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Fur seals and sea lions (Otariidae): identification of species and taxonomic review

Sylvia Brunner
Australian Marine Mammal Research Centre, University of Sydney, NSW 2006, Australia
CSIRO Sustainable Ecosystems, GPO Box 284, Canberra City, ACT 2601, Australia
University of Alaska Museum, 907 Yukon Drive, Fairbanks AK 99775, United States*

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Contents

*Correspondence address

Abstract The standard anatomical descriptions given to identify species of the family Otariidae (fur seals and sea lions), particularly those for the genus *Arctocephalus*, have been largely inconclusive. Specimens of some species conformed more to the description of others, overlapping in many identifying characteristics. Recent re-examination of the genetic basis of taxonomic diversity within otariids required matching by comprehensive new studies of skull morphometry based on large sample sizes, to provide a sound basis for re-appraisal of species limits in the family. The typical skull morphology of otariids fall into two general characteristics: a short, mesocephalic skull observed primarily in the fur seals and a more dolichocephalic skull common in most sea lions. Subfamily separation of otariid seals was not supported. Instead, a separation of genus, species and subspecies was proposed, with re-arrangement of taxonomy at the levels of genus, species and subspecies. *Arctocephalus australis*, *A. forsteri* and *A. galapagoensis* appeared congeneric, with only subspecific differences in morphology. *Arctocephalus townsendi* and *A. philippii* appeared congeneric, yet were morphologically divergent from the remaining *Arctocephalus*. Skulls of *Zalophus californianus japonicus* were significantly different from those of *Z. c. californianus* and *Z. c. wollebaeki*, and were considered a separate species of *Zalophus*.

> *. . . in no family of mammals, probably, have more diversities of opinion been expressed by zoologists, both with respect to the number of species in the family and their arrangement in genera and subfamilies, than in the Otariidae.* (Turner, 1888)

Key words otariid, fur seal, sea lion, taxonomy, description, morphometrics, skull, species, subspecies

Introduction

In many treatments, the Pinnipedia are a suborder of Carnivora and divided into three families: Odobenidae or walruses, the Phocidae or true seals and the Otariidae or eared seals (Rand, 1956; King, 1983). The family Otariidae are commonly separated into the subfamilies Otariinae, the sea lions and Arctocephalinae, the fur seals, based on the presence (in fur seals) or absence (in sea lions) of abundant underfur. This distinction is dubious, as abundant secondary hairs may have evolved twice in the history of the Otariidae or may have been retained randomly as a primitive feature of marine mammals and are indicative of a shallow-water adaptation to conserve body heat in an aquatic environment (Repenning *et al*., 1971).

Although most researchers today recognize there is little substance for a subfamilial split of the Otariidae, subfamilial recognition still appears in the literature. For instance, Rice (1998, p. 22) stated that "... studies showed that all the living species [of otariids] fall into two monophyletic groups which many authors recognize as subfamilies: Arctocephalinae for the fur-seals, and Otariinae for the sea-lions". The two groups of otariids are also referred to commonly as fur seals and sea lions. To address the issue of subfamilies, a morphometric comparison of the two groups is made in this study.

The southern fur seals are placed in the genus *Arctocephalus* that currently comprises eight extant species, whereas the northern fur seal, *Callorhinus ursinus*, is classified as a separate, monotypic genus. The sea lions comprise five monotypic genera.

The most widely accepted nomenclature for the Otariidae is described below, and is based primarily on King (1983). Rice (1998) introduced some changes to the taxonomy in his systematic review of marine mammals; these are currently not as widely accepted as that of King (1983), and are reviewed in this study.

