Geol 393

Reading the landscape of northern Lingít Aaní

Parts III Tantrums & IV Appendices

Cathy Connor & Richard Carstensen

September, 2022 • updates 2026

Contents

Cover: Oblique aerial from USGS Landslide Hazards Program. Taken 3 days after the Great Wave of '25, described below in my notes for 20250810

III Nature's tantrums

Preface 2025:

Chopping up the course manual Ever since wrapping up (sort of) the memorable 2022 Landforms class with Cathy Connor, I've intended to post the full course manual to *JuneauNature*. As with most projects of mine, however, it behaves a lot like bread dough. When do you punch it down the 'final' time?

In this case, the dough has swelled beyond capacity of a single breadpan, and we'll have to divide it. *JuneauNature* currently has a threshold size of 25mb. After optimizing, I think I'll be able to keep the first loaf (Parts I & II) and this second one (Parts III & IV) under that size. Another piece, *Stereopairs*, was originally part of *Appendices* but makes a logical third standalone.

Dig in or dodge? Radiolab's Nov-4 2022 podcast has an engaging presentation of the philosophy of climatic -&-gravity-inspired tantrums and our two-legged relationship to them. It's titled The Weather Report, and is one way to step back, however ephemerally, from our residential and proprietary biases. For questions of risk, insurance, stay-or-go, etc, drag slider to ~30 minutes. [1]

Took awhile, after 2022, for this part of the *Landforms* guide to take shape. The bizarrely-timed flying tree who crunched Terry Schwartz's house, and the Beach Road slide before it, were just a few precursors to what now—3 years later—feels like an escalating series of Southeast cataclysms. I started a page on *JuneauNature* called *Dodging nature's tantrums*, and began a tradition of putting other stuff on hold each time something unanticipated '*comes down*,' here and in a few other hotspots across the archipelago, to create a little scoping document.

Down being the operative word. They're all 'gravity events:' avalanches, mudslides, rock detachments and jökulhlaups. Each draft is dated, below, as separate chapter in this new *Section III*. First one, I admit, could be stretching the term 'tantrum' a bit. Seaforms like plow-furrows are massive legacies of something slower and more ancient. But they're undeniably embued with attention-getting gravitas. *And might some of them actually be 'tsunami-stutters,' not moraines?!*

In geomorphically stabler corners of the world, we think landforms are slowly, iteratively evolved. But some are created instantaneously. Witnessing those pulses with students and friends has been one of the illuminating, scary privileges of *Geo-393*.

Format of dated entries in *Part III Tantrums* was at first similar to *Part II Journals—ie*, organized chronologically rather than thematically, only difference being lack of boots on the ground. With exception of some Valley outburst assessments, my ponderings have been computer-based and site-unseen.

Then, on 20260413, we had a Great Wave zoom session at Koren's, convening local & distant expertise to wrestle with the North S'awdáan Fiord (Tracy Arm) mountainside detatchment. So that this document might serve as a sort of 'minutes' to that ongoing discussion, I'm moving sections on GLOF, Wrangell, Mudslide Apartments, etc, still farther back, to *V Miscellaneous tantrums*.

1 20260406: Another model we might look to for 'dodging' options is a piece in the spring issue of *Sierra*. At Warren, Rhode Island, they're debating (and denying!) a plan for staged buyouts, and "managed retreat" in response to sealevel rise.

Place-name rematriation at S'awdáan

Most archipelago residents could quickly find Tracy Arm on a map. That's depressing—not that the narrow glacial fiord is undeserving—but because Benjamin Tracy was not a nice guy. He commanded the Elmira, NY POW concentration camp, a cess-pool housing 10,000 confederate soldiers, where 25% died. My mother's father's father's father Malcolm McDonald was one of the lucky 75% (not that he deserved a fiord-name either). [1]

The cultural atlas (Thornton & Martin, eds, 2012; T&M12) has no Lingit place name for Tracy Arm. On a 2015 Goldbelt Heritage cruise, I asked Kingeistí, David Katzeek, what we should call it. He suggested Sít'ja.eeti aaní, *handiwork of the glacier*. If you're sheepish about pronouncing that, but want to honor poetic indigeneity, try just calling it Handiwork Fiord.

But here's a simpler idea. Consider, first, that only 3 names are mapped nearby by T&M12, and that the map-dots and translations are spatially & semantically ambiguous: **1) Sít'ḵú**, *glacier area* (Holkham B) **2) Kéet Noowú**, orca fort (Wood Spit) **3) S'awdáan**, *dungie grounds* (Sumdum—anglo corruption).

1 Later, Secretary Tracy terrorized 3rd world countries across the globe, as father of the "2-ocean navy." ● William Endicott was Secretary of War. ● *202604022:* South S'awdáan (Dawes) Glacier was named for Henry Dawes (1816–1903). C&I, watching a documentary on Sitting Bull, just learned that the Dawes Act of 1877 broke up communal tribal lands into individual plots, forcing agriculture upon the plains people. I guess you had to be really mean to earn a fiord or glacier in the late 1800s.

While David's nomination is undeniably artful, more rememberable & pronouncable names for ~~Tracy~~ & ~~Dawes~~ are simply North S'awdáan & South S'awdáan. [2]

2 Dots in T&M12 were placed by a non-Alaskan cartographer and are often offset. I've corrected them in my personal GIS.

1) Sít'ḵú (a pretty generic name, repeated in several more places throughout Língít Aaní—perhaps by elders loathe to share glacial power-names with white anthropologists) should probably be applied to the paired Tracy-Endicott fiords/Holkham Bay complex.

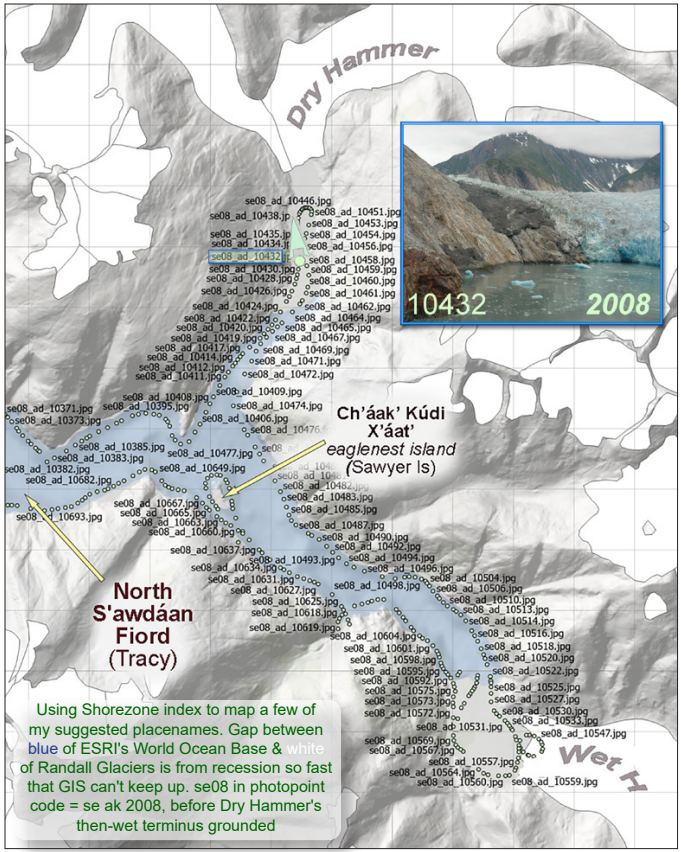
2) Forts were placed in defense of living sites, In English, "*Wood Spit*" is a rare example of an actual placebased non-commemorative. Mansfield in 1889 said it was "*wooded*." More typically, Orth explained that such labels honored some dude named Wood.

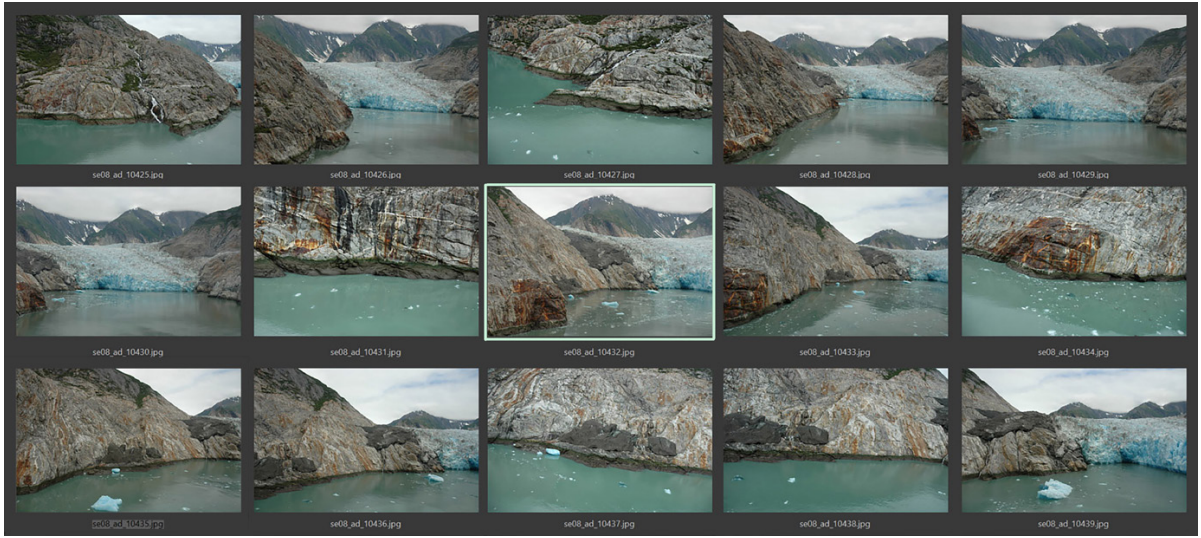
3) S'awdáan referenced a central village of S'awdáan Ḵwáan. T&M12's map-dot misplaces it—actually on larger baymouth spit, ~5 miles NW. Definition by T&M12 is "*Dungeness Crab Grounds*." But not all agree.

Kooshdáak'u, Bill Fawcett, Lukaax̱.ádi, fished here as a young man. He told me (on the same GHF voyage when David Katzeek proposed Sít'ja.eeti aaní) that the crab translation is wrong. S'awdáan Ḵwáan, said Bill, are "*people of the green water*."

X̱'unei's dictionary (and Lance, like Bill, is Lukaax̱.ádi), gives alternate translations: "*people of the greenstone area*", vs *"people of the dungeness crab area*." Since the word for dungies is spelled differently—s'áaw—i'm inclined toward Kooshdáak'u's translation.

As for green**stone** vs green **water**, the former is a rather loose geologist's term for assorted green-hued metamorphics. Some cultures did use "greenstone" for hardrock carvings, but whether 19th-century Tlingit adopted the term—from Sumdum miners perhaps?—may be lost to history. Again, Bill's translation, *green water,* rings truer. Check out fiord color, inset, & on following pageflipper orthos.





Shorezone covered the entire shoreline of Lingít Aaní between 2004 & 2010. Here's their 2008 obliques from head of Dry Hammer Fiord on my personal drive. Flight index, previous page.

You can access these singly from NOAA's map-based portal. Uncheck everything but *Still photos*. If you have fast internet and don't use Shorezone a lot, this may work for you.

But I'm an obsessive cartographic storyteller, instantly addicted to the power of this now-"*historical* [1] " collection. On completion, Steve Lewis at NOAA loaded a drive for me with the entire half-terrabyte collection. (video also shot but low-res) Happy to loan this drive. I use it on nearly every project that includes coastline—as most do in this watery northern homeland.

In Shorezone I virtually 'flew' all of North & South S'awdáan Fiords, scanning forests for clues to successional status, especially near my proposed Little Ice Age termini, interpreted mostly from new submarine imaging—also thanks to NOAA—called BAG (Bathymetric Attributed Grid).

Above gentler beaches, Shorezone clearly shows whether forests are old- or young-growth (beyond or within the LIA advance). But here in Lingít Aaní's 'drowned Yosemite' you can virtually 'fly' for a clueless quarter mile past forest-excluding cliffs. That makes the near-100% coverage of Shorezone all the more valuable.

Setting aside disagreement over what S'awdáan (Sumdum) actually means, we can probably agree that an entire Kwáan ***took this name from these waters***. Seems to me the best way to 'fix' a recognition of the geography of the '*crab&seal people*' for future generations is to rematriate this name for the trunk and limbs of their territory.

Okay, up-fiord, consider its forking, volatile headwaters. Orth (1967) is mute on Sawyer (a UWGN: unimportant whiteguy), only that Mansfield named the glacier (singular!) in 1889. My icelines show north & south tribs merged then, no need for separate names.

North S'awdáan (Tracy) is a crooked rifle-barrel. Considering its repeated firings by glacial advance and great waves—these forking trib-valleys would house the firing pins, or harking to prior technologies, the cocked hammers. Since N&S are already applied to the forking main arms—North and South S'awdáan Fiords—let's call the fiord-head glaciers Dry Hammer & Wet Hammer.

An **eagle** nest on ~~Sawyer~~ Island was tagged & mapped by Mike Jacobsen, FWS, in 1985. The Great Wave of '25 scalped almost all but one lucky spruce, and probably nests went with them. But let's commemorate eagle reproduction with Ch'áak' Kúdi X'áat', *eaglenest island*.

1 No joke! Historical! Because we have the photopoint index it should be easy to load xyz's to drone for selective repeat photography.

Carried over from companion document *geo393.pdf*—essential intro to the rather infantile discipline of NW-coast submarine geomorphology, central to our concerns over 'gravity events' both slow & fast.

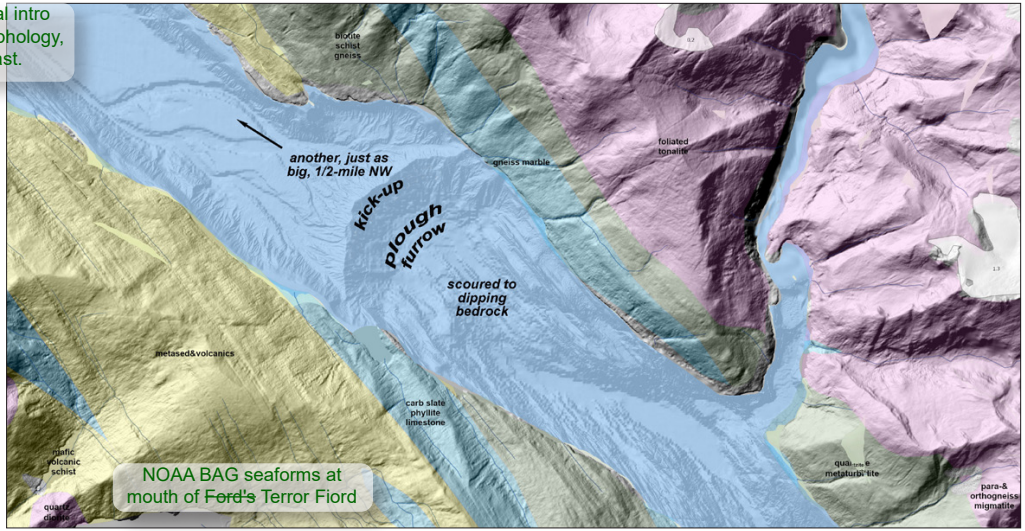
Seaforms

In my surf-geo map keys I typically divide features into 'ancient' (mostly early Holocene) and 'recent' (mostly LIA-to-present). A review of marine landforms is on pages 19-20 of Carstensen & Connor (2013).

Marine landforms exist of course ***below*** today's sea level as well as—thanks to rebound—*above* it. Maybe we should call the submerged ones "seaforms?" [1] Never until this course have I paid much attention to em, cept when bouncing clench-fisted over The Bar at mouth of Sít' Eeti Geeyí, *bay replacing glacier* (Glacier Bay). As local mariners know, those wave-generating shoals were dumped at Little Ice Age max-extension of the bay-filling glacier, a submarine terminal moraine.

But are those drowned glacial features simply watery replicas of their exposed counterparts? Perusing some extraordinary new bathymetric hillshades, I'm beginning to think not. I've introduced the question under *Glacial landforms,* in *1geo393.pdf*, but much about their formation appears to be marine.

In preparation for the S'awdáan (Holkham) cruise, 20220911, for which I was regrettably sick and absent, I began to explore bathymetry, discovering that the bay-mouth moraines are shaped differently from



those—mostly recent LIA—that form on land. Then, at course's end, ranging more widely over the archipelago in *World_Ocean_Base,* and *NOAA-BAG* rasters, I noticed these features weren't restricted to the S'awdáan area but occurred in other heavily glaciated mainland fiords and ***even some island bays*** (next page). This led to correspondence with landform-masters Streveler, Baichtal, Motyka and Cowan. And of course, any time you talk with those folks you end up spinning off into stuff you could never have anticipated.

Sea-truncated eskers at Shahéen, *head creek* (Shaheen Cr), down in Hinyaa Aaní (POW)?! An 800-foot-high submarine 'kickup' moraine from northwest-punching ice that re-emanated from Nass-River Tsimshian country in, maybe, Younger Dryas days?!

Wow! And this is just the low-hanging fruit, waiting to be plucked by anyone willing to learn the ABCs of digital cartography. Take that GIS class! You won't be sorry!

1 In geospeak, "subaerial" refers to actual landforms above sea-level, presumably to contrast with "submarine." But WTF?! Using "**sub**" to describe something **above**?! Subaerial is my nomination for most irritating-&-layperson-excluding science term of 2025. Below the air?! ***Paleeezzze!***

Actually, you don't even need GIS to start exploring the shape of submarine waters—only for performing more creative analysis, or to sculpt personalized visuals. Meanwhile, just log on to NOAA's Bathymetric Data Viewer, as described in more detail on next page. Every time I visit, I find a new area of the archipelago's been surveyed and added.

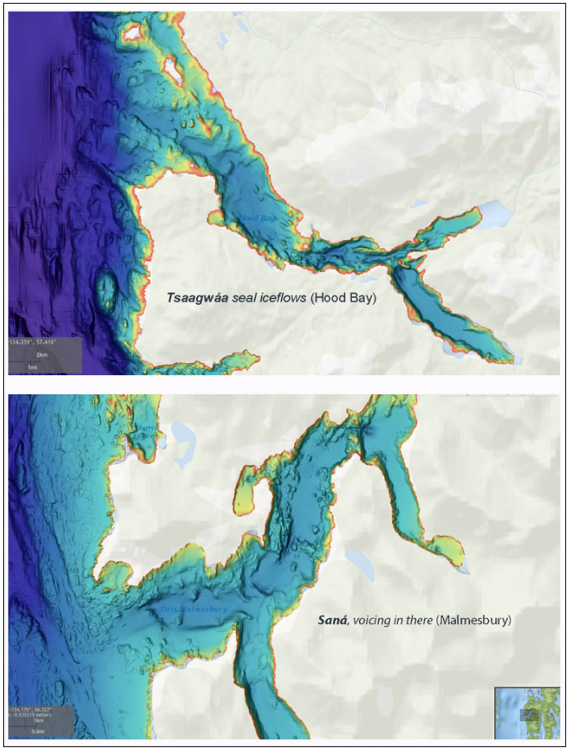
NOAA's new bathymetric hillshade called BAG gives unprecedented ability to visualize these surprisingly persistent underwater footprints. If they have a name I'm unaware of it, so am calling them 'plough-furrow-craters' and 'kick-ups,' in contrast to the less excavated push moraines that form on dry land. [1]

My best guess is these are 'Younger Dryas' moraines, 40 times older than Little Ice Age moraines—also largely submarine—at both fiord-heads. [2] If so, they're contemporaneous with a few submarine features in Chilkat country—possible Younger Dryas bars at Pyramid Island and baymouth at Dayeisáank'i, *Dayei little cove* (Taiyasanka Harbor). I know of few others this prominent in Lingít Aaní, and can find nothing published on them.

Younger Dryas(?)-era terminal and recessional 'plough-furrow' moraines occur not only on mainland but on ***islands of the Archipelago!*** Upper one's on Xutsnoowú, *bear-fort* (Admiralty) and the lower example is from Kooyú X'áat', *cavelike entrance island* (Kuiu). Screengrabs are from NOAA's Bathymetric Data Viewer. Check em out; you don't need GIS to zoom in and study these online.

PS 20221103: I've just learned from Roman Motyka that some consider baymouth moraines at S'awdáan to be early Neoglacial, perhaps ~3,000 yrs old. Such massive surges are unknown in Áak'w and northern-T'aaḵú Aaní where LIA advance exceeded (and obliterated) any prior Neoglacial moraines. But I can sort-of(?) imagine large, swollen transboundary icefields above S'awdáan, perhaps responding to differing precip/temp conditions, somehow pushing glaciers 18 miles downfiord. And 3 millennia—rather than the 3 centuries since LIA-max—*would be* long enough for development of scrubby cedar-hemlock old growth now cloaking S'awdáan's lower arms down to high tide line.

But similar baymouth moraines on islands that today barely have glaciers, let alone icefields, give me pause. Younger Dryas? Plausible. Early Neoglacial? On southern



Kuiu? Whew! Tougher sell. Veins (2001, p46) says CI dating shows ice-free highlands on Mitkof by 11kbp:

"There is no geologic or historical evidence to suggest that any cirque glacier existed on Crystal Mountain during the Holocene"

1 Tracks in sand of a running animal who suddenly stops leave what I call a 'kickup,' or raised mound along the leading edge. So, like these mystery furrows they're simultaneously erosional (the gouged foot-crater) and depositional (the frontal ridge)

ps: Cathy Pohl is not a fan of my "*plough-furrow*" analogy. She points out that a plough creates a sharp V in contrast to a glacier's U-shaped valley. And where a plough comes to a stop, you probably don't get this rounded-front effect.

