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Geological background and geomorphology of the Boundary Bay intertidal zone, British Columbia

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Geological Survey of Canada
Current Research 2024-2

2024

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ISSN 1701-4387
ISBN 978-0-660-69552-5
Catalogue No. M44-2024/2E-PDF
https://doi.org/10.4095/332491

Recommended citation

Hill, P.R., 2024. Geological background and geomorphology of the Boundary Bay intertidal zone, British Columbia; Geological Survey of Canada, Current Research 2024-2, 18 p. https://doi.org/10.4095/332491

Critical review
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Correction date:

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Abstract: This paper presents geological and geomorphological background information on Boundary Bay, an intertidal shoreline located near Delta and Surrey, British Columbia, based on recently collected lidar data. The tidal flats overlie older deposits of the Fraser River delta and, locally, Quaternary deposits. A previously collected radiocarbon age suggests that the delta has been under transgression for approximately 4000 years. The modern shoreline has been extensively diked for land reclamation and flood protection since the late 19th century. Narrow extents of salt marsh are present seaward of the dikes. The high intertidal zone is strongly wave influenced, as evidenced by abundant shore-parallel bars, whereas the intermediate intertidal zone is tide dominated being characterized by incised tidal channels and eelgrass-stabilized interchannel areas.

Résumé : Le présent article fournit de l'information géologique et géomorphologique de base tirée de données lidar récemment recueillies au sujet du littoral (zone intertidale) de la baie Boundary, située près de Delta et de Surrey, en Colombie-Britannique. Les dépôts de l'estran surmontent des dépôts plus anciens du delta du fleuve Fraser et, par endroits, des dépôts quaternaires. Un âge radiocarbone déterminé antérieurement suggère que le delta est soumis à une transgression depuis les derniers 4 000 ans environ. Le littoral actuel a été largement endigué depuis la fin du XIXe siècle pour la mise en valeur des terres et la protection contre les inondations. D'étroites étendues de marais salés sont présentes au large des digues. La zone intertidale supérieure est fortement influencée par les vagues, comme en témoignent les nombreuses barres parallèles au rivage, tandis que la zone intertidale intermédiaire est dominée par les marées et se caractérise par des chenaux de marée encaissés et des zones interchenaux stabilisées par la zostère marine.

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INTRODUCTION

This report is prepared in support of the NRC-NRCan-CSSP project, “Nature-Based Infrastructure for Coastal Resilience and Risk Reduction.” Boundary Bay is the location of two proposed living dike projects by the cities of Delta and Surrey, BC. A living dike is defined as a “coastal flood protection system that also protects and enhances existing and future coastal and aquatic ecosystems” (SNC-Lavalin, 2018). The preliminary high-level assessment of the application of the living dike concept by SNC-Lavalin (2018) in Boundary Bay identified several important gaps in the available information for this area, including the need for a detailed description of either the historical or the present geomorphologic processes in the Boundary Bay area. This report attempts to fill this gap, based on a literature review and on newly collected lidar data.

BACKGROUND

General setting

Boundary Bay is located on the south side of the Fraser Delta between Point Roberts U.S.A. and White Rock, B.C. (Fig. 1). It forms part of the traditional territory of the Coast Salish people, including the Tsawwassen and Semiahmoo First Nations, and borders on the municipalities of Delta, Surrey, and White Rock, B.C., as well as Point Roberts, WA. The 12 km wide bay is less than 10 m deep everywhere, with respect to chart datum, and the inner part of the bay is characterized by broad intertidal flats (Fig. 2). No active channels of the Fraser River flow into Boundary Bay, but two smaller rivers, the Serpentine and Nicomekl rivers, enter through Mud Bay on the east side of Boundary Bay (Fig. 2). The mixed semi-diurnal tide has a mean tidal range of 2.7 m and a maximum spring tidal range of at least 4.1 m (Swinbanks and Murray, 1981). The bay is open to an open-water wind fetch of 25 km or more from the south. The strongest winds blow from the south-southeast (Fig. 3).

The bay rests primarily on Holocene deposits of the Fraser River that reach up to 150 m in thickness along the northern edge of the bay (Jol and Roberts, 1992), but are seen to thin southwestward toward the peninsula of Point Roberts (Jol and Roberts, 1988). Point Roberts and the eastern headland between White Rock and the Nicomekl River (Fig. 1) consist of Quaternary sediments of the Vashon Drift and Capilano Sediments (Armstrong, 1981; Dunn and Ricketts, 1994). Pre-Vashon sediments, including Quadra Sands and Semiahmoo Drift, are exposed in the bluffs of both promontories, providing a source of sediment supply to the adjacent shoreline.

Paleogeographic evolution

The presence of glacial deposits in the region indicate that the entire area presently occupied by the Fraser Delta and Boundary Bay was covered by glacial ice in the late Wisconsinan (Clague et al,, 1989; Darvill et al. 2018). The glacial ice started to retreat approx. 18 000 years ago. Very soon after, while global sea level was still low, the continental shelf was exposed and a land route along the coast became available for southward migration of humans into North America (Darvill et al. 2018). In regions occupied by the ice, the ice load depressed the crust. Seismic and borehole evidence from the Lower Mainland region defines a late Pleistocene surface characterized by an irregular topography and elevations extending from above present sea level to more than 300 m below (Clague et al., 1998). Simple reconstruction of this surface in relation to the raised relative sea level indicates that, at the initial stage of ice-sheet retreat, most of the region would have been flooded by the sea, forming a broad embayment extending into the Fraser Valley. The sea level at this initial stage (approx. 18 000 yrs BP) would have been up to 150 m higher relative to present day (Fig. 4a; Clague et al. 1982).

As the ice retreated from the Strait of Georgia and Lower Mainland area, the ice load was released, and the crust rebounded, resulting in a rapid lowering of relative sea level (James et al. 2005). Within a short time (by approx. 13 000 yrs BP), higher areas of the Late Wisconsinan glacial surface, including the Tsawwassen/Point Roberts and Surrey uplands, began to emerge as islands, still disconnected from the mainland (Fig. 4b). This paleogeographic reconstruction corroborates Semiahmoo oral history that their ancestors once used an offshore island in the vicinity of Point Roberts (H. Chappell, J. Charles, Semiahmoo First Nation, pers. comm., 2021).

Radiocarbon ages from boreholes in the Fraser Delta suggest that the Holocene delta was beginning to build out from the Fraser Valley by 9000 yrs BP (Williams and Roberts 1989). By 8000 yrs BP, relative sea level was close to its position today and a delta channel had extended out to the northeast corner of Boundary Bay. Hutchinson et al. (1995) mapped the distributary channel system, from seismic profiles (Fig. 4c) and constrained its age as an active system to between 8000 and 6000 yrs BP. At the same time as the delta channel advanced into the area, there is evidence for the use of coastal resources by humans at an archeological site in North Delta (Glenrose Cannery site) including remains of seal, salmon, eulachon, sturgeon, clams, and bay mussels, found associated with pebble tools (Matson and Coupland, 1995). The Hutchinson et al. (1995) map suggests that the site would have been located on the banks of the proto-Fraser River (Fig. 4c).

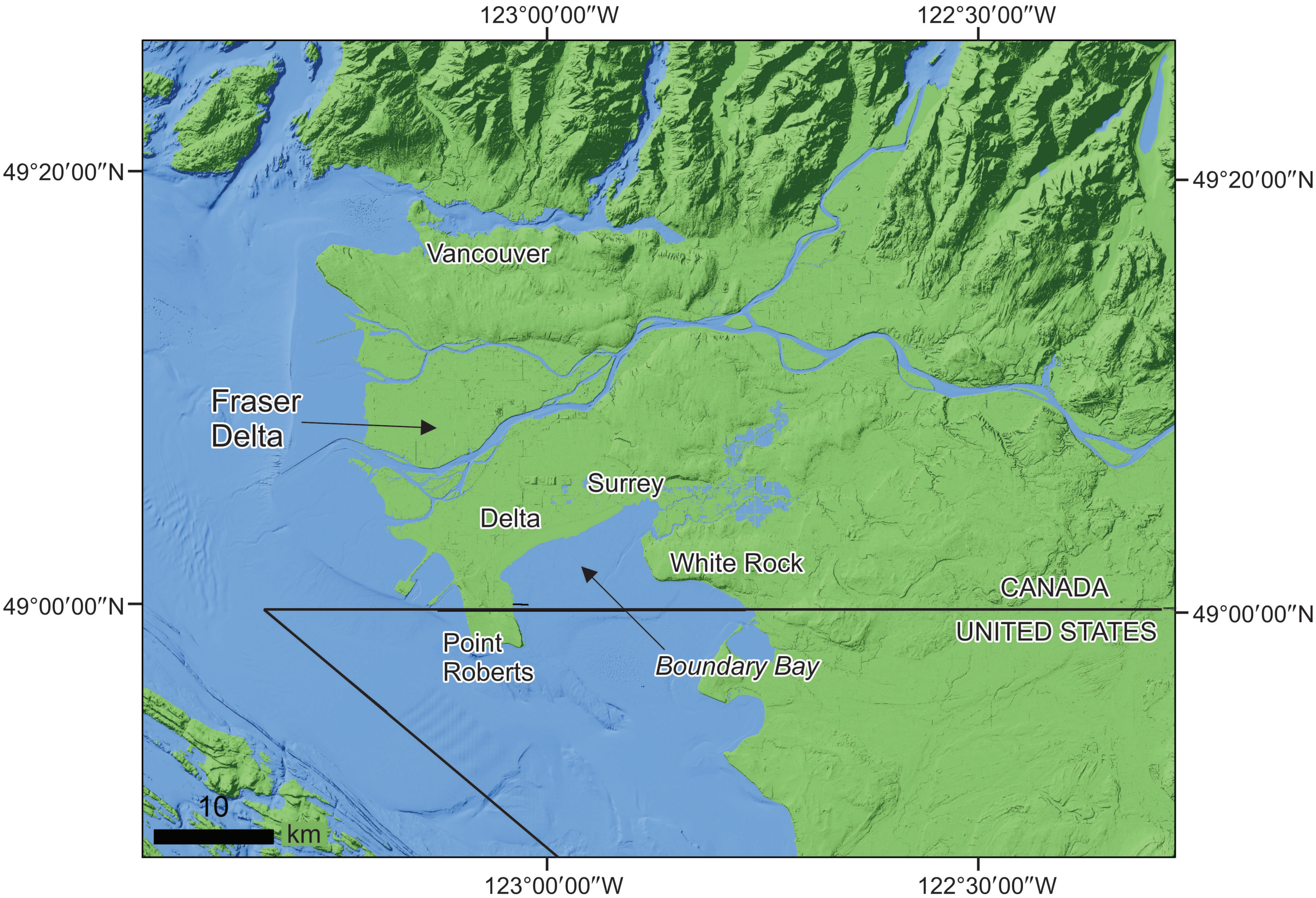

Figure 1. Map showing general location of Boundary Bay.

