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Oceanography

of the

British Columbia Coast

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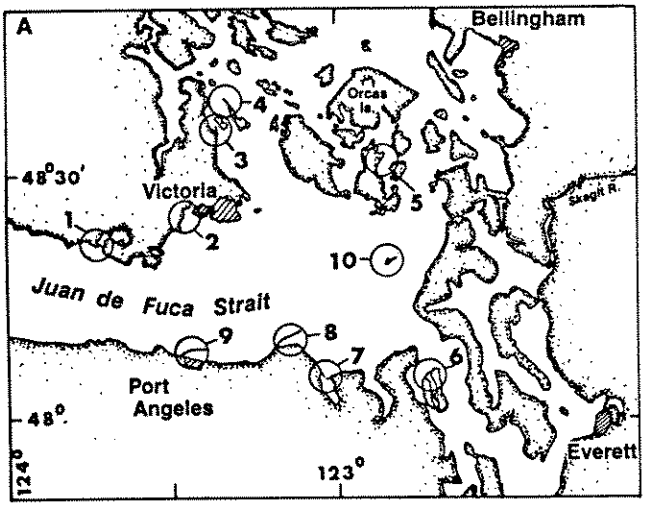


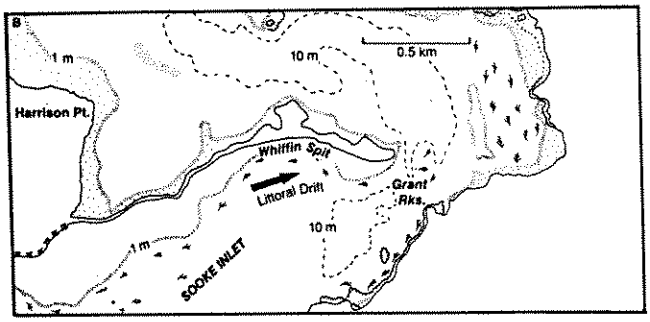
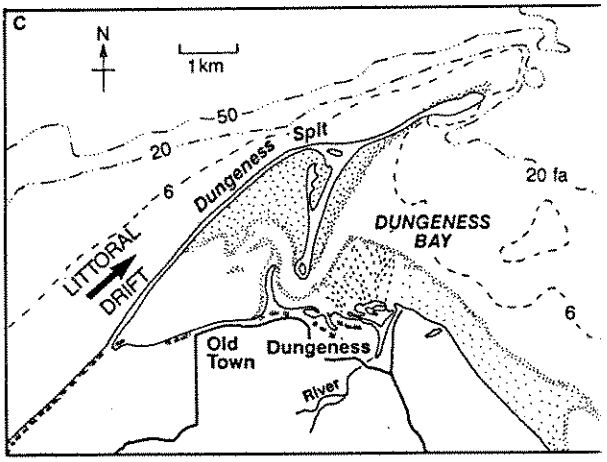


FIG. 2.26. Prominent spits in the eastern sector of Juan de Fuca Strait (A) 1. Whiffin Spit; 2. Esquimalt Lagoon (Cobourg) Spit; 3. Cordova Spit; 4. Sidney Spit; 5. Spencer Spit; 6. Spit (Marrowstone Is.); 7. Gibson Spit; 8. Dungeness Spit; 9. Ediz Hook; 10. Smith Island Spit; with expanded view of Whiffin Spit (B).



