

# Distribution of an Acoustic Scattering Layer, Petermann Fjord, Northwest Greenland

OS31A-1355

## Background of the data

The **Peterman Glacier Experiment of August 2015** was a comprehensive paleoceanographic and paleoclimatological study of the marine-terminating Petermann Glacier and glacier outlet system in Northwest Greenland. The purpose was the reconstruction of past and present glacial history to better understand the fate of floating ice shelves that act as critical buttresses to the Greenland Ice Sheet<sup>(1)</sup>.

### Seafloor mapping was a critical component of the experiment.

- 35 days aboard the Swedish Icebreaker ODEN
- Two echosounders were run throughout the expedition providing **continuous acoustic coverage of the study area (Fig.2)**:
- ➔ **EM122 (12 kHz) multibeam**:
  - Primary purpose: Mapping submarine glacial morphology.
  - Bonus: Water column data.
- ➔ **EK80 (15-30 kHz) broadband split-beam**:
  - Primary purpose: Detect features in the water column.
  - Focus: Find indications of *gas seeps* in the water column.
  - Additionally, a small launch running an **EM2040 (200 kHz)** multi beam was deployed in shallow locations.

### Initial findings

- Few seeps were found. However...
- The mapping team noted an **acoustic scattering layer (SL)** in the EK80 and EM122 water column data, which was observed to **change depth in a consistent manner** that appeared to be related to location.

Review of EK80 data at CTD locations (Fig. 3) resulted in what appeared to be a **strong spatial coherence in the SL distribution**—

- the SL was consistently shallow (< 200m) in Petermann Fjord,
- deep (> 250m) in Hall Basin/ Nares Strait,
- and absent or very deep around the western edge of Hall Basin and Petermann Fjord

—**corresponding to our limited understanding of the complex circulation pattern in the study area** including inflow of warmer Atlantic waters and outflow of subglacial waters (Fig. 4).

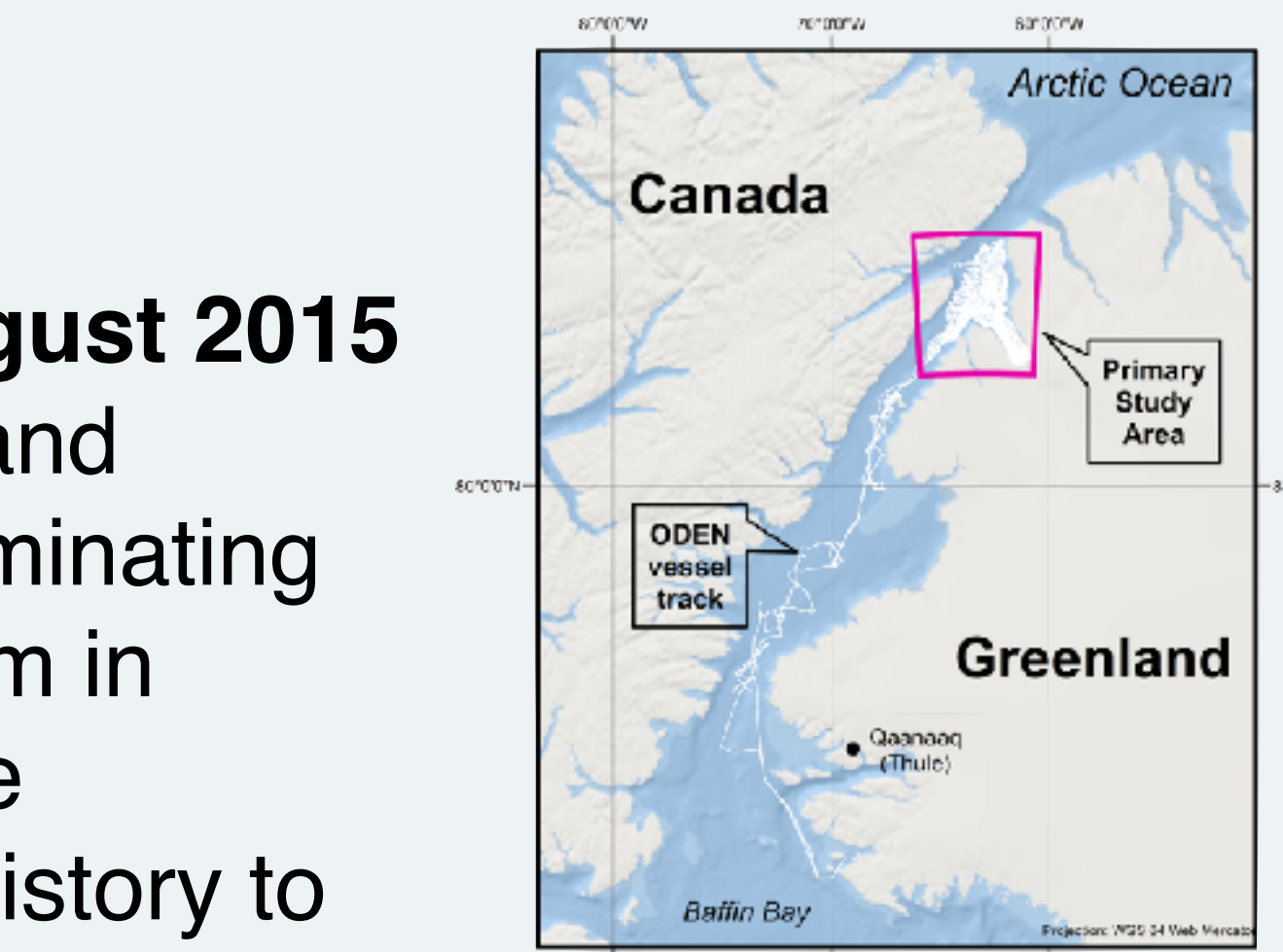


Fig. 1: Location map, Petermann Glacier Experiment.