Between 8000 and 4500 yrs BP, the Fraser Delta continued to build out toward the Strait of Georgia and into Boundary Bay (Williams and Roberts, 1989; Clague et al., 1998), connecting the upland areas of Point Roberts and Surrey as a continuous land area. The presence of a buried peat deposit containing pollen from saltmarsh plants, located approximately 1 km offshore within Boundary Bay and radiocarbon dated at 4350 ± 100 yrs BP (Kellerhalls and Murray, 1969), indicates that the delta saltmarsh fringe extended further offshore at that time than it does today, implying that relative sea level has risen by approximately 0.6 m since that time. Delta subsidence (*see* below) probably accounts for this marine transgression. Many shell middens dating from 4500 to 400 yrs BP are located around the shoreline of Boundary Bay (Murray, 2008), suggesting extensive occupation of the shoreline by First Peoples.

Recent subsidence and relative sea level rise

Regional GPS and InSAR data indicate a correlation between the thickness of Holocene deltaic sediments and subsidence, related to ongoing consolidation of the young sediments. Average vertical motions of between 1 and 2 mm a^{-1} characterize areas of thick sediment accumulation in the Fraser Delta, whereas areas of consolidated Pleistocene deposits show negligible vertical motion of 0.1 mm a^{-1} (Mazzotti et al., 2009). These measurements confirm the inference of differential subsidence rates of Kellerhalls and Murray (1969) based on observations of raised beaches and middens above the present shoreline at Beach Grove (near Point Roberts) and drowned freshwater peats on the east side of the bay (Shepperd, 1981).

Modern coastal infrastructure

The modern coastline of Boundary Bay is characterized by the presence of dikes extending around most of the bay. Prior to dike construction, the coastline of Boundary Bay was included on a map defining the line of boundary between the United States and British possessions (Anonymous, 1846). Based on symbols on the map, it appears that the natural marsh extended 1 km or more inland from the coast on the north side of Boundary Bay (Northwest Hydraulic Consultants Ltd., 2018). On a slightly later map, Col. R. Clement Moody's hand-drawn sketch map of 1859, the land area surrounding Boundary Bay was described as "marsh" (Murray, 2008). Construction of the dike system commenced in the late 1800s (Brown, 1971), causing conversion of extensive marsh areas into agricultural land. Comparison

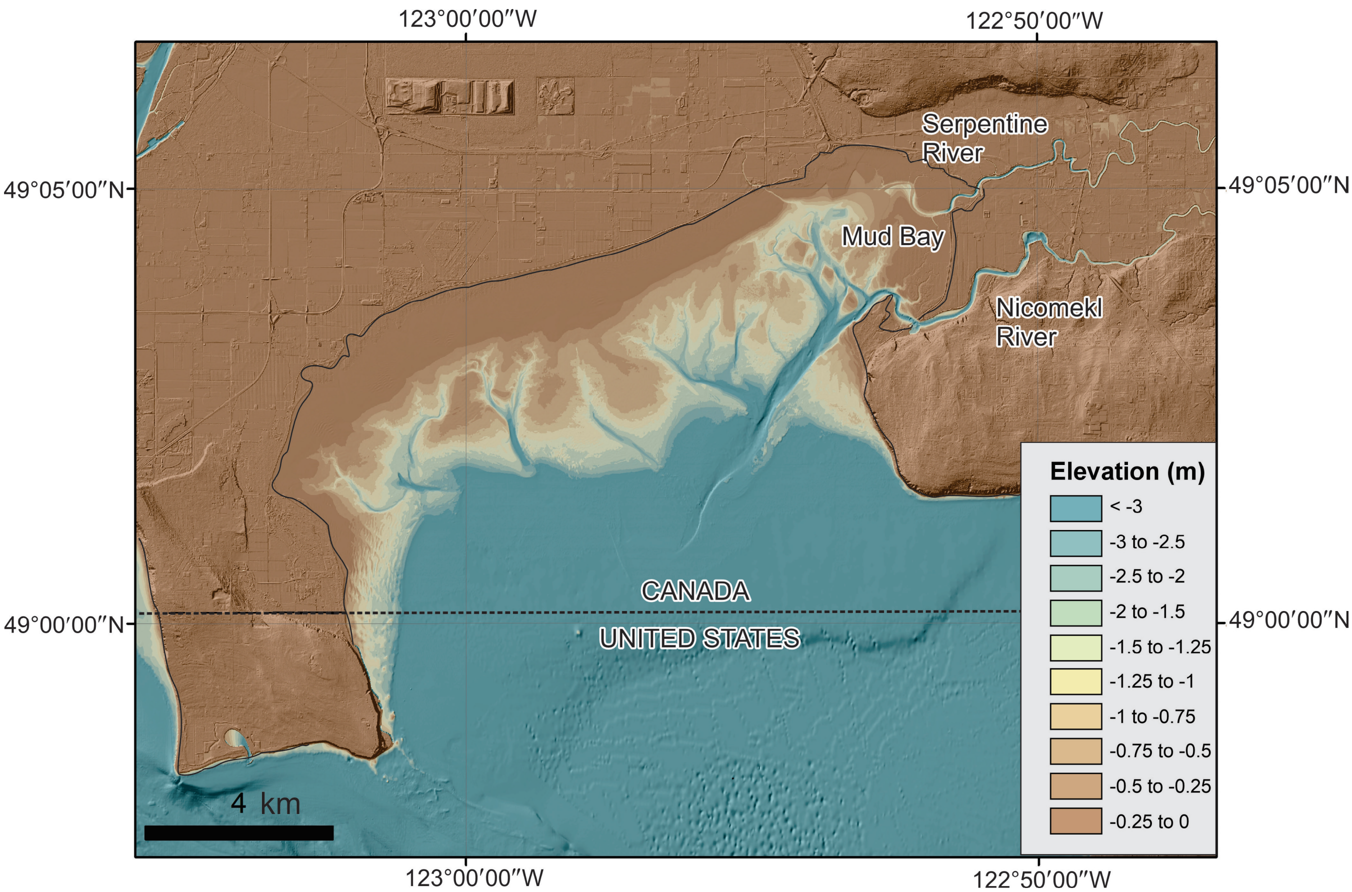

Figure 2. Digital elevation model of the study area showing the high-tide coastline in black and the two freshwater courses, the Nicomekl and Serpentine Rivers.

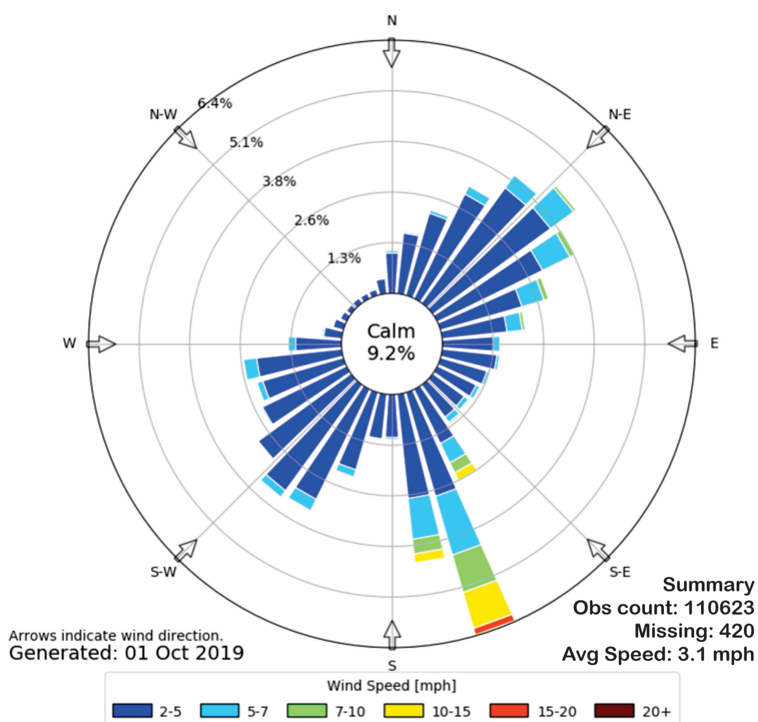

Figure 3. Wind rose from meteorological station at White Rock, B.C. (Iowa State University, 2023).