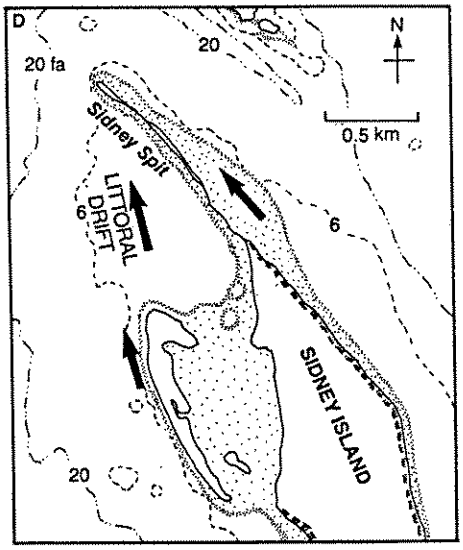


FIG. 2.26. Expanded view of Dungeness Spit (C), and Sidney Spi

Spits and Cusps

A spit (or hook) is a beach with one end joined to the shore and the other end free where it terminates in a hook or recurve (Fig. 2.26). The spit elongates in the direction of longshore sediment drift and can be an alongshore extension of an existing beach or may be aligned across the direction of the prevailing waves. Spits are most common on irregular coasts where they often grow across bay mouths and the entrances to rivers and extend them in the direction of the littoral drift. In this way, spits provide an effective mechanism to straighten out existing bumps in the coastline. Some of the more striking examples of spits (as well as those in Fig. 2.26) include Rose Spit and Sand Spit in the Queen Charlotte Islands, Ediz Hook and the Smith Island Spit (Fig. 2.27) in the eastern sector of Juan de Fuca Strait, Goose Spit (Pl. 5) near Comox, and Rebecca Spit on Quadra Island. Sequim Bay southeast of Dungeness illustrates an embayment that has been almost totally cut off from the sea by the growth of two spits at its mouth.

Ediz Hook (Fig. 2.28) is a textbook example of how spits evolve and what effects man can inadvertently have on their stability. Formation of this spit started about 14,000 yr ago when glaciers began retreating from de Fuca Strait and local sea level was roughly 30 m l than it is today. As the ice melted and sea level rose Elwha River, 13 km west of Port Angeles, cut throug glacial deposits and carried sand and gravel to the S These sediments were then transported eastward b prevailing littoral current set up by the action of up- winds and waves, and the river delta grew to the east 2.28a). Sea level continued to rise and additiona ments were added to the alongshore drift throug erosion of adjacent sea cliffs. This led to the creati small spits to the east of the delta, the forerunners o present day hook (Fig. 2.28b). Growth of Ediz H began in earnest once sea level had approximately rea its present level a few thousand years ago. With the tinued deposition of material from the Elwha Rive the erosion of sea cliffs, the spit grew eastward as a na extension of the shoreline, which itself turns abr southeastward at the base of the spit (Fig. 2.28c). A same time the sea cliffs were eroding southward westerly base of the spit was migrating southward Periodically, moreover, waves would breach the spi carry sand to its inner side by "overtopping," a pr

