A late Pleistocene Steller sea lion (*Eumetopias jubatus*) from Courtenay, British Columbia: its death, associated biota, and paleoenvironment

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Abstract: A partial juvenile Steller sea lion (E*umetopias jubatus*) skeleton from nearshore marine sands at Courtenay, Vancouver Island, British Columbia has been radiocarbon dated to 12 570 ± 70 BP. This date is supported by both stratigraphic and regional sea-level emergence data and is similar to radiocarbon dates on a Steller sea lion humerus from Bowen Island, just north of Vancouver. The juvenile apparently died from a blow to the braincase, most likely caused by a Steller sea lion bull. The Courtenay specimen is significant since very few Pleistocene otariid fossils are complete enough to be assigned to modern taxa. Associated mollusk remains indicate that the marine paleoclimate of the fossil locality was considerably colder than now — close to that along the northern reaches of Cook Inlet and Prince William Sound, Alaska. Pollen and plant macrofossils collected from the Courtenay site clearly demonstrate the presence of lodgepole pine (*Pinus contorta*) forests nearby during this early late-glacial interval. Fish remains (mainly Pacific cod and walleye pollock, with some salmon) from this site probably reflect selection by adult sea lions at a rookery.

Résumé : Un squelette partiel d'une otarie juvénile de Steller (*Eumetopias jubatus*) provenant de sables marins côtiers à Courtenay, sur l'île de Vancouver, daterait de 12 570 ± 70 ans avant le présent selon une datation au radiocarbone. Cette datation est corroborée à la fois par des données stratigraphiques et d'émergence régionale du niveau de la mer; elle est aussi similaire aux datations au radiocarbone de l'humérus d'une otarie de Steller provenant de l'île de Bowen, tout juste au nord de Vancouver. Le juvénile est apparemment mort d'un coup au neurocrâne, probablement de la part d'une otarie de Steller mâle. Le spécimen de Courtenay est important car très peu de fossiles d'otariidés du Pléistocène sont assez complets pour être assignés aux taxons modernes. Les restes de mollusques associés indiquent que le paléoclimat marin de la localité fossilifère était considérablement plus froid que présentement — se rapprochant de celui des tronçons nord de Cook Inlet et du golfe de Prince William, en Alaska. Des macrofossiles de plantes et de pollens recueillis au site Courtenay démontrent clairement la présence de forêts de pin tordu (*Pinus contorta*) à proximité au cours de cet intervalle tardi-glaciaire précoce. Les restes de poissons (surtout de morue du Pacifique et de goberge de l'Alaska, avec un peu de saumon) de ce site sont probablement le reflet d'une sélection par les otaries adultes d'une roquerie.

[Traduit par la Rédaction]

Introduction

Since few Pleistocene otariid fossils are complete enough to be assigned to modern taxa, the Courtenay specimen is significant. Only two other Pleistocene Steller sea lion fossils have been reported from British Columbia, the Courtenay specimen being the most complete from Canada. Pleistocene *Eumetopias* has also been reported from Alaska and California.

The purpose of this paper is to describe and figure the best-preserved bones of the skeleton (including a discussion of the likely cause of a hole through the top of the cranium — OB); discuss the discovery of the fossil, its locality, stratigraphic context, radiocarbon age, and background data on modern *Eumetopias* pertinent to the find, as well as paleoenvironmental implications of the bones (CRH) and associated organic material (plants — RWM; invertebrates — RLMR, CRH; fish — KMS; bird — CRH).

Discovery of the fossil and related fieldwork

In January 1995, when winter rain had caused much erosion at the Courtenay fossil site, RLMR noticed the top of a "seal" cranium projecting from sand speckled with marine shells. He picked it up, discovering more bones below. Since

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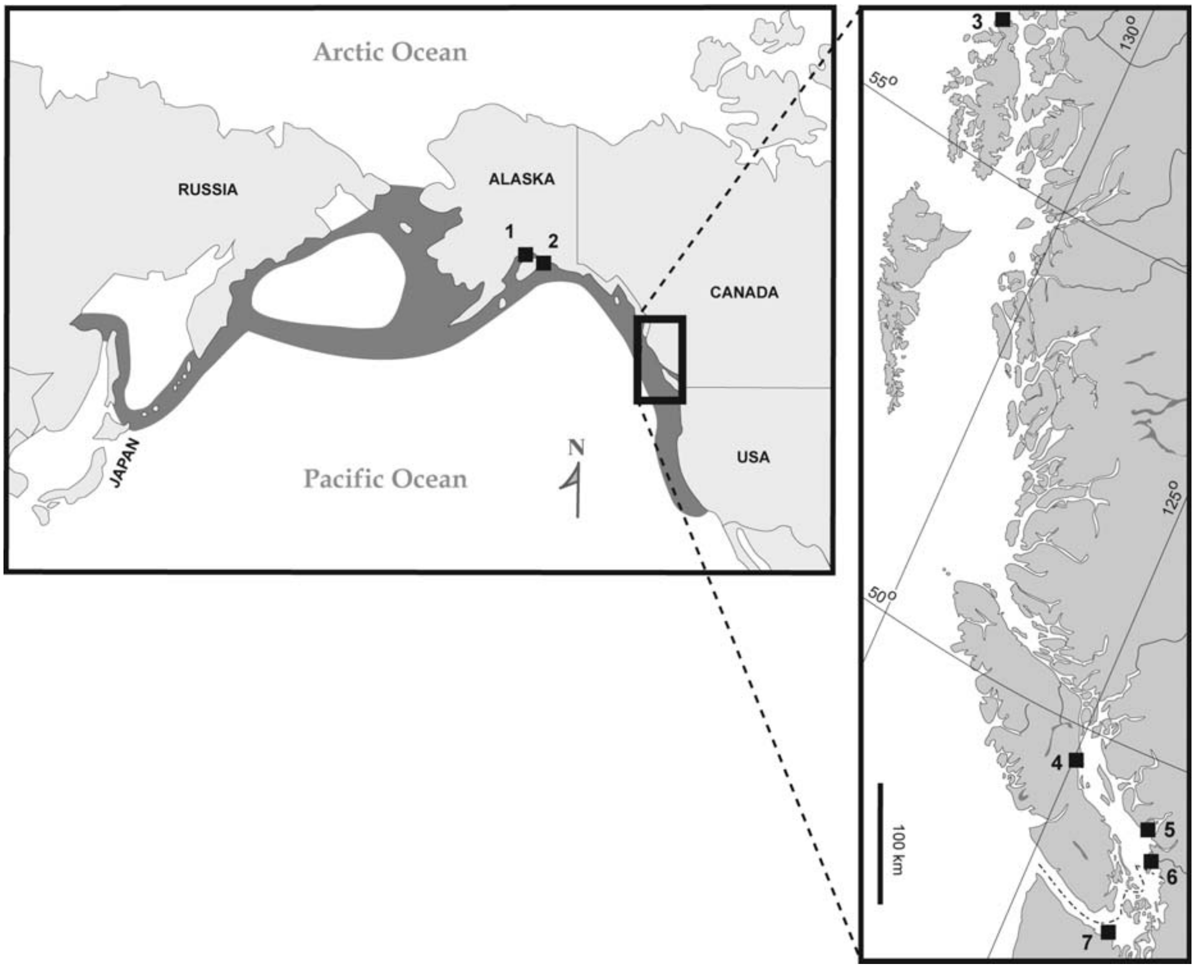
Fig. 1. Current world distribution of Steller sea lions (Schusterman 1981, fig. 3; Jefferson et al. 1993; Rice 1998) in relation to late Wisconsinan records of the species from Courtenay (4), Bowen Island (5) and Vancouver localities (6), British Columbia. The following sites are also marked: Cook Inlet (1), Prince William Sound (2), and On Your Knees Cave, Prince of Wales Island (3), Alaska; and Sequim (7), Washington.