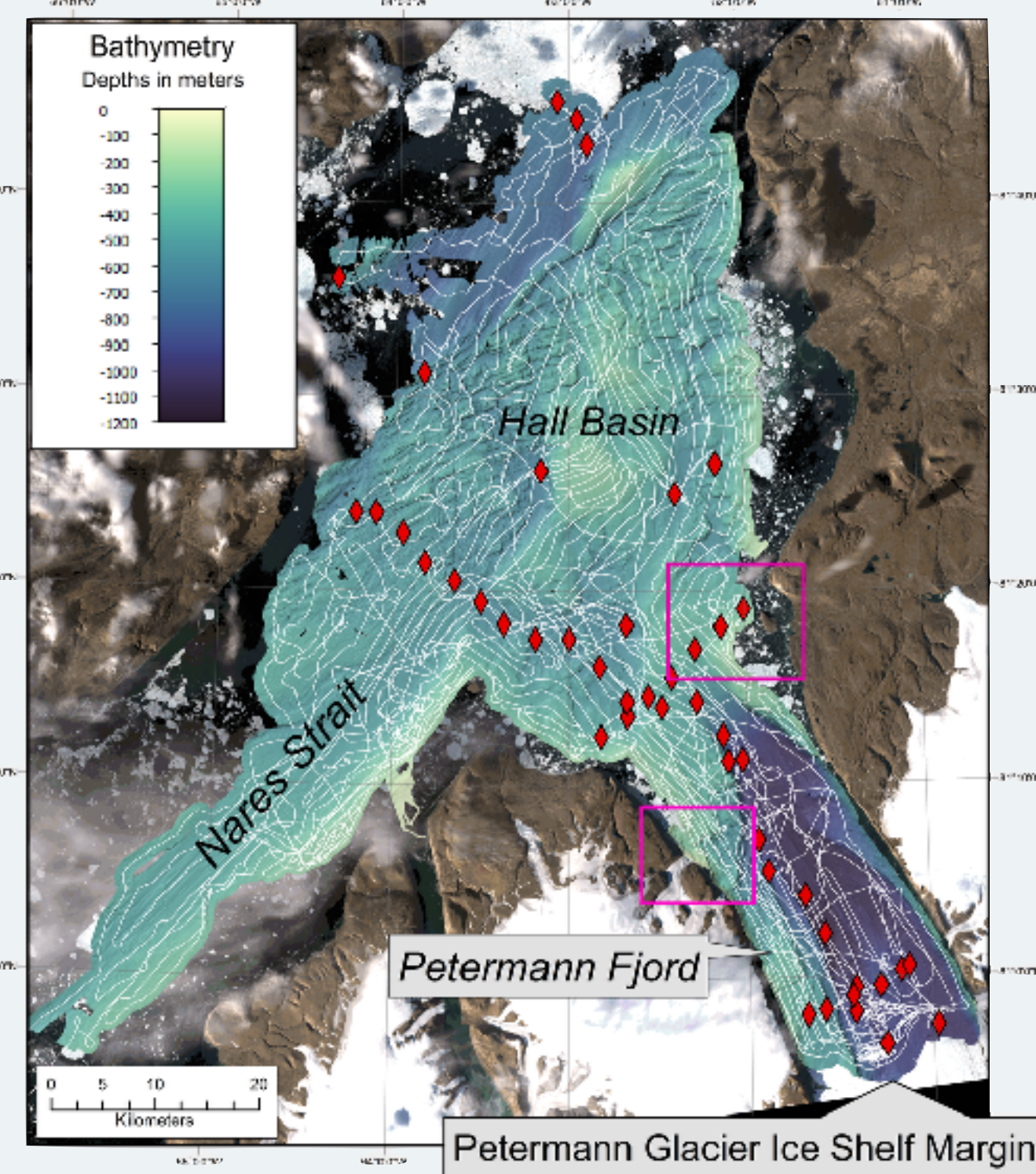


Fig. 2: Primary study area. The ship track is shown in white and is an indication of the sonar data collected; red diamonds show the locations of CTD stations. Pink boxes show the location of the acoustic observations shown in Figs. 5 and 7.