2 I have no evidence for a ~13-12K YBP date, but use the term Younger Dryas merely as 'placeholder,' to indicate a prominent push moraine *way* farther out than LIA advances but way *less* than Great Ice Age termini, far out on the continental shelf. Ellen Cowan points out that we lack evidence for climatic conditions conducive to massive advances in our archipelago in YD times.

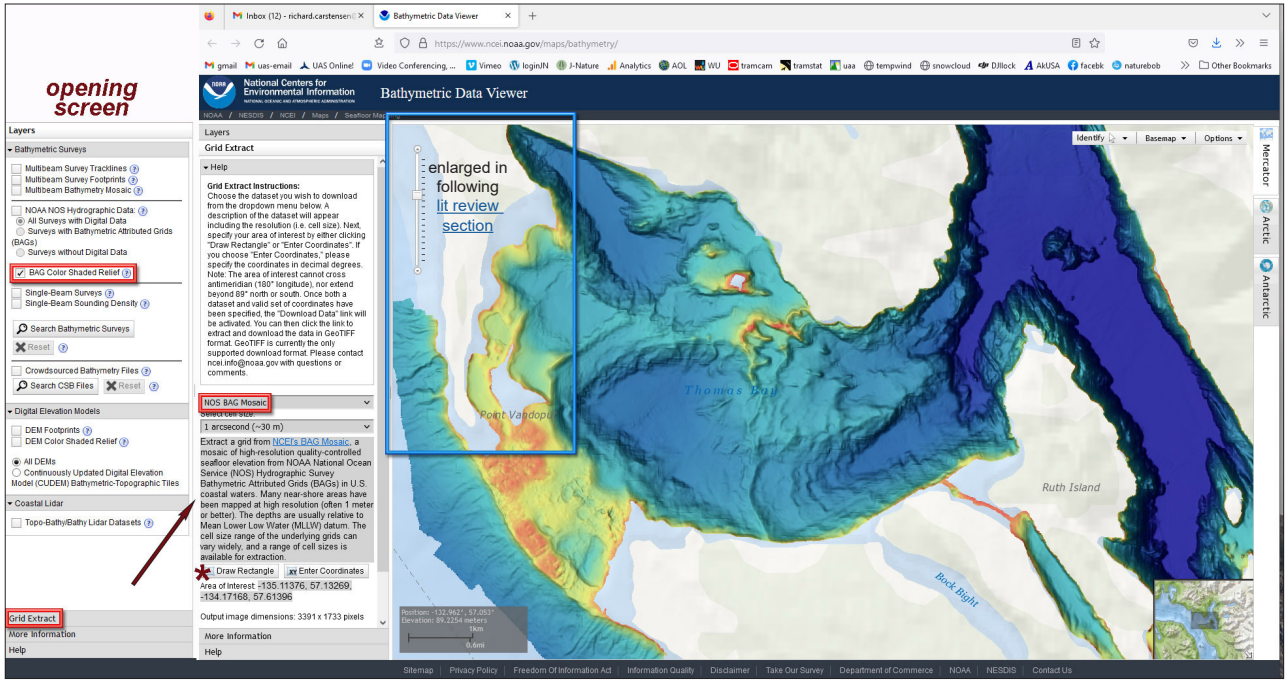
Instructions for BAG downloads

Thanks to Bruce Simonsen for explaining this rather convoluted process. In this example from Taalḵú, (Thomas Bay), the DEM is way higher res than WOB, and the BAGs (Bathymetric Attributed Grids) can be individually downloaded from NOAA's Bathymetric Data Viewer. Zoom in to your area of interest, then follow these steps, as shown on my screengrab:

- On opening TOC, uncheck everything but *BAG color-shaded-relief*
- click *Grid Extract* on bottom
- When new TOC opens, pulldown NOS BAG mosaic and default scale [1]
- Check *Draw Rectangle* and drag over desired area with your mouse.

The download screen will send a raster .tiff to your specified destination.

My current interest in BAG detail is sorting out ancient from recent terminal and recessional moraines (?), and understanding why they seem to be shaped so differently than moraines that form on land.



Taalḵú, *widemouth basket* (Thomas Bay) on NOAA's Bathymetric Data Viewer. Default color spectrum makes depth easy to recognise, and hillshade elucidates topographic subtleties invisible on simple sounding-charts, such as **'plough-furrows' and frontal 'kick-ups.'** I've selected this example to show that similar features at S'awdáan, *dungie town* (Holkham Bay) are not unique to that glaciated inlet. More frontal kick-ups are mapped and discussed in following journal entries.

1 just used default scale for the new tracy-BAG and it was really coarse. I zoomed in closer and chose 3m pixel. It's beautiful!

20230200 Plough furrows

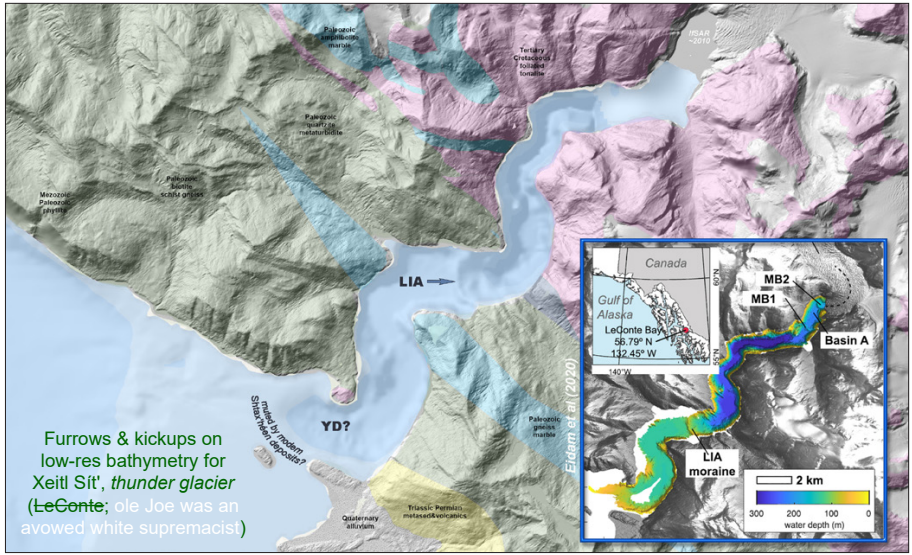
Pulling the class journal together, I sent out a query to our glacial historian friends on the subject of Little Ice Age (LIA) and much older advances, and the differences in their expression above-&-below modern sealevel. I included maps and speculation, especially on the question of 'plough furrows' and 'kickups.'

Roman Motyka sent me Eidam *et al* (2020), on which he is coauthor. Eidam's 2016 2m bottom raster is way sharper than this map from ESRI's *World_Ocean_Base*, comparable with NOAA-BAG, to which their multibeam echosounder survey hasn't been added. But even this coarse 40m-pixel model is good enough to show deep furrows noted elsewhere. The Eidam paper describes ongoing glacier dynamics in relation to morainal bars (MB) and deepwater behind that results from this ploughing. At Xeitl Sít', *thunder glacier* (~~LeConte~~) distance from LIA to a much older furrow at bay mouth is not so great as at S'awdáan.

Back home, Roman followed up with Viens (2001), also new to me, and called to compare observations of forest structure-&-age, and moraines of land & sea. His colleagues' work at S'awdáan entry—although much less work's been done here than at Xeitl Sít'—suggests early Neoglacial timing, compatible with my observations of old growth throughout lower Sit'kú.

Now I'm *really* wishing I hadn't been sick for the 20220913 cruise! Although Shorezone's 2008 obliques certainly help, to even better understand glacial flux through the mouth and upper fiords of S'awdáan, we need a series of high-res mid-zoom telephotos of forest structure along a transect from Sit'kú entry to calving glaciers. [1] Coring and groundtruthing is nice, but you can tell a lot from strategic boat-based photography, especially in the wonderful light that our students captured on their catamaran visit.

For starters, let's go back into some old journal notes, and scanned



35mm slides. On my ~~Ford's~~ Terror Fiord AK Disco visit in 1994 we got flown in to what C&I deemed the LIA-max-moraine fork-camp in 'The T' and picked up by Lynn Schooler near Sit'kú entry bars. My journal for 19940815 says that coming back out:

> *"Never saw TSHE (or any conifer but spruce) anywhere in Ford's Terror until just above narrows camp, where old growth suddenly begins, a scrubby forest of PISI, TSHE, TSME, CHNO and PICO. I was too focused on the tide to notice where they began, but it couldn't be far above the narrows."*

Okay, so I *wasn't* falsely remembering ancient trees, 17 miles upfiord from baymouth plough-furrows. CHNO is the pre-name-change genus-species code for yellow-cedar. On 0816 I even noted cedar dieback on NE side of Sit'kú near our last bay-entry camp, and it's picked up on Hennon's map of yellow-cedar mortality patches. [2]

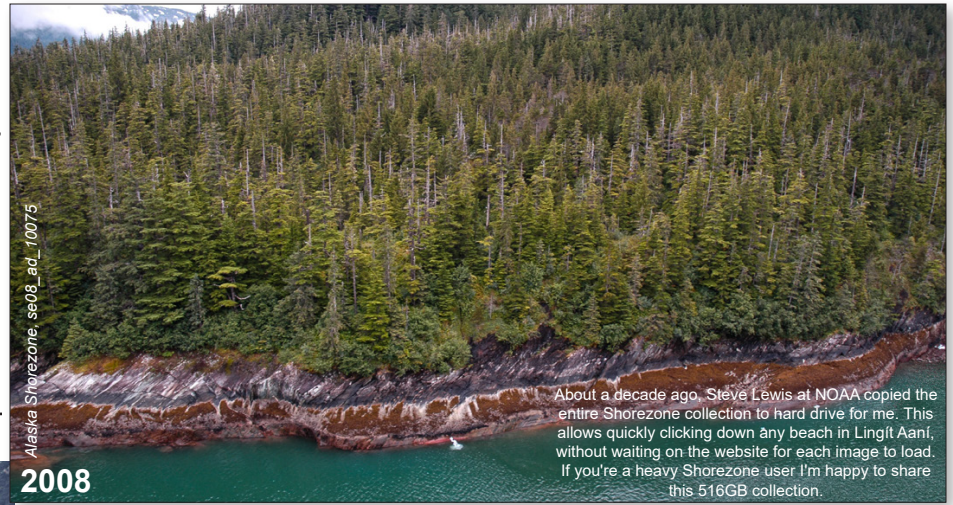
1 Still better would be tree coring under direction of Greg Wiles. Dendrochronology now uses way more sophisticated tools than just relative ringwidth.

2 We decided "*Indian Village (aban'd)*" on USGS topos was misplaced, belonging farther NW on the curving spit/moraine. There *is* a cabin near the ~~Powers~~-Creek site [*noTN?*], where Audrey Sutherland had an oft-recited bear encounter. But the S'awdáan were smarter village-siters. Later, in 2013, one of the students in *Why do we live here* selected this bar for her 'power-spot.' even tho we'd

In the evening light PISI, TSHE and CHNO showed in distinctively different colors, which I tried to shoot. The PISI seems mostly confined to a coastal belt, with TSHE on risers and CHNO on terraces."

This could *not* be country overwhelmed by LIA advance all the way to baymouth entry bars. My scanned 35mm slide below is coarse, but shows widespread, rather tall snags, indicative (like cedar dieback on right) of multigenerational old growth.

Checking the 2012 update to Hennon's yellow-cedar dieback map I noticed a patch just above the beach inside the point on this 2008 Shorezone oblique #075. This land would've been glaciated to at least 500 feet elevation when an ice-tongue pushed out to Harbor Island. Cedar snags in photo #075 are shorter than the ones in my 1994 photo. They hold slender, dead tops long after death, while spruce and hemlock snag-tops more quickly rot and collapse. Neither my medium-sized 1994 hemlock old growth, nor small-tree yellow-cedar



purposefully withheld the locations of actual villages. Her family was from Tlakw.áan, *eternal town* (Klukwan), and she didn't fear cold. WDWLH manual, page 27.

dieback could possibly be found inside Little Ice Age moraines.

But how far up-fiord can we trace this old growth? I suspect it ends rather suddenly, but can't yet say what, if true, that signifies. I've 'cruised' the entire north and south fiord walls with Alaska Shorezone, scanning forest texture on hundreds of obliques. Granted, they're cocked down, centered usually on low-tide line, but many zoom out enough to show coastal forest texture.

On left, next page, is Shorezone's 'threshold' image sz919, where hemlock old-growth gives way to mostly barren tonalite walls, with occasional spruce clinging to ledges. Track & photopoints are Virginia Crapo's, with brick-highlights for photos 5 & 6. Crapo-5 is directly north of sz919. Her annotated photos, like Shorezone's, show occasional stands of pure spruce for the next 6 or 8 miles, but no unimpeachable old growth.

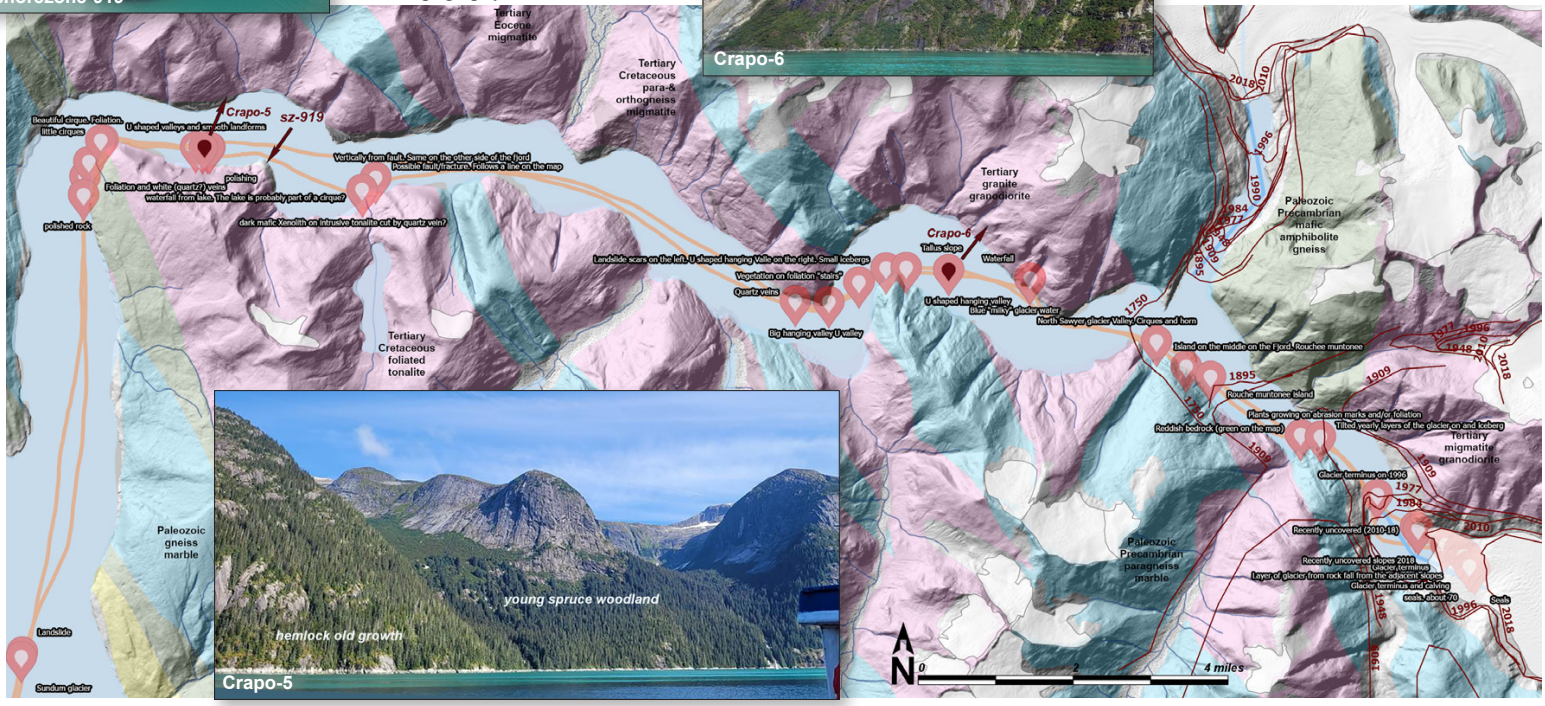
I admit that's hard to reconcile with my mapped Little Ice Age Maximum, around 11 miles up-fiord (east) of the apparent old-to-young forest transition. Sure, this fiord is Yosemite-steep, and granitic bedrock is not the happiest place for hemlock old growth. But on scattered benches and up relatively mellow side valleys, 11K years (Younger Dryas) or even just 3K years (Roman's early Neoglacial scenario) should've allowed

enough seed travel and soil development for scrubby ancient forest to scab-over glacial wounds of upper S'awdáan fiords.

Old-growth 'control' fiord OK then, could we find a 'control' with similar topography and bedrock, but

no suspected Little Ice Age or Neoglacial tidewater advances?

Yes, I think so. Gushká Tlein, *big lap* (Rudyerd Bay) in Sanyaa Aaní (Misty Fiords), 200 miles southwest, has no nearby transboundary icefield or even shrunken extant cirque glaciers. It's a



'banana-belt' expression in the same Coast Range batholith as our S'awdáan fiords to the northwest. [3]

We lack high-res bathymetry there, but don't need it to confirm presence of deep, outward-arching plough-furrow moraines and kickups. [4]

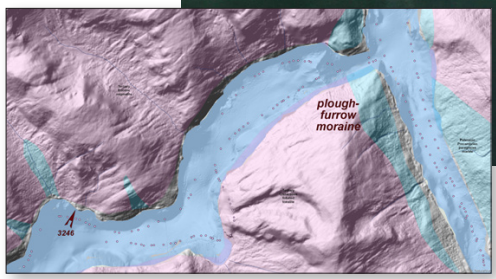
The **T** in Ǥushká Tlein, *big lap*, mapped here, results from CIS-max glacial exploitation of a NW-SE running band of weaker non-granitics (bluegreen)—a fine analog to same-aligned strips of Paleozoic paragneiss and marble reamed out by CIS precursors to North & South S'awdáan (Tracy & Dawes) Fiords. Forests on these baked metamorphics are structurally diverse and slightly more robust than on the pink-coded granitics. Shorezone has many lovely close-ups there, but for granite-to-granite consistency I chose #3246, on right.

Misty, turns out, has a *very* different forest than the adolescent-looking stands in geologically analogous upper S'awdáan fiords. Wow! Now I'm *really* curious!

Okay! In 2025, suddenly enabled by more BAG from southern mainland fiords, let's take a closer look at *big lap,* Ǥushká Tlein. While Viens *et al* have documented early Neoglacial moraines 3k-to-1kbp on arms radiating off Stikine Icefield (*ie*, pre-LIA), in these milder southern mainland mountains I can imagine no source for Neoglacial readvances.

So, comparing these *very* old furrow-&-kickup moraines to fresh ones at North & South S'awdáan, has there been erosion or softening of features?

Hardly! Some but not most LIA end moraines have radiating downbay distributaries—most exceptionally in the South S'awdáan inset. These slowly fade. But crests of even the oldest remain crisp, millennia later, probably due to large boulders



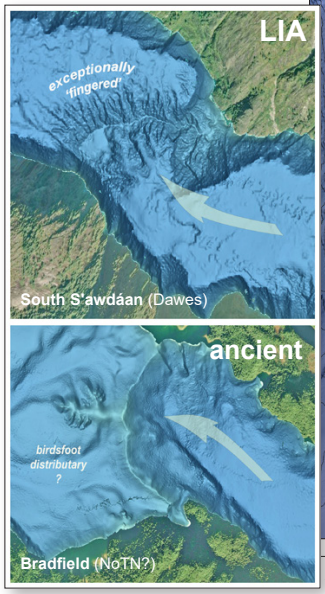
Above: Shouldn't North S'awdáan (Tracy), down-fiord from its Little Ice Age maximum advance, look like this, on all but steepest cliffs? In Ǥushká Tlein, *big lap* (Rudyerd Bay) no milky glacial sediment stains clear, sterile waters. Scrub-forest is ancient—structurally & floristically diverse. Slender snagtops indicate scattered yellowcedar dieback. ● **Left**: Even low-res bathymetry shows deep furrow moraines such as this one just below the **T**. As on our central islands this area experienced no strong Little Ice Age glacial expansion, and, probably (?) no early Neoglacial surges either. Across Lingít Aaní, which furrow moraines are early vs late Holocene?