'Otariinae'
- *Otaria* Péron, 1816
  - *byronia* (de Blainville, 1820)
- *Eumetopias* Gill, 1866
  - *jubatus* (Schreber, 1776)
- *Neophoca* Gray, 1866
  - *cinerea* (Péron, 1816)
- *Phocarctos* Gray, 1844
  - *hookeri* (Gray, 1844)
- *Zalophus* Gill, 1866
  - *californianus* (Lesson, 1828)
    - *californianus* (Lesson, 1828)
    - *wollebaeki* (Sivertsen, 1953)
    - *japonicus* (Peters, 1866)

'Arctocephalinae'
- *Callorhinus* Gray, 1859
  - *ursinus* (Linnaeus, 1758)
- *Arctocephalus* Geoffroy Saint-Hilaire and Cuvier, 1824
  - *australis* (Zimmerman, 1783)
    - *australis* (Zimmerman, 1783)
    - *gracilis* (Nehring, 1887)
  - *galapagoensis* Heller, 1904
  - *gazella* (Peters, 1875)
  - *forsteri* (Lesson, 1828)
  - *tropicalis* (Gray, 1872)
  - *pusillus* (Schreber, 1776)
    - *pusillus* (Schreber, 1776)
    - *doriferus* (Wood Jones, 1925)
  - *philippii* (Peters, 1886)
  - *townsendi* (Merriam, 1897)

The standard anatomical descriptions given to identify species of otariids, particularly those for the genus *Arctocephalus*, have been largely inconclusive. Specimens of some species conform more to the description of others, overlapping in many identifying characteristics (King, 1983). The problems of identification lie primarily in the original taxonomic studies that were based on small sample sizes, sex and age bias, and misidentified specimens. Allen (1880, p. 227) stated that "... of about fifty synonyms pertaining to the Eared Seals, probably two-thirds have been based, directly or indirectly, upon differences dependent on sex and age, and the rest upon the defective descriptions of these animals by travellers ...".

Morphometric studies on species of *Arctocephalus* have rarely focused on more than one or two species at a time, making any comparative studies difficult. King (1983) stated that species of *Arctocephalus* are so widely dispersed over the world that it has always been difficult to get reasonable numbers of specimens of each species, and to assemble enough skulls in one place for comparative analyses. Repenning *et al.* (1971) analysed a significant number of skulls but were able to access only a small number of mixed age and sex of some species available at that time (e.g. *A. townsendi*, *A. philippii*, *A. gazella*, *Z. c. japonicus*), basing their results on these. Sivertsen (1954) had only one specimen each of *A. philippii* and *A. townsendi* that he used to separate these from the *Arctocephalus* as a distinct genus, *Arctophoca*. Repenning *et al.* (1971) used a larger sample size (11 *A. townsendi* and five *A. philippii*) although their samples included both sexes and contained at least five subadults and three juveniles. Repenning *et al.* (1971) retained both species within the genus *Arctocephalus*. Subsequently, King (1983) accepted the arrangement of eight extant species by Repenning *et al.* (1971), as did most other researchers. Since Repenning *et al.* (1971), a complete taxonomic review of the Otariidae, based on new material, has not been undertaken.

Some taxonomic studies of otariid seals at the species level have been published. For instance, King (1983) stated that it was not possible to find any osteological characters of the skull that might infallibly distinguish *A. forsteri* from *A. p. doriferus* at any stage of maturity and between the skulls of males and females. Nevertheless, she mentioned that skulls of adults could be separated visually because of the greater size of *A. p. doriferus*. The inability to differentiate between these species was due primarily to small sample sizes and a paucity of information on growth of the skull for both sexes. This problem has since been addressed by Brunner (1998*b*) who provided visual and statistical methods to separate *A. forsteri* from *A. p. doriferus*, by utilizing large sample sizes and identifying the variation in cranial morphology for different age groups in both males and females.

In most instances, sample sizes used for classification were insufficient to eliminate bias from sexual dimorphism and incomplete cranial growth. The inadvertent pooling of sexes and subadults has contributed significantly to the present taxonomic confusion (Brunner, 1998*a*, 1998*b*). In species such as *A. philippii* and *A. gazella*, the original descriptions were based upon juvenile specimens only and little was known about the exact skull proportions in adult specimens (Sivertsen, 1954). A primary component of this study was to utilize adult skulls only for taxonomic review (Brunner, 2000).