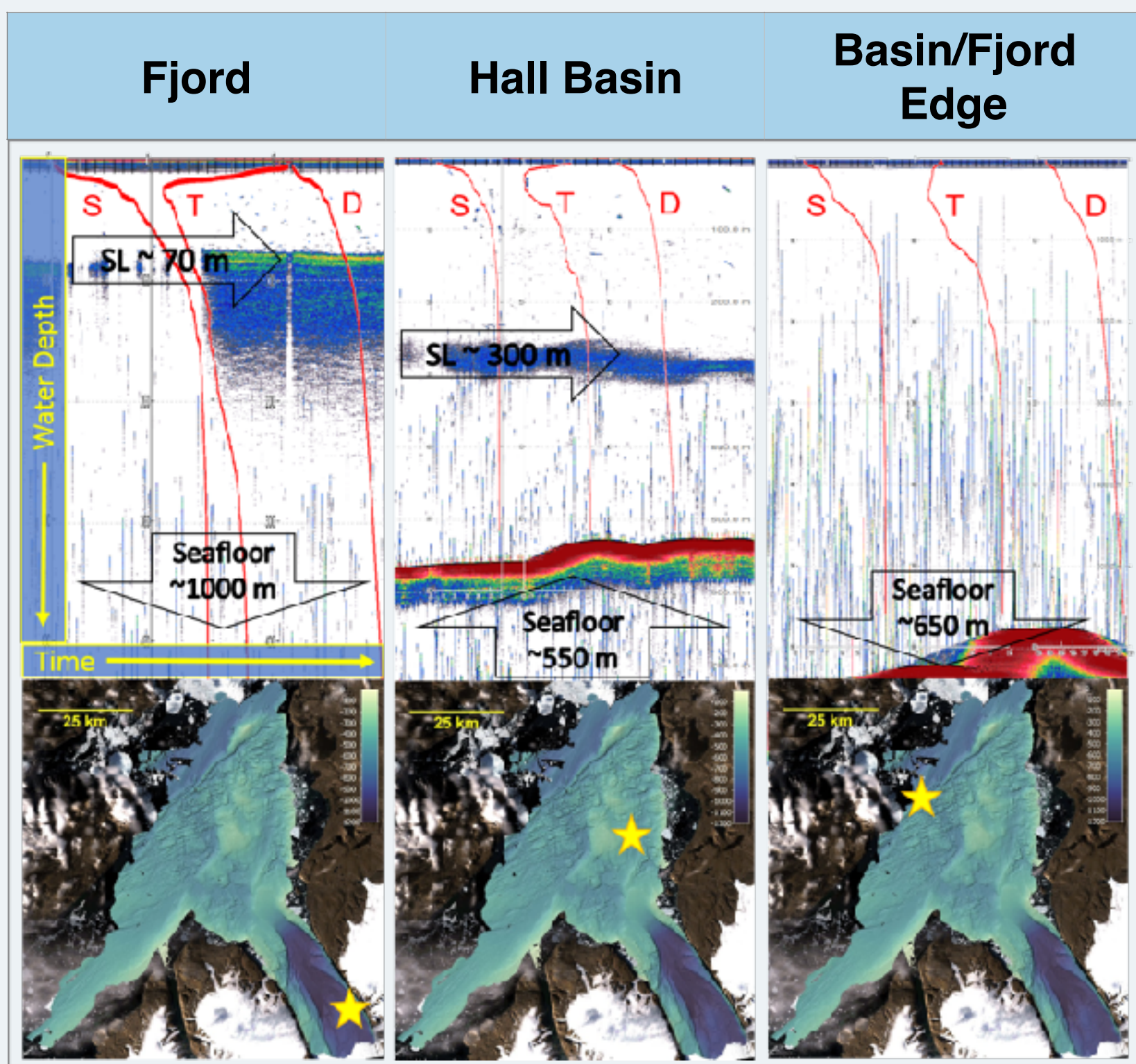


Fig. 3: Examples of EK80 files from different locations in the study area overlaid with corresponding salinity, temperature, and density profiles from the CTDs. The SL is visible in the left and center water column images (top row).

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Based on the initial findings, **our question:**

**Is the acoustic scattering layer a proxy for spatial and temporal changes in water mass structure and interactions<sup>(3)</sup>?**

➔ If so, it implies that continuous acoustic coverage may be a powerful proxy for oceanography.

## What is the acoustic scattering layer?

Acoustic scattering layers have been observed in all oceans, and typically consist of concentrations of marine organisms. However in a dynamic environment such as the study area, glacial sediments in the water column can also cause scattering. No biological or water samples were taken to confirm the presence of either marine organisms or sediment. **So what are we seeing? Based on acoustic observations:**

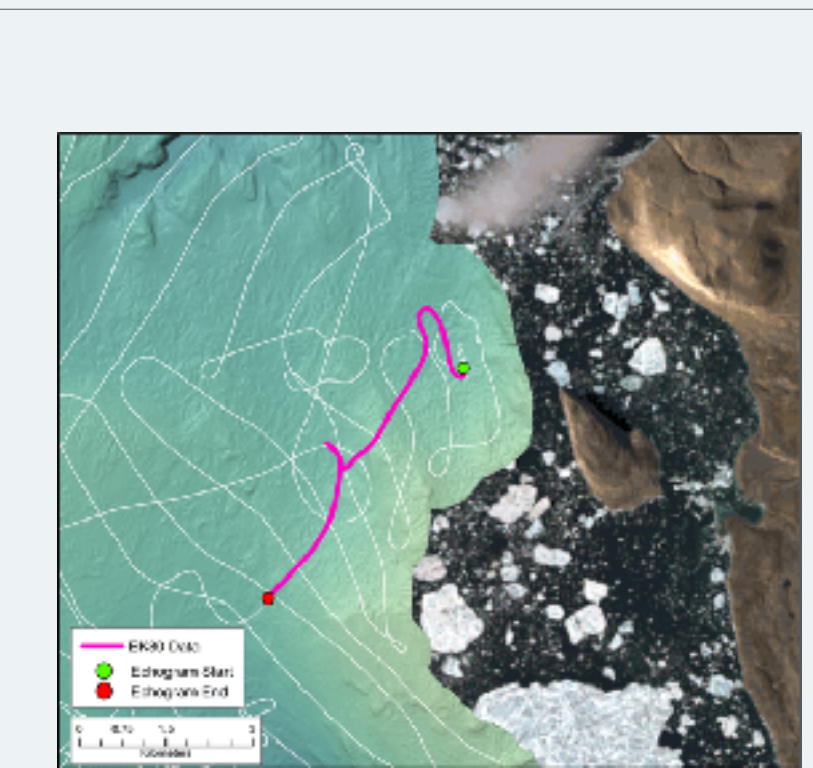


Fig. 5: Location of echogram shown to the right.