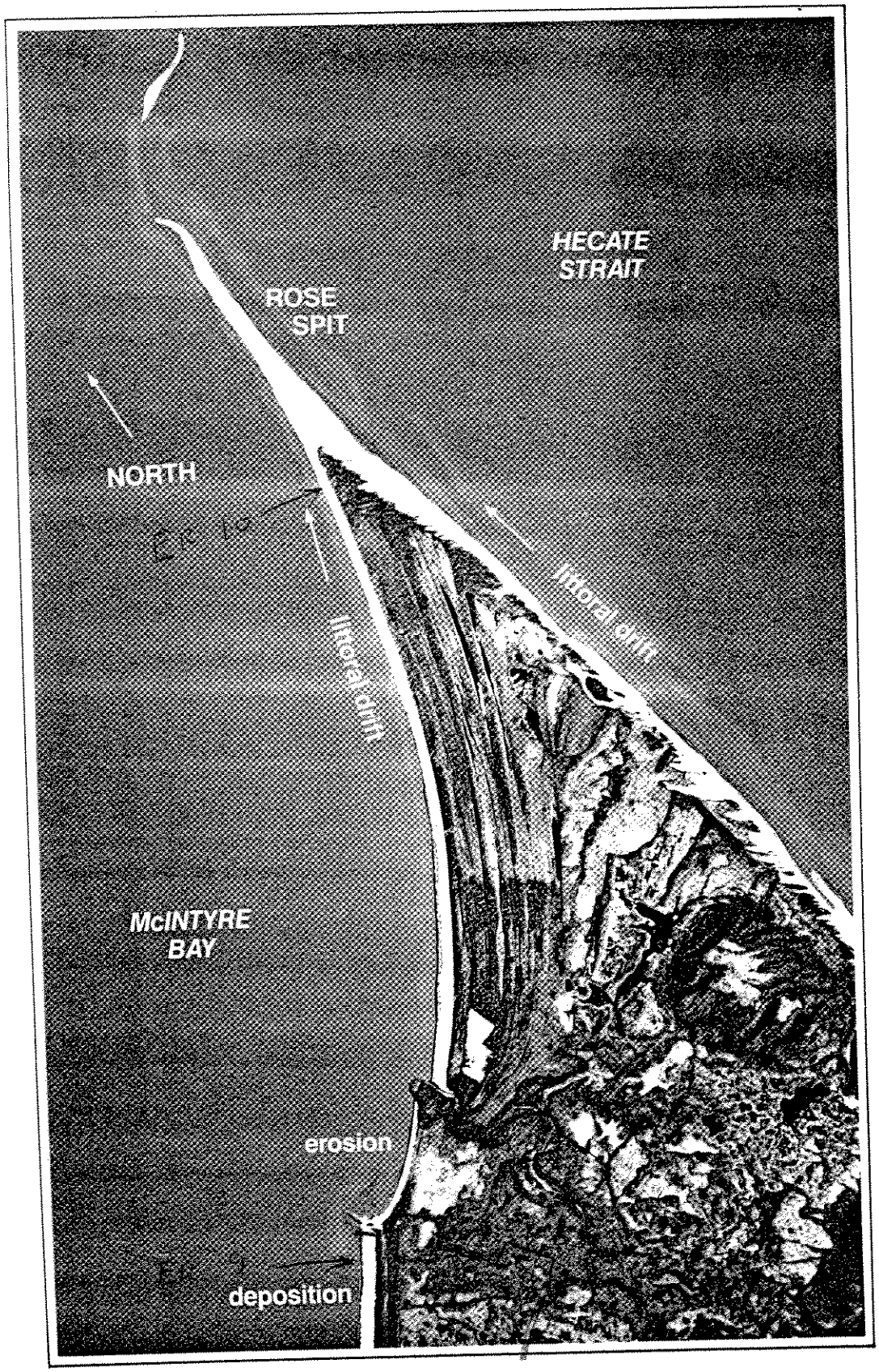


FIG. 2.38. Natural groyne system of headlands along northeast coast of Graham Island, Queen Charlotte Islands. Rose Spit at top of photograph. Northward littoral drift causes sediments to accumulate on upstream side of each promontory and erode from downstream side. Series of relict shorelines inland of present beach formed at times of higher sea level stands following last ice age. (B.C. Government Air Photo 1973)