The nomenclature for the Otariidae has been equally problematic. Up to 1816, two species only were known; later the number exceeded 50, most of which proved to be synonyms (Sivertsen, 1954). Péron (1816)[1] first identified the eared seals under the genus *Otaria*. The eared seals were then raised to the rank of family by Brookes (1828), under the name Otariadae. This classification was not generally adopted until 1866, when it was revised by Gill (when introducing the name Otariidae) and used immediately by Gray and subsequently by most researchers (Allen, 1880). Gray, Turner and others had previously considered the Eared Seals a subfamily of the Phocidae for which Gray, at different times, used the names Otariina and Arctocephalina, the latter also being adopted for the name of the group by Turner in 1848 (Allen, 1880).

Allen (1870) divided the Otariidae into two groups, Trichophocinae for the sea lions and Oulophocinae for the fur seals, alluding to their pelage. Von Boetticher (1934) rejected Allen's names and identified the sea lion and fur seal groups with the names of their included genera. He also added a third category: the 'mitte-robben Phocarctinae' to contain only *P. hookeri*, presumed to possess pelage intermediate between the fur seals and sea lions (Scheffer, 1958).

Gray (1869) divided the family into five tribes, Otariina, Callorhinina, Arctocephalina, Zalophina and Eumetopina, primarily with reference to the number of postcanines (PCs) and the position of the posterior pair. He also separated these tribes into two 'sections', based on the posterior extension of the palate (Otariina, consisting of the genus *Otaria*, and the remaining tribes mentioned above).

In 1873, Gray proposed another arrangement of the Otariidae in which they were placed in two primary divisions according to the number of PCs (6-6, 5-5; or, 5-5, 5-5) (Allen, 1880). By 1874 he added a new tribe, Gypsophocina, and united Callorhinina, Arctocephalina and Eumetopiina into one tribe under the name Arctocephalina, thus reducing the number to four: Otariina, Gypsophicina, Arctocephalina and Zalophina.

Around this time, Gill (1872) made two primary divisions of the family, the genus *Zalophus* constituting one division and the remaining otariids the other.

Genera

The first generic division of the Otariidae was introduced by Cuvier (1824), who separated the family into 'Arctocéphales' (*Arctocephalus*) and 'Platyrhinques' (*Platyrhinchus* = the current name, *Otaria*) with *Phoca ursina* (type, *Arctocephalus delalandii* Cuvier = *Callorhinus*; *A. antarcticus* Gray = *Arctocephalus pusillus pusillus*) and *Phoca leonina* (type, *Otaria jubata* = *Otaria byronia*). Prior to 1824 the only commonly recognised genera were *Otaria* and *Arctocephalus* (Allen, 1880).

Gray (1859) separated the northern fur seal from *Arctocephalus* under the name *Callorhinus*, and Gill (1866) recognized a further two genera, namely *Eumetopias* and *Zalophus*. The former had for its type and only species the northern sea lion, or *Leo marinus* (Steller) (= *Eumetopias jubatus*), while the latter was founded on *Otaria gilliespii* (Macbain)

[1] References to early nomenclaturial history can be found in Allen (1870, 1880) and Scheffer (1958).

(= *Zalophus californianus*). At this point, there were five recognized genera:

(i) *Otaria* (Péron 1816, type *Phoca jubata* Forster = *Otaria byronia*)
(ii) *Arctocephalus* (Cuvier 1824, type *Phoca ursina* Linnaeus, = *Callorhinus* Gray 1859, and not Cuvier)
(iii) *Eumetopias* Gill, 1866 (type *Otaria californiana* Lesson, = *Arctocephalus monteriensis* Gray, the intended type being *Otaria stelleri* Müller = *Eumetopias jubatus*)
(iv) *Zalophus* Gill, 1866 (type *Otaria gilliespii* Macbain = *Zalophus californianus* Lesson)
(v) *Halarctus*, Gill (type *Arctocephalus delalandii*, Gray, = *Arctocephalus*, Cuvier 1824).