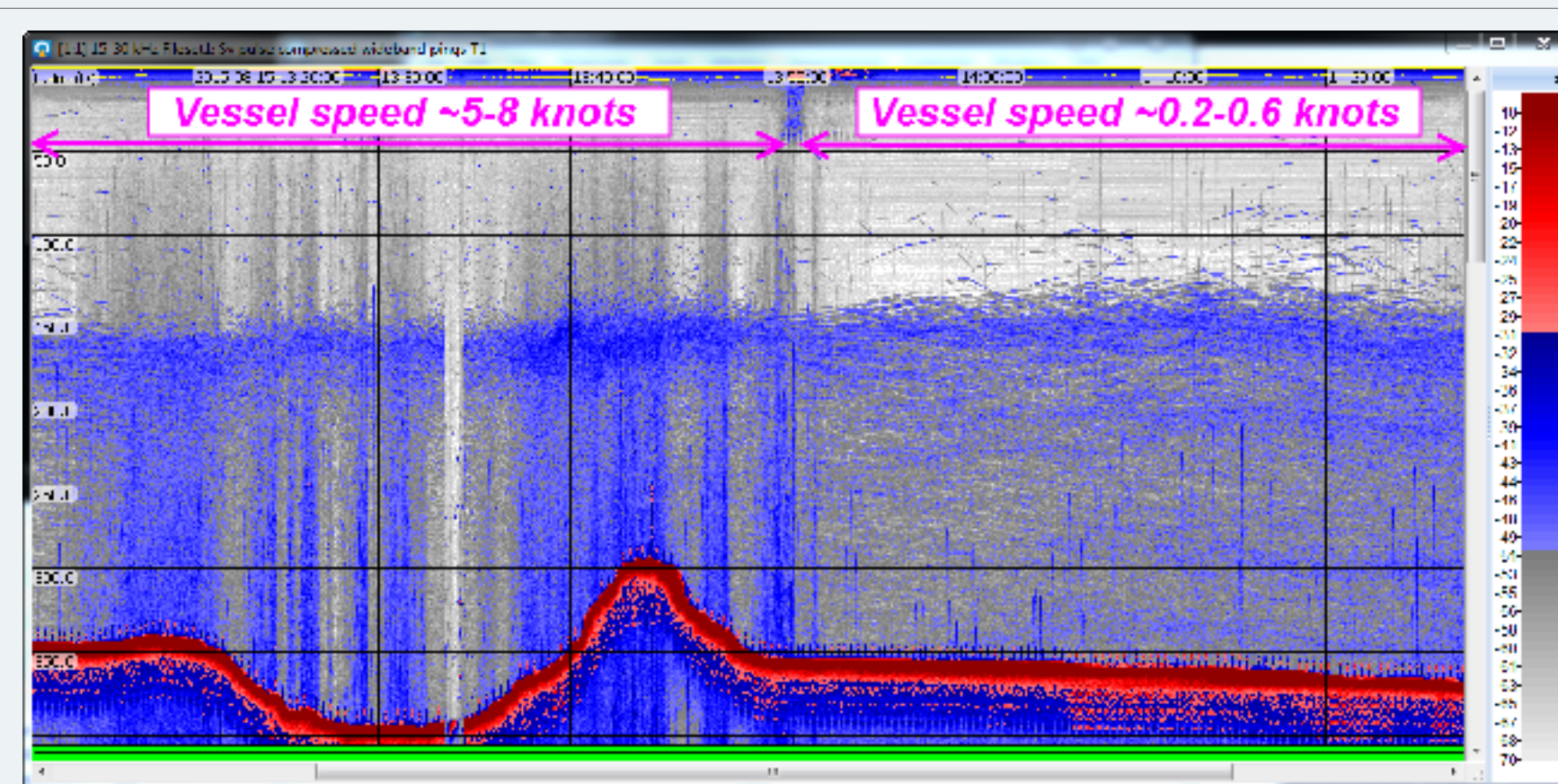


Fig. 6: EK80 data. SL visible between 125 - 200m. Individual organism tracks visible when vessel slows.

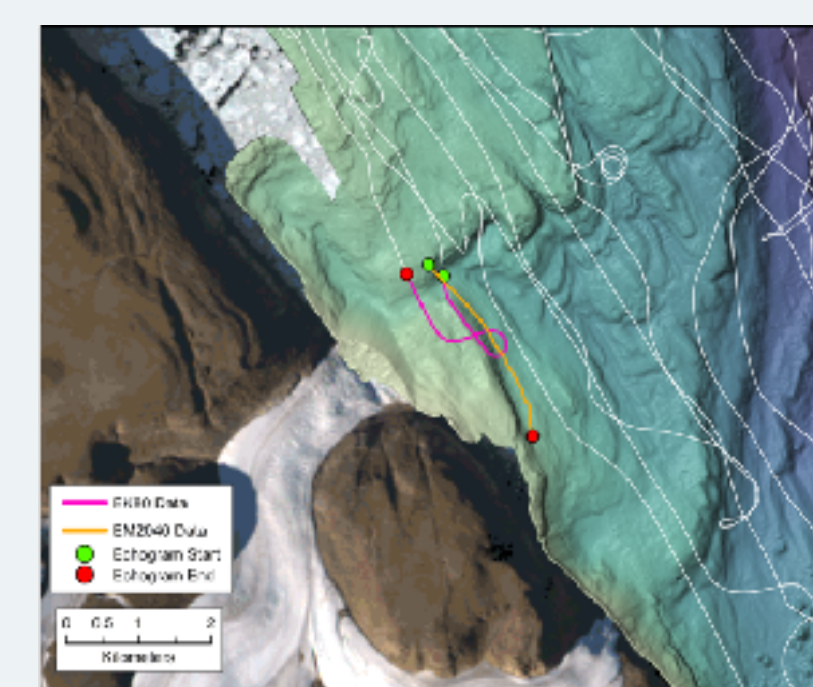


Fig. 7: Location of echogram shown to the right.