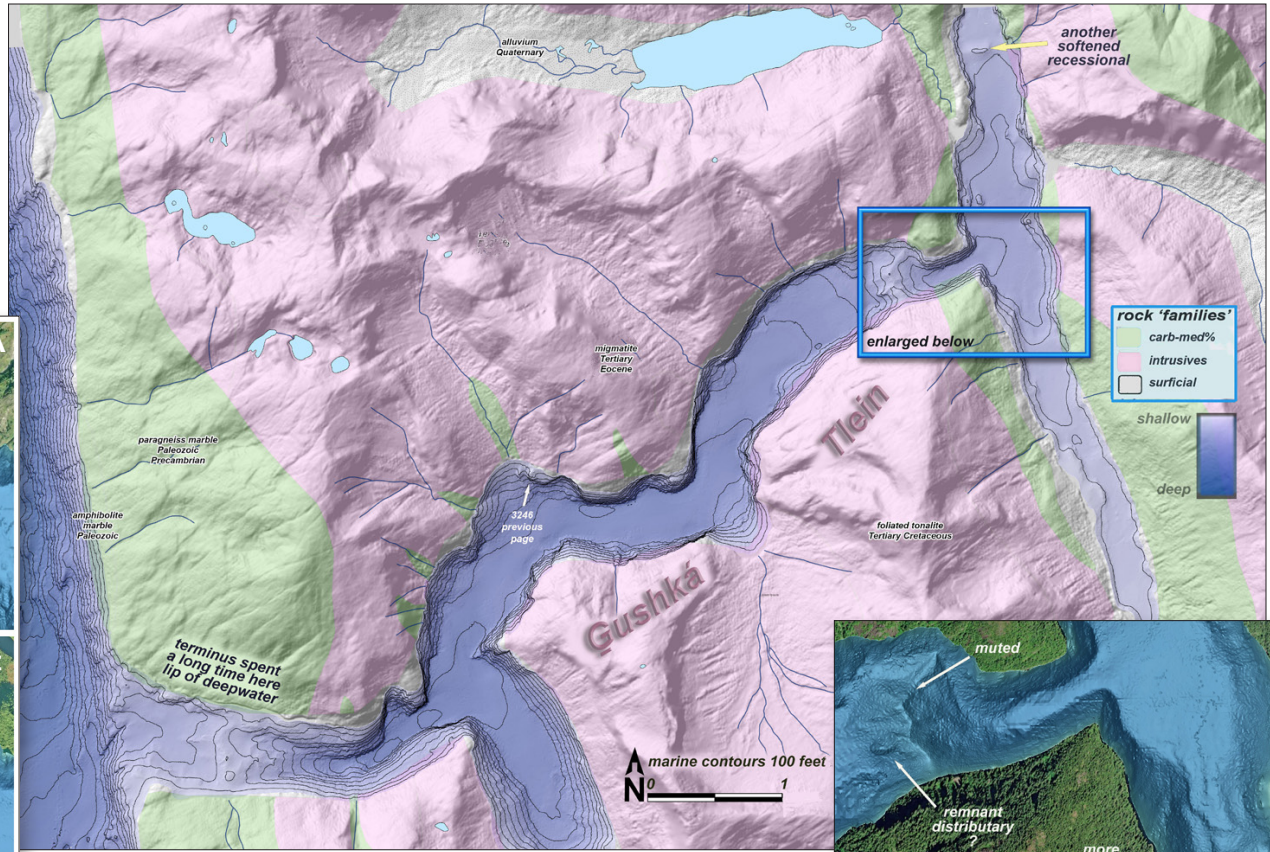
3 In both fiordal labyrinths, forests are stunted, largely unappealing to mills and fellers, who've therefore generously allowed us to keep these hungry scenery-farms (like Muir's beloved Yosemite) as "*protected*" Wildernesses. In reality, not much to protect them from, except selfie-seekers and their gallivanting enablers.

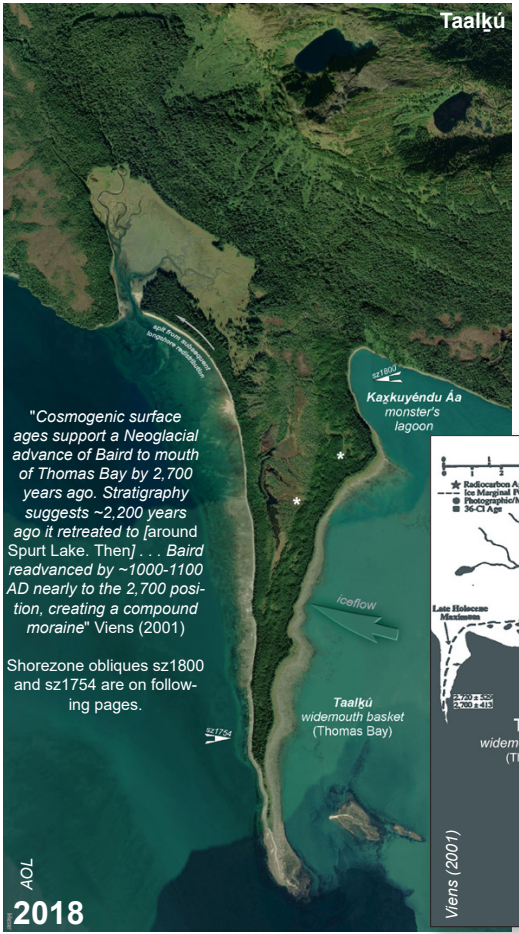
4 **2025** We since acquired BAG! Next page has example, but I'll keep this 'primative' bathymetry for historical amusement.

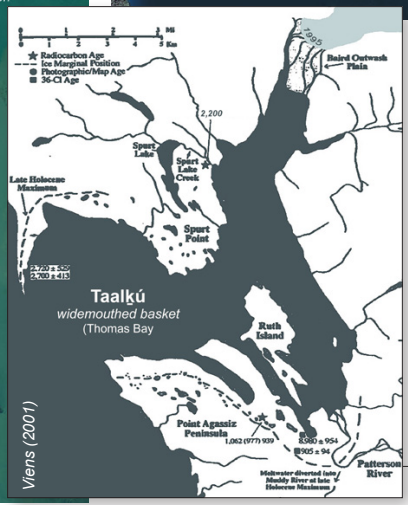
that water currents couldn't displace. Compare young (Dawes) to old (Bradfield) moraines in vignettes below.

On rightstide map I've changed my medium-carb rocks to green to better set off the pale-to-dark-blue water spectrum of increasing fiord depth.

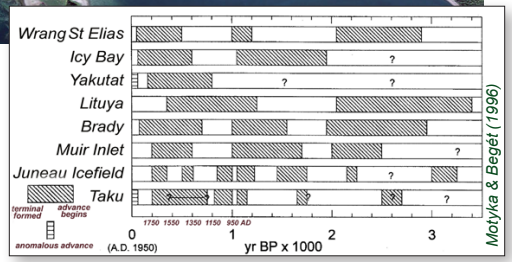








Early Neoglacial moraines, clockwise: Taalḵú • S'awdáan • Regions compared from Motyka & Begét (1996). No key in paper, so mine is best-guess. • Dates for Taalḵú from Viens (2001).



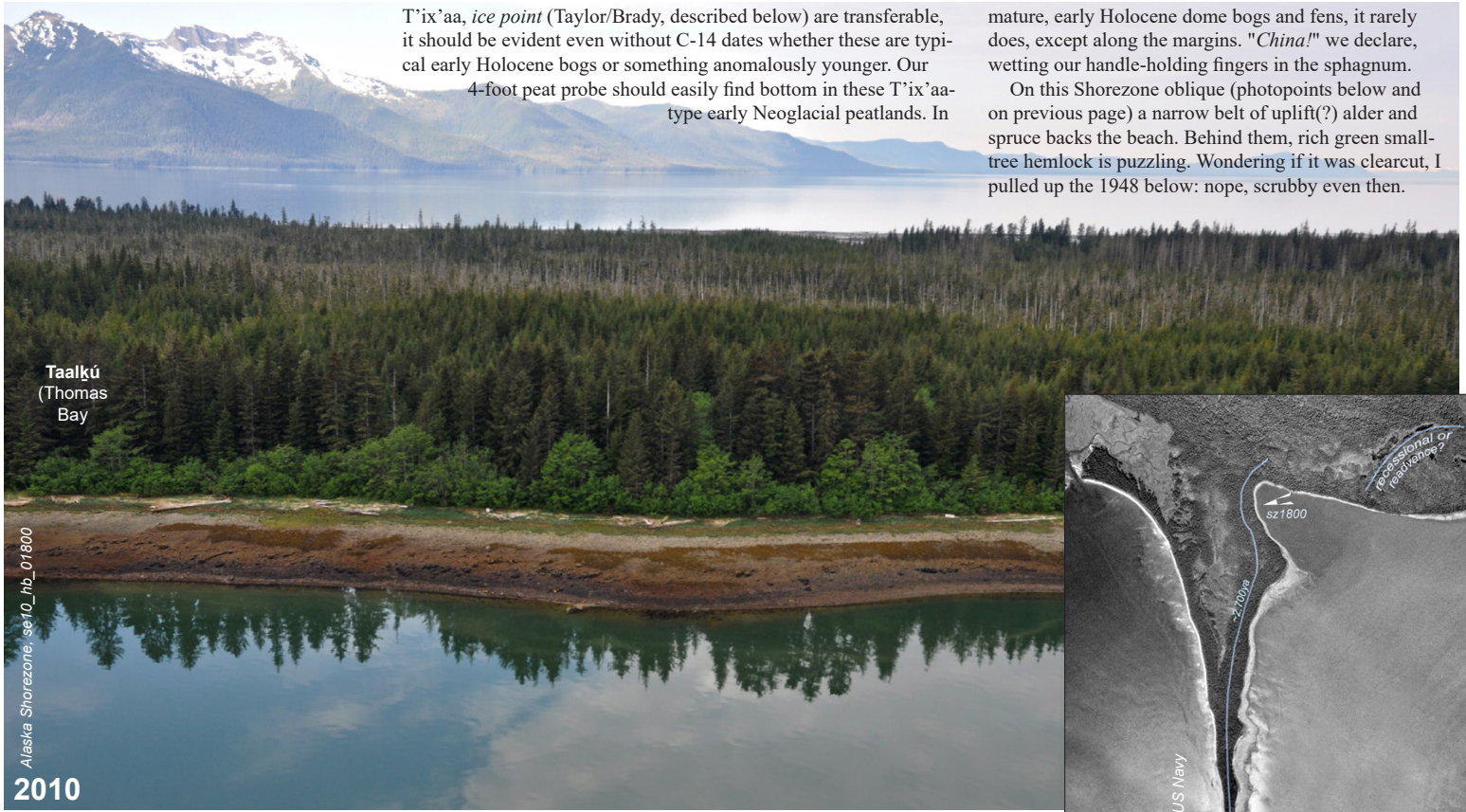
Age in the literature

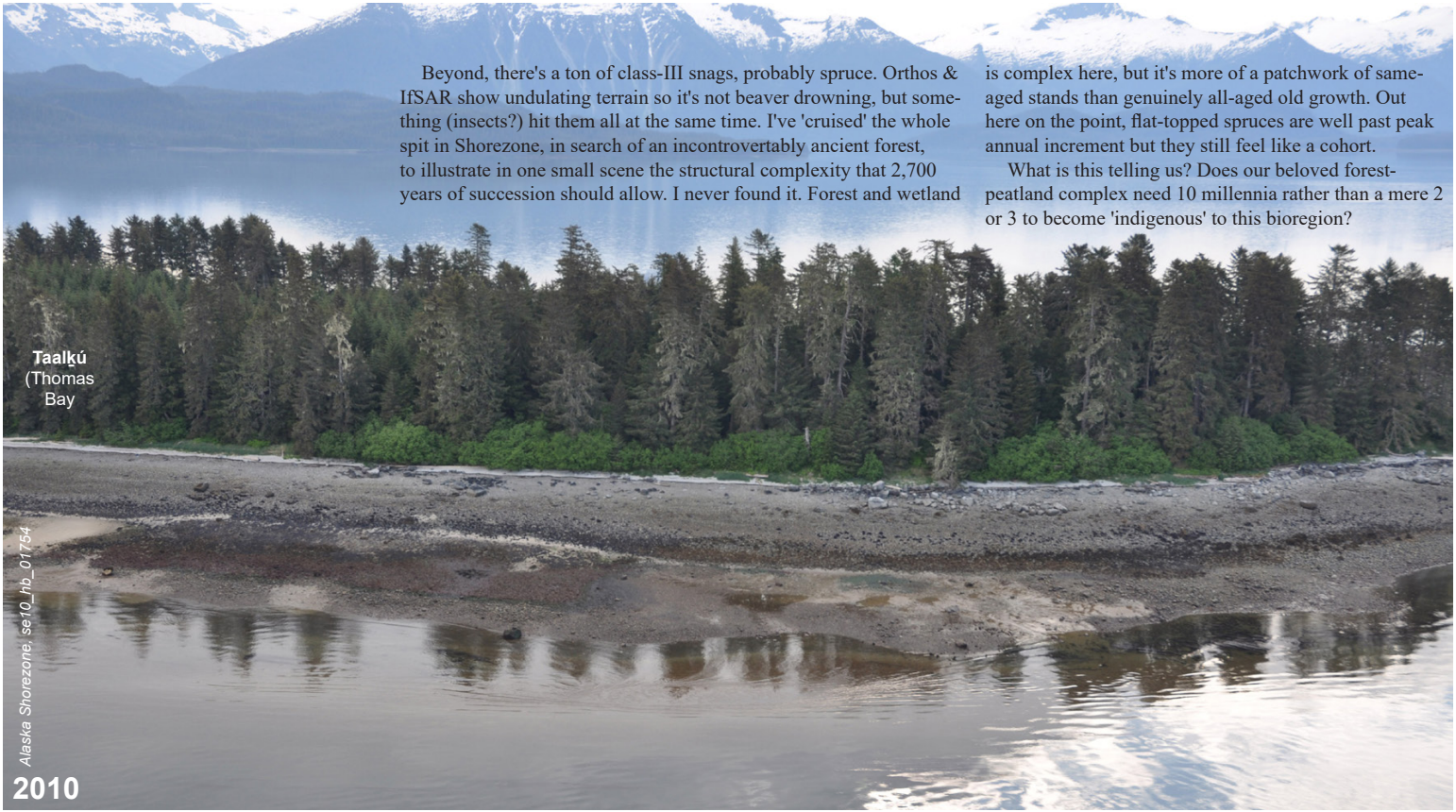
Little has been published for Sít'ḵú (Tracy-Dawes-Holkham). But what about other mainland fiords? Viens (2001) studied Taalḵú (Thomas Bay, left). Roman compared regions (1996, bars above), and Derksen (1976) gave dates for an unusually timed advance at Sít' Tlein (Brady Gl) .

On AOL's orthos, the ~2,700 year-ago advance at Taalḵú pushed out an entry bar that looks *a lot* like S'awdáan's, above. Are they roughly contemporaneous? Or is S'awdáan's bar much older, maybe Younger Dryas? Could clues be found in the peatlands I've marked with asterisks? If my impressions of peatland age at

T'ix'aa, *ice point* (Taylor/Brady, described below) are transferable, it should be evident even without C-14 dates whether these are typical early Holocene bogs or something anomalously younger. Our 4-foot peat probe should easily find bottom in these T'ix'aa-type early Neoglacial peatlands. In mature, early Holocene dome bogs and fens, it rarely does, except along the margins. "*China!*" we declare, wetting our handle-holding fingers in the sphagnum.

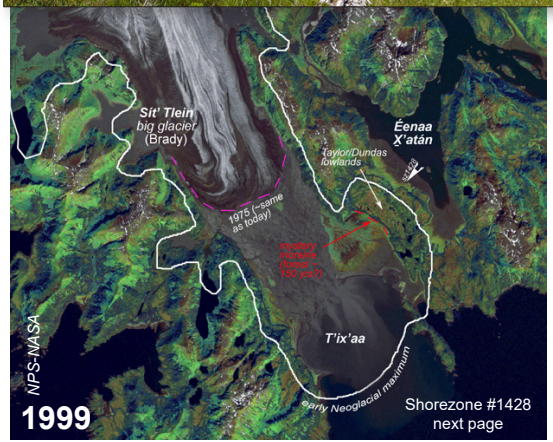
On this Shorezone oblique (photopoints below and on previous page) a narrow belt of uplift(?) alder and spruce backs the beach. Behind them, rich green small-tree hemlock is puzzling. Wondering if it was clearcut, I pulled up the 1948 below: nope, scrubby even then.





Beyond, there's a ton of class-III snags, probably spruce. Orthos & IfSAR show undulating terrain so it's not beaver drowning, but something (insects?) hit them all at the same time. I've 'cruised' the whole spit in Shorezone, in search of an incontrovertably ancient forest, to illustrate in one small scene the structural complexity that 2,700 years of succession should allow. I never found it. Forest and wetland is complex here, but it's more of a patchwork of same-aged stands than genuinely all-aged old growth. Out here on the point, flat-topped spruces are well past peak annual increment but they still feel like a cohort.

What is this telling us? Does our beloved forest-peatland complex need 10 millennia rather than a mere 2 or 3 to become 'indigenous' to this bioregion?



Clockwise: Derksen (1976) showed that from 1960BP to 1230BP (adding 50 yrs gives 2010-1280yrs before *today*) Sít' Tlein (~~Brady~~ Glacier) spilled laterally into the pass between T'ix'aa, *ice point* (~~Taylor~~ Bay) and Éenaa X̲'atán, *spruceroot scraper lying there* (W Arm ~~Dundas~~). ● Shallow, terraced peatland has not yet muted the contours of underlying glacial, alluvial & lacustrine landforms. ● Floc-bottomed pit-ponds in mature (>10K) peatlands throughout Lingít Aaní almost never display their rocky substrate. Ponds like these should offer some of the easiest 'field-marks' for early Neoglacial terrestrial moraines.

Journal for 20040623:

*"Geomorphology of the Taylor/Dundas lowlands is a fascinating puzzle. No doubt Streveler can [*ps and did*] fill us in on the Neoglacial history here. Meantime, here is my intrepretation: Maximum LIA expansion of Brady Glacier left a prominent forested moraine along the NE margin of the Taylor Bay mudflats. Trees here are tall, open-grown, first-generation spruces like on Barco moraines. Outside (NE) of this we found a unique peatland mosaic. It's*

definitely more advanced than anything I've seen on a LIA surface, but not truly ancient-feeling. There's the usual spectrum from sphagnum bog to rich fen. However, none of the peat is as deep as you'd expect from 10 or so millennia of accumulation. Many peatland ponds—both bog & fen—have boulders still showing on the bottom, never seen in mature Holocene peatlands, where millennia of organic accumulation buries rock foundations. Low peatland between forested ridges in some places appears subtly terraced, as if colonizing different levels of lightly trenched outwash channels. Again, this would be obscured by deeper peat accumulations in a more mature system.

Superficially at odds with this interpretation of a 'relatively youthful peatland,' forest NE of LIA lateral is definitely multi-generation. Spruce leader growth is negligible and there are large, ancient hemlocks. Old pines also occur in some boggy areas. I'd guess at least a millennium has passed since last glacial disturbance. So how do you explain arrangement of moraine-like ridges that run both NW-SE and NE-SW outside of our supposed LIA lateral?

My guess is Brady advanced in early Neoglacial—unlike in the Bay proper—exceeding final LIA advance. If this happened 1000 to 2000 years ago, it would explain the mature-forest-but-young-peatland, bouldery pond bottoms, and maybe also the interstadial (?) stumps we found en situ, just protruding from the water. As for contrasting alignment of moraines, maybe they were laid down by glaciers of different thicknesses and stages of retreat. NE-SW ones roughly parallel a bouldery LIA (?) moraine at head of Fern Harbor

SW across pass between Éenaa X'atán (W Arm Dundas) and T'ix'aa (Taylor Bay). Asterisk on dark forest band in mid distance is vigorous even-aged spruce on the Little Ice Age moraine.

2005

Alaska Shorezone, se05_ml_1428

20221000 Email thread; furrows-&-kickups

RC to Greg S, Jim B, Roman M [1]

Hey guys,
During the Landforms class I just finished teaching with Cathy Connor, I became intrigued by what appear to be end- and recessional moraines on some of the new, high-res surveys that NOAA calls BAG (Bathymetric Attributed Grids). Can't find anything published on this, and am wondering what you all can tell me. Attached course-manual page called *BAG-downloads* explains how to peruse, extract, and pull em into arcmap.

I first noticed these features at entry to S'awdáan, *green-waters* (Holkham), probably the most widely acknowledged morainal bathmouth bar. I have no insight into ages of these 'plough-furrows' except that they're way farther-in than the shelf-perched cordilleran maximum, and way farther-out than any Little Ice Age advances I know of. I'm also calling them 'kickups.' A runner on sand, suddenly stopping, leaves a 'kickup' print with raised frontal ridge, both erosional and depositional.

I know of only one above-sea moraine of this age, and it's associated with this same advance. Why are pre-LIA terrestrial moraines so hard to find, but submarine ones so common?

The Bathymetric Data Viewer is an eye-opener for distribution of these plough-furrow kickup tracks. They're not just on the mainland, as in these excerpts for S'awdáan, Terror, Taalḵú, but also out on the islands, eg: Saná, *voicing in there* (Malmesbury) and Tsaagwáa *seal iceflows* (Hood Bay)

LIA moraines that form on dry land are just draped over whatever surface the glacier overrode; outwash, bedrock, etc, and aren't typically backed by these deep gouges. What was going on with these presumably tidewater(?) glaciers that created such different-looking tracks?

Hope you're all well . . . *rc*

1 baichtal557@gmail.com • rjmotyka@alaska.edu

GS to RC Hello Ricardo The lovely features you show remind me a lot of those in upper Lynn Canal that are very likely latest wisconsin age, which probably implies YD. Your features do look **terrestrially made**, [*rc bolds*] which implies to me that regional iceload was not fully relieved—also congruent with a latest Wisconsin age.

RC to GS Thanks, Greg, Those upper-Lynn features you've pointed out to me—Laxách' (Pyramid Island) maybe, & Dayeisáank'i (Taiyasanka) entry bar—haven't been covered by NOAA-BAG surveys. It'll be interesting to see how they look, when/if we get better bathymetry. Of course, in the case of Pyramid, seafloor upvalley has since been smoothed over by river deposits.

Depending where these NOAA-BAG moraines were riding on the sloshing water-bed, they could have been hundreds of feet deeper when formed. As for the 'plough-furrow' excavations, I'm picturing a great deal of soupy bay-floor infilling between CIS max and YD-or other re-advance, which'd be easily scooped and pushed ahead into 'kickups.' Does that make sense? And is it likely they'd remain so crisp and well-defined-looking for 10 millennia? How bout those distributary canyons outboard of Holkham entry? Shouldn't they have been erased by now?