rain was washing the site away, he returned and sieved (0.4 mm mesh) the sediments in a 1 m × 1 m square around the spot, finding more bones.

The first author arranged to borrow the bones (which turned out to represent a juvenile Steller sea lion, *Eumetopias jubatus*) and associated organic material from the Courtenay and District Museum to check their identification and radiocarbon date them. To get a better idea of the stratigraphy and probable geological age of the fossil locality, he contacted Quaternary geologist, Dr. John J. Clague, who visited the site in July 1996. The first and second authors visited the site together in September 1998, collecting more marine shells, but no bones.

Locality and stratigraphic position

The Lerwick Road site (49°43.06′N, 124°58.44′W, about 80–90 m asl; Fig. 1) is on the northeastern margin of Courtenay, Vancouver Island, British Columbia. It lies near the top of a ridge which runs from Comox Harbour to Miracle Beach. Fossil-bearing sands near the crest of this ridge were likely derived from glacial till and reworked by wave action and currents as the area "rebounded" during deglaciation. The stratigraphic sequence here consists of a relatively thin (about 60 cm) layer of oxidized sand, overlying a blue-gray silty sand with organic remains, from which the sea lion fossil came (Fig. 2). Clearly, these sands are part of a complex of marine–glaciomarine sands and gravels (Capilano Sediments) overlying till (Vashon Drift) of the last (Fraser) glaciation, which, in turn, may overlie Quadra Sand (Fig. 3). The fossiliferous shallow-water sediment (probably deposited in water < 10 m deep) containing the Steller sea lion fossil, is about 12 500 to 12 000 radiocarbon years old according to the sea-level curve of Mathews et al. (1970) (J.J. Clague, personal communication, July 19, 1996).

Radiocarbon date

Radiocarbon analysis of bone collagen derived from part of a neck vertebra (left half of CDM 996.20.13b) of the Courtenay sea lion yielded an AMS date of 12 570 ± 70 BP (Beta-115202), normalized to 12 720 ± 70 BP. This date conforms with Clague's stratigraphic interpretation that the littoral sands enclosing the sea lion fossil are about 12 500 to 12 000 radiocarbon years old, and therefore are best referred to late Wisconsinan Capilano Sediments (Fig. 3). It is

Fig. 2. Lerwick Road site, Courtenay, showing source (see circle near top centre, ~30 cm across) of the juvenile Steller sea lion remains in blue-gray silty sand with abundant marine mollusk shells (photo by RLMR).

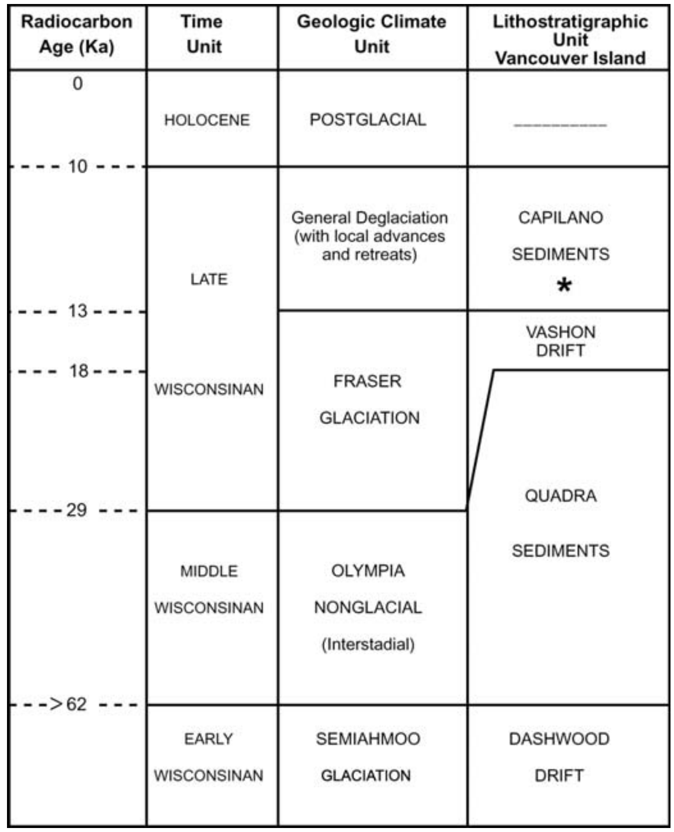


Fig. 3. Late Pleistocene stratigraphy of Vancouver Island, British Columbia (modified from Gascoyne et al. 1981, table 1; Harington and Beard 1992). The asterisk indicates the approximate source of the fossil Steller sea lion pup from Courtenay in the Vancouver Island stratigraphic sequence.

worth noting that two AMS radiocarbon analyses on a female Steller sea lion left humerus (CMN 52050) excavated from a 1.8 m-deep well on Bowen Island (about 120 km southeast of Courtenay on the opposite side of the Strait of Georgia) yielded normalized dates of 13 180 ± 90 BP (Beta-79860 CAMS 18423) and 12 700 ± 270 BP (Beta-16164). So the Courtenay and Bowen Island specimens are nearly contemporaneous. Further, Cowan (1941) mentioned a radius of an immature Steller sea lion discovered in sewer excavations in Vancouver — probably from late Pleistocene raised delta and marine deposits (see Dispersal history).

Abbreviations

AMS, accelerator mass spectrometry radiocarbon technique; asl, above sea level; CMC, Canadian Museum of Civilization, Gatineau, Quebec; CMN, Canadian Museum of Nature, Ottawa, Ontario; CDM, Courtenay and District Museum, Courtenay, British Columbia; GSC, Geological Survey of Canada, Ottawa, Ontario; LGM, last glacial maximum; TL, total length. Radiocarbon-date laboratories: AA, University of Arizona Accelerator, Tucson, Arizona, USA.; Beta, Beta Analytic Inc., Miami, Florida, USA.; CAMS, Center for Accelerator Mass Spectrometry, Lawrence Livermore Laboratories, California, USA.; I, Isotopes, a Teledyne Company, Westwood, New Jersey, USA.; L, Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York, USA.

