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# Clarifying the marine limit in Northern Spitsbergen and its implications for coastal lake archives

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ARISING FROM: A. G. Auer et al. *Communications Earth & Environment* https://doi.org/10.1038/s43247-025-02064-z (2025)

Auer et al.[1] suggest that the NE Spitsbergen ice cap, Åsgardfonna, drained melt-water directly into Lake Berglivatnet throughout the entire Holocene. Previously, similar-looking loss on ignition curves and age-depth models from Svalbard lakes have been interpreted to suggest ice-free Middle Holocene catchments[2], in contrast, the end-member (grain size) modelling suggests otherwise[1]. Ice cap persistence does, however, agree with recent works which also concluded (through different means) that the southern portion of Åsgardfonna survived the Holocene thermal maximum[3,4]. The manuscript[1] presents intriguing data and it will be exciting to see how the end-member-modelling approach would provide more detail to a classical Svalbard Holocene lake record, like Linnévatnet[5]. However, Berglivatnet was a marine basin following deglaciation. Through subsequent glacio-isostatic emergence, the catchment was isolated into the present-day freshwater lake. The actual regional marine limit (ML) around Berglivatnet (which is understated in the text[1]) has direct implications for sedimentation within the lake as well as how one should interpret the record. This comment proposes that the post-glacial ML exceeded the 46 m a.s.l. basin elevation, supported by both regional sea-level literature and prominent local geomorphological signatures (including landforms and sediments deposited within the catchment). The (isolation) basin's marine influence provides another (unaccounted) source of fine-grained sediments within the catchment, resulting in a more complex sedimentary history within the lake then previously interpreted.

The manuscript[1] states that both investigated lake basins (Berglivatnet, 46 m a.s.l. and Lakssjøen, 74 m a.s.l.) are located above the post-glacial ML exhibiting continuous, 14.5 ka BP records of lacustrine sedimentation. In the subsequent description of the regional post-glacial ML i) data from some literature is prudently selected, ii) other relevant literature is absent, and further iii) a ML elevation from another reference is inaccurately presented. The text implies excessive uncertainties (associated with the relative sea-level history) and the need for more work. This following section strives to reduce uncertainty with the regional ML, contrasting the description by Auer et al. with observations described within relevant literature on relative sea-level from the area.

1) The ML at Gråhuken (~42 m a.s.l., located ~29 km to the NW) is described, citing early sea-level work from the region[6]. However, the ML from the more proximal Mosselbukta (~65 m a.s.l., located ~22 km to the N) which is also presented in the same early study is omitted[6]. Furthermore, Gråhuken's location to the NW of Berglivatnet is also relevant, given MLs decrease from East to West across North Spitsbergen due to the configuration and load history of the former Svalbard Barents Sea Ice Sheet[7] (Fig. 1A).
2) Reference is made to the lake study of Femmilsjøen[8], located proximal to Vassfarbukta (~12 km north of Berglivatnet), in which the ML is not investigated, but suggested to be ~65 m a.s.l., like that of Mosselbukta[6]. However, the text[1] does not refer to a more recent investigation which presents a detailed map and sediment description from the Vassfarbukta region highlighting marine deposits located up to 72 m a.s.l.[9] (Fig. 1B; Fig. S1).
3) The text[1] inaccurately describes the ML in Flatøyradalen, stating its elevation at 39 m a.s.l (in reference to a whalebone found beneath a 45 m palaeoshoreline). The actual ML is approximately double that elevation, described as at least ~79 m a.s.l. (Fig. 2, 8 from ref. 4).

Investigations of past sea-level have long formed the backbone of our understanding of ice-sheet configuration and history[10,11]. The mapping of MLs—the highest shoreline or marine sediment deposit in a post-glacial environment—have guided palaeo-reconstructions, even prior to the development of radiocarbon dating the driftage deposits found within them[12]. Consequently, decades of detailed shoreline mapping in Svalbard have resulted in one of the greatest densities of post-glacial relative sea-level curves on Earth[2,11,12]. However, inherent uncertainties still exist within the investigations at the palaeo-sea level. Uncertainties can derive from (but are not limited to), 1) what material is dated[12], 2) the variable depositional elevations of driftage on the shoreface[12,13] and 3) relative elevation constraints (specifically the comparison between techniques; hand-leveling, to corrected/noncorrected geoid DEM data)[13–15]. To address uncertainty, sea-level index points are often presented with conservative error bars for field-sample elevations (ex. ±2 m). Furthermore, radiocarbon dates of driftage found within shorelines might tend to prioritise analysing material without a marine reservoir. Additionally, studies may pair ages where marine and terrestrial samples are found at the same elevation (in addition to presenting the 2-sigma uncertainty).