Aside from my sidevalley extension into Gilbert-Holkham pass, do you know of any large terrestrial moraines of YD age? Have you seen Jim's poster of little 'washboard moraines' digitized from Bobby's Hoonah LiDAR? Why did Northeast-Chich foster transverse moraines while Tàan (POW) built longitudinal drum-lins—where LiDAR shows they're far more ubiquitous than just the widely-recognised ThorneRiver swarm? Or, with increasingly detailed surface (and below-surface?) models will we discover that such patterns say more about state of our technology and the limitation of our search-images than what's actually on the ground?

JB to RC&GS Good morning. I am traveling right now. There are other features. In Zemovia Strait there is a sharp moraine. From Revilla to Ham Island is a terminal moraine where Dixon entrance glacier went past Behm Canal heading north. There is an 800 foot high moraine from Cleveland Peninsula to Kasaan Peninsula where Dixon entrance glaciers went north. Many small moraines on POW and eskers. I have it all digitized. Will ship it to you when I return home.

Also. Everywhere along the west coast of POW at **-102 to -104 m is a terrace.** I believe this was the **Younger Dryas** shoreline.[2]

RC to JB&GS Thanks, Jim, Safe travels! Looking forward to picking this up on your return. Yeah, I can find all of those larger moraines, even on the relatively coarse *World_Ocean_Base*. The Cleveland-to-Kasaan one is amazing. So, maybe large terrestrial YD moraines are relatively uncommon because most-vigorous read-vances were from well-loaded icefields oozing out to marine fiords—only occasionally sloshing up as in Gilbert-Holkham? Very cool that the YD shoreline outside of Tàan is so far below sea level!

JB to RC&GS I have digitized all the drumlins, crag and tails, moraines, and eskers. Some 3000+ features. I'll send it all to you when I return. The great epiphany is that a lobe of ice came north from Dixon to the east of Dall down Uolla Channel across Lulu and into The Gulf of

2 Compare my **bolds** in Jim's & Greg's notes, above. If my mainland fiords behaved anythign like JB's minus 300ft YD sea level on Taan (POW) that'd fit Greg's guess that my submarine landforms were terrestrially formed. But wasn't the mainland on the opposite limb from outer Taan of the isostatic seesaw?

Esquine and out to the west.

Check out the esker at ~55.74761, -133.24092 I've crawled around on it. The high stand of the sea 10,800 years ago eroded its edges.

GS to JB & RC If so, that would suggest that relatively little LGM ice was lost (or reestablished) worldwide by YD times. Unless tectonism has seriously confounded things locally. In the first-mentioned supposition, the YD? moraines at mouths of upper Lynn feeder fjords were made WELL above SL…

ps someday I'd like to discuss the biotic implications of what we now suppose we know about ice/topographic history of the last 250K yrs.

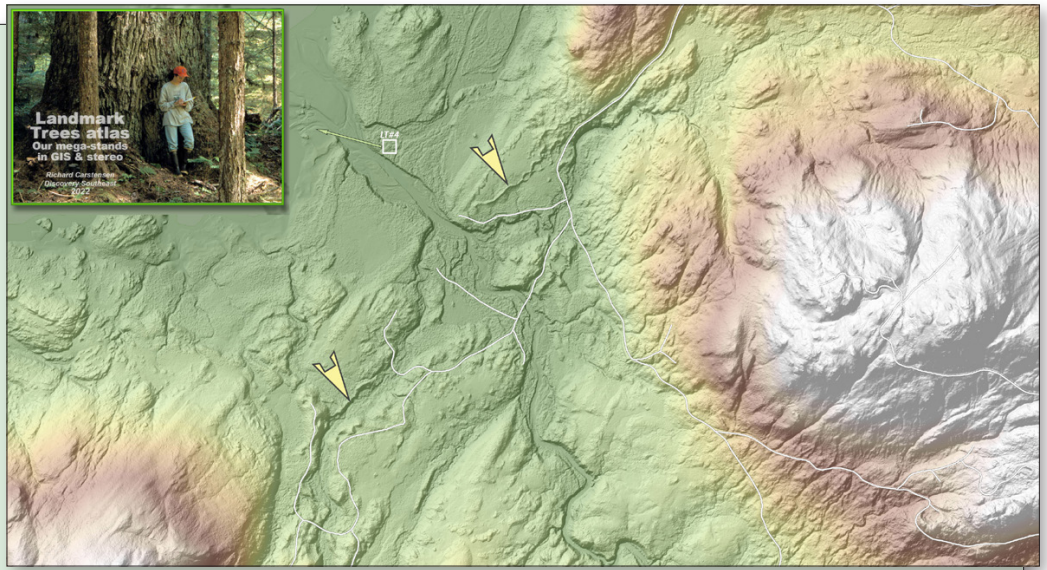
JB to RC&GS Agreed. I am sure the timing of development and final collapse of the forebulge accounts for the position of the terrace. Hope all is well Greg. Your daughter and I have been playing phone tag for ever.

GS to RC Many good questions. Not being adept at manipulating your tools, they'll probably be up to you, etc, to resolve.

Lately i've been revisiting deepsea and ice climate proxies, trying to get a full sense of landscape dynamism during the last 250K yrs. One takehome is that ice gyrations and all things accompanying them were almost unimaginably complex (and often abrupt). Our holocene bias has tended to make me unaccepting of this.

The second takehome for me is to be careful ascribing simultaneity amongst them. [3] And to their biotic effects.

RC to GS So maybe my plough-furrows and kickups



weren't all made at the same, early-holocene time? What do you think about persistence in the marine environment? The ones at S'awdáan (Holkham), where we have such pretty resolution, look like they were carved and shoved-up yesterday. Does tidal scour only soften channel-margin shoals, leaving seafloor landforms pristine for millennia? Could those Holkham-mouth distributary canyons really be ancient relicts?

Yeah, a conversation about biotic implications would be interesting. Though i'm not sure, aside from you and Dan Mann, who's capable of spanning that disciplinary gulf.

I hear you about techno distractions and don't wish to drag you into that. But if there's areas you'd like to see maps for, let me know. Northern yellow arrow, above, is the esker Jim mentioned, near our #4 Landmark acre at Shahéen. I see another, on SW side of today's creek.

RM to RC GS JB Hi Richard, We are traveling for another day or two. Back Tues eve. The features in Endicott Arm were already noted by Austin Post several decades ago based on NOAA bathymetry of the time [*40m pixel?*]. We think it is related to the LIA advance judging from tree coring that was done. [*RC: much more rumination on this question for North S'awdaan follows, but I'm STILL baffled*

3 RC: resembles comment from Ellen Cowan, following, that we should be careful about calling everything Younger Dryas.

by contradictory clues.]

Such features are relatively common for tidewater glacier fjords. I attached a paper by Eidam and others 2022 on our work at LeConte Gl. Look at figs1 & 5.

Love to talk to you more. Ciao

RC to RM Thanks for the fast reply. Jim is traveling too, but has likewise promised more detailed reply on his return. He's been working with the rapidly growing library of Southeast LiDAR surveys to digitize pre-LIA glacial features all over the archipelago. I hadn't seen Eidam *et al* (2020) and look forward to reading it. [4] Those deepwater reaches behind end- and recessional moraines result from what I've been calling 'plough-furrows' and frontal 'tipups.' (MBs, morainal banks, in your parlance) Quite different looking from moraines that form on land. They're surprisingly common, judging from recent NOAA-BAG surveys, but most appear to be Younger Dryas [or at least pre-LIA]. So it's interesting to see your more recent example from Xeitl Sít', *thunder glacier.* Your measurements of great interannual fluxes [5] make it all the more puzzling that, once formed, such landforms (or seaforms?) could persist in relatively pristine condition for millennia.

Cathy Connor also assumed those Holkham entry bars were recent LIA and said to check in with you. I'll be eager to look at your evidence. Beach fringe trees may be young, but there's abundant old growth, including very ancient yellow-cedar and even Hennon-mapped dieback all over the lower portions of both northern (Tracy) and southern (Endicott) arms. Safe travels!

4 Eidam (2020) is about recent LIA morainal bank processes, Roman's a coauthor. Realtime observations of features that sure look a lot like the much older plough furrows I've been struggling with.

5 As well as Cowan & Powell studies in Glacier Bay

Later question to Ellen Cowan

RC to EC Hi Ellen . . . Just scanned your abstract *[for GB science symposium]* and realized you're the best one to answer questions I've had about deeply gouged trenches & 'plough-furrow' moraines in mainland fiords south of the Taku, and, strangely, even out on the islands.

Attached are some pages with maps and above-water clues—forest and peatland ages—from a course i taught in 2022 with Cathy Connor.

These submerged features seem way farther from glacial sources than anything I've heard about from the Little Ice Age outside of Glacier Bay, but also way less extensive than the great ice age when the whole archipelago was covered.

So, if they are millennia old—I'm thinking younger dryas?—why do they look on NOAA's new hi-res bathymetry like they were formed yesterday? Your work in The Bay shows copious sedimentation and instability. Is the sea floor in other places kinda frozen in time?

EC to RC Hi Richard, Thanks for sharing your beautiful images with me. A few things come to mind that might pertain to the submarine landforms that you have observed. The plough-furrow features look similar to morainal banks which are deposited during still stands of the glacier by submarine discharges and ice contact deposits but are left unsupported on the upstream side when the glacier abruptly retreats. Those processes would produce an angled (at repose) mound on the downfjord side and a steep trough on the upfjord side of the feature.

As Roman pointed out in his paper, tidewater glaciers can respond to local instabilities as well as climate change. I think that there would be a difference between landform preservation between very active glacier fjords that housed ice streams and those that have smaller glacier catchments. The high deposition rates track with the glacier terminus position so if retreat was rapid older submarine landforms might not have been buried and appear pristine. However currents and icebergs could have an impact. Paul Carlson's OpenFile report has some cool images Open-File Report 02-391

The dating of submarine landforms is difficult. We usually try to correlate the underwater feature with ages that are known from onshore (which is your take on this as well). I am **cautious about calling on the Younger Dryas** because there doesn't seem like there is much climate impact to build up glaciers in the region. That is the take-away from the recent Wilcox *et al* 2020 paper (attached). [6]

I can't wait to get back to SE AK next week! I will look forward to talking with you more at the Greg Streveler Symposium. Best wishes, Ellen

Dr. Ellen A. Cowan ● Dept of Geological & Environmental Sciences ● Appalachian State University, Boone, NC ● (828) 262-2260

I've formatted the Carlson *et al* paper for more careful perusal, and filed it with other geo papers in *E:\Dactive\1 classes&projects24g\2022classes\20220900connorclass\carlson*.

6 RC: Since this comment from Ellen I've used Younger Dryas only as 'placeholder' to vaguely signal anything from LGM to LIA in age. But if indeed our local YD episode was muted, as suggested by Wilcox *et al* (on which Jim was coauthor), how does that jive with Jim's hugely different YD sea levels? If YD SL was 300 ft *lower*, and ~11k Shaheen esker *higher*, where was the LGM shore? Wilcox *et al* is veg-focused, no mention(?) of sealevel change, or how its obvious volatility might be reconciled with a locall muted YD.

20250810 Great Wave of '25

Preface: This amazing outburst came 3 days before the '**OTHER ONE**' that everybody in Áak'w Táak (Mendenhall Valley) was prepping for in trepidation. Can't blame Valley folks, or local media, for sidelining this earth-vibrating episode, 67 miles SE. Back in mid-August, we had other things on our minds.

But now the summer-2025 valley flood is behind us. And the **REAL** Great Wave of '25 is crying for some cartography and a pageflipper-series, to better understand the '*what-where-&-how*,' and a little about *when*, in the greater sweep of glaciomarine history. How often, for example, do waves like this sweep down the 'rifle-barrel' fiords of northern Lingít Aaní? Where else are melting glaciers 'debuttressing' unstable mountainsides?

Compared to Glacier Bay, Taku Inlet, or Thunder (LeConte) Bay, glaciologists haven't applied themselves to dating or even mapping the terrestrial and marine landforms of North S'awdáan Fiord (Tracy Arm). This 'sleeper' Great Wave should awaken us to the importance of such understanding.

Great wave in the media

Although we Áak'w-&-T'aakú folks are trying to ignore the ***Much Greater Wave***—preoccupied as we are with Wooch Eel'óox̲'u héen—a little internet digging turns up useful reports:

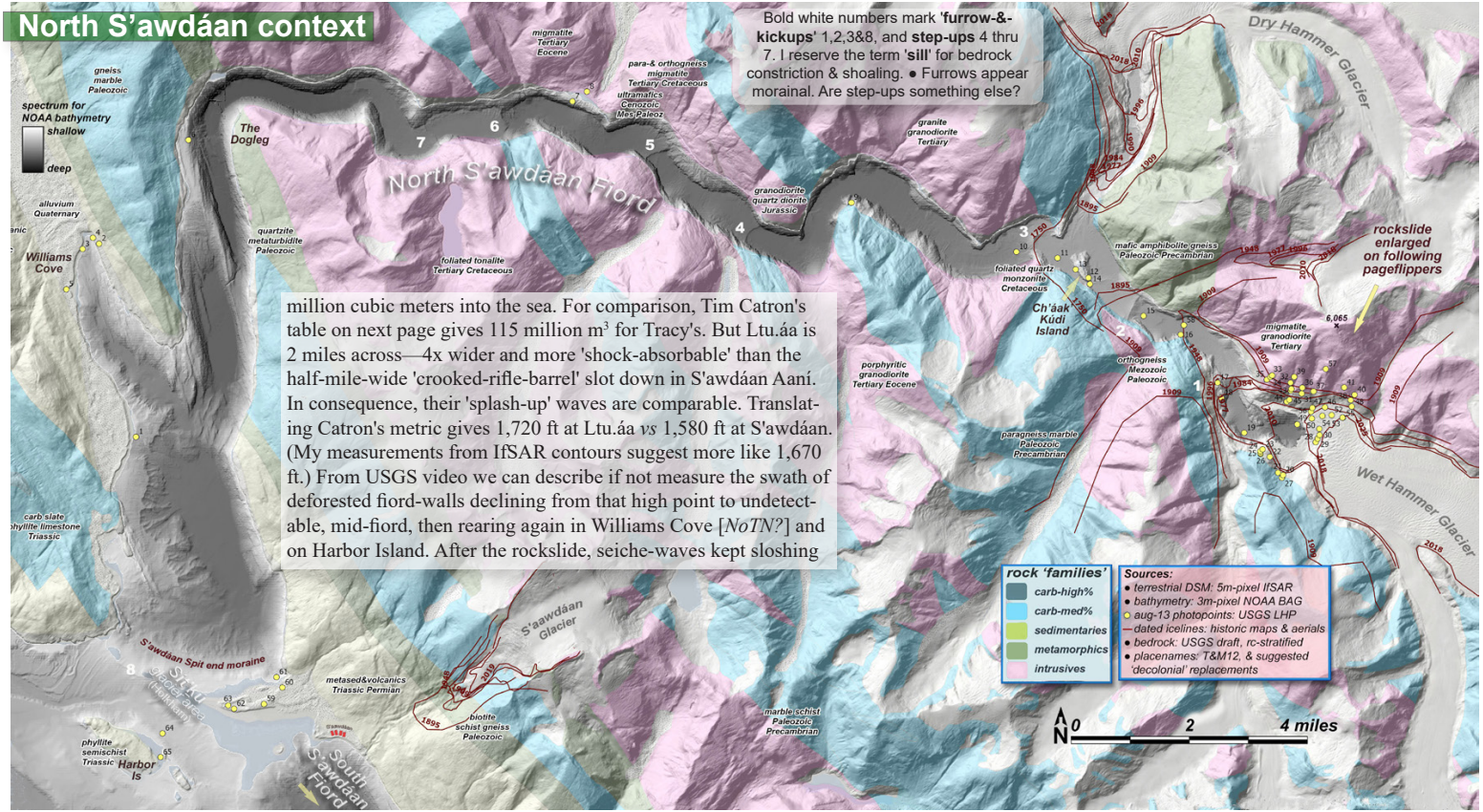
- USGS Landslide Hazards Program: page titled *2025 Tracy Arm Landslide-Generated Tsunami*, to be updated as new findings emerge. Primary source for following journalistic interpretations.
- Michael West AK Earthquake Center initial video review
- Ned Rozell UAF Geophysical Institute
- Tim Lydon *The Guardian*
- Tim Catron *Geohub* This kid is brilliant. Don't be fooled by the flat-affect "AI-voice." He's the real deal.

In the 2 weeks since this catastrophic rockslide, we've heard little about it in local news. [1] If the world's largest cruiseship had been in North S'awdáan Fiord (Tracy Arm) when the mountainside released, it probably wouldn't have come back out, promoting this fiord to front-page news around the world. For the past 3 years, my town has focused on an annual summer disaster—outbursts from Suicide Basin—that are like polite and predictable after-dinner burps compared to this mountain-shaking catharsis.

Only one great wave in the past century compares to it; the 1958 release from a fiord-head schist-wall in Ltu.áa, *bay inside the nostril* (Lituya), triggered by a magnitude 7.8 earthquake on Fairweather Fault, and sending 230

1 It was the *Guardian's* US newspaper, not a local news source, that picked up Lydon's thorough review. The *Juneau Independent* ran only a brief note about stranded kayakers asking for help on social media, and later reprinted Rozell's piece linked above.

From the USGS-LHP page linked above, you can download 80 hi-res stills like this oblique, and even 4 gigs of *.mov* video from their chopper-flight. For geo-sleuthing, that's well worth the time and file size. EXIF data were preserved in zip transfer, so after giving each image a more concise 2-digit ID#, I generated photopoints—yellow dots on map, next page. This view from oblique-#25 faces NW to contact of rockslide with the ice.


North S'awdáan context
Bold white numbers mark 'furrow-&-kickups' 1,2,3&8, and step-ups 4 thru 7. I reserve the term 'sill' for bedrock constriction & shoaling. ● Furrows appear morainal. Are step-ups something else?
million cubic meters into the sea. For comparison, Tim Catron's table on next page gives 115 million m³ for Tracy's. But Ltu.áa is 2 miles across—4x wider and more 'shock-absorbable' than the half-mile-wide 'crooked-rifle-barrel' slot down in S'awdáan Aaní. In consequence, their 'splash-up' waves are comparable. Translating Catron's metric gives 1,720 ft at Ltu.áa vs 1,580 ft at S'awdáan. (My measurements from IfSAR contours suggest more like 1,670 ft.) From USGS video we can describe if not measure the swath of deforested fiord-walls declining from that high point to undetectable, mid-fiord, then rearing again in Williams Cove [NoTN?] and on Harbor Island. After the rockslide, seiche-waves kept sloshing
rock 'families'
carb-high%
carb-med%
sedimentaries
metamorphics
intrusives
Sources:
• terrestrial DSM: 5m-pixel IfSAR
• bathymetry: 3m-pixel NOAA BAG
aug-13 photopoints: USGS LHP
dated icelines: historic maps & aerials
• bedrock: USGS draft, rc-stratified
• placenames: T&M12, & suggested 'decolonial' replacements
N
0
2
4 miles
Dry Hammer Glacier
Wet Hammer Glacier
North S'awdáan Fiord
South S'awdáan Fiord
S'awdáan Glacier
S'awdáan Spit end moraine
Williams Cove
Harbor Is
Ch'áak Kúdi Island
The Dogleg
rockslide enlarged on following pageflippers
gneiss marble Paleozoic
spectrum for NOAA bathymetry
shallow
deep
alluvium Quaternary
quartzite metaturbidite Paleozoic
foliated tonalite Tertiary Cretaceous
migmatite Tertiary Eocene
para-& orthogneiss migmatite Tertiary Cretaceous
ultramafics Cenozoic Mes.Paleoz
granite granodiorite Tertiary
granodiorite quartz diorite Jurassic
foliated quartz monzonite Cretaceous
mafic amphibolite gneiss Paleozoic Precambrian
migmatite granodiorite Tertiary
orthogneiss Mezoicic Paleozoic
porphyritic granodiorite Tertiary Eocene
paragneiss marble Paleozoic Precambrian
carb slate phyllite limestone Triassic
metased&volcanics Triassic Permian
biotite schist gneiss Paleozoic
marble schist Paleozoic Precambrian
phyllite semischist Triassic
6,065
1895
1909
1948
1958
1984
2018

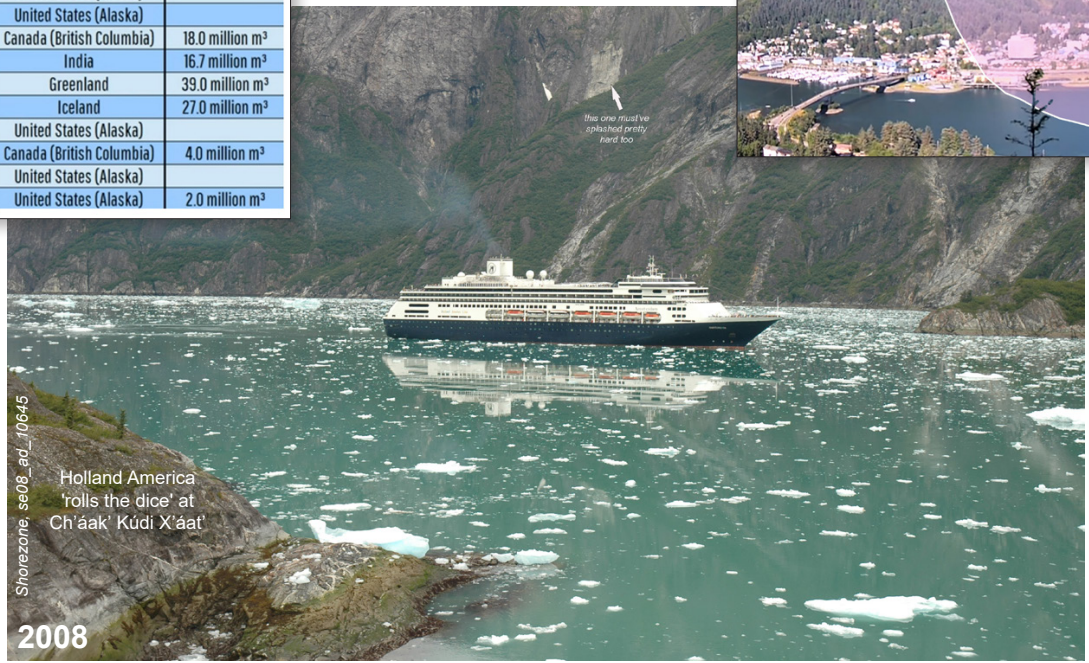
Screengrab from Tim Catron's GeoHub review.