Stellar sea lion

Description

Order Carnivora Bowdich, 1821
Family Otariidae Gray, 1825
Genus *Eumetopias* Gill, 1866
Eumetopias jubatus (Schreber, 1776) (Steller sea lion)

The specimen CDM 996.20, Table 1, Figs. 4–7 consists of a partial skeleton of a juvenile Steller sea lion, approximately five months old according to degree of suture fusion of the cranium (Sivertsen 1954) and lack of epiphyseal fusion of the long bones. The following sutures are open: occipito-parietal, squamosal–parietal, interparietal, interfrontal, coronal, basioccipital–basisphenoid, basisphenoid–presphenoid (maxillary and premaxillary–maxillary sutures were not preserved, but would likely have been open). Thus the individual is best characterized as a young "cub" (suture age 9) in Sivertsen's (1954, p. 13) terminology. The fact that the modern ranges of Steller and California (*Zalophus californianus*) sea lions overlap extensively and misidentification sometimes occur between juvenile or subadult male *Zalophus* and

Table 1. Measurements of a partial cranium of a late Wisconsinan juvenile Steller sea lion (*Eumetopias jubatus*) from Courtenay, British Columbia compared with a modern cranium of the same species from Sartine Island, British Columbia.

	Measurements (mm)[a]							
Specimens	1	2	3	4	5	6	7	8
Partial cranium (CDM 996.20.5). Late Wisconsinan, Courtenay, B.C., ~5 months old.	112.2	116.8	66.8	56.2	80.1	92.9	108.6	89.4
Cranium (CMN 32799). Modern, Sartine I., B.C., ~1 year old (Sivertsen 1954).	119.6	115.2	72.0	57.6	82.7	99.8	107.8	89.3

[a]1. Maximum width across zygomatic arches (ventral part of suture); 2. Maximum width across parietals; 3. Maximum width across supraorbital processes; 4. Minimum width of cranium at constriction behind supraorbital processes; 5. Minimum width across auditory meati; 6. Length between upper lip of foramen magnum and anterior of basisphenoid; 7. Length from midpoint between centre of supraorbital processes and parieto-occipital suture; 8. Maximum height of cranium taken at auditory meati (across auditory bullae).

Fig. 4. Left side view of the Courtenay Steller sea lion (*Eumetopias jubatus* CDM 996.20.5) cranium. Note the generally unfused sutures denoting an approximately five-month-old pup, the nearly complete zygomatic arch, and the puncture near the top of the cranium. Scale in millimetres and centimetres.

yearling or subadult female *Eumetopias* (Schusterman 1981) is indicative of the problem facing us in identifying the specimen. Fortunately, the complete skull of an immature male Steller sea lion (CMN 332799 collected at Sartine Island, British Columbia in 1961) was found that matches almost exactly that of the fossil, except that it is slightly older according to the somewhat greater degree of suture fusion (suture age 10; see Sivertsen 1954). Characteristics of CDM 996.20 that match modern *Eumetopias jubatus* skulls and help to differentiate it from *Zalophus californianus* are (1) the quadrate-shaped supraorbital process; (2) caniniform third upper incisor (I^3); (3) the shape of the auditory bulla (see Fig. 7); (4) the shape of the occipital condyle, particularly the supralateral extension; and (5) the great similarity in size of juveniles (Table 1). So the Courtenay specimen is referred to a juvenile Steller sea lion (perhaps a male). Among the greatest changes occurring between immature and adult Steller sea lion crania is that the latter increases greatly, not only in size, but in postorbital length and development of a strong sagittal crest (e.g., Schusterman 1981, figs. 4, 5; Brunner 2002).

Genetic studies (analysis of mtDNA haplotypes) have revealed the presence of two genetically different populations of Steller sea lions (Bickham et al. 1996, 1998). Presumably the Courtenay specimen is ancestral to the Pacific Northeast stock, rather than the Beringian stock. Should the Courtenay specimen's DNA be well enough preserved, it would be interesting to test this hypothesis.

Parts of the skeleton that are preserved follow.

Cranium

CDM 996.20.5 (Figs. 4–7) is complete, except for most of the region anterior to the orbits (there is, however, a fragment of the left premaxilla with the shell of a third incisor (LI^3)), the right lateral portion of the occipital, the basioccipital, and most of the right zygomatic arch. Sutures

Fig. 5. Dorsal view of Steller sea lion (*Eumetopias jubatus* CDM 996.20.5) pup cranial fragment from Courtenay. Note the mainly unfused sutures and the puncture on the left parietal that apparently caused the death of the pup. Scale in millimetres and centimetres.

