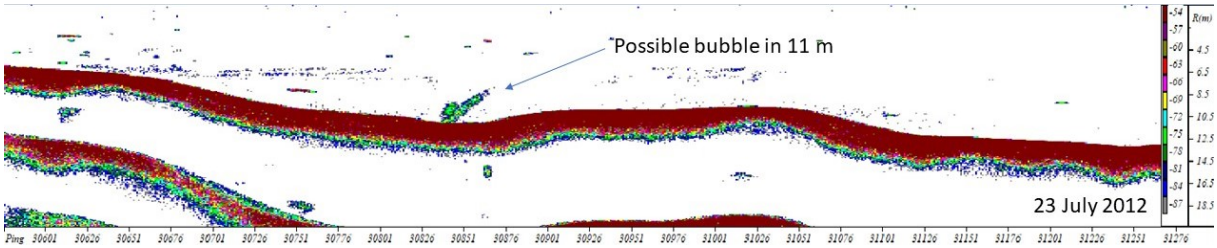

Figure S5: *The only potential discernible bubble observed over the 3 surveys occurred in 11m of water on 23 July 2012.*

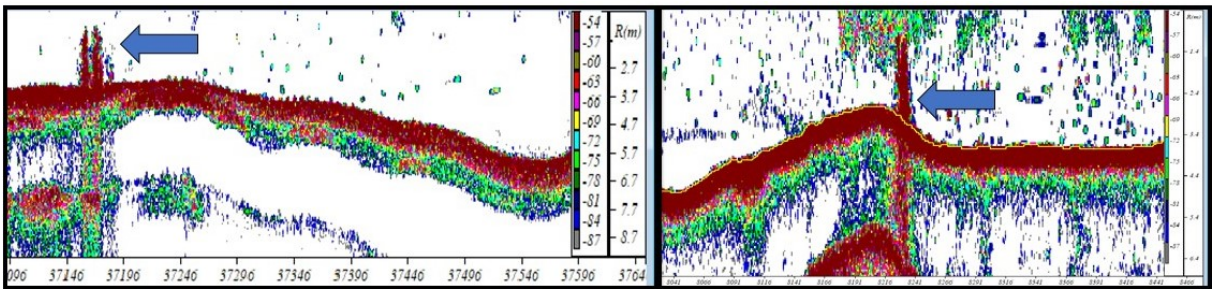

Figure S6: *Examples of potential bubble plumes observed on 23 July 2012, marked by blue arrows.*