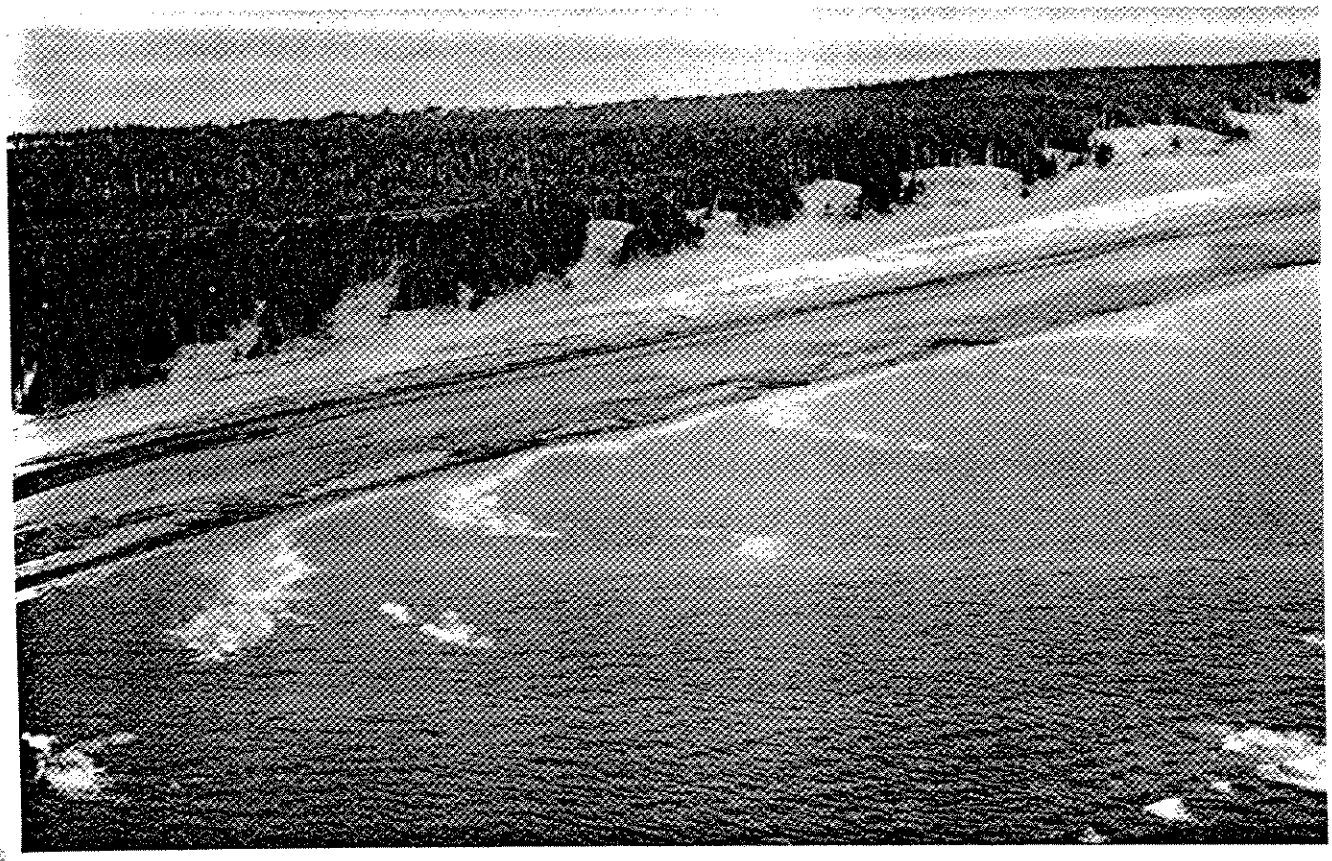


FIG. 8.11. Modified rip cells (horizontal circulation cells) near Rose Spit, Queen Charlotte Islands, July 1979. Rhythmically spaced cells caused by waves breaking over bars that project from shoreline; circulation pattern is shoreward flow along transverse bars and seaward rip current mid-way between bars. Large dunes in background over 10 m high and driven into forest by strong southeasterly gales. (Courtesy J. Harper)

rock offshore of the Airport road, and the area in front of the former Wickannish Inn. Midway between these areas, and at the prominences at either end of the beach, the waves converge to produce comparatively large breakers that drive the longshore currents feeding into the rip currents.

In many instances, the offshore beach profiles are uniform so refraction is the same along the entire beach and there is no differentiation in wave set-up, yet rip currents still persist. This fact has recently led to a theory based on the combined effect of incoming waves with another type of surface wave called an edge wave. Unlike the shoreward propagating sea or swell waves, edge waves depend on the beach or "edge" for their existence, and lean against it for support much like an ordinary wave traveling along a wall or the side of a pool. Thus, the crests

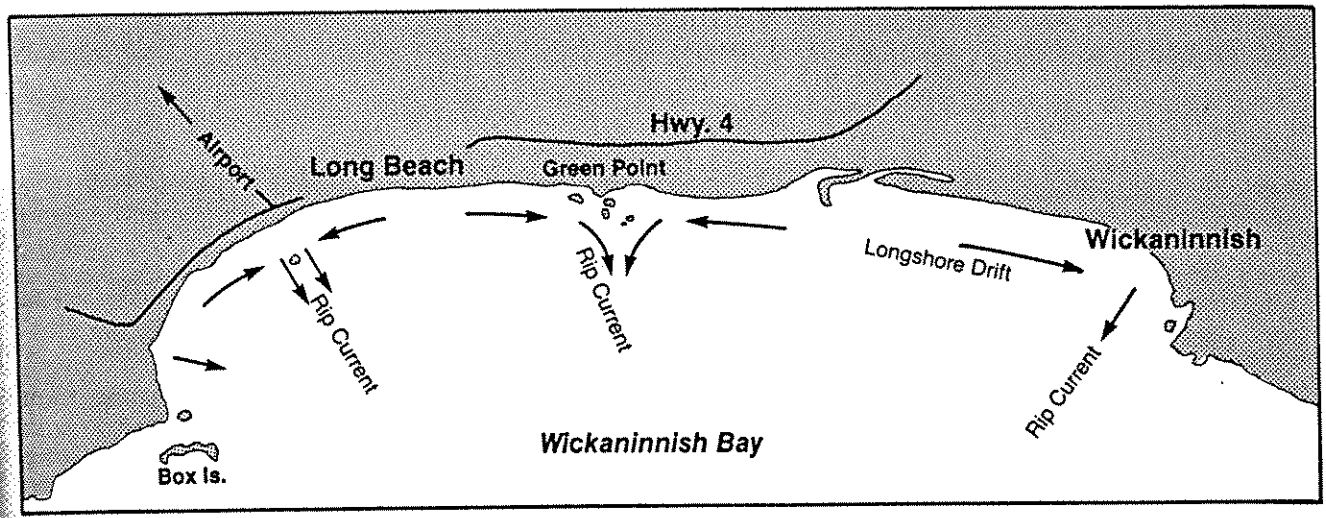


FIG. 8.12. Prevailing pattern of longshore currents and rip currents during summer in Wickaninnish Bay (Long Beach) on west coast Vancouver Island. (Parks Canada 1974)