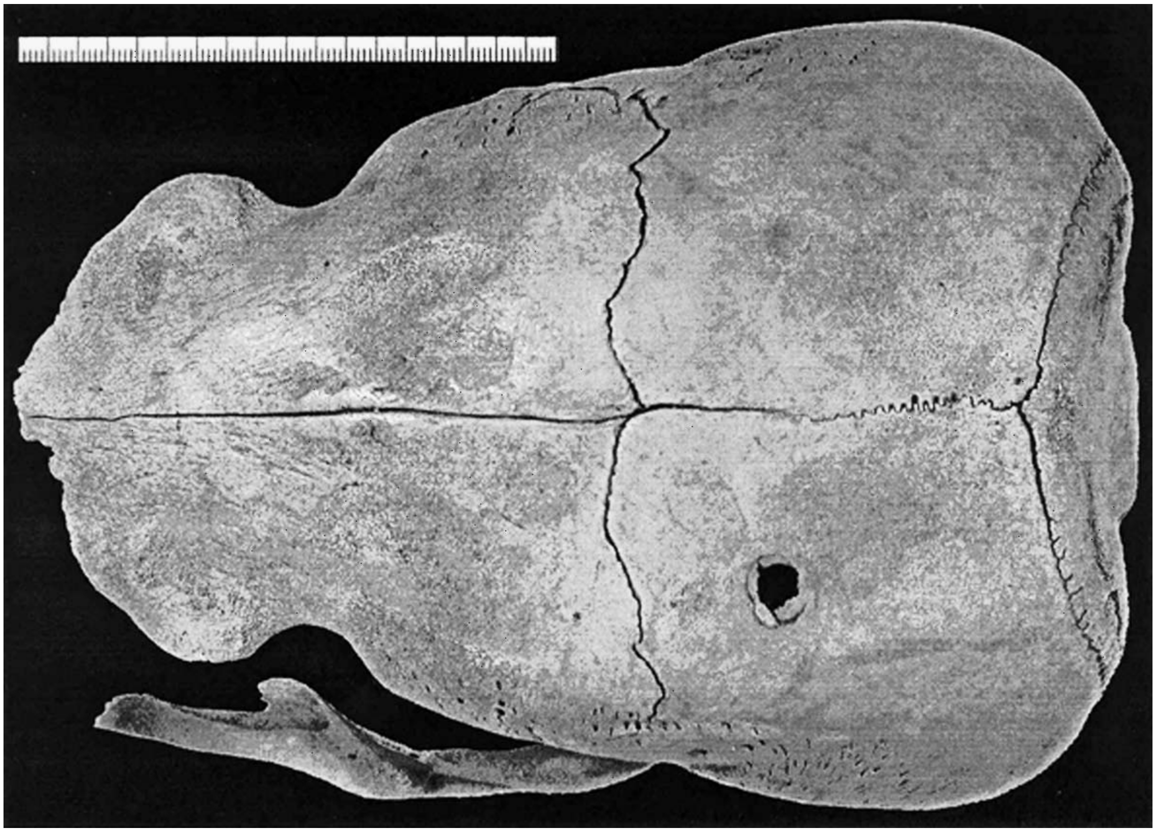


Fig. 6. Detailed dorsal view of the roundish puncture in Fig. 5. The surrounding ring crack indicates that a sharp blow penetrated fresh bone. Scale in millimetres and centimetres.

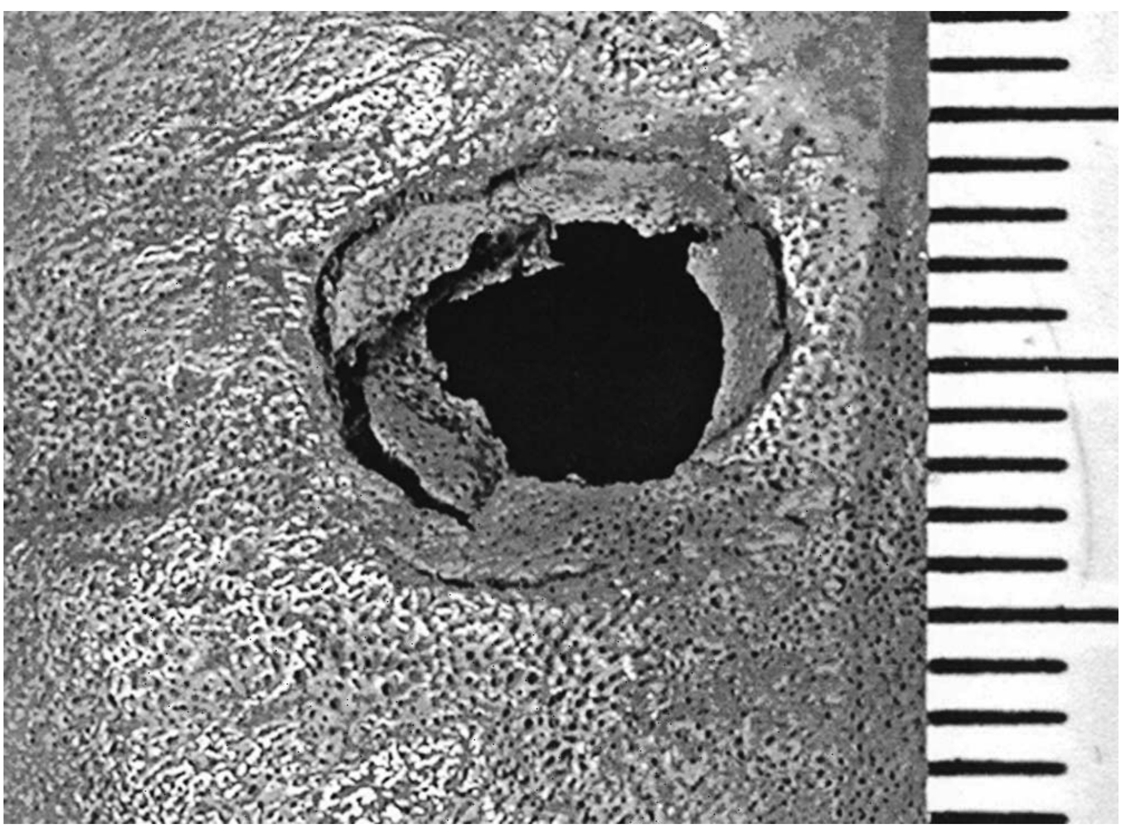
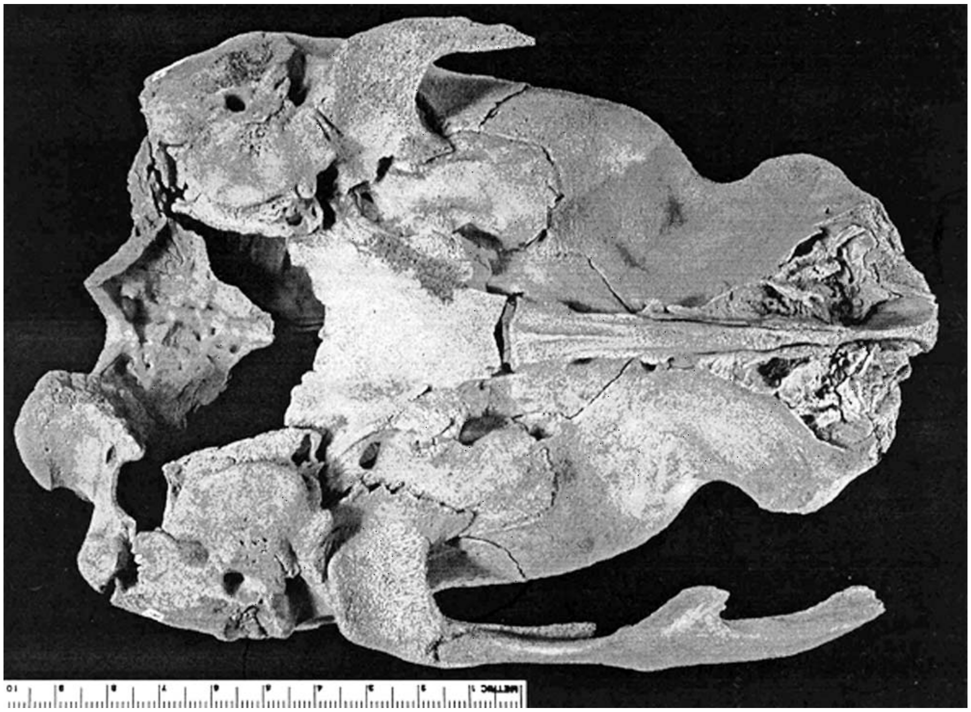


Fig. 7. Ventral view of the Steller sea lion (*Eumetopias jubatus* CDM 996.20.5) pup cranial fragment from Courtenay. Note the characteristic shape of the *Eumetopias jubatus* auditory capsule. Scale in millimetres and centimetres.



surrounding the occipital are unfused. Of interest is a roundish puncture (Figs. 5, 6) that penetrates the braincase in the central part of the left parietal, which will be discussed later in the text.