Location	Date	Max Height	Cause	Country	Landslide Volume
Lituya Bay	Jul 9, 1958	524m 1720ft	M7.8 Earthquake, Landslide	United States (Alaska)	229.5 million m³
Tracy Arm	Aug 10, 2025	483m 1580ft	RC: 1670ft Landslide	United States (Alaska)	114.9 million m³
Spirit Lake	May 18, 1980	250 m	Volcanic Eruption, Landslide	United States (Washington)	2,800.0 million m³
Dickinson Fjord	Sep 16, 2023	200 m	Landslide	Greenland	4.6 million m³
Taan Fjord	Oct 17, 2015	193 m	Landslide	United States (Alaska)	70.0 million m³
Lituya Bay	Oct 27, 1936	150 m	Landslide	United States (Alaska)	
Lituya Bay	1854	120 m	Landslide	United States (Alaska)	
Elliot Lake	Nov 28, 2020	106 m	Landslide	Canada (British Columbia)	18.0 million m³
South Lhonak Lake	Oct 4, 2023	100 m	Landslide	India	16.7 million m³
Karrat Isfjord	Jun 17, 2017	90 m	Landslide	Greenland	39.0 million m³
Lake Askja	Jul 21, 2014	62 m	Landslide	Iceland	27.0 million m³
Lituya Bay	1899	61 m	Landslide	United States (Alaska)	
Chehalis Lake	Dec 4, 2007	38 m	Landslide	Canada (British Columbia)	4.0 million m³
Lituya Bay	1874	24 m	Landslide	United States (Alaska)	
Penderson Lagoon	Aug 7, 2024	17 m	Landslide	United States (Alaska)	2.0 million m³

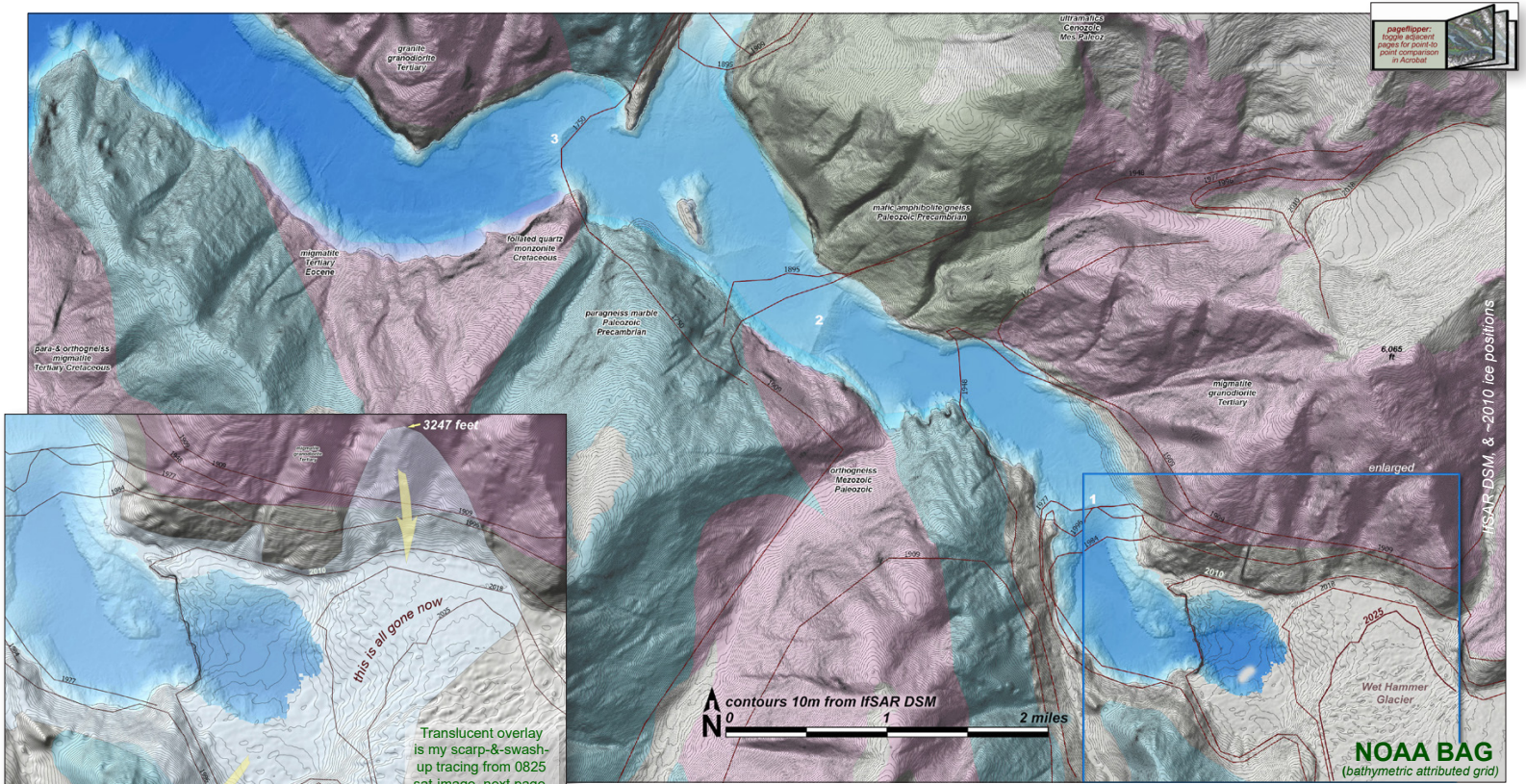
around in North S'awdáan and Sít'k̲ú, *glacier area* (Holkham Bay) for more than a day.

Write me what you notice in the following page-flipper series. For my sister-&-fellow naturalists of Áak'w & T'aak̲ú Aaní, it'll help to first transpose the rockslide scar onto a more familiar background (upper right). We're accustomed to backyard mountains in the range of 3K to 3,500 feet. That's because they're friable metamorphics, ground to modest heights by the CIS (cordilleran ice sheet).

But this newest Great Wave began 22 ravenflight miles inland. In Áak'w Táak, (M-word Valley), that'd be twice as far back as the ~7K-ft Towers. In both locations, such 'interiority' puts you well back from soft, sculptable country rock, into resistant granitics who rise twice as high as Shaa Tlaax̲. Same with the summit above this new rockslide scar, typed Tertiary migmatite/granodiorite by USGS—**6,065 feet!** And our Great Wave started from halfway up. This was a **big** one!

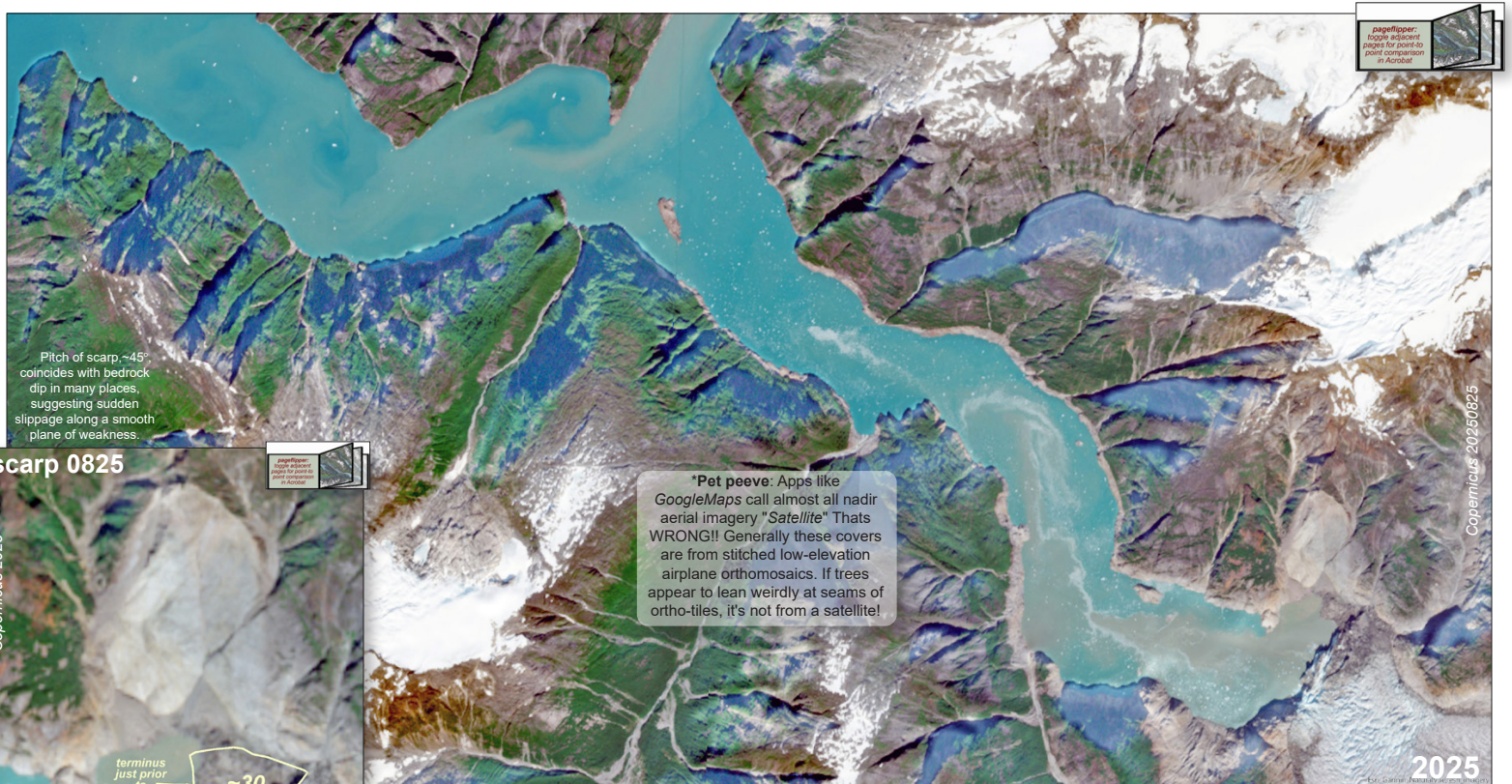


text resumes after following 5 pageflippers



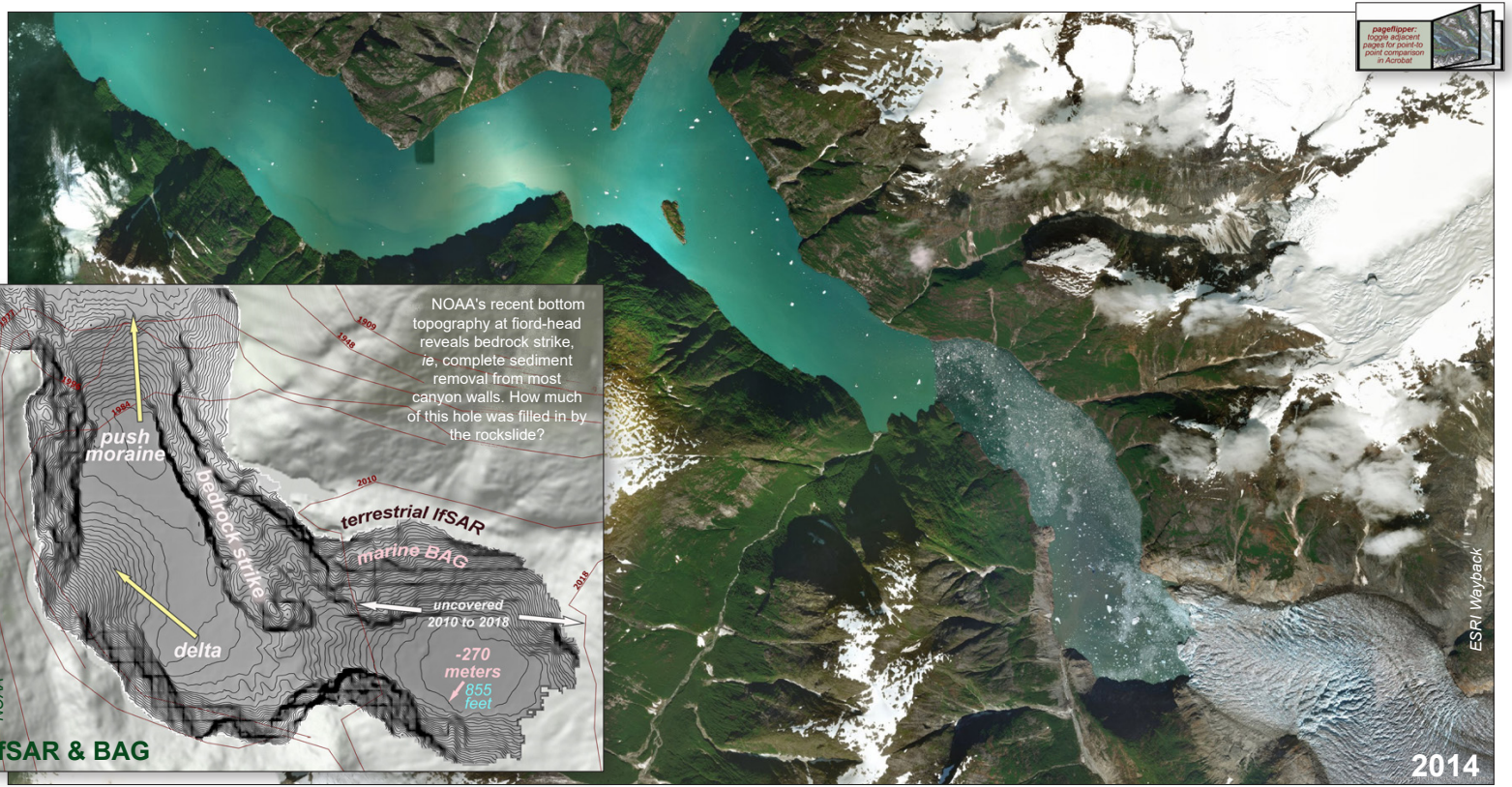
Flipper 1-of-5 Bedrock and dated icefront lines over 5m-pixel IfSAR terrain. Bathymetry is the awesome brand-new BAG from NOAA that I output at 3m-pixel, revealing 'furrow&kickup' punctuations #s1, 2 & 3. Darkest blue is deepest. Collapse was in part a response to glacial evacuation of the deep hole. My contours from ~15-yr-old IfSAR are obsolete over that area.

Carstensen

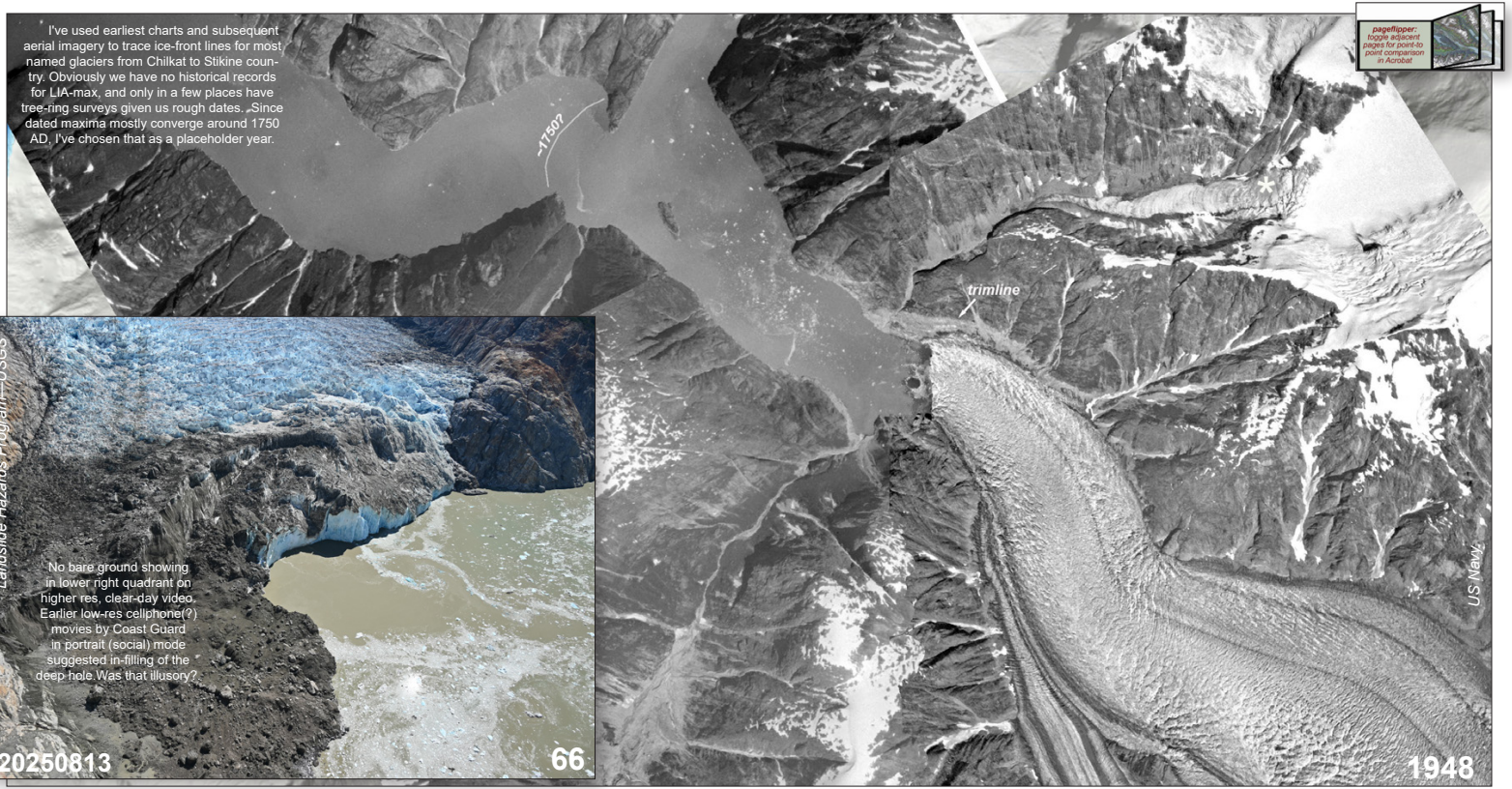


Flipper 2-of-5 Copernicus is a free site for hot-off-the-press sat-pics—lower-res than following plane-based orthos * but giving timely info after natural & anthro-perpetrated disasters (like surreptitious cruisedock logging **:)**. Their 0812 cover, 2 days after the slide, was cloud obscured. By 2 weeks later, bergs had cleared to 'normal' density. Two colors of water: background bluegreen, vs grey-brown ultra-dense surface plume from continued copious erosion.

Flipper 3-of-5 Most recent ESRI cover was 7 yrs before the rockslide. On this northwind day, still-tidal Dry Hammer Glacier spewed a silt-plume while Wet Hammer's was backed up at a bedrock sill, enlarged in the green box. ● That cruiseship was cocked at an inadvisable angle to a 400-foot wave. Will pilots henceforth hold an up-fiord point, then back out, like penitents never mooning sternsides to the Queen? Still wouldn't help for quartering richochets.



Flipper 4-of-5 Toggling back against 2018, Wet Hammer Glacier receded 0.5 mile in 4 years, not surprising over deep water. Inset above totals just 0.65 mile retreat from 2010 to 2018, so rate accelerated through the second half of that period. ● I can't get enough of the marvelous new bottom mapping by NOAA BAG, accruing more rapidly than oceanographers and benthic geomorphologists can make sense of it. Assuming Wet Hammer scoured the fiord-sides to bedrock, that conical delta from a minor, withering trib glacier was built in a mere 30 years. ● As for depth of glacial scouring, Cowan *et al* (2010) found that LGM scoured Glacier Bay to bedrock but LIA advances did not. Why the difference here?



Flipper 5-of-5 Clear trimline just north of 1948 terminus descended at a strong angle. To distinguish glacial trimlines from wave-scars, check gradient. The latter can run for miles through 'rifle-barrel' fiords with little drop in elevation. Not so, this pale 'bathtub ring,' paralleling the steeply declining ice surface. ● Asterisk in upper right marks a glacier descending from cliffs, amputated and vanished by 2014. Otherwise, recession in high, north-facing cirques has been far less dramatic than on valley glaciers below. At peak-LIA, all converged, but so far I don't think they advanced beyond the 1750-line.

Ch'áak' Kúdi X'áat' series

se08_ad_10650

Left: Bracketing the rockslide with low-res satellite imagery from Copernicus. On Aug-7th green trees still thinly covered the island. On 0812, 48 hrs after the slide, entire south arm still choked with bergs. By 0825, 2 weeks later, currents had drifted them out.

Two 'historical' obliques from Alaska Shorezone. USGS obliques on next page are not precise 'pageflippers' but still make useful comparisons.

Left: ~~Sawyer~~ Island. I'm going with Ch'áak' Kúdi X'áat', *eaglenest island*.