Chapter 14. Northern Shelf Region

Queen Charlotte Sound, Hecate Strait, and Dixon rance form a continuous coastal seaway over the conti- ital shelf of the Canadian west coast (Fig. 14.1). Except the broad lowlands along the northwest side of Hecate ait, the region is typified by a highly broken shoreline islands, isolated shoals, and countless embayments ich, during the last ice age, were covered by glaciers t spread seaward from the mountainous terrain of the inland coast and the Queen Charlotte Islands. The egular countenance of the seaway is mirrored by its thymetry as re-entrant troughs cut landward between allow banks and broad shoals and extend into Hecate rait from northern Graham Island. From an eanographic point of view it is a hybrid region, similar many respects to the offshore waters but considerably odified by estuarine processes characteristic of the otected inland coastal waters. Deep-sea processes, tides, inds, and river discharge are all important factors in the stablishment of the currents and water structure in this emiexposed marine environment.

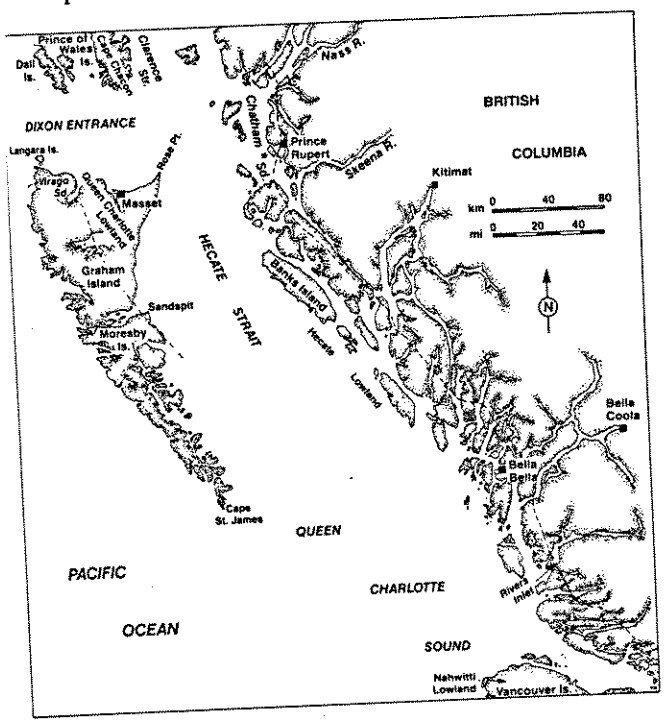


FIG. 14.1. Map of northwest Pacific coast. Broken lines show extent of coastal lowlands; wave measurements taken at star near Prince Rupert.

A Brief History

Long before the arrival of the "discoverers," the north coast Indians had evolved one of the most distinctive and sophisticated cultures in the Americas. The Haida, or "people" of the Queen Charlotte Islands, were especially skillful seamen and fishermen, whose sleek war canoes were almost as long as the ships of the early Spanish and British explorers. The Haida also were gifted carvers and produced a volume of art work which, like that of the mainland tribes of the Kwakiutl and Tsimshian, is only now becoming appreciated by the general public.

The first Europeans to sail the west coast of British Columbia were Spaniards. Under the command of Juan Perez they reached the vicinity of the Queen Charlotte Islands in 1774 before returning to a landfall at Nootka Sound on Vancouver Island. Quadra followed in 1775, but it was not until after Cook's voyage of 1778 with the *Resolution* and *Discovery* that the white man, or "Yetshaida" (iron men) as the Haida called them, began to explore in earnest the northern coastal waters. During his sojourn at Nootka that year Cook had received a number of soft, luxuriant sea otter furs which, after his death in Hawaii, members of his crew sold for high prices on arrival in China in 1779. News of his ships' windfall caused trading ships of several nations to sail to the coast to obtain sea otter furs for the China market.

It was the search for furs that brought about most of the early exploration of the coast. Dixon Entrance, for example, was named after Captain George Dixon, master of the 200-t *Queen Charlotte*, that passed the mouth of the channel in 1787 during a trading expedition for sea otter furs. (The channel was named in 1788 by Sir Joseph Banks who had been botanist and naturalist on Cook's round-the-world voyage in the *Endeavour* from 1768 to 1771 and in whose honor Banks Island in Hecate Strait is named.) "As he sailed southward Dixon met with a large island or islands, where he purchased a large number of sea otter skins. Rounding the southern termination of the land which he named Cape St. James, he sailed northward along the eastern shore until he recognized ahead the high mountains seen some days before, northward of a large opening in the coastline. Dixon thus ascertained the land he had been trading along was a large island or islands, and gave them the name of his vessel, Queen Charlotte isles. In 1789 Captain Gray, of the American trading sloop *Washington*, visited these islands, and named them after his vessel. As the ownership of the islands was established in Great Britain . . . the group has long been known by their present name." (Walbran 1971)

Hecate Strait received its name in 1861 after H. M. surveying vessel *Hecate*, a paddle-wheel sloop, 780 t, 5 guns, and brigantine rigged that worked the British Columbia coast from December 1860 to December 1862. The name for Queen Charlotte Sound was given in 1786 by the commander of the *Experiment* after the wife of George III of England, and adopted by Vancouver during his charting of the coast between 1792 and 1794.