Vertebrae

Most of the left half of the axis (CDM 996.20.4); parts of two other cervicals (CDM 996.20.13b and CDM 996.20.13c); parts of nine thoracics and lumbars (CDM 996.20.13a, and CDM 996.20.13h to CDM 996.20.13p) with four centra (CDM 996.20.13d to CDM 996.20.13g), as well as two epiphyseal plates (CDM 996.20.13c and CDM 996.20.13s).

Ribs

Left first, second and third ribs (CDM 996.20.12a, CDM 996.20.12b, and CDM 996.20.16i).

Sternum

First sternebra (CDM 996.20.16d).

Forelimbs

Left scapula lacking epiphyses (CDM 996.20.14 — maximum height = 110.0 mm, greatest length and width of the glenoid process = 41.4 mm × 26.2 mm, and greatest dorsal length = 118.6 mm, as preserved); left humerus lacking epiphyses (CDM 996.20.15a), right humerus lacking epiphyses and heavily eroded at ends of shaft and on deltoid crest (CDM 996.20.15b).

Pelvis

Part of left anterior (ilial) portion (CDM 996.20.16d), left ischium (CDM 996.20.19), and left pubis (CDM 996.20.13h).

Hindlimbs

Left femur lacking epiphyses (CDM 996.20.10); left fibula (CDM 996.20.11); left calcaneum (CDM 996.20.18).

Metapodials and phalanges

22 unidentified elements, largest to smallest, most lacking epiphyses — CDM 996.20.16c, CDM 996.20.16g, CDM 996.20.16b, CDM 996.20.16a, CDM 996.20.16h, CDM 996.20.16f, CDM 996.20.16e, CDM 996.20.16n, CDM 996.20.16m, CDM 996.20.17a, CDM 996.20.16k, CDM 996.20.16l, CDM 996.20.16i, CDM 996.20.17b, CDM 996.20.7m, CDM 996.20.17c, CDM 996.20.17f, CDM 996.20.17d, CDM 996.20.17l, CDM 996.20.17g, CDM 996.20.17i, CDM 996.20.17e, CDM 996.20.17j, CDM 996.20.17k.

Indeterminate

CDM 996.20.13g and CDM 996.20.17h.

Probable cause of the cranial puncture

Four perimortem features (i.e., features originating at or near the time of death) appear on the vault. There is a large puncture on the left parietal bone centred 17.8 mm posterior to the left coronal suture and 22.3 mm lateral to the interparietal suture (Fig. 5). The feature is slightly oval in shape and measures 10.2 mm along the long axis (which runs parallel to the left coronal suture) and 8.2 mm wide. Within the outer puncture border there is a concentric ring of four bone fragments deflected and angled internally (Fig. 6). The central hole produced by the puncturing action measures 6.1 mm along the long axis (the same orientation as the outer fracture) and 5.3 mm wide. Internally there is significant beveling, measuring 10.4 mm in diameter, exposing the internal spongy (diploic) bone. There are no radiating fractures associated with the feature. The overall impression of these characteristics leads to the interpretation that the feature was produced by a conical-shaped object partially penetrating the vault to the extent that there was likely damage to soft tissue structures surrounding the brain, and probably to the brain itself, from this object and (or) the detached bone fragments.

A second feature indicating perimortem contact with a round-tipped object is present in the left temporal bone, 17.2 mm anterior to the midpoint of the occipitomastoid suture, and is represented by a shallow indentation into the outer table. This feature measures 2.2 mm in diameter and is associated with three radiating linear fractures of the outer table spanning 14.0 mm. One fracture clearly goes all the way through the bone and is visible on the endocranial surface.

Two other microscopic linear fractures are visible on the outer table of the vault. There is a 22.0 mm-long fracture running roughly anterior–posterior and centred on the right parietal bone ~25.0 mm superior to the right squamosal suture. And on the left parietal there is a 17.2 mm-long fracture running anterosuperiorly from the left squamosal suture. Neither of these two fractures appears endocranially. The linear fractures on the right and left parietals, and possibly some sutural separation, are likely the result of deformation of the vault associated with the slow loading consistent with the crushing action produced by the jaws of a predator.

There is no direct evidence that the large puncture feature of the left parietal and the indentation on the left temporal bone are linked to a single predator action; however, the spacing between the centre points for these features is 78.1 mm, falling within the range of measurements between maxillary canine tips from a CMN sample of five subadult and adult male Steller sea lions.

Steller sea lion background

Dispersal history

The earliest recognized otariids, the group including the sea lions, are ~12–11 Ma (mid-Miocene) from the North Pacific (Repenning 1976; Barnes et al. 1985; Berta and Deméré 1986). Sea lions, the most recently derived of the otariids, had evolved by about 3 Ma or somewhat earlier (Pliocene) and had crossed the equator within the past 3 million years. Sea lions diversified after northern and southern Pacific populations had been isolated, leading to the dispersal of Steller and California sea lions in the north and Australian (*Neophoca cinerea*), southern (*Otaria byronia*), and New Zealand (*Phocarctos hookeri*) sea lions in the south (Berta and Sumich 1999). The earliest fossil assigned to *Eumetopias* is from 2 Ma deposits in Japan (but see Miyazaki et al. 1995). A partial skeleton of *Eumetopias jubatus* was recovered from Pleistocene deposits in California (Loughlin 2002).

The Courtenay specimen, fossils from Bowen Island, and probably Vancouver, show that Steller sea lions occupied both coasts of the Strait of Georgia some 13 000–12 500 years ago under cooler paleoclimatic conditions than now (see Radiocarbon date). Further, Steller sea lion remains dating to and after the LGM have been reported from On Your Knees Cave, Prince of Wales Island, Alaska (Fig. 1). Specifically, a premolar tooth of *Eumetopias jubatus* has been AMS dated to 20 820 ± 650 BP (AA-36651), a canine tooth of *E. jubatus* has been AMS dated to 20 170 ± 450 BP (AA-33790), and an "artifact" of "cf. *E. jubatus*" has yielded an AMS date of 5780 ± 40 BP (CAMS-42382) (Heaton and Grady 2002, 2003).

Present distribution

Steller sea lions spend most of their lives in a narrow belt of coastal waters, hauling out on rocky offshore islets (Banfield 1974). The species is abundant and widely distributed around the North Pacific from Hokkaido, Japan in the west to southern California (San Miguel Island) (Schusterman 1981, Jefferson et al. 1993, Rice 1998; Fig. 1). The centre of abundance (nearly 100 rookeries) is probably the Aleutian Islands. About three-quarters of Canadian Steller sea lions are found in major rookeries on Scott Island and Cape St. James, Queen Charlotte Islands (Bigg 1985).