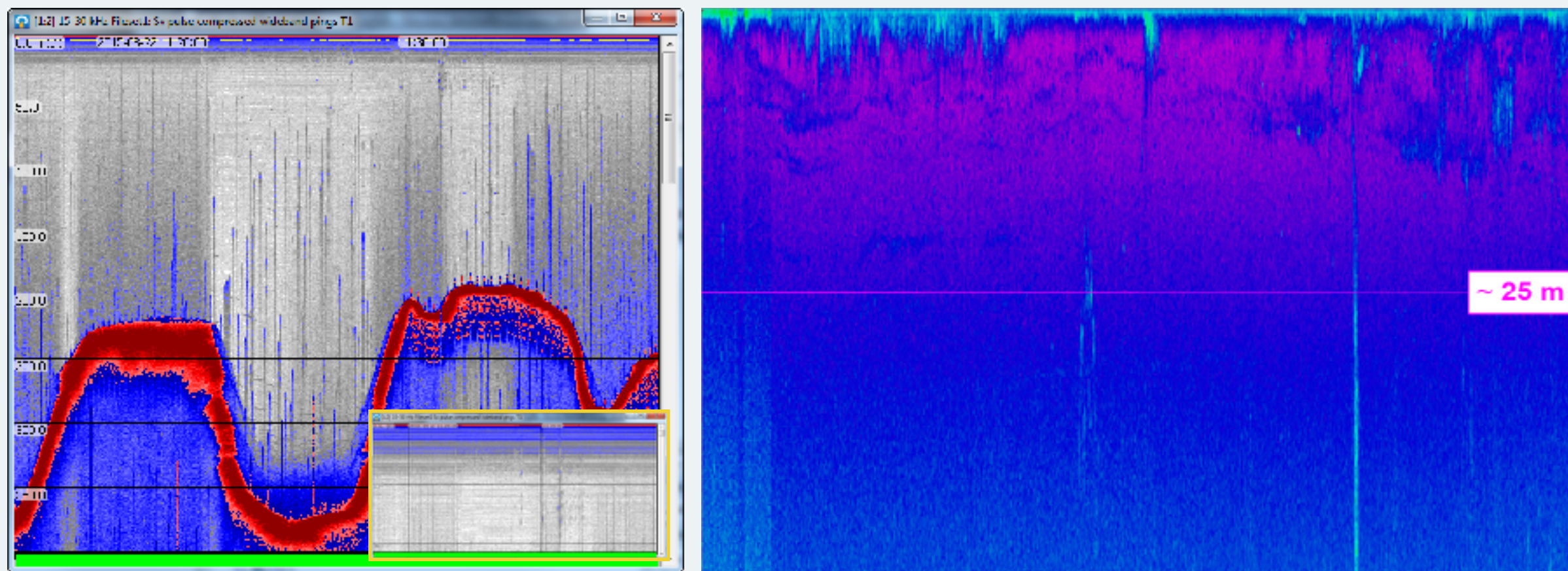


Fig. 8: Left, EK80 data with inset of top 50m of water column; there is no visible sediment. Right, EM2040 data; sediment is clearly visible at top of water column.

**Marine Organisms:** During periods of slow vessel speed/drift, acoustic tracks of individual organisms are visible both entering and within the scattering layer. This behavior, and the relatively high target strengths observed (-65 to -35 dB, uncalibrated volume scattering), indicate a high number of mobile, large scatterers — fish? — with the possibility of smaller, lower target strength organisms interspersed (plankton?).

**Sediment:** The higher frequency EM2040 allowed us to observe sediment plumes near side-glacier outlets. The plumes had a different appearance and depth distribution than the SL. The top 25m of the EK80 data, where sediment was observed in the EM2040 data, is too noisy to be useful; there are no obvious plumes of falling sediment visible below 50m in the data from either sonar. Though sediment could very well be contributing to the scatter we observe in the EK80 water column data, *we don't think it is the primary cause.*