Shoreline Features

The coastal seaway lies within the Hecate Depression, a segment of a continuous, low-lying area that ex-

tends from Puget Sound to Alaska (Fig. 1.11, 14.1). This depression includes the narrow, 20–50 km wide plain along the island-strewn mainland coast (the Hecate Lowland), the low relief northeast corner of Graham Island (the Queen Charlotte Lowland), and the rocky flatlands of northern Vancouver Island (the Nahwitti Lowland). To the east lie the Coast Mountains, to the west the open Pacific Ocean and the insular mountains of the Queen Charlotte Islands. The latter are especially rugged and plunge steeply into the sea off western Morseby Island. Nearly vertical sea cliffs over 200 m high are common and the short gravelly beaches that have managed to form are mostly associated with the numerous fiords that indent the outer coastline. The contrast between this area and the inner coast is striking.

The shoreline of the Nahwitti Lowland consists of shallow, open embayments, rocky intertidal zones, long stretches of gravelly beaches, and numerous small river deltas. Within the Hecate Lowland, the coastline is characterized by discontinuous sand, gravel, and boulder beaches between low rocky headlands. The Skeena River which enters these lowlands some 20 km south of Prince Rupert, has the second largest delta in British Columbia, and extends about 30 km to the west into Chatham Sound and adjoining channels. Unlike most deltas in British Columbia, it is neither at the head of an inlet nor directly exposed to a large body of open water, and exhibits no extensive tidal flats. However, the river sediments have effectively broadened the delta by "cementing" together the various islands situated seaward of the river mouth. Also, currents at the mouth of the river, which may attain speeds in excess of 1.5 m/s (3 kn), have formed extensive bars. The bars have megarippled surfaces with heights to 0.5 m and spacings over 10 m.

The Queen Charlotte Lowland has some of the most fascinating beach forms in British Columbia. Along Virago Sound, large beaches have been created through wave erosion and onshore current-induced movement of offshore bottom sediments. Between Massett and Rose Point to the east, similar processes have led to the formation of a continuous sand beach with a 200-m wide foreshore that slopes gently into Dixon Entrance (Fig. 14.2). The backshore is characterized by a series of dunes and ancient beach forms to 10 m above present sea level. In addition to widening the beach, the vast nearshore supply of sediment is transported eastward in the littoral zone, where it eventually contributes to the growth of Rose Spit that projects more than 12 km to the northeast of the trees on Rose Point. The beach-type environment continues some 6 km south of Rose Spit, but with a foreshore that is steeper