Pertinent biological facts

Females deliver a single pup from late May to early July, the sex ratio slightly favouring males (Gentry and Withrow 1986, Loughlin 2002). Pups grow rapidly, attaining about 34 kg by two months and about 80 kg at the age of one year, changing from gray-brown to chocolate brown after six months (King 1983). An approximately five-month old pup like that represented by the Courtenay fossil, would still have been nursing. Adults feed on fish, squid and octopus, clams, shrimp, and crabs. Remains of fish, clams, and crabs are associated with the Courtenay specimen (see Paleoenvironment).

The usual cause of death in young pups is drowning, or they may be crushed by bulls. The species has only a few predators besides humans, killer whales, and sharks. Wounds on the front of the body are usually caused by other sea lions, whereas wounds on the hind end may be caused by sharks and killer whales (Gentry and Withrow 1986).

Adult males (the largest sea lions) reach a length of about 3 m and weigh about 1 tonne. While breeding they appear to be in a frenzy and chase away juvenile males. Adult males sometimes kill the pups (Reeves et al. 2002).

Paleoenvironment

Regional paleoenvironment based on microfloral and microfaunal remains

Studies of foraminifers, diatoms, and dinocysts from glaciomarine sediments in the Strait of Georgia (adjacent to the Lerwick Road site and spanning a similar period: 12 470 – 11 700 BP) characterize successive paleoenvironments. The Strait was deglaciated rapidly about 12 500 BP by in situ downwasting — the first paleoenvironment representing near-ice conditions under the influence of turbid meltwater. After 12 000 BP abundant planktonic diatoms and dinocysts indicate warmer surface-water temperatures (Guilbault et al. 2003).

Associated plant remains

Three samples from the fossil site were analyzed for pollen and plant macrofossils. One sample was a small amount of silty sand (~0.5 mL) from a recess in the fossil pelvis. A larger sample of gray silty sand with marine mollusks was collected from the matrix enclosing the skeletal remains. The third sample from that matrix consists of two fragmentary coniferous seed cones.

Standard procedures were employed to digest the two sediment samples, using hot 10% HCl and HF to remove carbonates and silicates, respectively, followed by KOH treatment to dissolve humic components. After washing in distilled water, the sample residues were mounted in glycerin jelly for microscopic analysis. The small sample from the pelvis was essentially barren, with only rare organic fragments. The larger (~5 mL processed) matrix sample produced a polliniferous residue with enough microfossils for quantitative analysis and interpretation. From a pollen sum of 351 fossil grains, this sample was dominated (94%) by pine pollen of the *Diploxylon* type, almost certainly produced by *Pinus contorta* (shore pine or lodgepole pine). This interpretation is based on the relatively small size of the pollen grains and on comparisons with other localities of late-glacial age, where macrofossils of lodgepole pine have been identified. Identification of the two cones as *Pinus contorta* by comparison with modern reference material validates this interpretation. Other palynomorphs recorded from the sediment matrix are listed in Table 2, which also compares our pollen record with two other late-glacial marine sites from nearby Englishman River (Terasmae and Fyles 1959) and from the adjacent mainland at Haney, British Columbia (Mathewes 1973). All three localities represent near-shore marine deposits laid down during higher sea levels created by glacio-isostatic depression of the crust.

It is significant that all three sites are overwhelmingly dominated by pine pollen (88%–94%) accompanied by small amounts of other arboreal pollen such as *Picea* (spruce), *Abies* (fir or balsam), *Tsuga mertensiana* (mountain hemlock), and *Alnus* (alder). Non-arboreal vegetation is only recorded by small amounts of herb and shrub pollen and spores of ferns and fern allies. Such pollen spectra are well known in the palynological literature of the Pacific Northwest as typical of recently deglaciated environments (Mathewes 1973; Brown and Hebda 2002). With respect to southern Vancouver Island, Brown and Hebda (2002, p. 353) indicate that "*Pinus* woodland covered the landscape in the early late-glacial interval" based on pollen analytical investigations at several lake and wetland sites. The early records from these sites are similar not only in pine dominance but also in comparable representation of other trees such as spruce, fir, and alder. It is also significant that at the Englishman River section of Terasmae and Fyles (1959), fossil cones of *Pinus contorta* were found in conjunction with the high pollen values, paralleling our results. It is clear from the pollen, macrofossils, and radiocarbon dating of marine fauna that the sea-lion remains from Courtenay were preserved in sediments laid down during the early deglaciation, when lodgepole pine forests were present on nearby uplands.

Associated marine invertebrate remains

Of 25 species of marine invertebrates reported from Unit J (Capilano Sediments) (Wagner 1959, table XIV), 22 (88%) are known from Lerwick Road (Table 3). This molluskan evidence indicates that climate was considerably colder than present (Wagner 1959, p. 26). Although we have not calculated the mean of latitudinal "midpoints" for each species at the Courtenay locality (see Wagner 1959, pp. 41–49) it is probably close to that of Unit J…about 60.9°N (Wagner 1959, table XX). Therefore, sea temperatures at Courtenay near 12 500 BP would be close to those off the coast of Alaska along the northern reaches of Cook Inlet and Prince William Sound now. By a similar process using modern analogues, Wagner (1959, p. 50) estimates a water depth for Unit J of 0–15 fathoms (or 0–27.4 m, compared with Clague's more recent estimate (see section on Locality and stratigraphic position) of < 10 m).

Associated vertebrate remains: Fish

A total of 21 fish bones were recovered in association with CDM 996.20. Most were well preserved, with both small and large elements represented.

Description

Order Salmoniformes
Family Salmonidae
Genus *Oncorhynchus* Suckley, 1861
Oncorhynchus sp. (Pacific salmon)

Material

The anterior portion of a left dentary (CDM 2003.16.1) and five vertebrae (three caudal (CDM 2003.16.2 to CDM 2003.16.4) and two unidentifiable as to position (CDM 2003.16.5 and CDM 2003.16.6)) are attributable to *Oncorhynchus* (salmon). The dentary has two in situ teeth and bases for six additional teeth. It is identical in all aspects to modern *Oncorhynchus* dentaries, but could not be assigned to species. Four vertebrae are almost complete, while the fifth is a centrum fragment; they could not be assigned to species. The elements represent individuals of between 30 and 85 cm in TL.

Comments

Oncorhynchus fossils are reported from Pliocene and Pleistocene North American sites (e.g., Carlson and Klein 1996) and are common in coastal British Columbia archaeological sites dating back to about 9000 (e.g., Cannon 1991; Stewart and Stewart 1996; R. Wigen personal communication, 2003). Salmon are abundant in modern coastal British Columbia waters. As adults, they spend most of their lives offshore, returning to coastal streams to spawn after several years (Hart 1973). Three large studies found salmon a preferred dietary item of modern *Eumetopias*, based on analyses of the stomach contents of sea lions from Alaska, including the Aleutians (Pitcher 1981; Merrick et al. 1997; Loughlin 2002). Two smaller studies (Mathisen et al. 1962; Fiscus and Baines 1966) found little or no evidence of salmon in *Eumetopias* stomachs, but they had several stated shortcomings.