While the highest dated shoreline could potentially be the ML, unfortunately, this is often not the case. This (dated) altitude is generally

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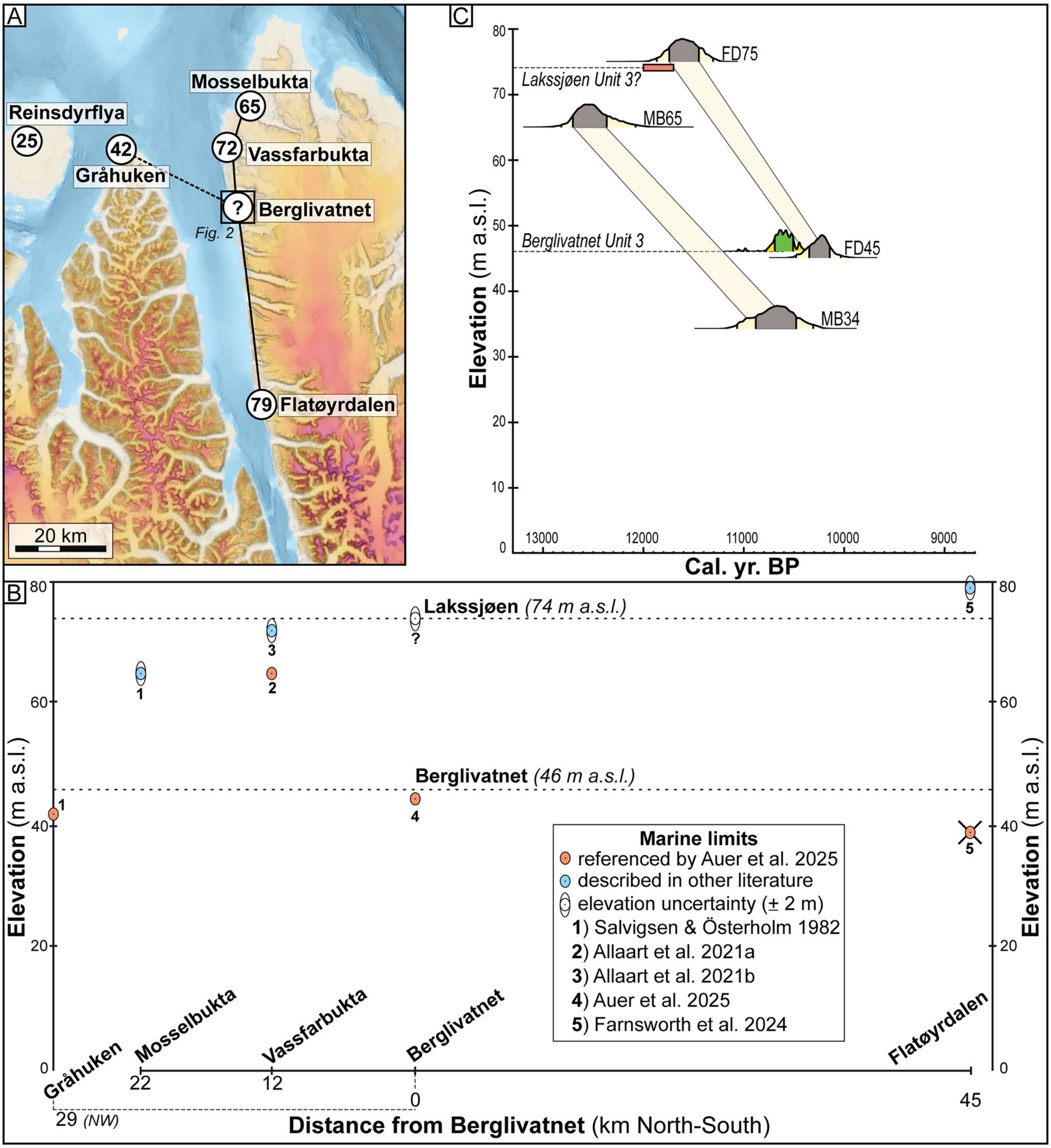


**Fig. 1 | Overview of marine limit elevations from Northern Spitsbergen.** Marine limits from North-central Spitsbergen, **A** circles mark sites described from literature with the corresponding local marine limit elevation (ML; m a.s.l.) Gråhuken and Mosselbukta[6]; Vassfarbukta[9]; Berglivatnet[1]; Flatøyrdalen[4]; Reinsdyrflya[11,18]. On the north coast of Spitsbergen, MLs decrease from East-West. **B** The elevation of MLs compared to the distance along Wijdefjorden (from Berglivatnet) and over to Gråhuken. Note, MLs from Wijdefjorden exhibit increasing elevation in-fjord (blue). Map and elevations derived from TopoSvalbard (courtesy of the Norwegian Polar Institute)[17]. Inaccurate reference to ML in Flatøyrdalen depicted with cross. Projections of land emergence through time, connecting the 95th percentile of recalibrated sea-level index points described from Mosselbukta (MB; at 65 and 34 m a.s.l.)[6] and Flatøyrdalen (FD; at 75 and 45 m a.s.l.)[4]. **C** The approximate age of Unit 3 from Berglivatnet (green histogram; 46 m a.s.l.) plots between the two emergence curves.