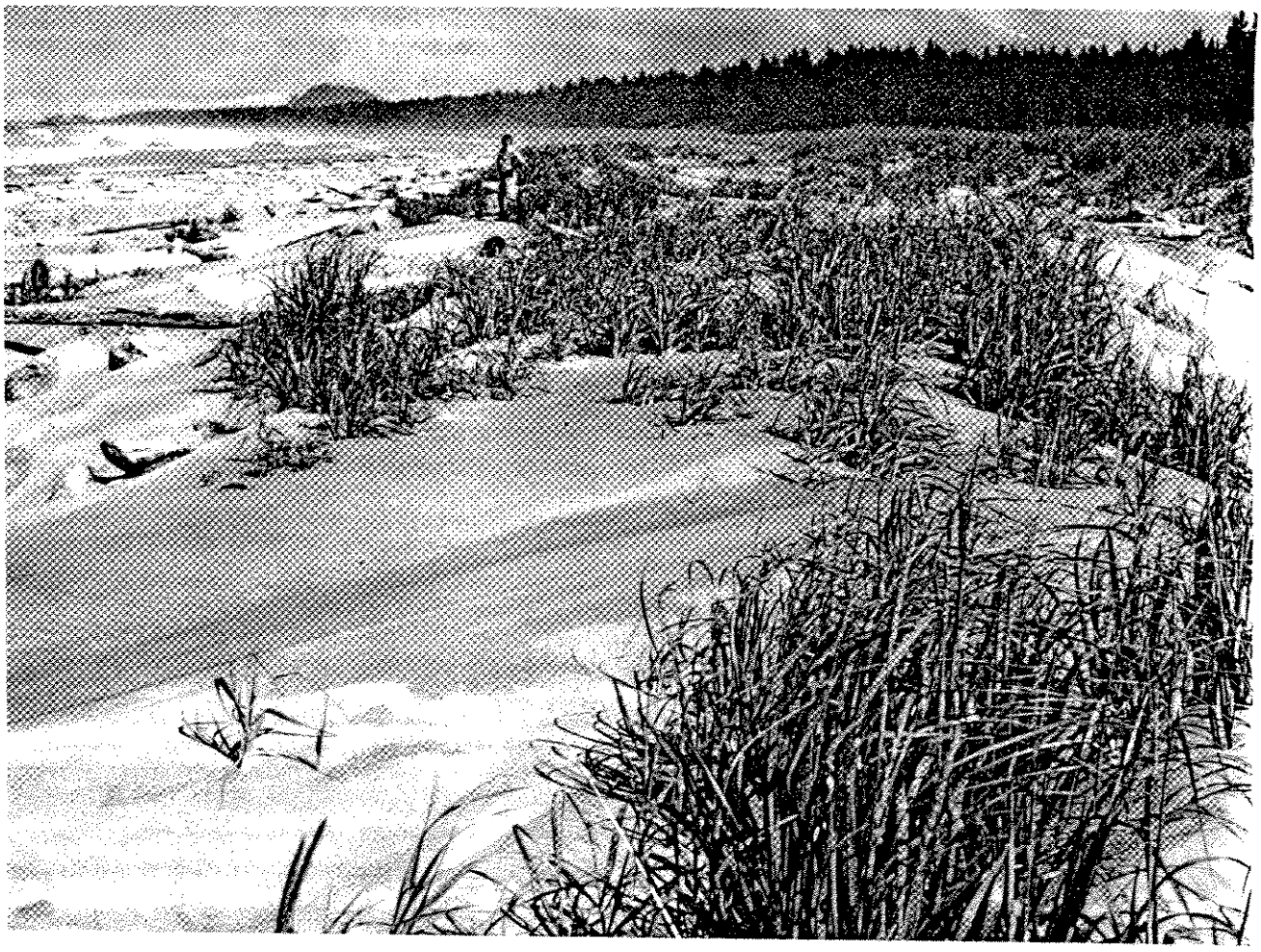


FIG. 14.2. Broad sandy beach, McIntyre Bay, facing Dixon Entrance, Graham Island, Queen Charlotte Islands. Beaches on northeast Graham Island are unlike most on British Columbia coast. Sediment is plentiful, beaches wide, with sandy and extensive backshore dunes. (Courtesy J. Harper.)

rower, and of coarser sediment than along the north st. Sea cliffs in this region range from 15 to 60 m high l dunes are present 100–200 m inland of the backshore : Fig. 8.11). In contrast to the north coast, beach iments are actively being removed by littoral processes, ich then carry them northward to Rose Spit.

Another pronounced depositional feature within the ıfines of the Queen Charlotte Lowland is Sand Spit ich curves for nearly 5.5 km half way across the en- ıce to Skidegate Inlet. As with the gradually eroding ches to the north, it suggests the presence of a net thward surface drift along the western shores of cate Strait.

Bathymetry

Dixon Entrance is an east–west depression in the tinental shelf bounded over most of the 170-km length the mountainous Dall and Prince of Wales islands to north and by Graham Island to the south. At the ward end it is split into two 400-m deep channels by rmonth Bank, a shallow ridge that rises to within 35 m the surface (Fig. 14.3). To the east, these channels ombine to form a single depression that gradually als to 270 m over a sill south of Cape Chacon, followed more rapid shoaling over the submarine ridge that arates Dixon Entrance from Chatham Sound. The n axis of the depression continues into Clarence Strait, 00-m deep trench leading 200 km seaward through the ska Panhandle.

Hecate Strait is the shallowest of the major channels t make up the Hecate Depression. It is also the least osed and has the most regular bathymetry. The axis of Strait is a narrow, 220 km long submarine valley that s the mainland flank, with depths that diminish from und 300 m in the south to about 50 m in the north. : northwest side of the Strait is a broad platform of ial sands and gravels less than 100 m deep, adjacent to flat coastal plain or strandflat of east Graham Island.