- **Below**: Wet Hammer terminus rested on a relatively shallow sill, but would shortly back into a 270-meter deep hole, accelerating retreat.

resuming from just before the pageflippers:

Okay, let's scale out to all North S'awdaan Fiord. In 2022, I scoped this cruise destination before Cathy Connor took our students here. I got sick by then & stayed home. *Jeez, imagine my guilt if a tsunami had converted em all to fish food!*

Mapping Sít'k̲ú, and other mainland fiords, I began to notice submarine 'plough-furrow moraines,' and corresponding lips or 'kickups.' They're especially striking on recent hi-res BAG rasters, but once your eye's attuned, you can even detect

Above: The Great Wave left a single spruce on south end of ~100-foot-high Ch'áak' Kúdi X'áat', *eaglenest* (~~Sawyer~~) *island*. That's the one you want rooted in your yard during the next Taku gale.

• **Right**: Toggling back against 2008 oblique, compare asterisks on zigzag ravine to help with orienting. Rockslide's just around the corner. Photopoints & camera bearing are on map, next page.

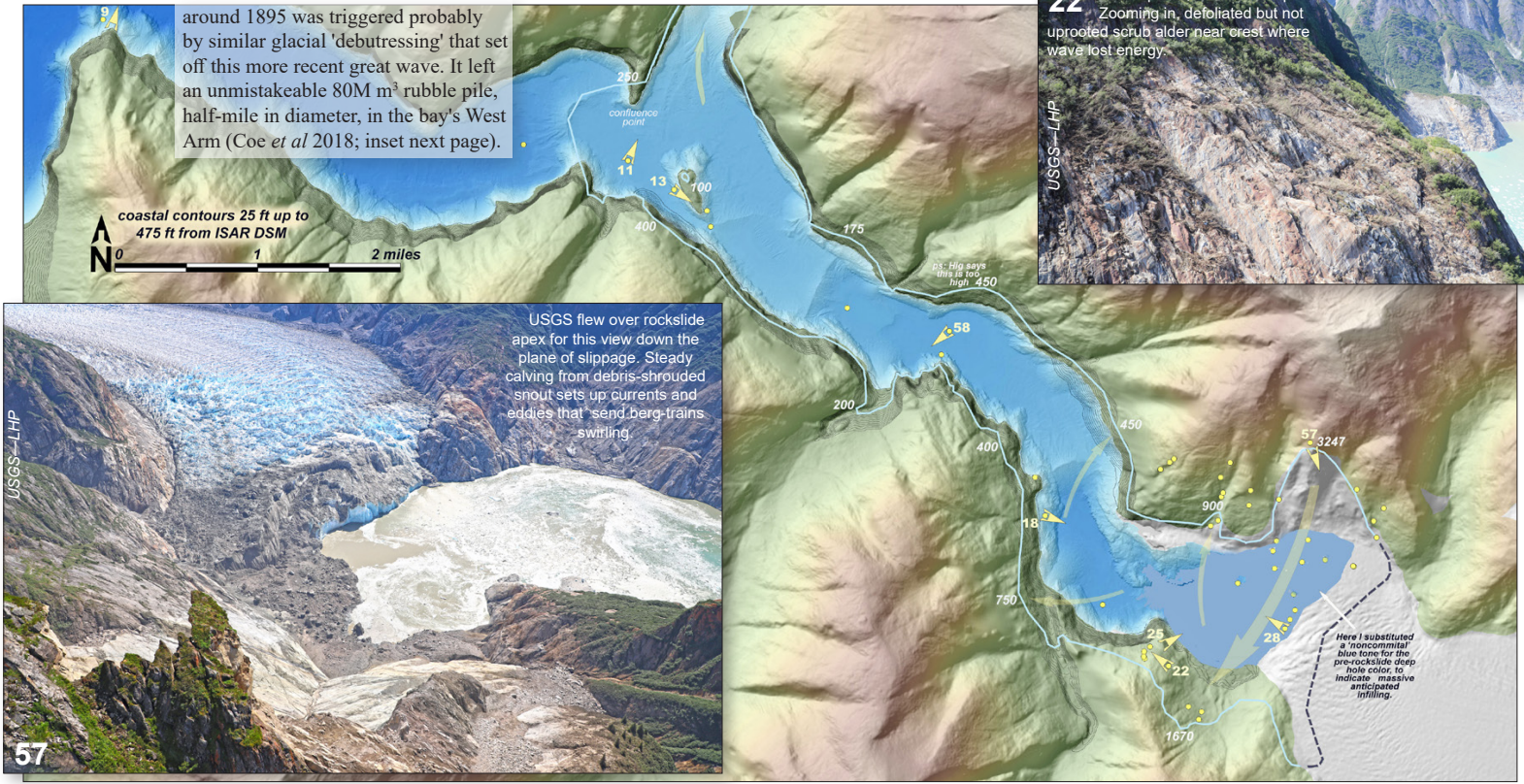
them on coarse, 40m-pixel bathymetric hillshades. **The fundamental puzzle is age**. They're way farther out from glacial sources than confirmed (ground-truthed) Little Ice Age moraines, but way less extensive than CIS (cordilleran ice sheet) maxima. [1]

Until the Great Wave of '25, I entertained no other agent for furrows-&-kickups than push moraines from glacial readvance. But could some bottom scarps instead be cut-&-fill from rockslide-generated waves?

Searching for mention of undersea topographic signatures from tsunamis, I find agreement that they can leave *stratigraphic* evidence, from dumping, cratering, resuspension, layer-disruption, etc. Turbidites from sediment laden currents can in fact be lithified and preserved for millions of years. In Sít' Eeti Geeyí, *bay in place of the glacier* (Glacier Bay), a rockslide

1 It's tempting to assign these intermediate sized moraines (?) to the Younger Dryas cold period. But in correspondence, I've been cautioned against jumping to such conclusions by Ellen Cowan (20250711) and Greg Streveler (2023), Wilcox, Fowell & Baichtal (2020) present evidence that, compared to the Atlantic, our NW Coast Younger Dryas was mild mannered, with only subtle changes—for example in palynologic signatures.

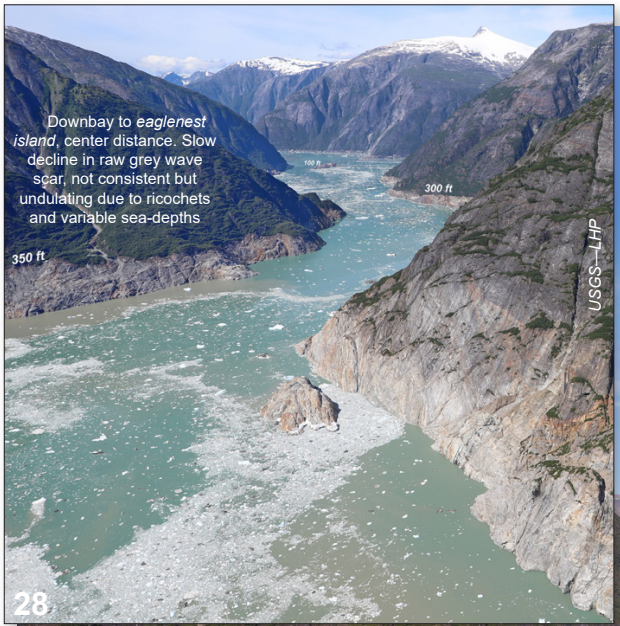
around 1895 was triggered probably by similar glacial 'debutressing' that set off this more recent great wave. It left an unmistakeable 80M m³ rubble pile, half-mile in diameter, in the bay's West Arm (Coe *et al* 2018; inset next page).



22 Closeup of 1,670-foot runup scar. Zooming in, defoliated but not uprooted scrub alder near crest where wave lost energy.

USGS flew over rockslide apex for this view down the plane of slippage. Steady calving from debris-shrouded snout sets up currents and eddies that send berg-trains swirling.

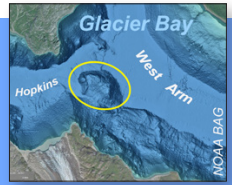
Wave-scar heights For a crude first-take on wave-scar elevations, I ran IfSAR contours. A LiDAR DTM in conjunction with vegetative point cloud will enable much better estimates, and presumably is a priority now for USGS-LHP. ● From post-rockslide *Copernicus* imagery, I've estimated scar heights in feet (*white italic #s*). A descending ricochet pattern off opposing fiord walls is suggested (translucent arrows), washing first to 1670 feet, then 900, 750, and 450 feet. After that the swash probably became more confused. The last major wave-scar at 'confluence point' cleared off brush to about 250 feet. Beyond, flying west down-fiord on USGS *.movs*, I see no scar appreciably higher than HTL (high tide line) trimline, **except in certain 'focusing coves.'** At 5:30am on 0810 when the slide occurred, sea was at about 5 feet, dropping toward a minus tide. So even a 10-foot swell rushing downbay wouldn't have reached HTL without an assist from runup swash.



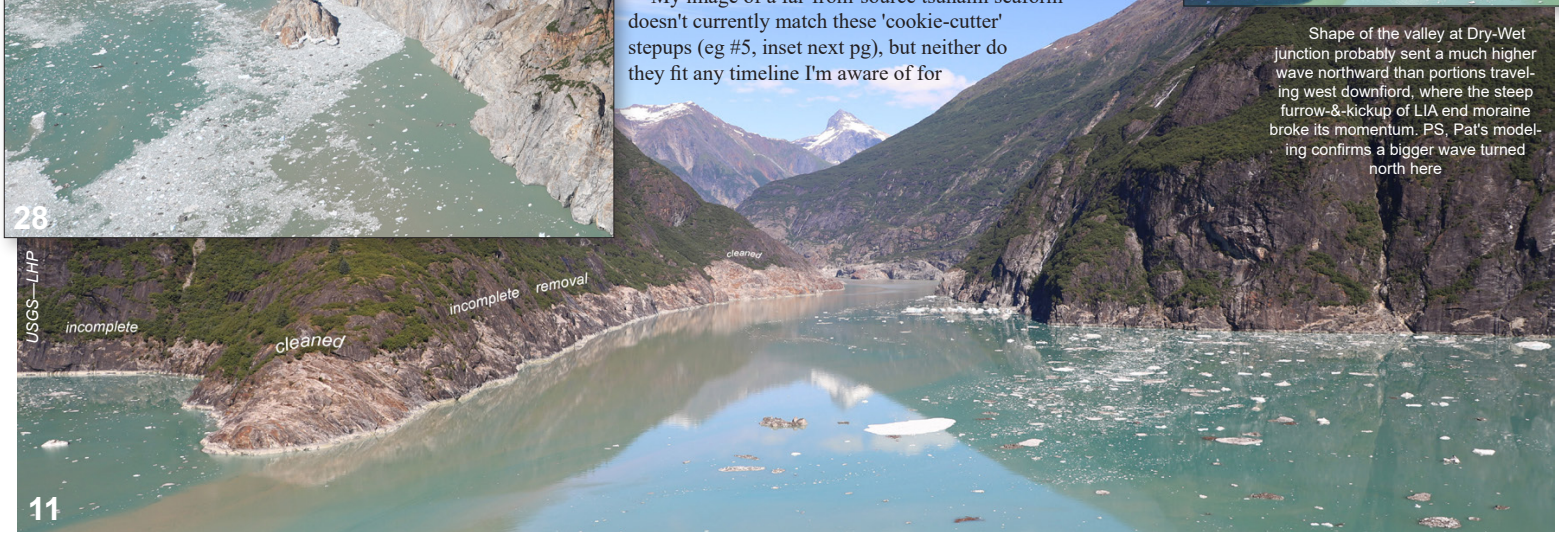
But that's a rockslide 'seaform.' How about cut-or-fill seaforms from associated waves, far from initial dump-site, that a trained eye could spot on NOAA BAG hillshades? Has anyone studied such features, or known what to look for?

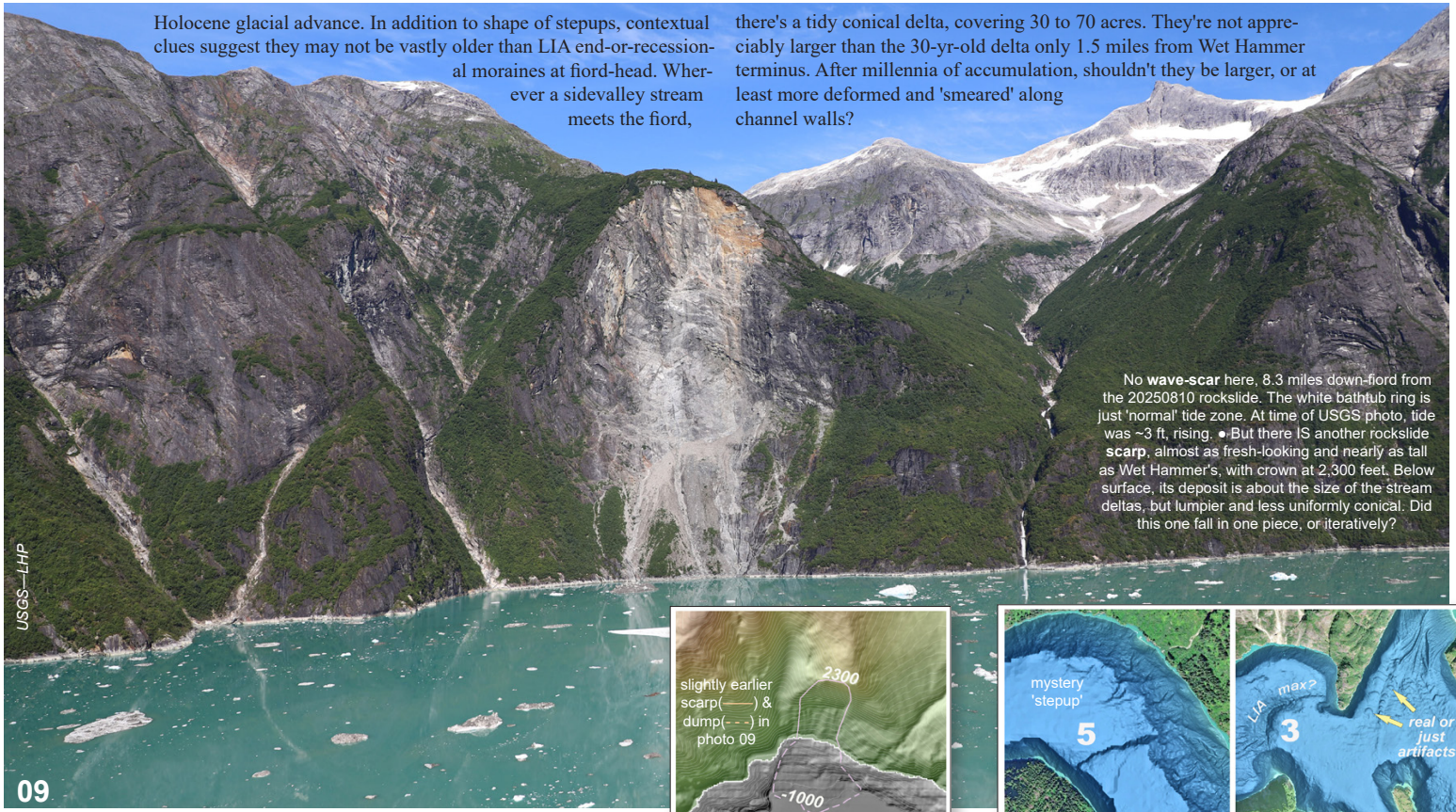
Returning to my numbered 'furrows-&-kickups' on North S'awdáan master map, #3 has the highest, 'textbook' crescent, presumably (?) its Little Ice Age terminal moraine. Continuing west, what I first took for older furrowed moraines seem on closer look to be simpler, 'step-ups.' In fact, #s 4 thru 7 have no 'kickups' or depositional 'lips' at all.

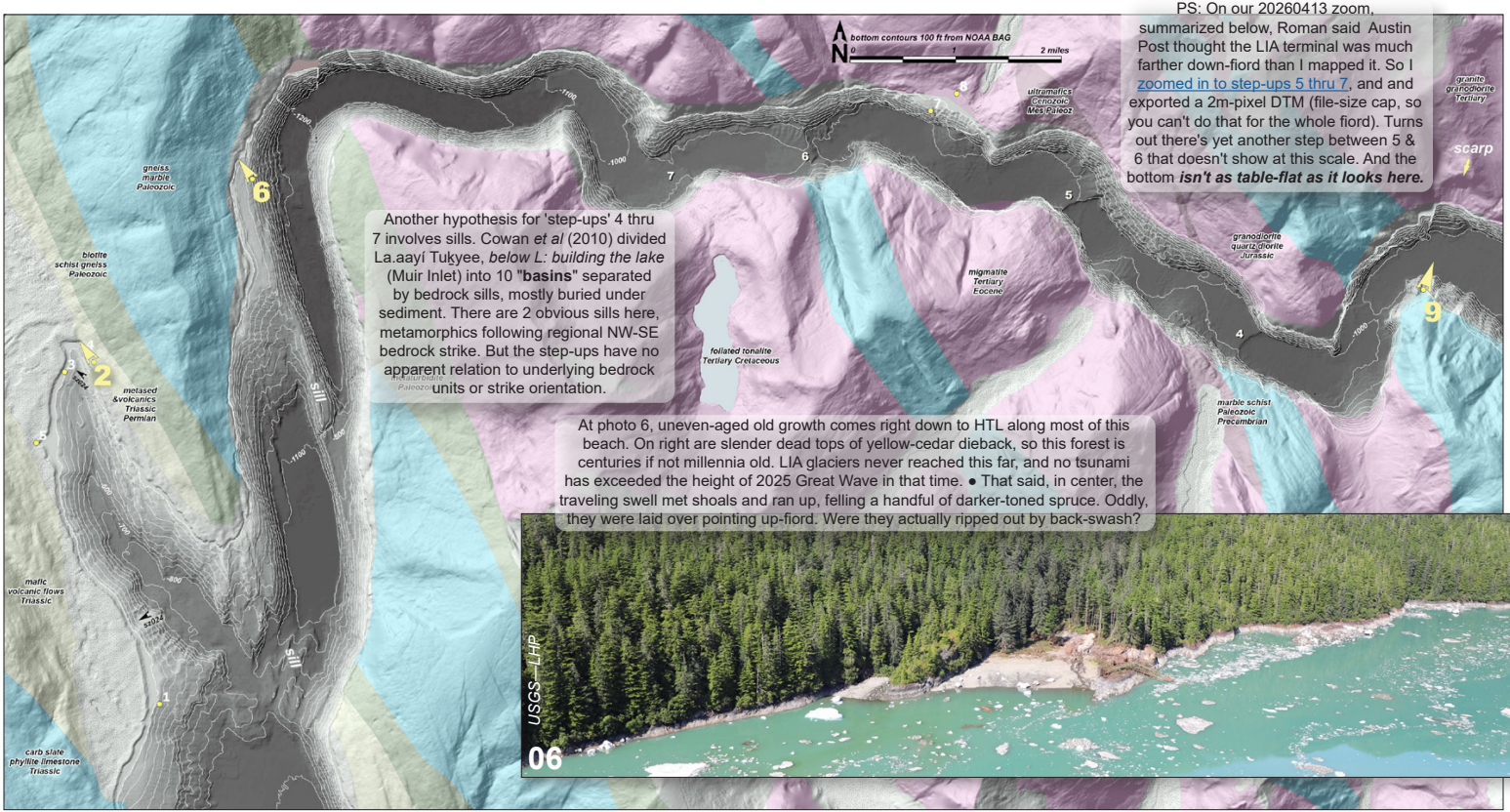
My image of a far-from-source tsunami seaform doesn't currently match these 'cookie-cutter' stepups (eg #5, inset next pg), but neither do they fit any timeline I'm aware of for



Shape of the valley at Dry-Wet junction probably sent a much higher wave northward than portions traveling west downfiord, where the steep furrow-&-kickup of LIA end moraine broke its momentum. PS, Pat's modeling confirms a bigger wave turned north here




Holocene glacial advance. In addition to shape of stepups, contextual clues suggest they may not be vastly older than LIA end-or-recessional moraines at fiord-head. Wherever a sidevalley stream meets the fiord, there's a tidy conical delta, covering 30 to 70 acres. They're not appreciably larger than the 30-yr-old delta only 1.5 miles from Wet Hammer terminus. After millennia of accumulation, shouldn't they be larger, or at least more deformed and 'smeared' along channel walls?
No **wave-scar** here, 8.3 miles down-fiord from the 20250810 rockslide. The white bathtub ring is just 'normal' tide zone. At time of USGS photo, tide was ~3 ft, rising. ● But there IS another rockslide **scarp**, almost as fresh-looking and nearly as tall as Wet Hammer's, with crown at 2,300 feet. Below surface, its deposit is about the size of the stream deltas, but lumpier and less uniformly conical. Did this one fall in one piece, or iteratively?
USGS—LHP
09
slightly earlier scarp(——) & dump(- - -) in photo 09
2300
~1000
mystery 'stepup'
5
LIA max?
3
real or just artifacts?
last definitive furrow moraine



But if wimpy deltas suggest youth, maybe other bottom features are pointing to deeper age. Why, in this lower-fiord reach, is the bottom so smooth, and so consistently deep—rarely >1200 or >900 feet? Does that result from millennia of bottom-leveling? Punctuated perhaps by great-wave reshufflings but sedimentarily

relaxed compared to a prolific delivery-system like Sít' Eeti Geeyí, *bay in place of the glacier* (Glacier Bay)? Scrolling Bay-bottom with NOAA BAG online viewer, shows furrow&kickup analogs to North S'awdáan's same-aged LIA terminal & recessionals (#s 1-3, context map), but *not* to the much older (?) evenly spaced step-ups (#s 4-7). Sít' Eeti Geeyí is <250 years old, so absence of step-ups there indicates these features—whatever they are—require **1)** more time, and/or **2)** some disturbance present in North S'awdáan but lacking in The Bay.