Order Gadiformes
Family Gadidae
Genus *Gadus* Linnaeus 1758
Gadus macrocephalus Tilesius 1810 (Pacific cod)

Table 2. Fossil pollen and spores from radiocarbon-dated late-glacial marine sediments in southern British Columbia. Numerical values are percent of total pollen and spores, except for [b] where value is calculated on total tree pollen.

	Haney[a]	Englishman River[b]	Courtenay, Vancouver I.[c]
Radiocarbon date:	12 690±190	12 360±250	12 570±70
Lab #:	(I-5959)	(L-391E)	(Beta-115202)
Arboreal pollen			
Pinus	91	88	94
Picea	1.2	2	tr
Abies	tr	2	tr
Tsuga mertensiana	tr	tr	tr
Alnus	1.6	8	3
Non-arboreal pollen			
Artemisia	tr	—	—
Asteraceae	tr	tr	—
Shepherdia	—	tr	—
Onagraceae	tr	tr	—
Polygonaceae	tr	—	—
Ericaceae	—	tr	—
Rosaceae	—	—	tr
Spores			
Polypodiaceae	1.4	tr	tr
Polypodium	tr	—	—
Cryptogramma	tr	—	tr
Lycopodium	tr	tr	—
Selaginella	tr	—	—

Note: tr indicates trace amounts of pollen and spores, 1% or less, or present but value unknown.
[a]Data from Mathewes (1973). Radiocarbon date on marine pelecypod shells.
[b]Data from Terasmae and Fyles (1959). Radiocarbon date on marine mollusk shells.
[c]AMS radiocarbon date on Steller sea lion vertebra.

Material

An articular (CDM 2003.16.7), a ceratohyal (CDM 2003.16.8), a lacrimal (CDM 2003.16.9), a premaxilla (CDM 2003.16.10), and a pharyngobranchial (CDM 2003.16.11) were all identified as Pacific cod. All come from individuals estimated at between 60 and 80 cm TL. These elements were compared with skeletons of four coastal British Columbia gadid or merlucciid species: *Gadus macrocephalus* (Pacific cod), *Theragra chalcogramma* (walleye pollock), *Microgadus proximus* (Pacific tomcod), and *Merluccius productus* (Pacific hake). Detailed descriptions of the specimens follow:

(1) A left articular, with only the distal end missing. It is identical to articulars of the modern Pacific cod and different from hake and tomcod articulars. It differs from Pollock articulars primarily in the attachment of the articulating surface to the main body on the medial side.
(2) The middle 20% of a right ceratohyal. It is identical to that of modern Pacific cod.
(3) A left lacrimal (60% complete) is identical to modern Pacific cod and unlike other gadid species.
(4) The anterior half of a left premaxilla, having tooth bases on the dentigerous surface but not teeth, is similar to specimens of Pacific cod, except the posterior process of the ascending arm extends more than in modern specimens. It differs in several ways from the pollock, tomcod, and hake.
(5) An almost complete pharyngobranchial compares well with Pacific cod elements and differs from walleye pollock and other gadids in the morphology of its dorsal canal.

Comments

Gadus has an abundant fossil record from the early Cenozoic, particularly the Oligocene, to present (e.g., Rosen and Patterson 1969). The first Canadian fossil record of *Gadus* was reported from late Pleistocene Champlain Sea deposits near Baie Comeau, Quebec (Gruchy 1971; McAllister et al. 1981). *Gadus* is abundant in coastal British Columbia waters today and is primarily a bottom-dweller in deep waters (up to 550 m), only occasionally occupying shallow waters (Hart 1973). It is favoured prey of *Eumetopias* based on analyses of Alaskan stomach contents (Pitcher 1981; Merrick et al. 1997; Loughlin 2002).

Gadus cf. *G. macrocephalus*

Material

A large cleithrum (CDM 2003.16.12), about 75% complete, is tentatively referred to Pacific cod due to the curve

Table 3. List of marine invertebrates collected from the Lerwick Road site.[a]

Gastropoda	
Euspira pallida (formerly *Natica clausa*)	arctic moon snail
Neptunea lyrata[b]	ridged whelk
Buccinum plectrum	lyre whelk
Margarites pupillus	puppet margarite
Trichotropis cancellata	chancellate hairy snail
Cylichnella eximia	bubble shell
Littorina sitkana	Sitka periwinkle
Littorina scutulata	checkered periwinkle
Puncturella multistriata[b]	many-ribbed puncturella
Acmaea pelta	shield limpet, and two unidentified species of limpets
Pelecypoda	
Saxidomus giganteus[c]	butter clam
Protothaca staminea	littleneck clam
Mya truncata[c]	truncated mya clam
Macoma nasuta	bent-nosed macoma
Yoldia myalis[b]	oval yoldia
Mytilus trossulus (formerly *Mytilus edulis*)	edible mussel
Hiatella arctica	arctic rock borer
Nuculana minuta	minute nut shell
Clinocardium nuttallii	Nuttall's cockle
Chlamys rubidus[c,d]	Hind's scallop
Chlamys hastata[d]	pink scallop
Bankia setacea	shipworm
Polychaeta	
Serpula vermicularis	tubeworm
Echinoidea	
Strongylocentrotus droebachiensis	green sea urchin
Crustacea	
Balanus sp.	barnacle

[a]Identifications by RLMR. Pincers of unidentified crabs are also present.
[b]Least common.
[c]Most common.
[d]Some scallop shells show signs of erosion by boring sponges.

and morphology of the anteromedial portion. While the distolateral shape is slightly more pollock-like than cod-like, overall the characters seem closer to Pacific cod.

Genus *Theragra* Lucas, 1898

Theragra chalcogramma Pallas, 1811 (walleye pollock)

Material

A right cleithrum (CDM 2003.16.13) and five vertebrae (three trunk (CDM 2003.16.14 to CDM 2003.16.16) and two caudal (CDM 2003.16.17 and CDM 2003.16.18)) have been assigned to walleye pollock. About 20% of the cleithrum is preserved and displays morphology on the anteromedial surface that is most like modern pollock specimens. A first trunk vertebra was assigned to walleye pollock, primarily because of a crest on the posterior surface of the basipophysis and a cresting of the posterior surface of the neural spine that is absent in Pacific cod. Two posterior trunk and two caudal vertebrae were assigned to pollock because of the greater organization of the ventrally situated trabeculae into struts.

Comments

Modern walleye pollock is common along coastal British Columbia occupying waters down to about 366 m (Hart 1973). No other *Theragra* fossils are known. Walleye pollock is the main prey of *Eumetopias* in the Aleutians and the Gulf of Alaska (Pitcher 1981; Merrick et al. 1997).