located below the true ML—leaving an unknown age for the earliest and uppermost marine shoreline. However, one useful approach is the collection of sediments from isolation basins[10]. These are lakes that were at one point submerged beneath the ocean (in a marine/brackish environment) and through glacio-isostatic adjustment have emerged from the sea, transforming (or isolating) into freshwater basins, e.g. ref. 15. Sediment archives which capture isolation sequences (for a given threshold elevation), relate to the geomorphological imprint of shoreline emergence on the landscape (at the same elevation). Marine sedimentation directly influences an isolation basin prior to, and during the isolation from the sea[8,14,15]. Furthermore, raised marine deposits (within an isolation basin catchment) like other post-glacial minerogenic material, can constitute unconsolidated fine-grained sediments susceptible to non-glacial erosion and redeposition within the basin long after the emergence from the marine environment[16].

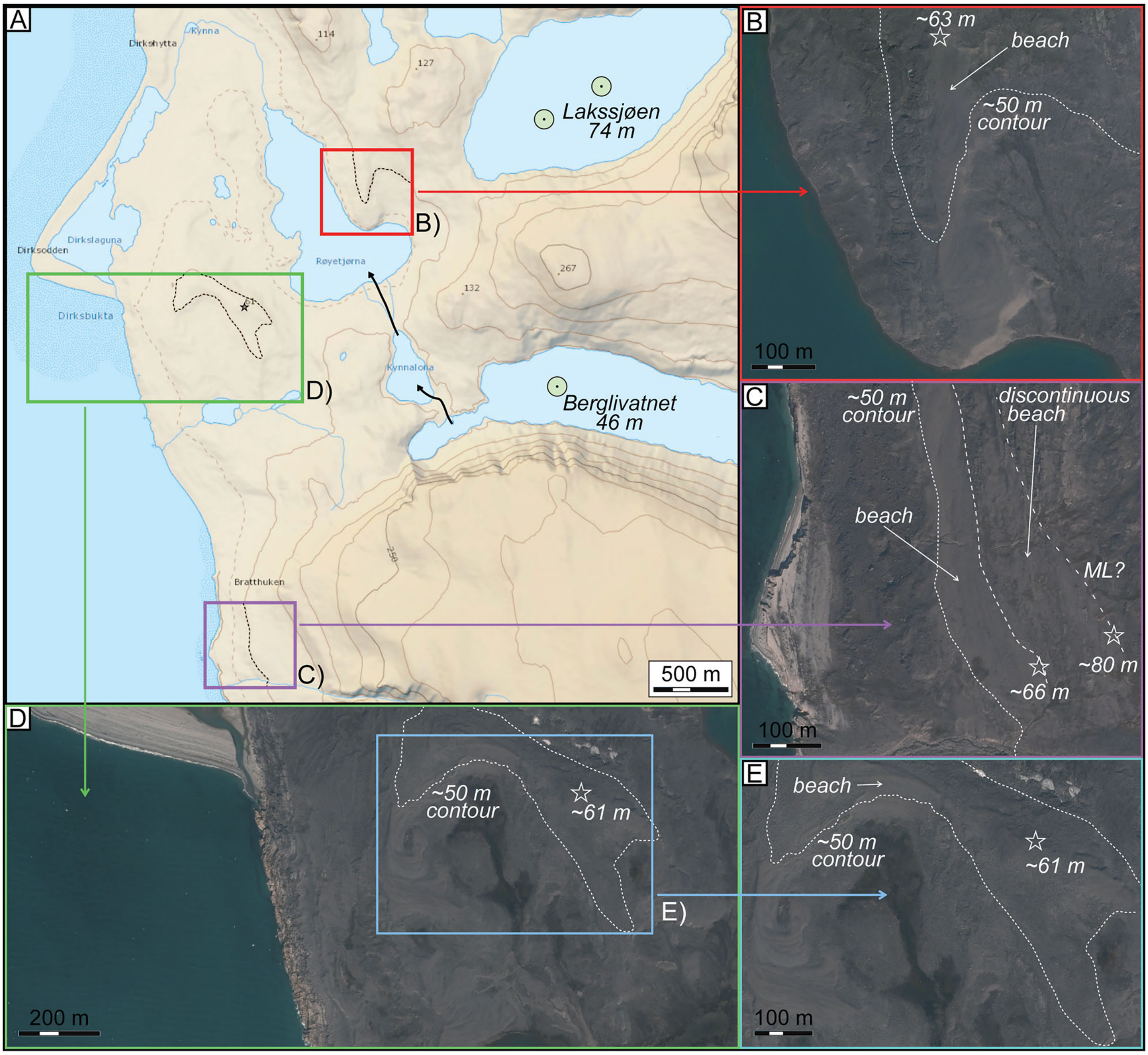


**Fig. 2 | Raised marine sediments and landforms deposited above the Berglivatnet basin elevation.** Topographic map and imagery showing terrain between Wijdefjorden and the Berglivatnet lake basin. **A** Black arrows indicate the outlet of Berglivatnet (46 m a.s.l.). Note, the basin is located beneath the 50 m contour line (lowermost solid contour). Inset boxes (**B**, **C**, and **D**) mark locations of aerial imagery where raised beach sediments are visible. The 50 m contour line (dashed-bold) is highlighted. Box **E** is an inset to image **D**. Stars mark the approximate location and elevation (±2 m) of the uppermost raised beach in each inset. Inset (**C**) shows discontinuous beach sediments extending up to ~80 m a.s.l. potentially reflecting the regional marine limit. Circles mark core sites from Auer et al. Imagery from TopoSvalbard, courtesy of the Norwegian Polar Institute[17].

While Berglivatnet is not interpreted as an isolation basin[1], nor has a precise sea-level investigation been conducted in the area, it is interesting to see how the age of Unit 3 relates to the regional sea-level (Fig. 1C). The sea-level history for Berglivatnet should in theory fall temporally between records located to the north (Mosselbukta) and the south (Flatøyrdalen), given the time transgressive deglaciation (and subsequent land emergence)[2,4,8,9]. Plotting recalibrated ages from marine limiting indicators described from both these sites provides an estimate of the regional emergence history[4,6] (Table S1). The approximate age of Unit 3 from Berglivatnet (green histogram; 46 m a.s.l.) plots between the two emergence curves, as one would expect from an isolation basin located between the two sites (Fig. 1C). Given the (undated) lower bound of Unit 3 from Lakssjøen (74 m a.s.l.) is the result of a similar isolation sequence, sea-level projections indicate an approximate age of 11,850 ± 100 years. BP for a ~74 m shoreline in the region (Fig. 1C).