02 Dicey anchorage Williams Cove was named for a hunting guide by his wife. It doubtless had a better-but-forgotten Lingít name, because passing mariners know it as refuge from heavy weather in the Xutsnoowú-to-mainland gale-tunnel. In pre-cruise scoping I posited a younger dryas moraine in the pass between Williams and Sweetheart Creek flats. Because dates of pre-LIA glacial features give us such mixed messages—and consensus-lapse among experts—let's get a palynologist into those peatlands just inside my putative YD moraine, for basal radiocarbon dates. My money is on ~10- to 12,000 years.

After running 21 miles [2] with runup scars only on points or shoals, the tsunami washed into this popular anchorage, thankfully boatless in early morning of 0810. Hard to visualize refraction around the enclosing point with enough power to clean out this forest. Maybe, instead, another ricochet, from waves bunching up on the S'awdáan Spit end moraine #8, then bouncing back northward?

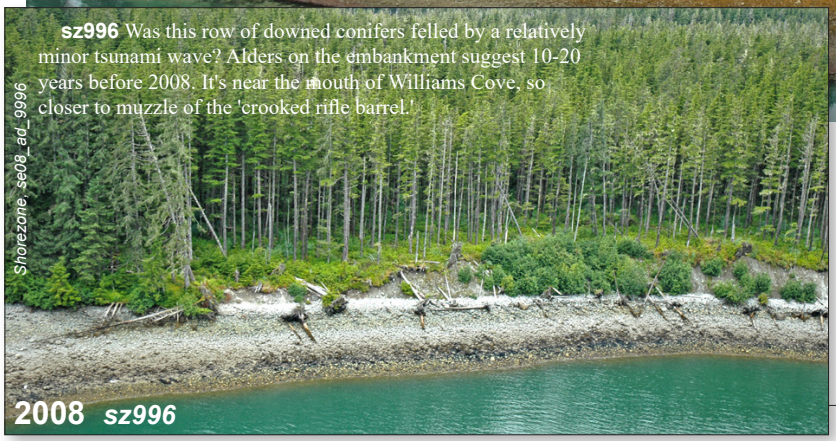
2 Channel thalweg distance, but not including ricochets or possible bounceback from end moraine.

If I saw this strikingly even-aged, snag-free hemlock forest up in the CBJ, I'd call it blowdown recovery from our 1883 windstorm. If instead, this is a tsunami forest, it holds important clues to periodicity and human safety. We'd find tipped-but-not killed trees at the back edge, and on sectioned 'cookies', could pinpoint exact year of the 'Even Greater Wave' from sudden growth-ring asymmetry.

I've labeled points A, B and C above and on a Shorezone oblique, next page. On first look, seemed odd the wave scalped everything above point B without leaving even stumps. Line A is a rhizome-bound layer of low-marsh soil, with even some grasses surviving on left photo margin.

We don't need Sherlockian deduction here, because on next page we have a 2008 Shorezone oblique (smaller black arrows on previous map). Turns out line B was the lower edge of high marsh grasses (*ie* never *were* any stumps here), grading gently into a narrow band of uplift meadow, barely above HTL . [3] My

3 Glacial rebound here is mapped as ~0.3-inches per year, half of Áak'w Aaní's. This explains lack of stumps in the brown denuded belt above line B. No trees grew here; it was just tidal marsh and supratidal meadow.



sz996 Was this row of downed conifers felled by a relatively minor tsunami wave? Alders on the embankment suggest 10-20 years before 2008. It's near the mouth of Williams Cove, so closer to muzzle of the 'crooked rifle barrel.'

reference arrows show the wave removed meadow and frontal forest to a distance slightly greater than A-to-B.

sz024 In other words, the forest felled in Williams Cove head was mostly the frontal band of 'uplift spruces,' and maybe just a few of the leading ranks of same-aged disturbance forest, whether dating to wind or another great wave. Point C marks the back edge of this stand.

LiDAR is expensive. I'm sure there's consensus by now that we need it for the head of North S'awdáan Fiord—but maybe not the whole thing? If so, I'd lobby for a disjunct mission over this cove, and the mysterious, undated morainal mouth of Sít'ḵú.

Carstensen

20260413 Great Wave zoom

This summer Greg Chaney and Hig took Pat Lynett from USC down to North S'awdáan fiord (Tracy Arm) to examine aftermath of the mountainside detachment & Great Wave. Greg's working on a movie, a 'sequel' of sorts to *Life on ice* (2013) about Hig & Erin's long walk. Koren agreed to host a half-in-person-half-virtual mapping show&tell using her largescreen tv. Invites went out to:

Patrick Lynett ● Bretwood Higman ● Cathy Connor ● Mike Hekkers & Di Johnson ● Mike Janes ● Kanaan Bausler ● Chris Wilbur ● Greg Chaney ● Eran Hood ● Roman Motyka ● Koren Bosworth ● Cathy Pohl

More folks with expertise above & below sea level that we should involve in future brainstormings:

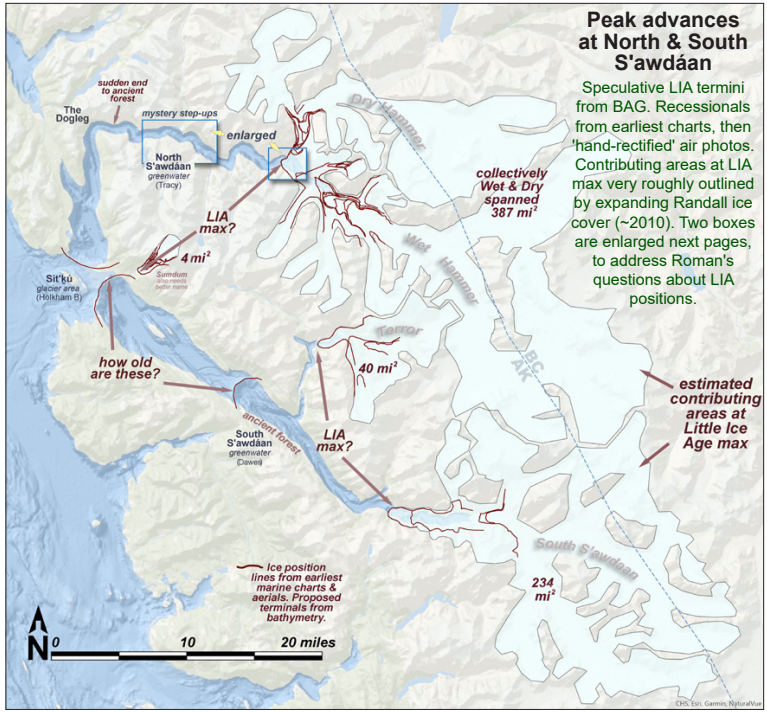
Ellen Cowan ● Jim Baichtal ● Ross Powell ● Dan Mann ● Chris Fastie ● Ben Gaglioti ● Greg Wiles

Since the meeting I've been reorganizing *3tantrums.pdf* into a more orderly progression, which I will post to *JuneauNature>CULTURE> Dodging nature's tantrums*. Let's use these 5 concluding pages to explore several questions that came up in our wide-ranging discussion. Meeting minutes, sort of.

A newbie at hosting zoom, I was happy we connected at all. Didn't think to record the session, but should've cause I remember only a fraction of what folks said. Hig scrambled up the wave scar in several places, and disagrees with some of my 'eyeballed' scar heights, traced from Copernicus post-wave imagery over IfSAR 25-ft contours. In particular, my 450-foot line, on north shore—last big slosh-up before the long down-fiord run—is too high.

Greg gave us a sneak preview of their drone video, and a bunch of animations from Pat Lynett's tsunami modeling. Hig says Pat did have access to the hi-res NOAA BAG for this modeling. Animations moved too quickly for me to absorb or remember details of wave behavior, but during one of em, midway between rockslide and mouth of Sít'ḵú, there seemed to be 'stutters' or implosions, maybe interacting with the 'crooked rifle barrel'. Would be helpful to freeze and overlay those collapses(?) onto the mysterious step-ups I've been scratching my head over.

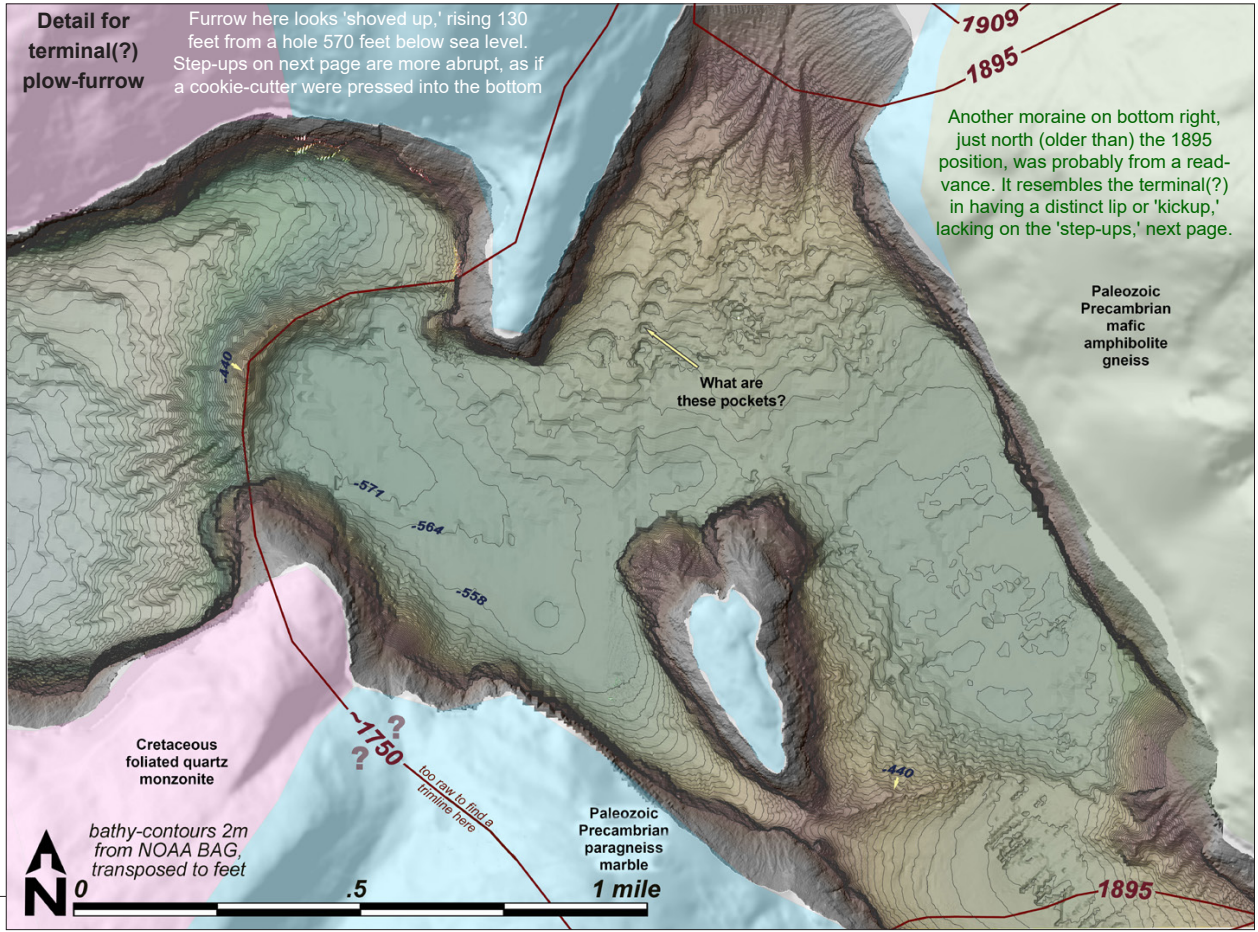
For me, biggest puzzler is timing & seaward reach of Little Ice Age *vs* prior, undated advances. Initial ruminations are above, including 1994 field notes from old growth at entry to ~~Ford's~~ Terror Fiord. I've never been far up South S'awdáan (Endicott-Dawes) but 'flying' the southside with Shorezone obliques, there *seems* to be a transition from ancient hemlock-spruce mix to more even-aged spruce inside my purported LIA terminal. Even there, on mellower topography than North S'awdáan canyon, a YG-to-OG transition is not as clean and textbook as I could hope for.



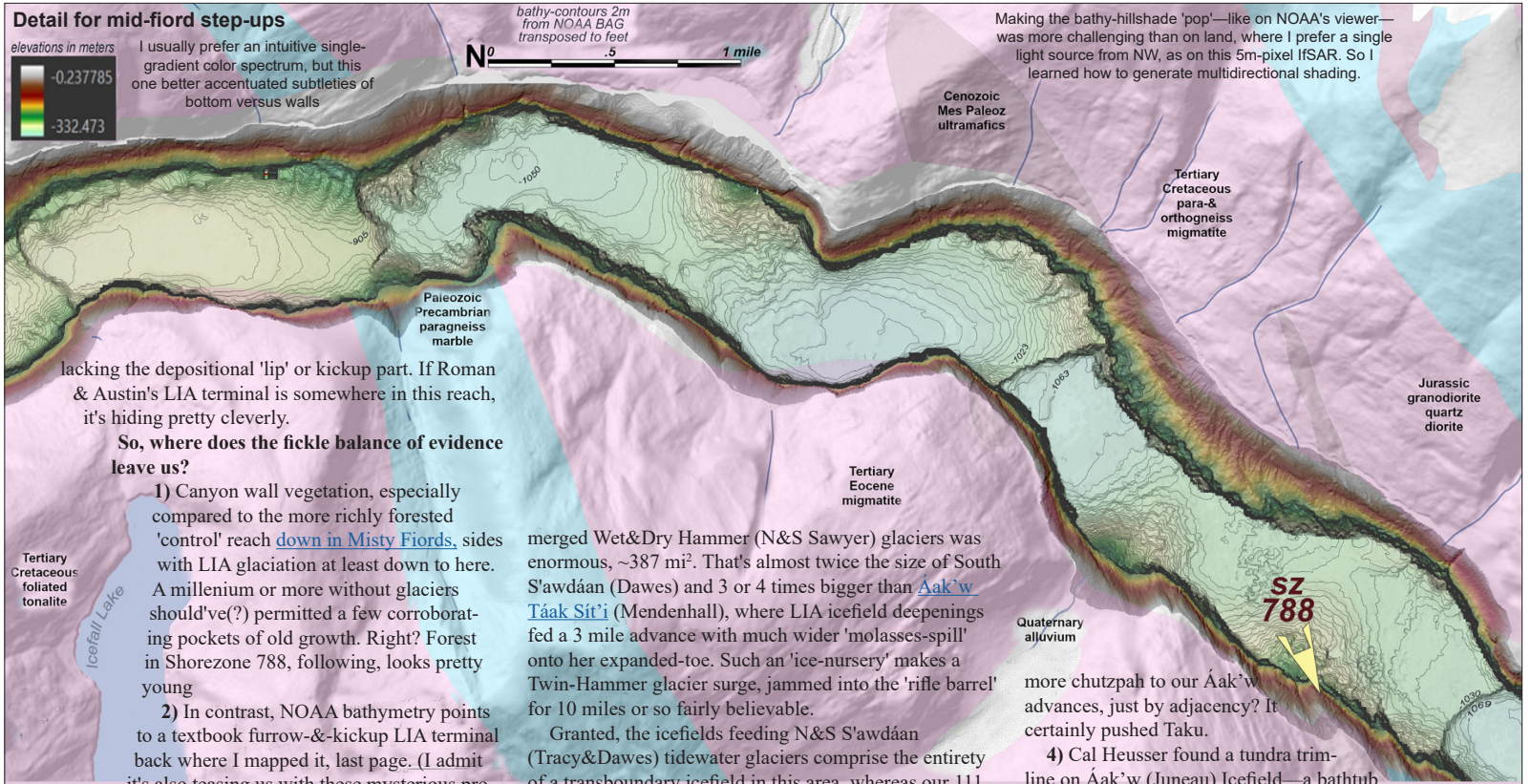
Some GIS users consider IfSAR "*crap.*" Dave Gregovich might not judge it that harshly, but did abandon efforts to extract tree heights (DSM minus DTM). I agree; for such applications it's too coarse. But I love IfSAR for what it is; a mid-resolution model covering all of Lingít Aaní, that emancipated us, 15 years ago, from the dark ages of 30m-pixel terrain models. I never use IfSAR's smushed-looking DTM; only the DSM showing everything up to tops of vegetation. We obviously have to account for that in tall tree country, but not at the landslide site. On barren slopes, when I compare IfSAR DSM contours to DTMs from 1m-pixel LiDAR, they agree within 10 or 20 feet.

Above-sea-level tracks of the LIA are even more elusive moving back to North S'awdáan 'rifle-barrel.' I see no incontestable old growth very far up-fiord from The Dogleg (map, previous page.) So are Roman & Austin correct that the LIA moraine lies somewhere between there and this deep-hole plough furrow—making this one only a recessional?

Earlier, using a lower-res export from BAG, fiord bottom between step-ups looked table-flat. That impression disappears when you extract a DTM at 2m-pixel, next page. But my claim that water depth is strangely consistent, never >1200 or <900 ft, holds up. Where bottom slopes, *very* gently, [1] it's usually a toeslope from steeper deltas at mouths of FS-mapped streams. Although bottom undulates more than I first concluded, these stepups are qualitatively different from clearly morainal furrows-&-kickups on previous page,



1 *Eg:* 50 feet rise over half mile run, or 2% slope; imperceptible if you were down there in a submarine. Explains why it seemed level on preceding lower-res hillshade



lacking the depositional 'lip' or kickup part. If Roman & Austin's LIA terminal is somewhere in this reach, it's hiding pretty cleverly.

So, where does the fickle balance of evidence leave us?

1) Canyon wall vegetation, especially compared to the more richly forested 'control' reach down in Misty Fiords, sides with LIA glaciation at least down to here. A millenium or more without glaciers should've(?) permitted a few corroborating pockets of old growth. Right? Forest in Shorezone 788, following, looks pretty young

2) In contrast, NOAA bathymetry points to a textbook furrow-&-kickup LIA terminal back where I mapped it, last page. (I admit it's also teasing us with these mysterious pro-glacial step-ups, 10 miles farther down.)

3) On the other hand, my LIA accumulation area for merged Wet&Dry Hammer (N&S Sawyer) glaciers was enormous, ~387 mi^2. That's almost twice the size of South S'awdáan (Dawes) and 3 or 4 times bigger than Áak'w Táak Sít'i (Mendenhall), where LIA icefield deepenings fed a 3 mile advance with much wider 'molasses-spill' onto her expanded-toe. Such an 'ice-nursery' makes a Twin-Hammer glacier surge, jammed into the 'rifle barrel' for 10 miles or so fairly believable.

Granted, the icefields feeding N&S S'awdáan (Tracy&Dawes) tidewater glaciers comprise the entirety of a transboundary icefield in this area, whereas our 111 mi^2 Áak'w Táak Sít'i accumulation area is only one corner of a sprawling, 1,500 mi^2 ice mass. Did that impart more chutzpah to our Áak'w advances, just by adjacency? It certainly pushed Taku.

4) Cal Heusser found a tundra trim-line on Áak'w (Juneau) Icefield—a bathtub ring showing 500 feet of LIA thickening. Is there anything similar above Twin Hammers? If so, probably

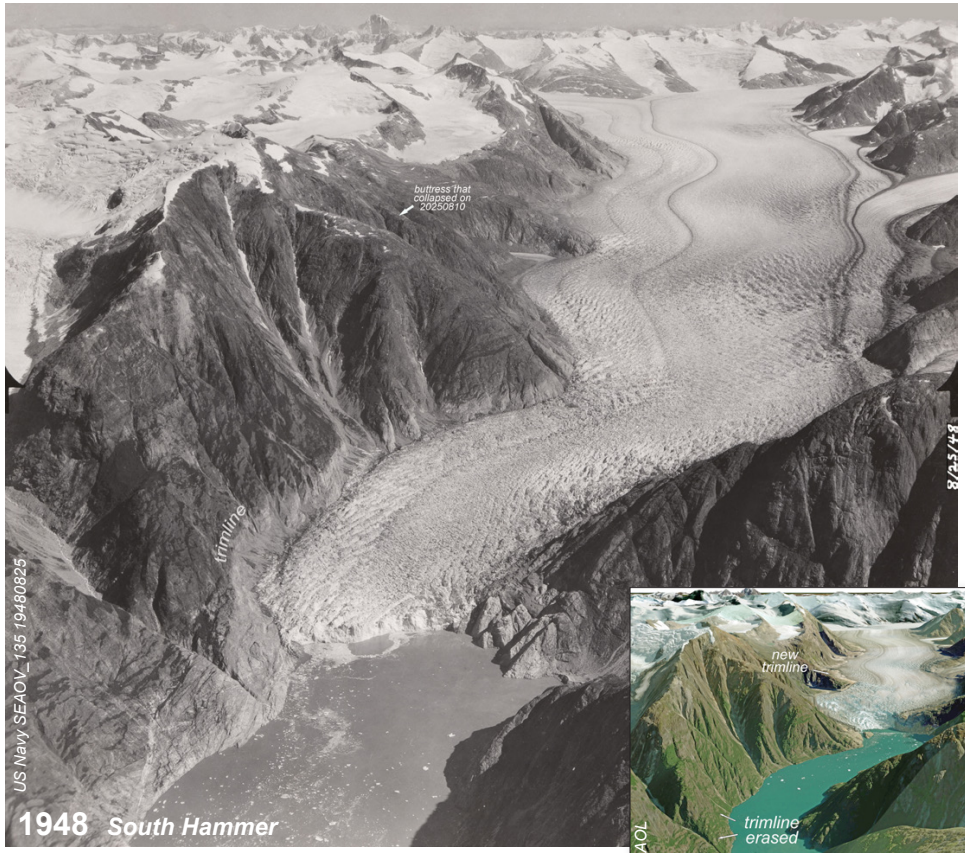
too subtle for airphoto interpretation, better delineated by botanists on the ground. Ericaceous alpine tundra is an old-growth community, with some cushions many centuries old.