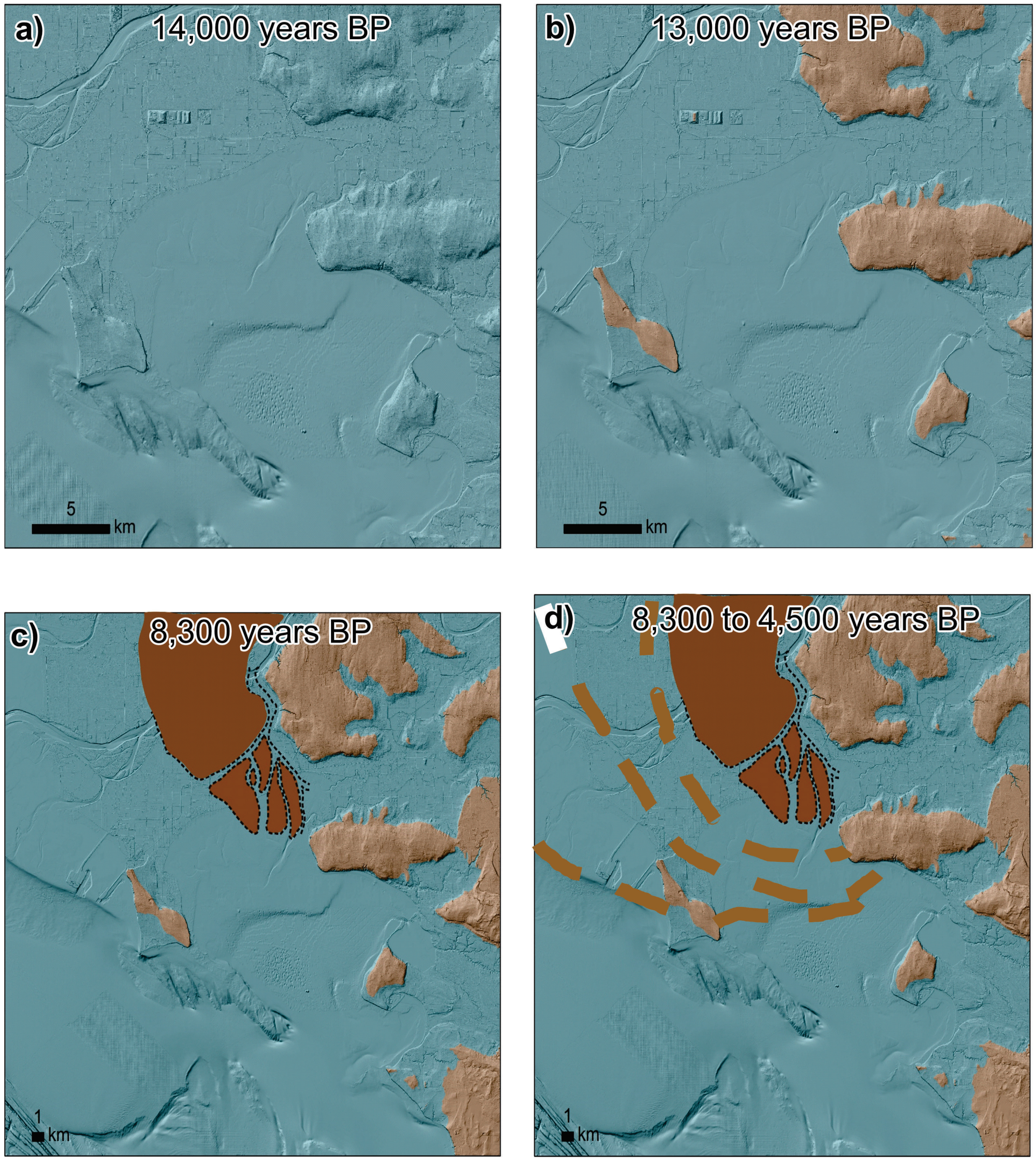

Figure 4. Interpreted paleogeographic reconstruction of the Boundary Bay area, based on previous work as referenced in the text. Blue colour represents areas submerged by the sea. Brown colours show emergent land areas. **a)** 14 000 yrs BP; **b)** 13 000 yrs BP; **c)** 8 300 yrs BP. **d)** 8 300 to 4 500 yrs BP. The brown dashed lines represent the front of the delta prograding seawards through this time period.

of the coastline position shown on the 1846 map with the 2019 lidar data indicates that only a small fringe of marsh was preserved along the western part of the bay.

In Mud Bay, located in the northeast corner of Boundary Bay, an airphoto analysis comparing 1949 and 2015 photos indicate that the natural marsh along the northern section of the shore has accreted locally in some areas (Northwest Hydraulic Consultants Ltd., 2018) where construction of Highway 99 (opened in 1962) filled in a broad embayment. In addition to dikes, the shoreline was modified significantly by construction of the CNR (now BNSF) Railroad in the early 20th century, including a 700 m long trestle bridge across the estuary of the Serpentine River. South of White Rock, notably along the shoreline of the Semiahmoo Reserve, the railway runs along a reinforced embankment, protected by riprap.

Airphotos also indicate that the position and planform of the tidal channels in Mud Bay have remained remarkably constant since 1969 (Northwest Hydraulic Consultants Ltd., 2018). Quantitative difference maps between lidar surveys in 2009 and 2013 show no change (within the systematic error limits) in elevation of the tidal flat surface (Northwest Hydraulic Consultants Ltd., 2018).

Previous morphological descriptions

Kellerhalls and Murray (1969) conducted a comprehensive field survey of the tidal flats and divided them into four geomorphological zones: saltmarsh, high tidal flats, intermediate tidal flats, and low tidal flats. They mapped the network of tidal channels that crosscut these zones and recognized the presence of algal mats on the high tidal flats, eelgrass on the intermediate tidal flats, and sand waves in both high and intermediate zones. Kellerhalls and Murray (1969) also presented current metre measurements made at the mouths of the tidal channels, noting that ebb currents generally exceeded flood currents, with a maximum current speed of 0.83 m s^{-1}. Two current metre stations were located in the subtidal zone and recorded lower speeds, showing a clockwise rotation of the current direction through the tidal cycle (Kellerhalls and Murray, 1969, their Fig. 5).

Swinbanks and Murray (1981) revised the Kellerhalls and Murray (1969) zonation, putting more emphasis on vegetation and bedforms. Algal mats form on the high tidal flats during the summer months, whereas eelgrass grows on the intermediate tidal flat. Two types of eelgrass are present: the native species *Zostera marina*, and an invasive species, *Z. japonica* (synonymous with *Z. americana* of Swinbanks and Murray, 1981; Bigley and Barreca, 1982). The area of the tidal flats covered by *Z. japonica* has expanded rapidly since the 1950s, when the species was introduced (Baldwin and Lovvorn, 1994). Dashtgard (2011a, b) carried out further work on the distribution of invertebrate traces in the bay for application to the fossil record.

METHODS

The present morphological analysis is based primarily on interpretation of a high-resolution (2 m) digital elevation models (DEMs) generated from lidar surveys conducted in 2009, 2013, and 2019. The two earlier DEMs were provided courtesy of the City of Surrey. The surveys were conducted between 2009-02-19 and 2009-03-13 and between 2013-04-03 and 2013-04-11. The DEMs are vertically referenced to Canadian Geodetic Vertical Datum of 1928 (CGVD28). Further details are provided in Northwest Hydraulic Consultants Ltd. (2018).

The 2019 survey was conducted between 2019-05-29 and 2019-05-30 by Woolpert Canada Inc. under contract to the Canadian Hydrographic Service (CHS). This survey used a Leica Hawkeye 4x airborne bathymetric lidar system. The DEM was generated with reference to the hydrographic chart datum, approximating to lower low water, large tide (LLWLT), which, based on direct point comparison, is locally 2.8 m below geodetic datum and 3.1 m below CGVD28.

A small part of the study area, not covered by the above lidar surveys, was filled using a DEM generated by Ocean Networks Canada (ONC). This DEM, gridded at 3 m, was compiled from multiple municipal- and provincial-source data sets, including lidar flown by various municipalities, as well as bathymetric data from CHS and the (U.S.) National Oceanic and Atmospheric Administration (NOAA). The vertical reference datum for this DEM is Canadian Geodetic Vertical Datum of 2013 (CGVD2013). In the Boundary Bay area, there is a small data gap at the boundary between Delta and Surrey resulting in an artifact where contours do not merge seamlessly, giving the false impression that the Serpentine River does not connect through to the ocean (at approximately 49°05′00″N 122°53′70″W; Fig. 2).

Swinbanks and Murray's (1981) map of the floral/sedimentological zones of Boundary Bay (their Fig. 2) was imported and georeferenced to facilitate comparison.

The lidar surveys were groundtruthed by direct observation during several field visits conducted between 2020 and 2022.

MORPHOLOGICAL INTERPRETATION

This geomorphological interpretation is provided with an eye to the morphodynamic processes that would influence design of living dike structures in the bay. An overview of the morphology is presented in Figure 5. In this shaded-relief presentation, the brown colours represent supratidal and intertidal areas with elevations above chart datum, approximately lowest low water. Blue colours represent the sub-tidal zone with elevations below chart datum.

The locations of shaded-relief images supporting the following detailed description are shown in Figure 6.

Salt marsh

The lidar enables more complete mapping of the salt marsh (Fig. 5) compared to the aerial photograph interpretation of Swinbanks and Murray (1981) whose map showed several areas of uncertainty. It extends continuously along the edge of the dike in the northwest corner of Boundary Bay, from the northern end of Beach Grove to approximately the mid point of the east-west extent of the bay. A small area of marsh in Mud Bay is intersected by the lidar, but the extent of marsh in this northeast corner of Boundary Bay is not mapped by the lidar. Comparison with the map of Swinbanks and Murray (1981) shows that the seaward extent of the salt marsh has not changed significantly within the time period 1979 to 2019, and within the resolution of the earlier survey.