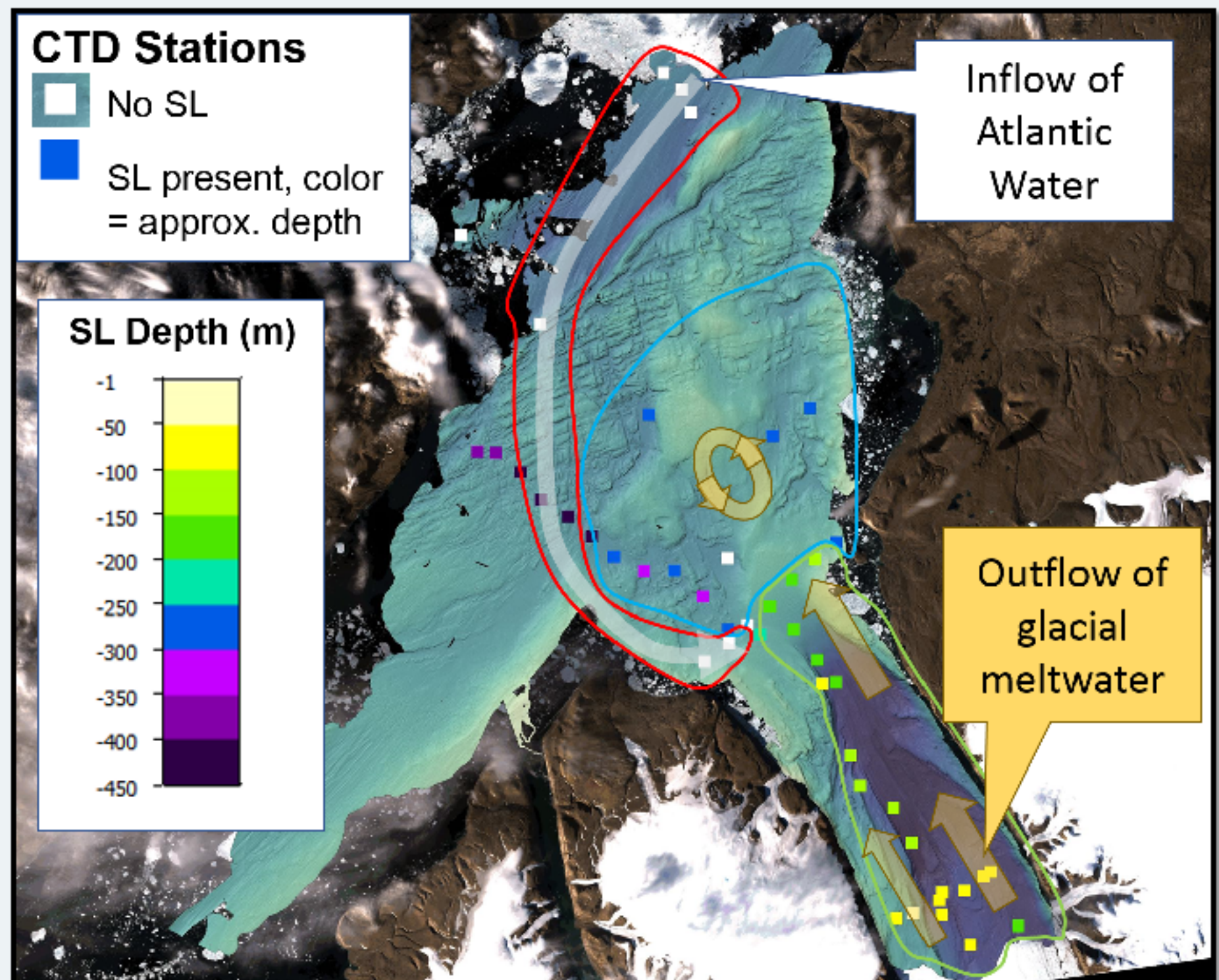


Fig. 4: CTD locations colored by the depth of the SL near that location, overlaid with a sketch of our understanding of the circulation pattern<sup>(2)</sup>.