On preceding nadir flippers, I was puzzled by 1948's clear trimline, close to South Hammer's terminus, but not extending far up-glacier. I even wondered if it was the LIA high-ice position. Answer; no. This oblique, and replication in arcpro's tipup mode confirms that brush-&-herbaceous trimlines are ephemeral. In a mere 70 years, revegetation erases them. It does however indicate that downwasting along the last mile is more dramatic than farther upglacier, where ice surface is evidently more stable.

While my preceding clues #1&2 address distal ends of LIA advance, #s3&4 concern the source or 'glacier-feeding' end. While I'm tipping slightly toward Roman's opinion that LIA terminus was far down fiord from where I'm currently mapping it, what I can't reconcile is how ***thick*** that hugely swollen glacier should've been at junction of Hammer arms. A valley glacier can't extend 10 miles at zero grade.

Let's calibrate. Moving up this 1948 oblique, surface gains 1,000 feet in 5 miles. At that 19% grade, if she reached down into my step-ups map on previous page, it would've been 2,000 feet deep over my currently (improperly?) mapped terminus. Doing that, she'd also slither laterally far up mellower trib valleys, where gravity couldn't have swept away every last lateral moraine, or residue of backwatered GLOF impoundments.

Shorezone oblique *se08_ad_10788* shows one such valley. Inset map on right gives context and photo direction, at SE corner of my Stepups map. Forest development's more consistent with Roman's proposal; no old growth, just young spruce forest. But if there



US Navy. 1948. South Sawyer Glacier: Glacier Photograph Collection. Boulder, Colorado: National Snow & Ice Data Center. Digital media. Compare to 1948 nadir ortho, also showing an abrupt trimline here but not farther upvalley.

are lingering ice-edge features, LiDAR will eventually expose them. Elsewhere throughout Lingít Aaní, I've found LIA moraines even on relatively coarse IfSAR, especially the more prominent 'necklaces' in N-facing alpine cirques. So far, I see nothing suggestive in side valleys of North S'awdáan Fiord.

IV Appendices

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Lingít place names

Áak'w and T'aaḵú Aaní names

Mostly from Thornton & Martin (2012). Names marked O&K92 set come from a project by Marie Olson and Cecilia Kunz in 1991&92.

Áak'w, *little lake* (Auke Lake)
Áak'w Ḵwáan Sit'í, *Auk people's glacier* (Mendenhall)
Áak'w Noow, *little lake fort* (Auke Nu bluff)
Áak'w Tá, *little lake bay* (Auke Bay)
Áak'w Táak, *inland from little lake* (Mendenhall Valley)
Aanchgaltsóow, *nexus town* (Auke Rec)
Aas yatx'i x̱'aayi, *no transl* (Norway Pt O&K92)
Aangooxa Yé X'aat T'aak, *Aang. island* (Entrance Pt)
Aan Sakweis's'í, town, *no transl* (~Sweeny Cr)
Aanx̱'atinyé, *where mouth of land lies* (Canyon Island)
Aanyakax'áat'i, *island front of village* (Anyaka Island)
Anax̱ Yaa Andagan Yé, *where sun-rays hit first* (Douglas Hbr)
Angooxa Yé, *beside town slaves* (Fish Cr/Hut Pt)
Asx̱'ée, *twisted tree (dam)* (Eagle River)
Ax̱'aká, *the mouth* (Berner's mouth; approx Cove Pt)
Chaas'héeni, *humpy creek* (Sheep Creek)
Ch'eet' Taayi, *murrelet fat* (Cowee Creek)
Chookan.aani, *grassy land* (The Flats)
Daxanáak, *between 2 points* (Berners Bay)
Daxanáak L'éiw Shuká, *sandy end* (Berners flats)
Dayéi X̱'akax'áas, *waterfall at mouth of D.* (Dayebas Creek)
Deishú Áak'u, *little lake-end trail* (Outer Pt)
Deishú Áak'w, *little trail-end lagoon* (Oliver Inlet)
Dzánti, *flounder* (Capitol Hill)
Dzantik'i Héeni, *little flounder creek* (Gold Creek)
Dzisk'w liu kaadi, *little owl landslide* (on Thane Road)
Eeyák'w, *small rapid* (Salt Chuck)
Eix̱'gul'héen, *creek at end of slough* (Switzer Creek)
Ġaat Héeni, *sockeye creek* (Auke Creek)
Ġaat Héeni, *sockeye creek* (Snettisham)
Goochk'i Deik, *no transl?* (Basin Road)
Héen Tlein, *big river* (Inklen River)
It'ji Shaanáx̱, *sparkling valley* (Perseverance Valley)
Jánwu Teix'i, *mountain goat head* (Mt Golub)
Kaa Shaa Teiwalgi, *person's head rock hole* (on Windfall?)
Ḵáak'w X̱anseiyí, *below little man* (Point Sherman)
Ḵáak'w X̱an, *by the little man* (Kakuhan Range)
Ḵaalahéenak'u, *inside a person's mouth* (Peterson Creek S)
Ḵaalaká, *human mouth* (Auke Nu Cove)
Ḵaalaká, *inside the mouth* (Pearl Harbor)
K'aan Héenak'u, *porpoise little bay* (Smuggler's Cove)
Kaawa.ée Héenak'u, *Kaawa.ée's little creek* (Kowee Creek)
Kadigooni X'áat', *island with spring water* (Spuhn Island)
Katlaax̱ Jíni, *hand of moldy head* (Blackerby Ridge)
Kax̱digoowu Héen, *going back clear water* (Montana Creek)
Kax̱digoowu Héen Dei, *trail on M-word river*
Kax̱tóok, *cave* (Taku Lodge)
Keishixjix'aa, *runs up point* (Point Bishop)
Kichxaak', *wing island* (Shelter Island)
Kichxaak' Tux̱yee, *wing island bottom end* (North Pass~)
Ḵoosh, *oozing sore* (Thane)
Ḵutak.aan, *no transl?* (Lace River village)
L'anax̱eet'ak'w, aa atwu xaayi yé, *where she ate . . .*(Shrine of St Therese O&K92)
L'éiw Aan, *sand village* (Grizzly Bar? mismapped?)
L'eiwkalagé, *shiny beach* (Portland Is)
Lkoodaséits'k, *giant's name* (Peak 3,280)
Lkoodaséits'k Leikachoox̱'u, *L's windpipe* (waterfall, Taku)
Lkoodaséits'k Shàyi, *giant's head* (Peak 3,440)
Lkoot Saayee, *knee-crook of Lkoot* (William Henry)
L'ux̱, *silty water* (Herbert River O&K92)
L'ux̱ Sít'i, *silty water glacier*
Luknax daayi, *no transl* (Petersen Creek 25-mile O&K92)
Naahéeni, *tribe creek* (Hidden Creek, AK-BC)
Naa.yádi, *child of the clan* (Lincoln Is)
Neix̱a yei, *boat saver?* (Eldred Rk) Neix= save, yei = boat
Nex̱'w X'aayí, *cloudberry point* (Lena Pt)
S'aax̱ gooni, *groundhog spring* (on Thane Road O&K92)
S'awdáan, *dungie town* (Holkham Bay)
Sawdáat X'áat'i, *soldier island* (Indian Is)
Sayéik, *spirit helper* (Douglas Island) canyon channel
Séet ka, *canyon channel* (Gastineau Channel)
Shaa Tlaax̱, *moldy top* (Mt Juneau)
Shaa X'áat'i, *mountain island* (Coglan Island)
Shaanáx̱ Tlein, *big valley* (Lemon Creek valley)
Shakanáx̱k'w, *dead trees on mountain* (Funter Bay)
Shgóonaa Héenak'u, *Schooner's little creek* (Lawson Creek Village)
Shikaagi Noow, *thick-walled* (logs) fort (Outer Pt)
Shi kaa gi x'aa, *transl?* ("near Shaman Is" O&K92)
S'iknáx̱, *black bear town* (Limestone Inlet)
S'ik'náx̱ Aan Ġeeyí, *grindstone town bay* (Taku Harbor)
S'iknax̱sáank'i, *little one below S'iknax̱* (Taku Harbor alt name)
Sít', *glacier* (also used for Lemon Gl) (Mendenhall Glacier)
Sít'.áa, *glacier lake* (post-1910-Mendenhall Lake)
Sít' Áayi, *glacier lake* (Twin Glacier Lake)
Sít' Ġeeyí, *glacier bay* (Gilbert Bay)
Sitko, *no transl* (Whiting River, Douglas, 1842)
Sít'ḵú Héen, *glacier area creek* (Lemon Creek)
Sít' T'ak Aaní, *land with glaciers above* (Sittakany River)
Sit' ḵú, *glacier area* (both Snettisham & Holkham Bays)
Sít' Kuna Ġeeyí, *glacier-bidding cove* (terminus cove)
Sít' X'aayí, *glacier point* (Swede Point)
Taashuyee, *river/tide/mud-flats* (Mendenhall Wetlands)
T'aaḵú, *flood of geese* (Taku River)
T'aaḵú Kunaa Ġeeyí, *glacier-bidding bay* (Taku Inlet)
T'aaḵú Ḵwáan Sít'i, *Taku peoples' glacier* (Taku Glacier)
T'aaḵú Teix'i, *heart of T* (isle, Taku)
T'aaḵú X̱'aka.aan, *town at mouth of Taku* (Cherokee Beach)
Taaltsuxéi, *front of big flat basket* (Tulsequah River)
Taan X'áati, *sea lion island* (Benjamin Is)
T'aawák, Éix'i, *goose slough* (Yehring Creek)
Til'héeni, *dog salmon creek* (Salmon Creek)
Tlaksidak, *no transl* (Sweetheart Creek)
Tleix̱satanjín, *hand at rest* (Heintzleman Ridge)
Tool T'eik, *lowbush cranberries* (Peterson Creek N O&K92)
Tsaa T'ei Héen, *behind the seals creek* (Admiralty Cove)
Ts'eeni, *no transl* (A.J. Mine O&K92)
Was'as'éi, *giant's name* (Dorothy Peak 4,524)
Weineidei, *alkali deposit trail* (Hawk Inlet head)
Weineidei Aan, *alkali deposit village* (Fowler Creek)
Wóoshde X̱ 'al.at Yé, *place where mouth closes* (Tee Harbor)
Wooshkeenax̱ Deiyí, *trails above each other* (Roberts Trail)
Woosh eel'óox̱'u héen, *river that's murky together* (M-word R.)
X'áat' T'áak, *beside the island* (Douglas town)
X'unáx̱i, *camping place* (Auke Cape)
Xuts Lutú, *brown bear inside the nose* (Point Retreat)
Yaana.eit X'aat'i, *cow parsnip island* (off Spuhn)
Yadaa.at Kalé, *beautifully adorned face* (Mt Juneau face)
Yadat'ook, *glancing at it* (Lookout Point)
Yakwdeiyí, *canoe path* (upper Yehring)
Yanyeidí X'aayi, *Yanyeidí point* (Taku Pt)
Yaxté, *dipper* (Auke Lake/Bay)
Yaxwch'i Ḵaadi Táak, *sea otter slide back of bay* (Barlow Cove)
Yéilch Awataayi Yé, *raven ? place* (Lena shaman site)

g Ġ ḵ Ḵ x̱ X̱ Cut & paste from these letters; underlines will carry through into WordPress, Word, Indesign-to-pdf, etc. Even works in an Arcmap attribute table, retaining underscore in map-view.

Jilḵáat and Jilḵoot Aaní names from Thornton & Martin (2012).

Áa ka, *on the lake* (Chilkat Lake)
Áa Yuwaa Héeni, *lower belly of lake* (Chilkat Lake)
Aalséix, *resting* (Alsek River)
Aanyakax'áat'i, *island in front of village* (Anyaka Island)
Áanák'w, *little village* (9.5mile)
Áanák'w Noowu, *Áanák'w fort* (9.5mile)
Aanwán, *edge of village* (Chilkat Lake fan)
Aan Yanaade Héen, *running toward the village* (reversing outlet)
Aasnoowuta.aan, *town at back of aasnoowu* (N Chilkoot)
Áax'w Sáani Xoo, *among the little lakes* (Log Cabin)
Agóon, *isthmus of it* (behind Haines)
A Shakée, *top of it* (Chilkoot Pass)
Ayaan Héeni, *tutchone river (*Herman Creek)
Ayiklutu, *nostril of Ayik* (Seduction Point)
Ch'áak' Héeni, *eagle river* (Eagle Creek)
Ch'ak'ilú, *beak of small eagle* (Iron Mtn)
Cháatl Ist'eix̱í A Káa Wlilaayi Shaa, *mtn where halibut fisher melted* (in Takshanuks)
Cháatl Shakaxaakwk'ú, *cutoff halibut skull* (N of Taiya Pt)
Cheech Gíl'k'i, *porpoise little cliff* (13mile)
Chookan Áa, *grassy lake* (lower Kelsall)
Daak Uwa.iyi Yé, *where rocks slid out* (E Chilkoot Lake)
Daḵhéen, *inland river* (Takhin River)
Daḵhéen Shaa, *inland river range* (Takhinsha Range)
Daḵshaa, *inland* (Takshanuk Range)
Daḵshaanáx̱, *inland valley* (behind Klukwan)
Daxanáak, *between 2 points* (Berners Bay)
Dayéi, *to pack* (Dyea valley)
Dayéi Héen, *to pack river* (Taiya River)
Dayéi X'akax'áas, *waterfall at mouth of Dayéi* (Dayebas Creek)
Dayéi X'aa Lutú, *inside nostril Dayéi* (Taiya Point)
Dayeisáank'i, *Dayei little cove* (Taiyasanka Harbor)
Dayeisáank'i Héen, *Taiyasanka creek* (Ferebee River)
Deishú, *end of trail* (Haines)
Dzix̱kú, _____ (Tsirku)
Éech' Xágu, *igneous rock beach* (W Lutak)
Éexnax̱.á Jigei, *southern crook of arm* (Glacier River)
Eey X'é, *mouth of rapids* (Devil's Elbow, Tsirku)
Ga̲atáa X̱'ayahéen, *creek at entry to trapping grounds* (W Chilkat L.)
Ga̲gaan Gooní, *sun spring* (N of Letnikof)
Ga̲théeni, *sockeye stream* (Tsirku River)
Ga̲tx̱'ayeehéeni, *ready sockeye to eat river* (Wells)
Ga̲ay Kúdi, *eagle nest* (27-mile S-side)
Ga̲élák'w, *little mountain pass* (into Dry Bay country)
Ga̲eisán, *top of bay* (Mt Ripinski)
Ga̲il'k'i Seiyí, *at base of cliff* (9mile)
Ga̲il'yaká, *in front of cliff* (E Lutak)
Ga̲il' X̱'áak, *between cliffs* (upper Tsirku)

Goonák'w, *little spring* (William Creek)
Goonk', *little spring* (Reeves Creek)
Goon Héeni, *springs creek* (Rustaback Creek)
Guchk'ihéeni *river at hill base* (Clear Creek)
Ga̲uwakaan Teiyí, *deer rock* (Chilkoot River mouth)
Íx̱t'i Daakeidí, *shaman's coffin* (21-mile hill)
Jánwu Deiyí, *mtn goat trail* (upper Chilkoot Lake)
Jánwu GGíl'i, *mtn goat cliff* (above Yindastuki)
Jilḵáat, *cache* (Chilkat River)
Jilḵáat Wát, *mouth of Jilḵáat* (McClellan Flats)
Ka̲ach kulnux'á k̲ k'w *no transl* (Jones Point)
Ka̲as'eiltseen GGíl'i, *Chookaneidi man's name cliff* (E of Taiyasanka)
Kadagoon, *island with springs* (Kataguni Island)
Kaltsex̱x̱'i Héen, *kicking river* (Kicking Horse)
Kagit X'áati'i, *loon island* (Birch Island)
Ka̲atx'waaltú, *rockslide* (19-mile village)
Kax̱la Ku.aa, *puking into* (Nourse River)
Kaxwéix̱ Koogú, *cranberry pit* (28-mile)
Kéet Áak'u, *killer whale lagoon* (head Lutak)
Kéet Séedak'u, *killer whale little strait* (Tsirku-Takhin pass)
Kei Dax̱akji Héen, *river retreating upward* (21.5-mile creek)
Ketlga̲xyé, *where dog cries* (Battery Point)
K'ideiyí Héeni, *path at base* (27 mile)
Koosawu Áa, *narrow lake* (gorge, upper Chilkat)
Ku̲xdeinú, *whirlpool/eddy* (Battery Pt Cove)
Kwaan Haat Jiwdagoodí, *epidemic came to fight* (E Lutak)
Lax̱ách' ____(Pyramid Island)
Ldeiniyé, *no transl* (Pyramid Harbor)
Ldus'k'ihéen, *dries after snowmelt* (upper Lutak)
L'ehéeni, *__river* (Klehini)
Léiḵ'wk', *little red snapper* (Chilkoot Lake alt-name)
Léix̱'w Noow, *ochre fort* (Paradise Cove)
Ligooshi X'áa', *island with thumb* (Shikosi Island)
Lḵoot, *storehouse* (Chilkoot Lake outlet village)
Lḵoot Ka Áa, *on top of Lḵoot* (Chilkoot Lake alt-name)
Lḵoot T'áak, *back side of Lḵoot* (Lutak Inlet)
Lkoodaséits'k, *giant's name* (Rainbow Glacier)
Náanax̱.á Jigeí, *northern crook of arm* (N of Glacier Pt)
Nánde Héeni Yei Kéich Yé, *sits in water facing north* (3 Guardsmen)
Neixinté X̱'aak, *bluegreen claystone ravine* (19.5-mile)
Núkdik', *little grouse* (Nukdik Pt)
Núkdik' Shakée, *little grouse hill* (hill above Nukdik Pt)
Saak Shu Aaní, *eulachon camp* (Shakuseyi Creek)
Saak Aaní, *eulachon camp* (9mile)
Salwán, *no transl* (Sullivan Island)
Salwán T'áak, *back of Salwan* (delta inside Sullivan)
Séet X̱'ayík, *entrance to the strait* (Moose Valley)
Shakuwúx̱'k'u, *little wide-head* (Chilkoot Lake)
Shakkwásk'i, *little chamberpot at head* (Chilkat Lakehead)
Shgagwei, *rugged water* (Skagway)
Sít'i Shaanax̱, *glacier valley* (Little Boulder Creek)

Sít'i X'aayí, *glacier point* (Glacier Point)
Sí.áat'i Goon, *cold spring* (Moose Meadows Creek)
T'ahéeni, *king salmon river* (Tahini River)
T'á noow, *king salmon fort* (18-mile)
Tan.aaní, *fish jumping grounds* (Tanani Point)
Tan.aaní Ge̲iyi, *Tanani Bay* (Tanani Bay)
T'áax'aa Geiyák'u, *mosquito's little bay* (Lutak head)
Tax̱éil, *soft white rock* (W Lutak)
Tayayee, *lying-in-wait rock* (Tsirku fan apex)
Téeyi Héenak'u, *soaked dryfish creek* (Mink Creek)
Tlákw.aan, *eternal village* (Klukwan)
Tlax̱aneis Noow, *kingfisher fort* (20-mile)
Tléiḵw Xágu, *berry sand beach* (N of Tanani Pt)
Tsaa Teiyí, *seal rock* (E Lutak)
Ts'ei g̲eenk'i Yé, *magpie place* (E Lutak)
Tsikhéeni, *roasting spit river* (Bear Flats Creek)
Tsísk'u Gíl'i, *owl cliff* (Chilkoot entry)
T'ukyík, *in the cradleboard* (Iron Mtn shoulder)
Watkalch'áal', *willows at mouth* (Anman Creek)
Wooshdaḵanté, *quarreling rocks* (N of Tanani)
Wulix'áasi Héen, *waterfall creek* (Katzehin River)
X'aask'i.áa, *lake at base of waterfall* (upper Chilkat R)
X̱'áakw X'aayí, *spawned-out sockeye point* (West Lake Creek fan)
X̱'ákw.áayi, *spawning salmon lake* (13mile+)
X̱'ákwhéeni, *spawning salmon creek* (Eagle Creek)
X̱'akashaanax̱, *valley at the mouth* (mtn cirque)
X̱'akwhéenak'u, *little spawning river* (above Wells)
Xalak'ach' Héeni, *porcupine river* (Porcupine River)
Xasdahéen, *waterfall creek* (Haska Creek)
Xíxch' Kanduwataayi Yé, *where frog packs drift ashore* (S of Katzehin)
X'éitaa Héeni, *cutthroat creek* (Cabin Creek)
Xíxch'i Shaayí T'eik, *behind frog mountain* (S Frog Mtn)
Xóots Héeni, *brown bear river* (Assignation Creek)
Xuni'i Áa, *__lake* (Mosquito Lake)
Yakwyaax̱, *alongside boat* (Big Boulder Creek)
Yandeist'aḵyé, *faraway stuff drifts ashore* (Yindastuki near airport)
Yaana.eit Xágu, *heracleum sandbar* (delta inside Sullivan Is)
Ya_Kei Dlakwt Aan, *where sheep* paw up the side* (Goat Mtn)
*probably mistranslated: tawéi = *dall sheep*
Yéil Daa.áax̱u, *raven's dryfish bundle* (lower Chilkoot River)
Yéil Háatl'i, *raven shit* (Penn-W)
Yéil Héeni, *raven's river* (Kelsall)
Yéil Teiyí, *raven rock* (Clear Creek outlet)
Yéil Áx' Sh Wulgeigi Yé, *where raven swung* (canyon SE of Sinclair)