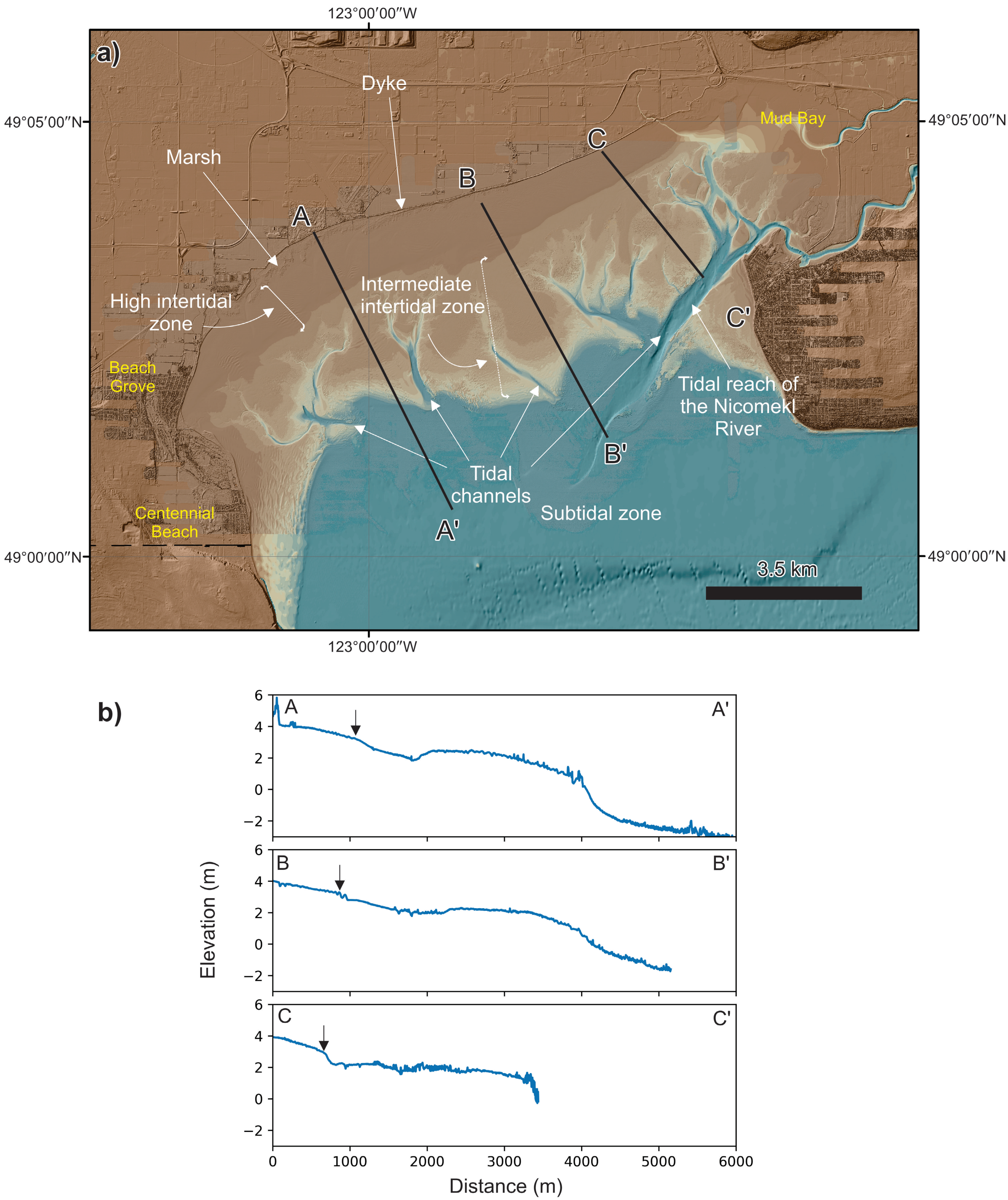

Figure 5. a) Shaded-relief map of Boundary Bay showing main morphological features, based on a lidar survey in 2019. Elevations are relative to chart datum. **b)** Elevation profiles A-A', B-B' and C-C' located as shown on a). The boundary between the high intertidal and intermediate intertidal zones is shown on the sections by the vertical arrow. Legend as in Figure 2.

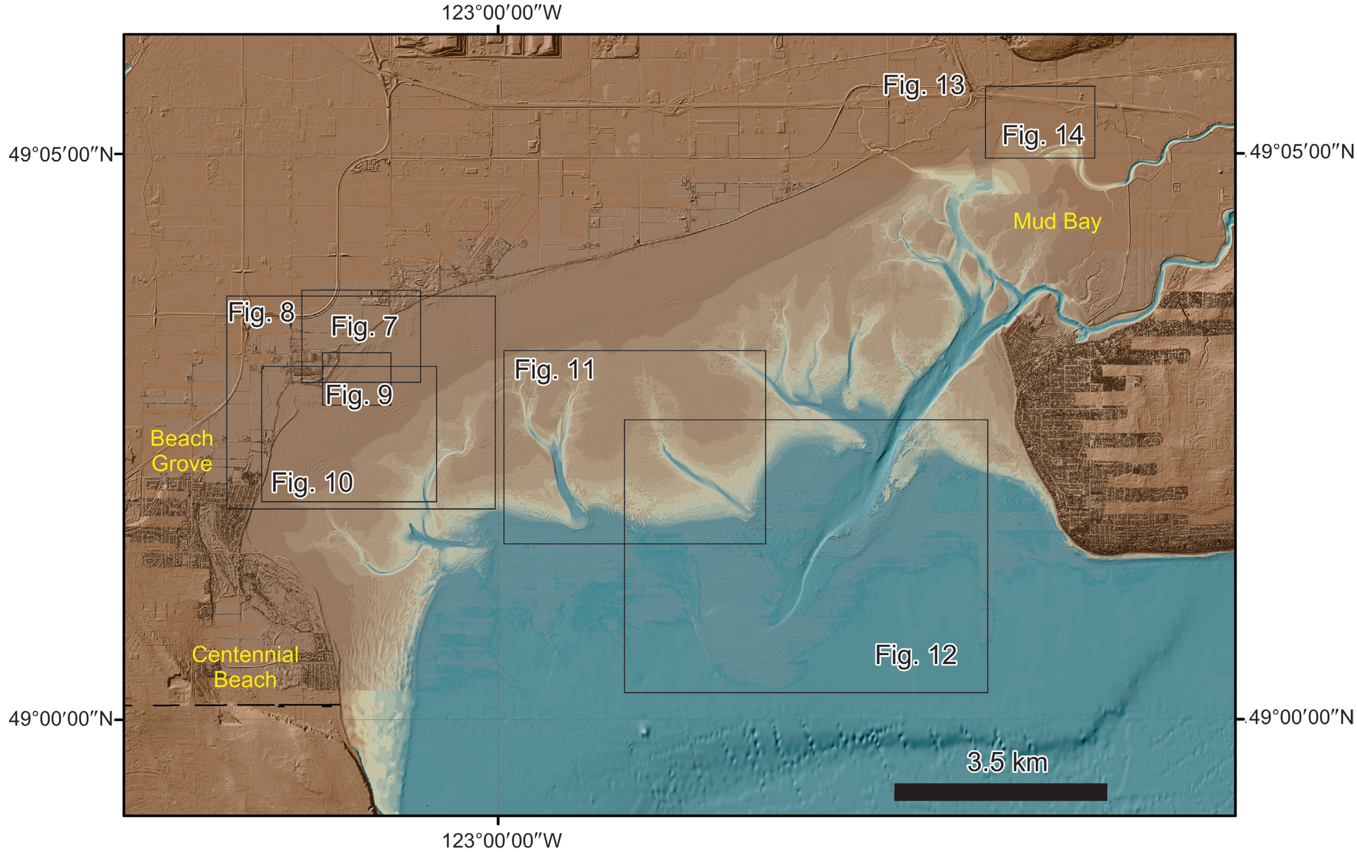

Figure 6. Index map for images presented in subsequent figures. Legend as in Figure 2.

The marsh surface is characterized by relatively smooth reflections, averaging approximately 4.5 m elevation, with locally hummocky topography (Fig. 7). Some sections of the marsh are intersected by dendritic tidal channels up to 0.8 m deep in their trunk sections.

The seaward edge of the marsh is typically a 0.5 m high escarpment, with an irregular, ragged planform at the scale of a few metres. On a broader scale, the marsh front shows numerous embayments, occupied by very shallow (less than 0.05 m) ebb-tide drainage channels, which converge further seaward into subtle 0.10 to 0.15 m deep channels that traverse the high intertidal zone (Fig. 7). Some of these embayments are characterized by flora representative of lower salinity conditions (G. Williams, pers. comm., 2020) suggesting that fresh groundwater outflow is actively occurring.

High intertidal zone

The area between the salt marsh escarpment and a break in slope at an elevation of 3.2 m forms a distinctive ramp-like morphological feature (Fig. 5), classified as the upper intertidal flats by Kellerhalls and Murray (1969). It includes the algal mat and upper sand waves zones of Swinbanks and Murray (1981) but given the seasonal nature of the algal mat growth, it is possible that the lateral extent of the algal mat zone would vary interannually. Furthermore, in the lidar imagery, it is evident that the 'sand waves' in this zone are not universally distributed as a shore-parallel zone seaward of the algal mat zone, but are concentrated in rhythmic alongshore groups (Fig. 8). Therefore, the definition of a single high intertidal zone is preferred in this report.

The inner part of this zone, corresponding to the algal mat zone of Swinbanks and Murray (1981) is characterized by very low relief bars, with heights in the order of 0.05 m and lengths in the range 15 to 25 m (Fig. 9). The bars range from linear to linguoid in planform and are flat-topped, in contrast to other intertidal bars in the bay.