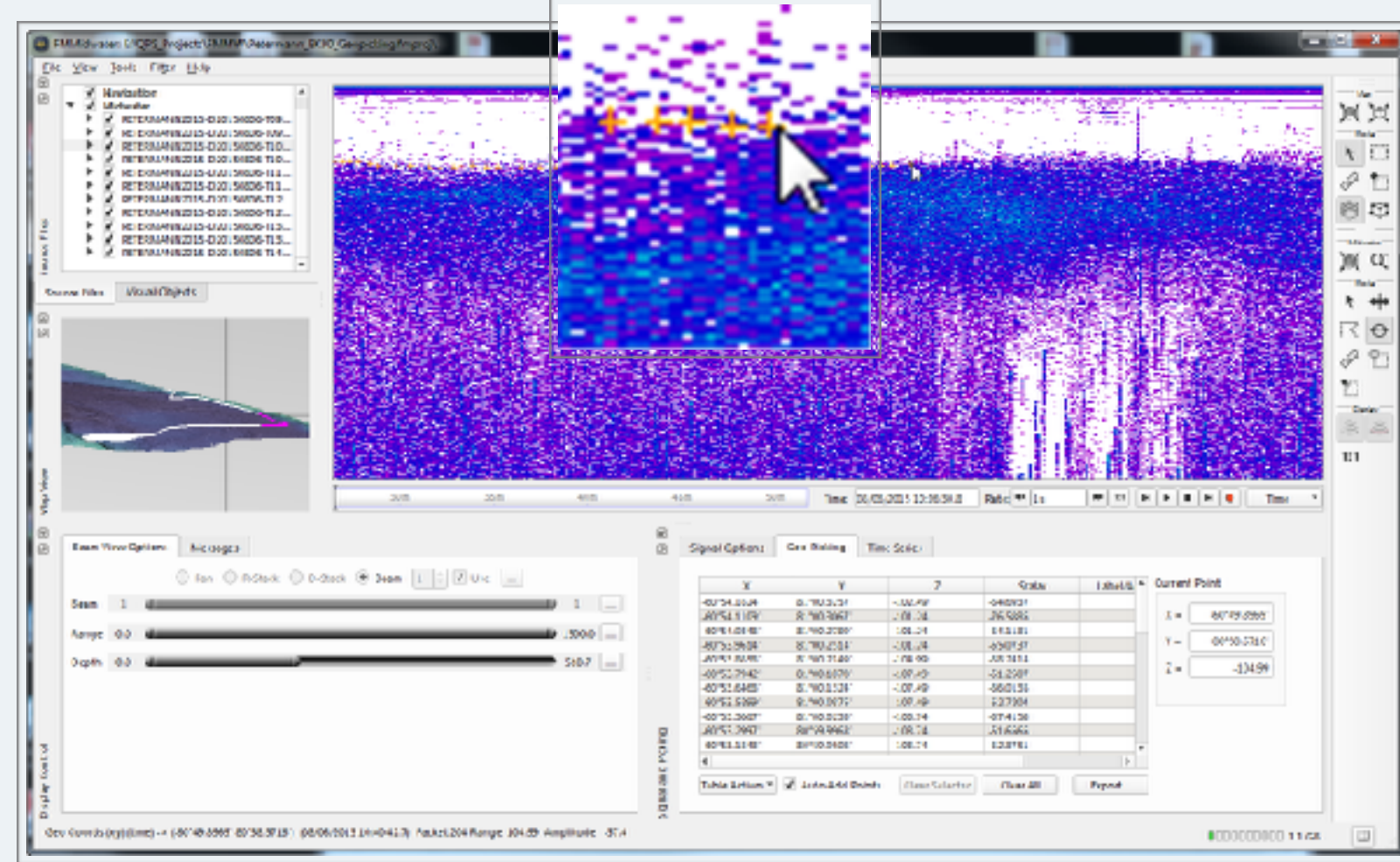


Fig. 9: An example of geopicking the SL from EK80 data in FMMidwater (not all SLs were so obvious).

### References:

1. Mix, A.C., Jakobsson, M., Andrews, J.T., Jennings, A., Mayer, L.A., Anderson, S.T., Brook, E., Ceperley, E., Cheseby, M., Clark, J., Dalerum, F., Dyke, L.M., Einarsson, D., Eriksson, D.B., et al., 2016, The Petermann Glacier Experiment, NW Greenland, in 2016 Fall Meeting, American Geological Society (AGU), San Francisco, CA, <https://agu.confex.com/agu/fm16/meetingapp.cgi/Paper/139793>.
2. Johnson, H.L., Münchow, A., Falkner, K.K., and Melling, H., 2011, Ocean circulation and properties in Petermann Fjord, Greenland: Journal of Geophysical Research: Oceans, v. 116, p. 1–18, doi: 10.1029/2010JC006519.
3. Mayer, L.A., Jakobsson, M., Mix, A.C., Heffron, E., Jerram, K., Hogan, K., and Münchow, A., 2016, Towards the Complete Characterization of Marine-Terminating Glacier Outlet Systems, in 2016 Fall Meeting, American Geological Society (AGU), San Francisco, CA, <https://agu.confex.com/agu/fm16/meetingapp.cgi/Paper/174118>.

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## Preliminary Results

**Distribution (Fig. 10):** There appears to be a pattern of SL presence along the eastern side of Hall Basin and the main fjord, and a pattern of absence along the western edge of Hall Basin. Central Hall Basin appears to be more complex.

**Vertical Distribution (Fig 11):** Vertical distribution at intersections generally followed the same depth pattern found in the initial investigation of CTD locations (Fig. 4). The vertical distribution using all of the geopicked information needs to be evaluated.

### Temporal Vertical Stability (Fig 11, table below):

15 intersections that occurred near the times of highest and lowest light (within 2.5 hours of local solar noon, 16:30 – 16:40 UTC, and local solar midnight, 04:30 – 04:40 UTC) were evaluated for temporal stability and any patterns of diel SL migration. Results regarding vertical stability and migration were inconclusive (see table below) with the SL going up, down, or staying the same with no obvious pattern. More intersections need to be analyzed.

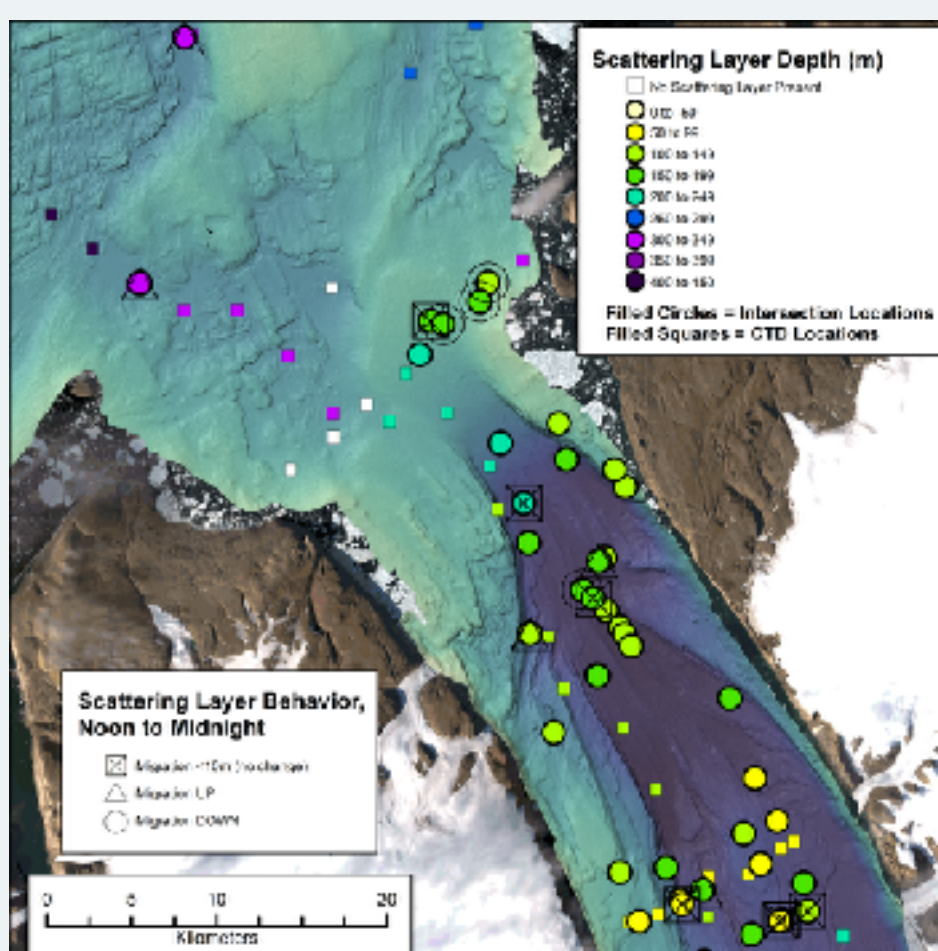


Fig. 11: Vertical distribution.