Some months after this separation, Peters (1866*a*) accepted the above classifications (albeit as subgenera) and included two others, namely the subgenera *Phocarctos* (type *Arctocephalus hookeri*, Gray = *Phocarctos hookeri*) and *Arctophoca* (type *Otaria philippii*, Peters = *Arctocephalus philippii*). Gray (1859) then added a new genus *Neophoca*, based upon *Arctocephalus lobatus*, Gray (*Arctocephalus cinereus*, Péron = *Neophoca cinerea*), which was referred previously to *Zalophus* by Peters. He also added two new subgenera of *Arctocephalus*, namely *Euotaria* (based on *Arctocephalus nigrescens*, Peters = *Arctocephalus australis*) and *Gypsophoca* (on *Arctocephalus cinereus*, Gray = *Neophoca cinerea*). The type for *Phocarctos* was also associated with *Otaria ulloae* (von Tschudi) which was later found to be *Otaria jubata* (= *Eumetopias jubatus*).

By 1869, Gray had retained 10 genera: *Otaria*, *Callorhinus*, *Phocarctos*, *Arctocephalus*, *Euotaria*, *Gypsophoca*, *Zalophus*, *Neophoca*, *Eumetopias* and *Arctophoca*. In 1871, *Euotaria* and *Gypsophoca* were treated again as subgenera of *Arctocephalus* by Gray but were re-introduced as genera in 1874. At this time, Gray made no reference at all to *Arctophoca*. Gill (1872, 1866) and Allen (1870) retained the five generic groups first recognized by Gill in 1866, with corrections in nomenclature introduced by Gray and Peters: *Otaria*, *Eumetopias*, *Zalophus*, *Callorhinus* and *Arctocephalus*.

Species

The history of species nomenclature for the Otariidae is more confused. Allen (1880) provided a detailed account, describing the naming by such authors as Anson, Pernetty, Forster, Weddell, Péron, Lesueur, Quoy and Gaimard, Lesson and Garnot, Byron and others. Allen (1880, p. 193) stated "To these authors, and to the often-quoted remark of Péron that he believed there were not less than 20 species of Otaries, we are indebted for much of the confusion and obscurity that must ever be inseparable from the early history of this group." The greatest inaccuracies with the early species accounts lay in the fact that they were described mainly by 'habits and localities of occurrence', with few accounts based upon tangible specimens (Allen, 1880). Scheffer (1958) also provided a systematic account of the Otariidae.

The status of the specific name for the southern sea lion is still controversial, with two names currently in use: *Otaria byronia* (type – *Phoca byronia* de Blainville, 1820) and *Otaria flavescens* (type – *Phoca flavescens* Shaw, 1800). *Otaria flavescens* was defended by Cabrera (1940, pp. 17–22), who concluded that the yellow seal *Phoca flavescens* of Shaw (1800) can only have been a southern sea lion pup after its first moult. *Phoca flavescens* Shaw is the earliest available name, with an appropriate type locality but uncertain identification, whereas the locality of *Phoca byronia* de Blainville is incorrect but its identification is obvious, including the prolonged roof of the palate (King, 1978; Rodríguez & Bastida, 1993) unique to *Otaria*. Rodríguez & Bastida (1993) asserted *Otaria flavescens* is the correct name, basing their argument primarily on pale coat colour, ear length and breeding locality; Rice (1998) also used the name *O. flavescens* for these reasons. Although light coat colour and albinism are rare in most otariids, they do occur; individuals from more than one species of otariid could be partially, or completely, albino. For instance, a lack of pigment in guard hairs appears in individuals of *A. gazella*, for both sexes and in all age groups, making the animals appear white although they are not albinos (Bonner, 1968; King, 1983). Rodríguez & Bastida (1993) stated that it is improbable *A. gazella* would be found in the locality of the type specimen, due to the location of breeding rookeries for *A. gazella*. Nevertheless, it is known that individuals of many species of *Arctocephalus* (including *A. gazella*) tend to stray from their normal range (Bonner, 1981, p. 181).

Although a light colour phase exists in the Southern sea lion, neonates are black, turning dark brown after the first molt, with occasional lighter shades (Oliva, 1988; Rodríguez & Bastida, 1993). Based on coat colour, it is possible the specimen from Shaw (1800) was a southern sea lion but it cannot be ruled out that it may have been another species. Rodríguez & Bastida (1993) did not compare ear length of Shaw's specimen with that of many species of otariids and Oliva (1988) stated that ear length of Shaw's specimen was too large for *O. byronia*. Conversely, the description of the palate in de Blainville's (1820) specimen can only have been that of a southern sea lion. For these reasons, the name *Otaria byronia* is used in this study, instead of *O. flavescens*.