The groups of higher relief, intertidal bars located in the outer part of the high intertidal zone (2.5 to 3.5 m elevation), are spaced 1.5 to 2 km apart and comprise multiple sets of short linear bars intersected by rip/drainage channels (Fig. 10). These bars have bar heights in the order of 0.3 to 0.5 m and wavelengths in the order of 50 to 70 m.

Intermediate intertidal zone

Tidal channels

Four tidal channel systems incise the intermediate intertidal flat (Fig. 5). Comparison with the Swinbanks and Murray (1981) map indicates that the positions of the

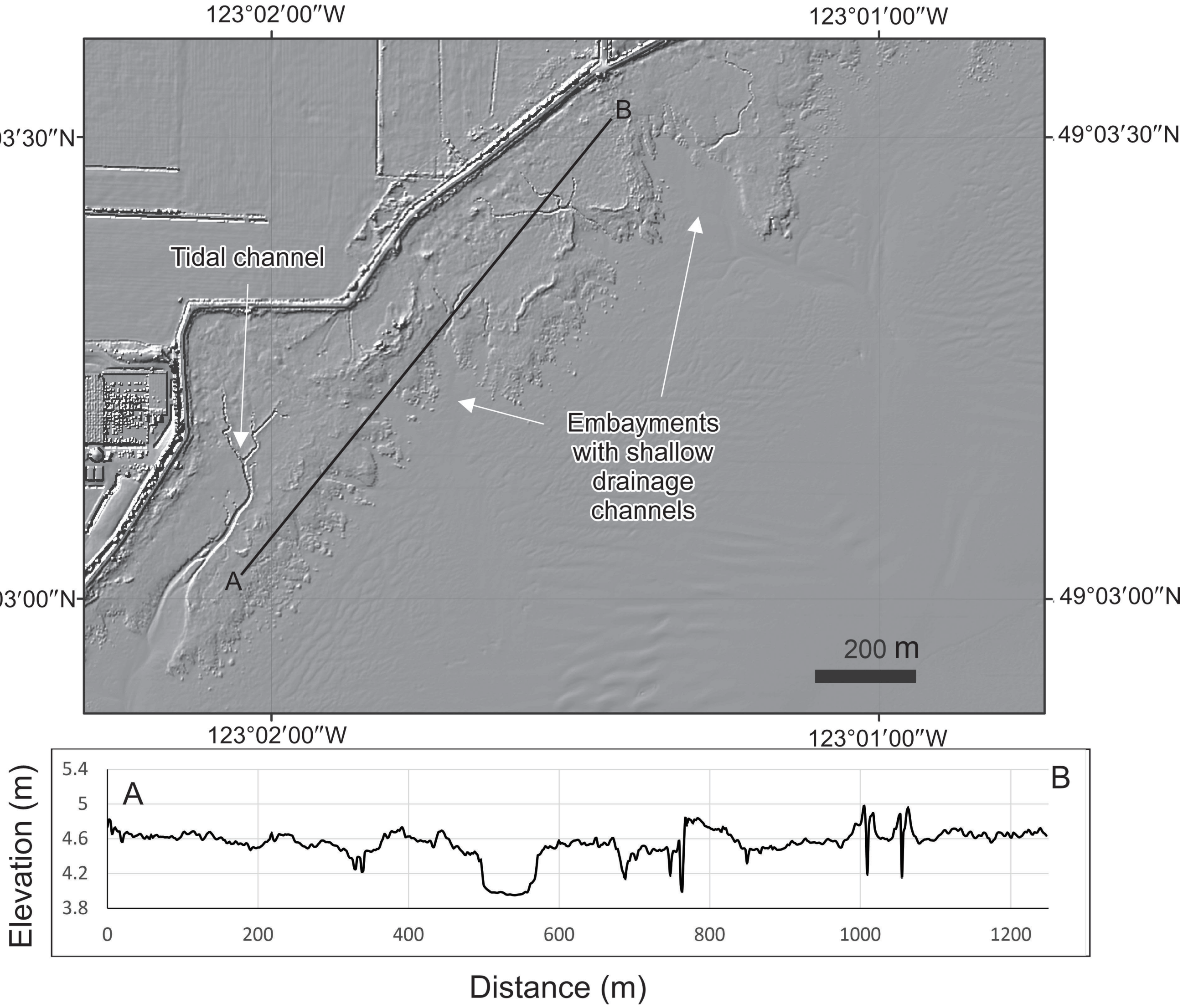

Figure 7. Shaded-relief image of a section of the fringing marsh, location shown in Figure 6. Elevation profile across marsh surface at section A-B.

trunk channels of these drainage systems have remained in approximately the same location between 1979 and 2019, but the fine networks of related tributary channels extend further inshore than mapped in 1979. However, this may only be a function of the resolution/interpretation of air photos used in the earlier work, rather than a real change. In the lidar DEM, the fine tributary channels are seen to extend to the base of the high intertidal ramp at approximately 2.7 m, but do not show incision in the ramp.

The tidal channels terminate at the lowest low-water mark, forming well defined promontories in the tidal flat contours (Fig. 11). These promontories resemble wave-formed deltas in planform (Bhattacharya and Giosan, 2003), with slight asymmetry toward the east, suggesting net longshore transport in that direction.

Tidal reach of the Serpentine and Nicomekl rivers

The Serpentine and Nicomekl rivers converge in the northeast corner of the tidal flat and form a >500 m wide, up to 8 m deep, subtidal channel that extends southwestwards across the intermediate tidal flats (Fig. 5). The lidar did not image the channel thalweg due to its depth. As it crosses the intermediate intertidal zone, the channel is flanked by broad intertidal levees that show a rough texture, interpreted as eelgrass, along its crest (Fig. 12). The lower flanks of the levees are covered by symmetric subaqueous dunes with crests oriented along the strike of the levee. The subtidal channel shallows abruptly and terminates in a delta-like protuberance at a depth close to lowest low water and a channel mouth bar (Fig. 12).

Figure 8. Shaded-relief image of a section of the high intertidal zone, location shown in Figure 6. The image highlights two morphological features: low-relief tidal channels and fields of intertidal bars. The dashed line indicates the seaward limit of the high intertidal zone.

Mud Bay

Mud Bay was not covered in the CHS 2019 lidar survey, but most of it was included in the City of Surrey 2009 survey (Fig. 13). In Figure 13, both surveys are shown with the same colour scale applied. The differences in colour saturation are due to the 2009 data being lower resolution. Some of the deeper areas of the Serpentine River channel are only coarsely interpolated and the limited extents of the surveys make it impossible to determine the connectivity of the channel in the northwest corner of the image. However, it is assumed that the channels visible in the two surveys do connect as indicated by the dotted lines.

With the exception of the Serpentine River channel, Mud Bay is extremely shallow (within 0.5 m of high tide), and therefore corresponds to the high intertidal zone of Boundary Bay. As its name suggests, compared to the rest of Boundary Bay, the substrate is muddy up to the marsh front near the high tide line. The topography is muted, with only a few small tidal creeks disturbing the largely planar mudflat surface.

The marsh is present as a narrow strip, less than 100 m wide, along the Highway 99 dike. It has a rhythmic, oblique serrated form with a spacing of 20 to 30 m alongshore (Fig. 14).

Subtidal zone

Beyond the lowest low-tide mark, the subtidal zone extends into U.S. waters as a shallow platform for a further two kilometres (Fig. 15). At a depth of between 5 m and 10 m (−8 to −13 m elevation relative to CGVD2013), the seabed descends steeply to approximately 35 m depth (Fig. 15). The prominent seabed escarpment steepens toward the east of the bay, reaching a slope of up to 4°. No seismic or subbottom profiles are available in this region to determine the underlying stratigraphy. Further work is required to determine if this escarpment represents a former delta slope, or the margins of a pre-Holocene surface.

DISCUSSION

The Boundary Bay tidal flats are interpreted to have formed in an area of the delta where no active channel has existed for several thousand years. The presence of 4350 ± 100 yr old buried peat (Kellerhalls and Murray, 1969) is direct evidence that the delta extended at least 1 km further offshore than the present day. A possible interpretation of the subtidal escarpment described above leaves open the possibility that it extended as much as 10 km offshore. Regardless, it is clear that the tidal flats are built on an