The bathymetry of Queen Charlotte Sound is consid- ly more complex than either Hecate Strait or Dixon rance because of shallow banks and three broad ughs that slice inland across the continental shelf from ths of 350–400 m (Fig. 14.3). Of these, the northern ugh is the most irregular and most extensive and trends) km northward along faulted, ice-deepened depres- ıs to form the deep channel of Hecate Strait. The tral and southern troughs, on the other hand, shoal ıer smoothly toward the mainland coast; the southern ugh divides about 60 km from the shelf edge to send a nch into Queen Charlotte Strait to the southeast. All e troughs have low sills at the seaward entrances and separated by wide shallow banks that are heavily fished draggers. These sills and banks appear to have glacial gins and are made up in part by recessional moraines stream outwash deposits left by retreating ice sheets. loratory oil wells drilled on the banks in the 1960s n encountered 3 km of marine sediment.

Due to the seaward funneling of land-derived sedi- ıts from the coastal mountains, the continental slope off Queen Charlotte Sound is comparatively gentle. There is also some evidence to suggest that the Queen Charlotte Islands once abutted Vancouver Island and effectively sealed off the Sound from any direct exposure to the Pacific Ocean. The subsequent northward movement of the Queen Charlottes along the Queen Charlotte fault created the present-day configuration.

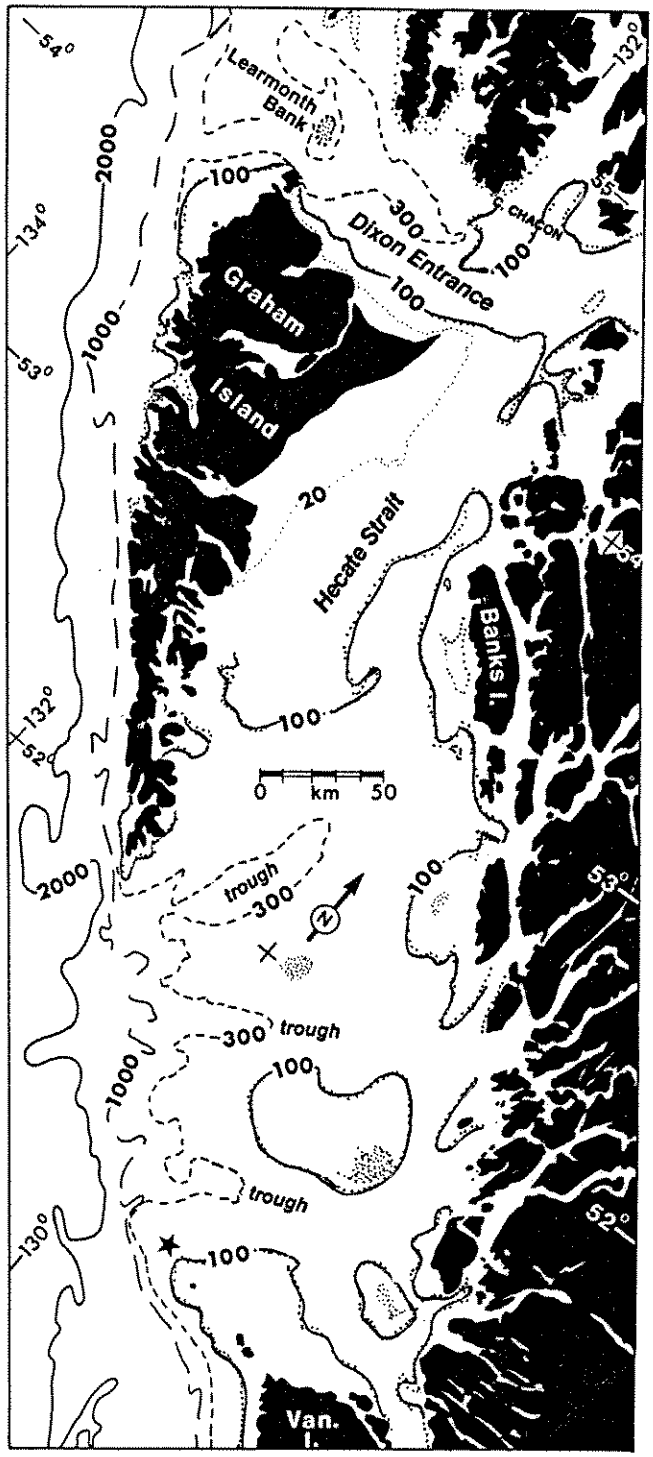


FIG. 14.3. Bathymetry of northwest coastal waters (m). Speckled areas denote shallow portions of banks. (Adapted from Chase et al. 1975)

Glaciation ?