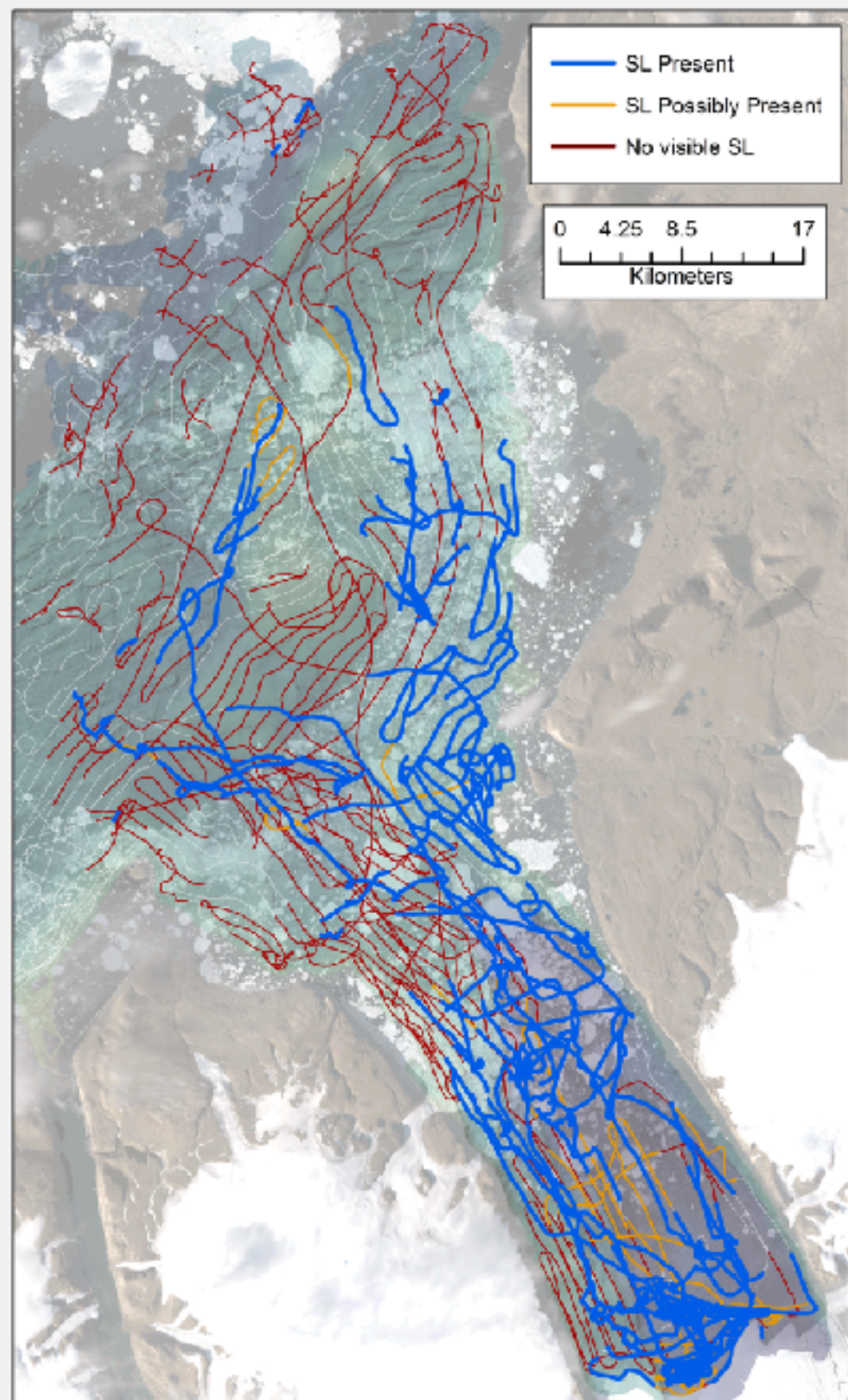


Fig. 10: Presence of SL in individual EK80 lines of data.

Near Solar Noon (~16:30 - 16:40)	~ 12 Hours Later	
		<b>Migration UP:</b> The top of the SL moved higher in the water column between solar noon and midnight at 5 of the 15 intersections. This is the expected behavior for organisms that undergo diel migration. Change varied from 16 - 89 m. The most dramatic variation, 89 m, is shown to the left.
		<b>Migration DOWN:</b> The top of the SL moved deeper between solar noon and midnight at 4 of the 15 intersections. Change varied from 14 - 65 m. The most dramatic variation, 65 m, is shown to the left.
		<b>Little change:</b> The top of the SL moved up or down less than 10 m at 6 of the 15 locations. The images on left show a downward change of 2 m between noon and midnight.

## Questions

**At this point in our project, we may have more questions than answers:**

- What is the observed SL really made up of? Can investigating the frequency response of the SL provide some insight?
- What is the significance of the SL disappearing on a given day in locations where it has otherwise been consistently present?
- What is the natural variability in the depth of the SL? What level of vertical change should we consider significant?