Geomorphic evidence of the post-glacial sea-level exceeding the elevation of Berglivatnet is visible within the lake catchment. Sediment deposits interpreted as raised beaches are remotely identified in the region between Berglivatnet and the modern coast of Wijdefjorden (Fig. 2; TopoSvalbard[17]). Continuous, preserved beach-ridge landforms can be mapped, extending over 60 m a.s.l. in numerous locations (Fig. 2B–E). Furthermore, discontinuous marine sediments could potentially extend up to an ~80 m a.s.l. ML (Fig. 2C). This remote mapping would of course be further strengthened by field investigation and ground truthing. However, the raised beaches clearly extend over the 50 m contour, while Berglivatnet is located beneath the contour at ~46 m a.s.l (Fig. 2).

Given the actual regional ML described from sea-level literature[4,6,9] (Fig. 1) and the geomorphic evidence of raised shorelines extending above the Berglivatnet lake elevation (Fig. 2), it is here proposed that the lake basin is located beneath the regional post-glacial ML. This evidence contributes to a simpler explanation for the formation of Unit 3: most likely resulting from the glacio-isostatic isolation of a marine/brackish basin (containing terrestrial organic material) during Early Holocene emergence, instead of neotectonic seismicity or a palaeo-glacial lake-outburst flood as discussed[1]. Furthermore, given Unit 3 is interpreted in both Berglivatnet and Lakssjøen, these records may provide evidence that the ML exceeded 74 m in this region.

A stratigraphic sequence that transitions from a marine (to brackish) to freshwater environment may not influence the results of grain-size modelling, although it should have an impact on how one interprets the stratigraphic record. The marine influence on the isolation basin introduces an unaccounted source of fine-grained sediments. What was believed to be a simple catchment, with accumulation primarily governed by glacial sedimentation is in fact a more complex system with a variety of sedimentary sources and processes. Ultimately, this highlights the critical importance of gaining a holistic geomorphological understanding of a lake catchment to accurately interpret the sedimentary record and robustly reconstruct catchment processes. In addition to catchment mapping[16], investigations of lake basins below (or proximal to) the regional post-glacial marine limit should employ proper foraminiferal, diatom and/or plant macrofossil surveys (e.g. ref. 15)—especially if reinterpreting the regional sea-level history.

## Data availability

Data sharing not applicable to this article as no datasets were generated or analysed during the current study beyond what is presented in the supplementary section.

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## Competing interests

The author declares no competing interests.

## Additional information

**Supplementary information** The online version contains supplementary material available at https://doi.org/10.1038/s43247-025-02640-3.

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