Family Gadidae

Material

A worn trunk vertebra (CDM 2003.16.19) is gadid.

Family cf. Gadidae

Material

A fragmentary vertebra (CDM 2003.16.20) is probably from a large cod.

Class Osteichthyes

Material

Two fish fragments (CDM 2003.16.21 and CDM 2003.16.22) could not be further assigned.

Summary

Two features stand out in the 21 fish elements recovered. Most notable is the lack of taxonomic diversity. About 75% of the assemblage is attributable to two cod species (Pacific cod and walleye pollock), with the remainder being salmon. The absence of common coastal inshore taxa, such as sculpins, flatfish, and rockfish, is enigmatic. Poor preservation may be responsible for the lack of bones of smaller fish, but larger taxa, such as most flatfish and rockfish, should be represented. Second, the bones were found in a layer of blue-gray silty sand, which was probably deposited in water < 10 m deep. Neither Pacific cod nor salmon are normally inshore fish; Pacific cod usually inhabits depths of up to 550 m. Pollock can be found anywhere from inshore waters to 366 m. So the presence of these groups and absence of others may reflect selection, not by the juvenile sea lion but by adults at a rookery (Sinclair and Zeppelin 2002).

Associated vertebrate remains: Bird

Of three bird bones recovered in association with the Steller sea lion remains, only one is clearly identifiable. It is complete, well preserved, and is described and discussed as follows.

Description

Order Anseriformes
Family Anatidae
Genus *Anser* Brisson 1760
Anser albifrons (Scopoli) (White-fronted Goose)

Material

A complete tarsometatarsus (CDM 2003.16.23) of an adult, with all surface details preserved. Total length of the specimen is 67.6 mm, larger than tarsometatarsi of Brant (*Branta bernicla*) and smaller than those of Canada Goose (*Branta canadensis*) in the CMN bird comparative collection. In size and shape, the specimen best matches a White-fronted Goose (e.g., CMN S-5581, an adult male of 68.7 mm TL that weighed 2796 g) and is referred to that species.

Comments

By the middle Miocene, most modern anseriform genera had appeared, but they did not become dominant elements in the freshwater fauna until the Pliocene (Howard 1973). The bone probably came from a White-fronted Goose that was following the Pacific Flyway between the Yukon Delta, Alaska, and southern California during the fall migration. The modern route seems to be off the western coast of Vancouver Island (Bellrose 1976, p. 106), but, occasionally, small numbers are driven ashore along the coast of southeastern Alaska. Perhaps the same held true for coastal Vancouver Island about 13 000 – 12 000 BP (see Dyke and Prest 1986), since this species generally occupies islands (in this case most likely a body of freshwater near the hypothetical Steller sea lion rookery — see Fish section summary), lake margins, grassy flats, valleys, and deltas.

Class Aves

Material

A complete 70 mm-long right posteriormost rib (CDM 2003.16.24) of a relatively large bird is preserved, as is a first phalanx (central digit?) of a bird about goose size. The phalanx (CDM 2003.16.25) is 221 mm in total length. These specimens could not be assigned beyond class.

Discussion

Finding remains of a juvenile Steller sea lion in situ in late Wisconsinan (~12 500 BP) coastal glaciomarine deposits is in accord with known habits and habitat of this species today. Presumably, it belonged to the Pacific Northeast stock rather than the Beringian stock (Bickham et al. 1996), was killed by a sharp blow that penetrated the braincase, and sank to nearshore silty sands already occupied by many invertebrate species (Table 3; J.G. Fyles collected marine shells from the Courtenay area that dated to 12 500 ± 450 BP (I-GSC-9), Walton et al. 1961, Clague 1980) that characterize Capilano Sediments (Fig. 3). The overlying 0.6 m-deep oxidized sands are presumably offlap deposits left by the receding ocean waters, as they drained away from what is now the Lerwick Road site. Since postcranial elements of the left side are best preserved, the young sea lion probably came to rest on that side. Bottom currents or scavengers may have dispersed most of the higher, right-side bones.

Probably, the five-month-old pup had a brownish coat and weighed about 45 kg when it died (see Pertinent biological facts). It may have been close to a rookery in what is now the Courtenay area and would have been suckled by its mother — was the pup separated, or had its mother died, before it was attacked? Furthermore, associated fish remains — mainly Pacific cod and walleye pollock, with some salmon — probably reflect selection by adult Steller sea lions at a rookery, and the fact that the fossil locality (now on the crest of a ridge running from Comox Harbour to Miracle Beach) would have been near the northeastern end of an elongate offshore island typical of many rookeries tends to support this hypothesis.

What caused the puncture on the top of the skull? Two hypotheses were considered:

(1) That the puncture was made by the angled blow of a right upper canine (RC^1) of a Steller sea lion bull, so no similarly large mark of the LC^1 would appear on the pup's cranium. CRH tried this using the cranium of an old bull (CMN 21949), and its RC^1 sunk about 6 mm from the worn tip, fit the hole. So, perhaps a bull in an aggressive frenzy, killed the pup. Adult and subadult males have been reported killing and eating Steller sea lion pups near the Pribilof Island (Reeves et al. 2002). A forensic study by OB (see Probable cause of the cranial puncture) seems to support this view. However, if the pup is about five months old as estimated, the bulls would likely have left the rookery.

(2) That the hole was made by the sudden, carefully directed thrust of a roundish, solid (ivory or antler?) spearpoint wielded by a human hunter. Although people are known to have occupied On Your Knees Cave,

northern Prince of Wales Island, Alaska (Fig. 1) about 10 000 years ago (Dixon et al. 1997) and they hunted mastodons near Sequim, Washington, just south of Vancouver Island, some 12 000 years ago (Gustafson et al. 1979; Harington 1996), the forensic study does not support this view. Further, human hunters would have recovered and butchered the animal, unless it escaped their clutches.

Conclusions

(1) About 12 500 years ago, evidently, a Steller sea lion pup was separated from its mother at a rookery and killed by a sharp blow to the skull by a bull.
(2) The body came to rest in nearshore silty sand on its left side in < 10 m of water, decaying in situ. Presumably most of the upward-projecting right side was eroded away by bottom currents or dispersed by scavengers.
(3) Marine invertebrate remains from the blue-gray silty sand indicate colder late Wisconsinan sea temperatures at the Lerwick Road site — nearest those of Cook Inlet, Alaska today. The fossil-bearing sediment was covered by about 60 cm of oxidized sand as land rose relative to sea level and the area was exposed.
(4) This is the most complete Steller sea lion fossil from Canada. Fossils from Courtenay, Bowen Island, and Vancouver show that Steller sea lions occupied both coasts of the Strait of Georgia some 13 000 – 12 500 years ago.
(5) In addition to the Courtenay sea lion remains, associated plant, marine invertebrate, fish, and bird remains provide details of local paleoenvironment about 12 500 BP.

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