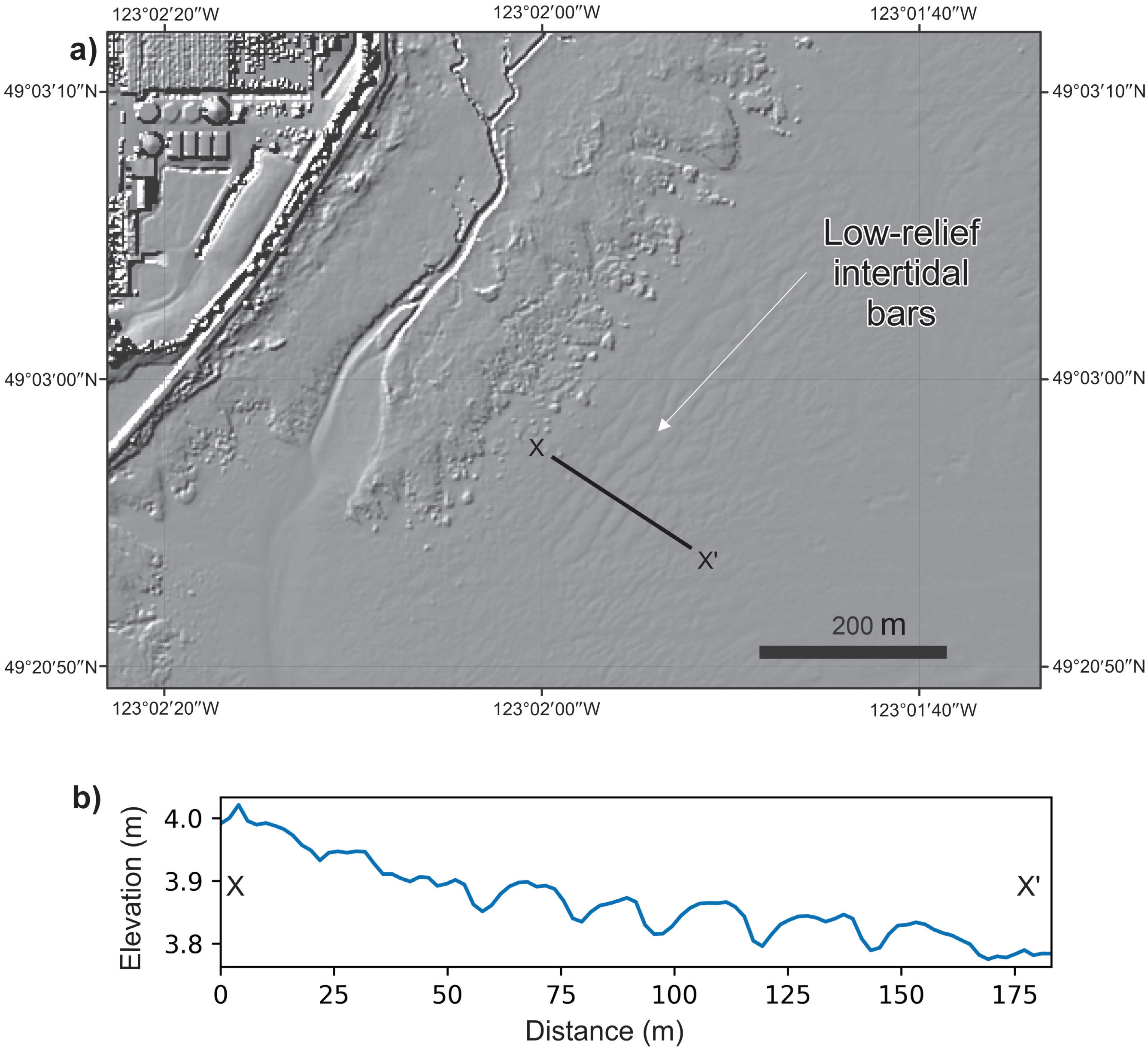

Figure 9. **a)** Close-up shaded-relief image of the low-relief intertidal bars of the high intertidal zone. Location shown in Figure 6. **b)** Elevation profile across low-relief intertidal bars at section X-X'.

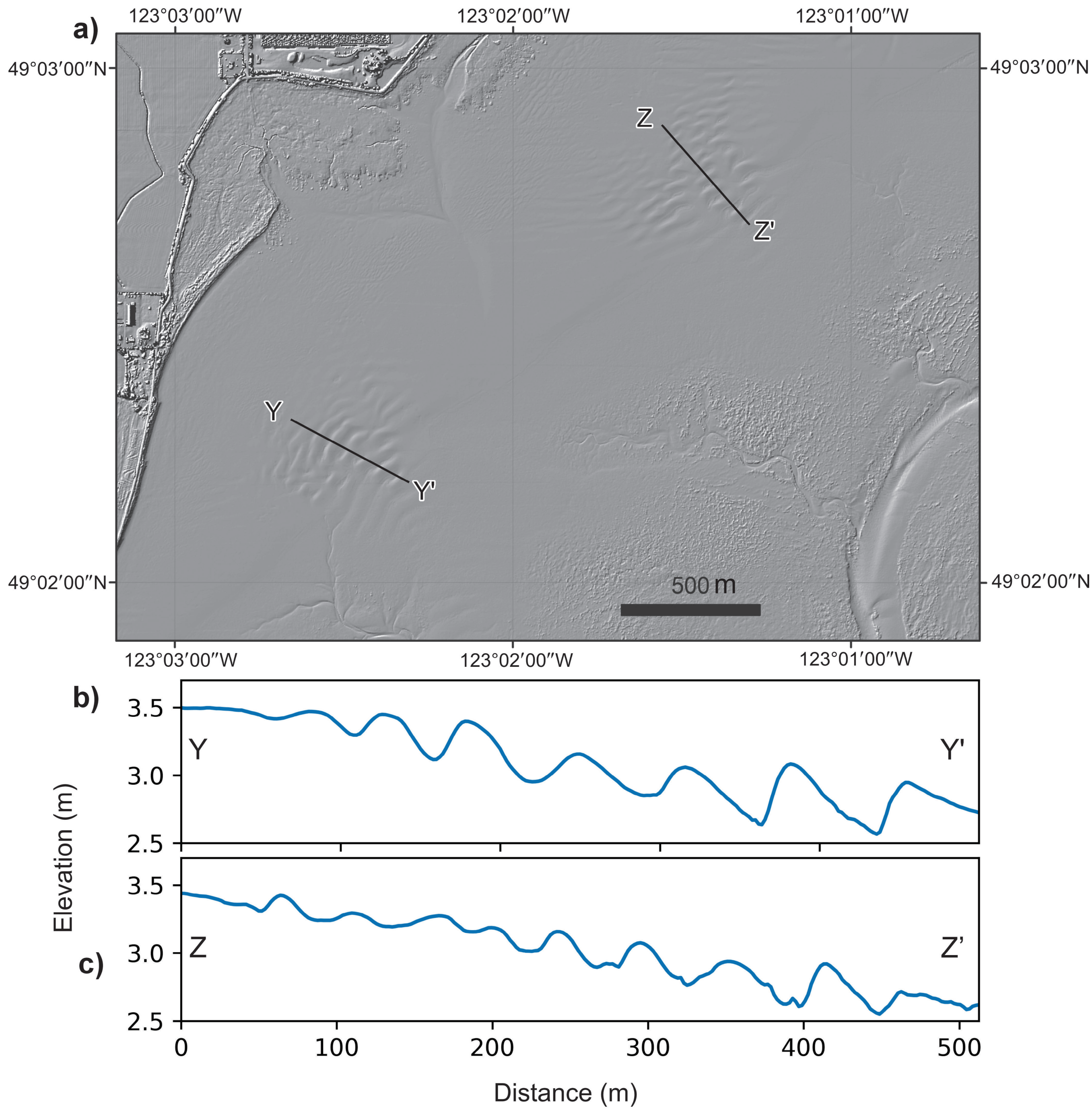

Figure 10. **a)** Shaded-relief image showing two groups of intertidal bars on the outer part of the high intertidal zone. Location shown in Figure 6. **b)** Elevation profile Y-Y'. **c)** Elevation profile Z-Z'.

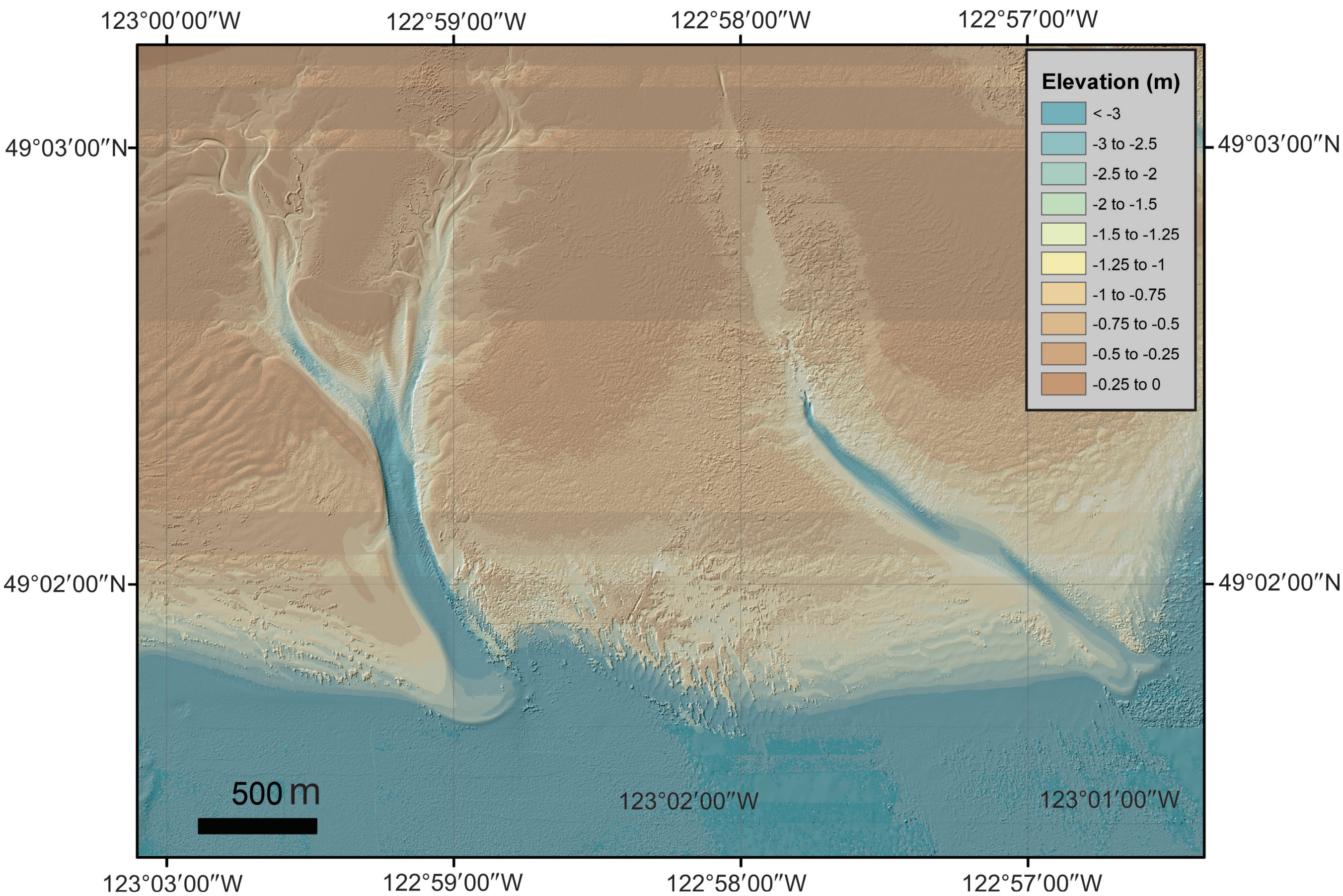

Figure 11. Shaded-relief image of the low-tide termination of two tidal channels. Location shown in Figure 6. Note planform resemblance to wave-formed deltas.

older surface that was transgressed over the last 4000 years, providing an explanation for the broad width of the tidal flats.

The morphological differences between the intermediate and high intertidal zones suggest that the relative influence of tidal and wave processes differs between the two zones. The mature, incised set of tidal channels present on the intermediate intertidal zone (Fig. 5) indicates the strong influence of tidal processes. The extensive growth of eelgrass in this zone likely acts to stabilize the inter-channel areas and favours deeply incised tidal-channel networks. The ubiquity of wave-formed bars in the high intertidal zone (Fig. 8–10) suggests that wave processes influence sediment transport in this zone. Whereas the tide inundates this zone on the higher tides, the ebb flows meander through inter-bar areas and are only weakly channelized through broad topographic swales. The rhythmic distribution of areas of bars versus swales along the high intertidal zone, particularly in the western part of the bay, suggests the presence of longshore cells of wave convergence and divergence.

The above observations are, of course, based on a snapshot of the morphology on a particular day, in this case for the main lidar survey in May 2019. It is not known how much variation on seasonal and inter-annual time scales occurs. Comparison with previous work (Kellerhalls and Murray, 1969; Swinbanks and Murray, 1981; Dashtgard 2011 a, b) and field observations over several years confirm that the broad morphological zonation described above does not vary significantly. However, it is quite likely that the distribution, form, and dimensions of the wave-formed bars would vary to some degree at these different time scales.

CONCLUSIONS

Recent lidar data has a supported an analysis of the Boundary Bay tidal flats from a geological and geomorphological perspective. The tidal flats overlie older delta deposits and/or Quaternary deposits and have evolved through approximately 4000 years of marine transgression. The intermediate intertidal zone is tide dominated and is characterized by incised tidal channels and eelgrass-stabilized interchannel areas. The high intertidal zone is wave dominated and characterized by wave-formed bars. Narrow remnants of a once more-broadly distributed marsh are present seaward of the dikes.

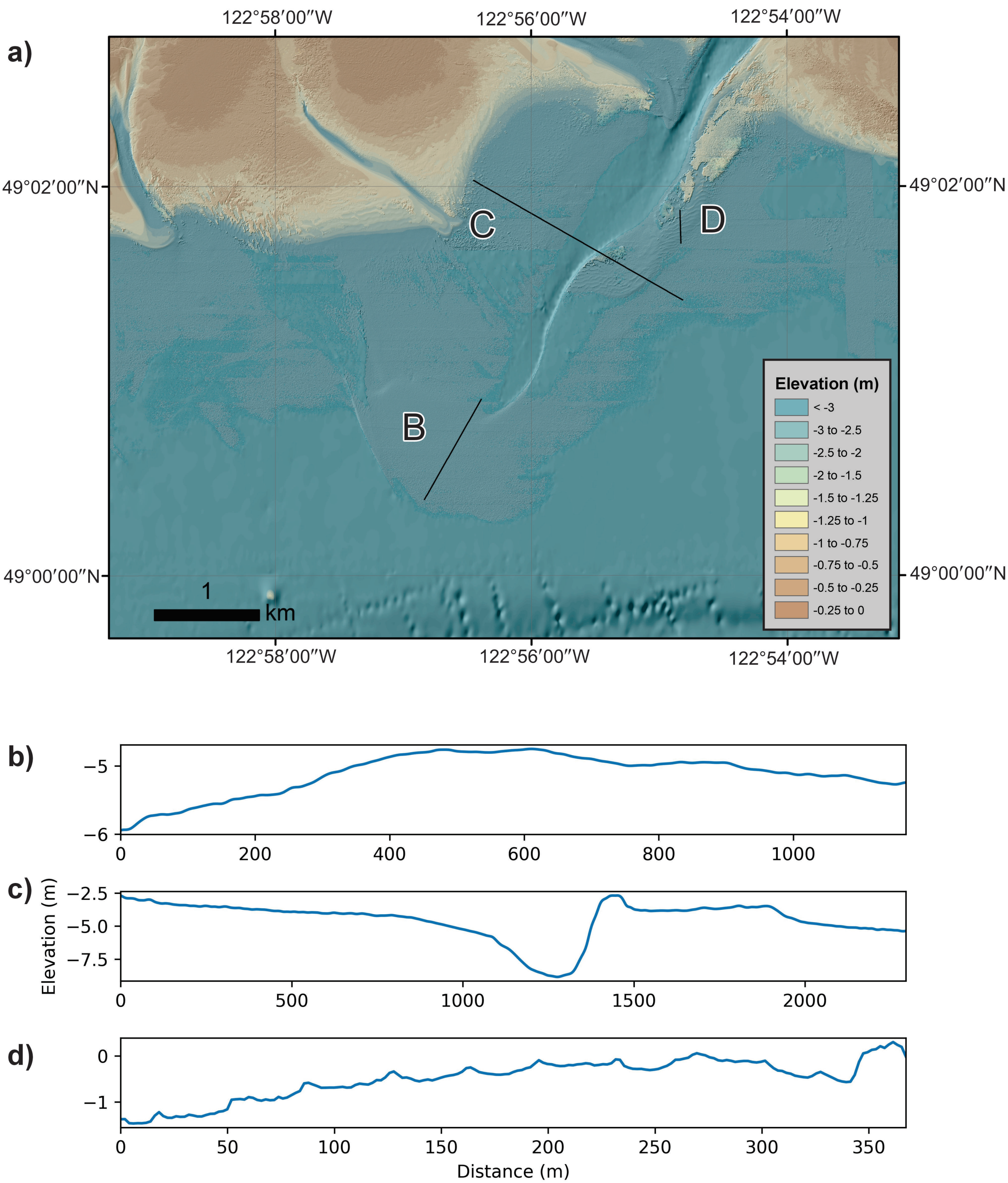

Figure 12. a) Shaded-relief image showing main features of the subtidal channel of the Serpentine and Nicomekl Rivers. Location shown in Figure 6. **b)** Profile B across mouth bar. **c)** Profile C across channel showing well developed levee on southeast side. Seabed texture suggests eelgrass vegetation on the levee. **d)** Profile D, possible symmetric wave ripples on the margin of the levee (H = 0.2 m; L = 40 m).

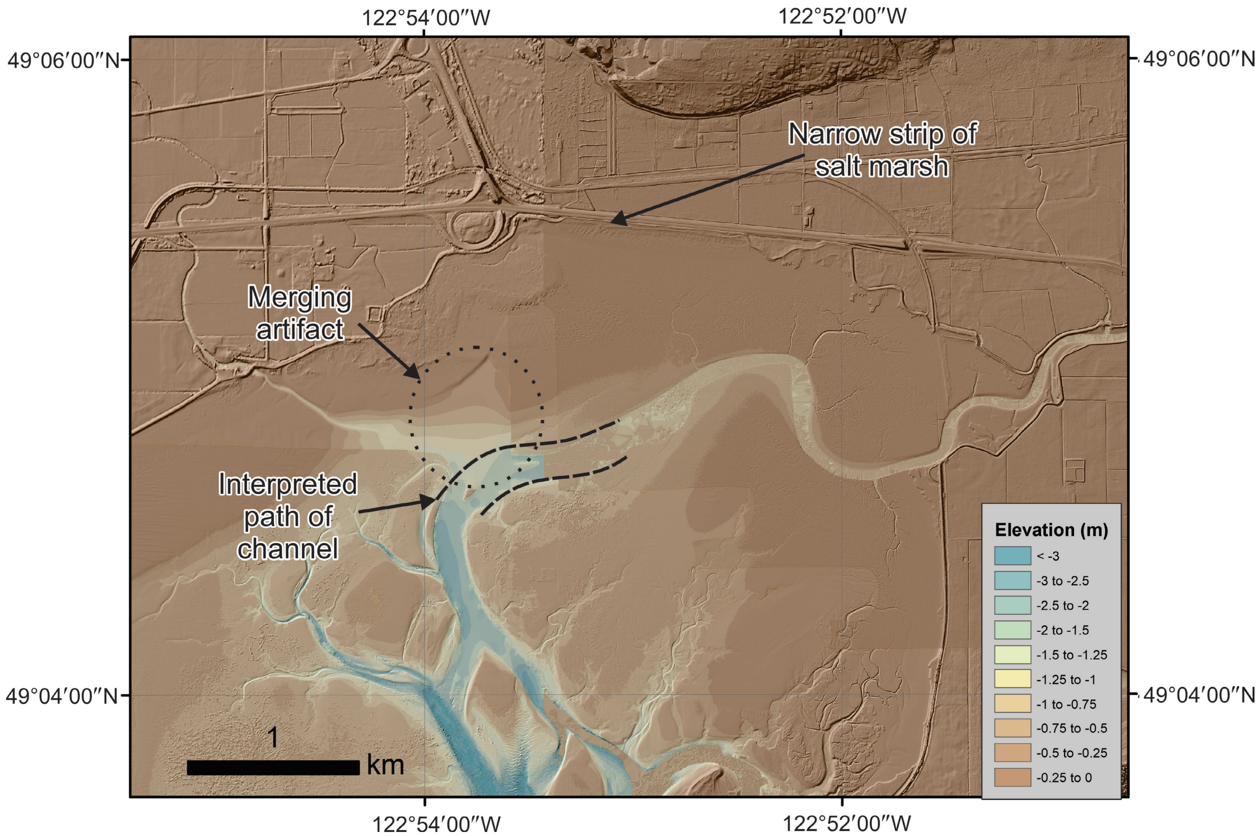

Figure 13. Shaded-relief image of Mud Bay based on two different lidar surveys (2009 and 2019 as indicated by slight different colour saturation). Location shown in Figure 6.

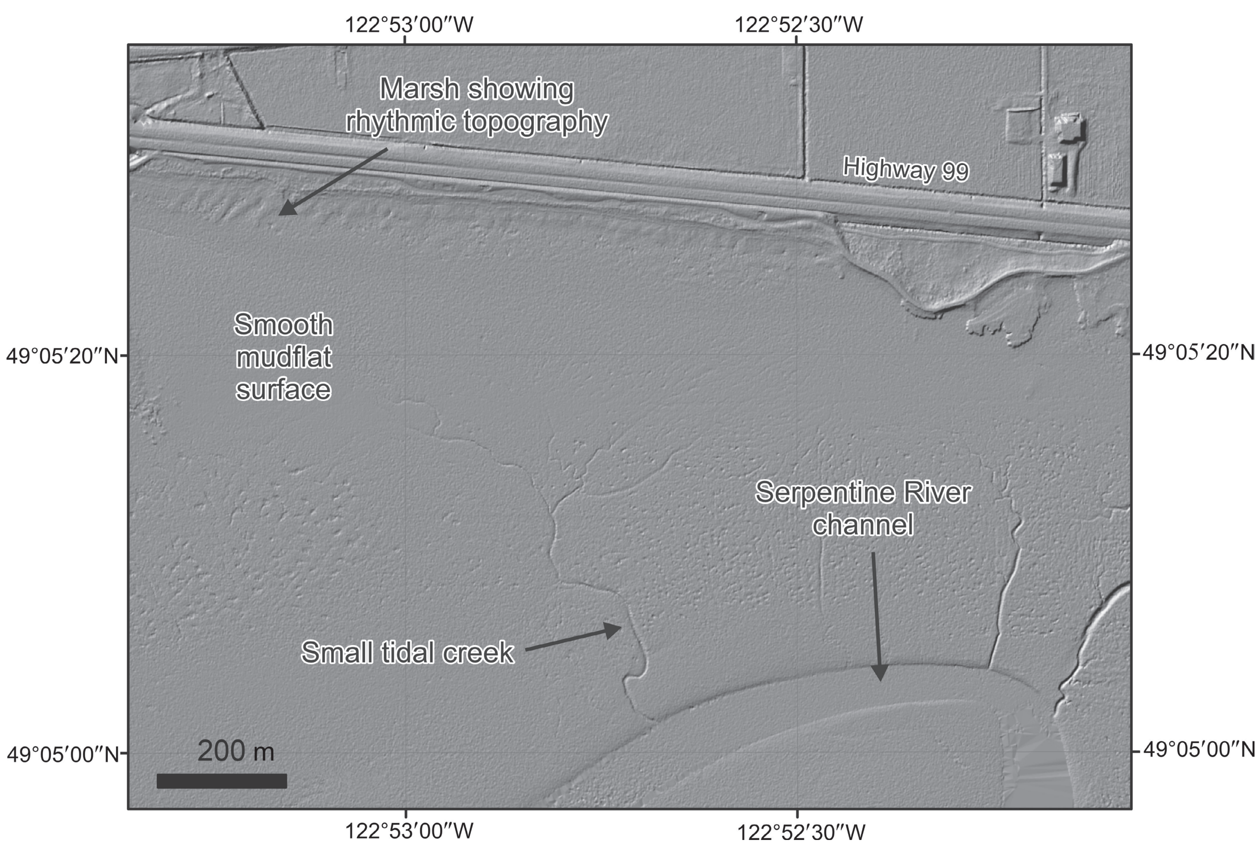

Figure 14. Shaded-relief image of the narrow fringing marsh in Mud Bay. Location shown in Figure 6.

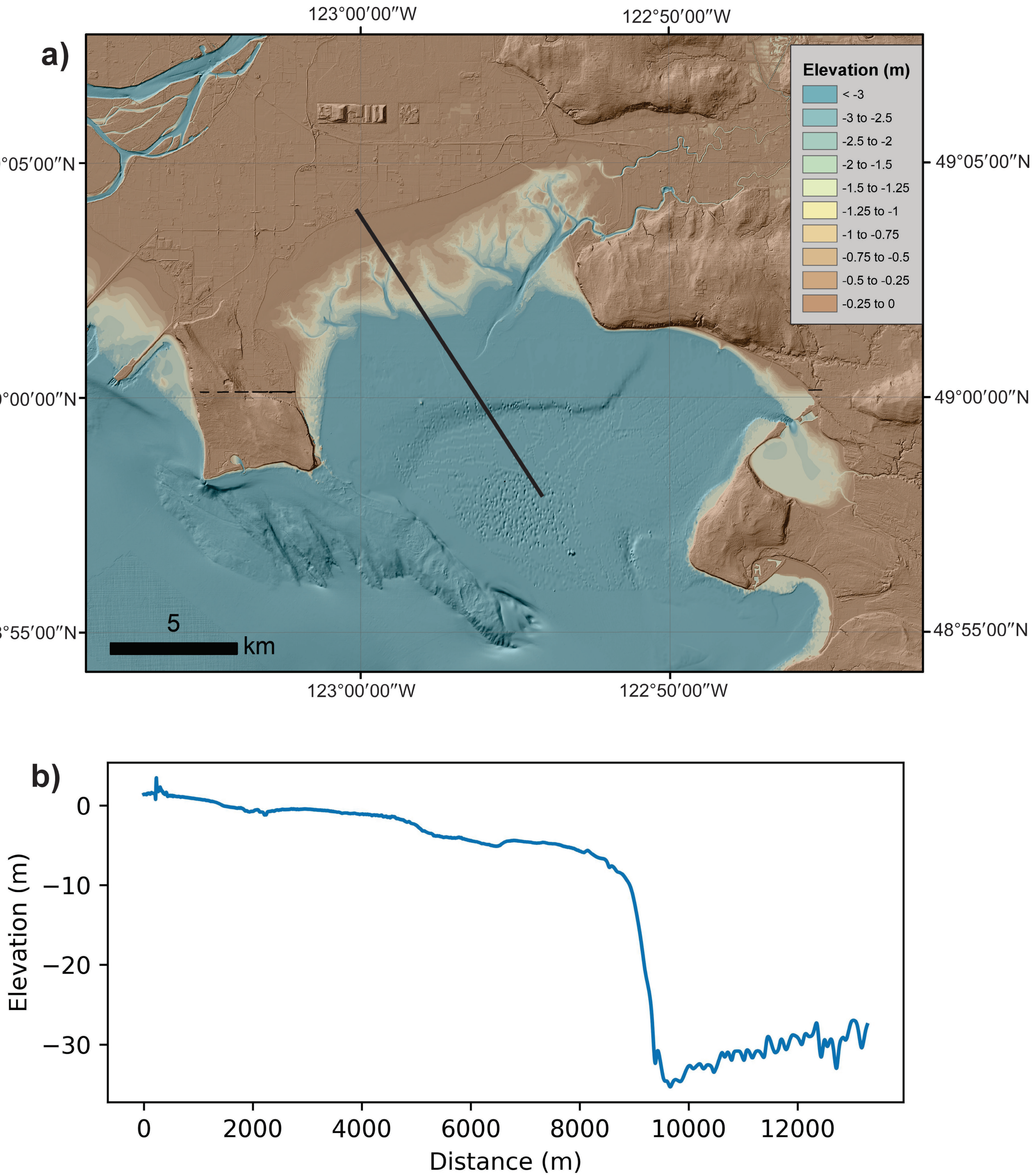

Figure 15. a) Shaded-relief image of Boundary Bay and the adjacent offshore, showing profile location. **b)** Elevation profile of line shown in a). Elevations referenced to topographic datum CGVD2013.

ACKNOWLEDGMENTS

Boundary Bay lies within the traditional territory of the Semiahmoo, Tsawwassen, and Tsleil-Waututh First Nations. Particular thanks go to Semiahmoo Chief Harley Chappell and Councillor Joanne Charles for the warm welcome to their territory, their sharing of knowledge, and their interest in the project. Funding for the work was provided by Public Safety Canada's Canadian Safety and Security Program (CSSP), under the "Nature-Based Infrastructure for Coastal Resilience and Risk Reduction" project led by Enda Murphy (National Research Council). NRCan's component of the project was conceived by Gwyn Lintern and managed by Michelle Côté. Communication with stakeholders, including First Nations and the cities of Delta and Surrey, was greatly assisted by the Living Dike Roundtable and its Technical Working Group. The Canadian Hydrographic Service conducted the lidar survey of Boundary Bay, which was processed into a digital elevation model (DEM) by Robert Kung. The City of Surrey provided access to lidar survey DEMs of Mud Bay and numerous technical reports pertinent to the project. Ocean Networks Canada provided access to the Greater Vancouver area DEM, which was derived from multiple data sets including data owned by Vancouver Fraser Port Authority. Walkabouts and scientific discussions with the aforementioned individuals, Eric Balke, Shahin Dashtgard, John Readshaw, and Gary Williams are much appreciated. Gwyn Lintern reviewed an early draft of the manuscript.

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