The South American fur seal, *A. australis*, was recognized as two subspecies initially by King (1954) and subsequently by Rice (1998) and others. King (1954) suggested *A. australis* should be classified into two subspecies, a 'larger' form, *A. a. gracilis*, found on the Falkland Islands and a 'smaller' form, *A. a. australis*, from the mainland. It was observed later that three skulls of the Galapagos fur seal, *A. galapagoensis*, were included in King's mainland sample of 11 specimens (Bonner, 1981). Thus, the subspecific split based upon this analysis is doubtful and is reassessed in this study.

The genus *Zalophus* comprises three sub-species: *Z. c. californianus* (California sea lion), *Z. c. wollebaeki* (Galapagos sea lion), and *Z. c. japonicus* (the presumed-extinct Japanese sea lion) (Scheffer, 1958). Itoo (1985) compared the cranial morphology of the three subspecies and suggested *Z. c. japonicus* may be a distinct species of *Zalophus*, rather than a subspecies of *Z. californianus*. Rice (1998) considered all three as separate species based on work by Itoo (1985) for the Japanese sea lion, and Sivertsen (1953, 1954) for splitting *Z. c. californianus* and *Z. c. wollebaeki* into separate species. Itoo (1985) used the number of PCs as one of the primary separating variables to remove *Z. c. japonicus* from the species

Z. californianus. The number of PCs in the genus *Zalophus* varies significantly in all three groups, thus cannot be applied definitively as a guide to separate *Z. c. japonicus* from the species group. Sivertsen (1954) used eight adult male skulls of *Z. c. californianus* for his taxonomic comparisons with adult male *Z. c. wollebaeki*, one with a suture index of only 21. For adult female *Z. c. wollebaeki*, Sivertsen (1954) used only one specimen in his comparisons with adult female *Z. c. californianus*; the small sample sizes for taxonomic comparisons would allow for significant error. For these reasons, separation of the genus *Zalophus* into species by Sivertsen (1953, 1954), Itoo (1985) and Rice (1998) is questionable and the group will be considered subspecies as recognized by Scheffer (1958), King (1983), Reeves *et al*. (1992) and Maldonado *et al*. (1995) until tested analytically in this study.

In Australia, the presence of more than one species of *Arctocephalus* has long been acknowledged. Flinders (1814) recognized a brown and black fur seal in Bass Strait (see Warneke, 1982), although the taxonomy of these animals has been confused. Those seals that occur in Western Australia, South Australia and Victoria have been referred to by various names, but usually as *A. doriferus* (Wood Jones, 1925), and those in Tasmania were distinguished as *A. tasmanicus* (Scott & Lord, 1926). King (1968, 1969) showed that two taxa were in fact present, the New Zealand fur seal, *A. forsteri*, in the waters off South Australia and the southern coast of Western Australia, and a larger species in Tasmania, Victoria and New South Wales, which she identified as *A. doriferus* (this name gaining precedence over *A. tasmanicus*). King (1969) noted the similarity between *A. doriferus* and *A. pusillus*, and had concluded that these two fur seals were conspecific, while Repenning *et al*. (1971) compared skulls of all species of *Arctocephalus* and concluded independently that they too could not distinguish between skulls of *A. pusillus* and *A. doriferus*.

The discipline of taxonomy is central to our knowledge and appreciation of biological diversity, and should be based on both morphometric and molecular approaches that contribute towards a ‘total evidence’ approach to the study of biodiversity. The current examination of genetic diversity and relationships within the Otariidae (Maldonado *et al*., 1995; Lento *et al*., 1997; Wynen *et al*., 2001) requires matching by comprehensive new studies of skull morphometry based on large sample sizes, in order to provide a sound basis for reappraisal of species limits in the family (Boness, 1996). Controversy surrounding the assertion that the sperm whale, an odontocete, is more closely related to mysticete whales than to other odontocetes (Milinkovitch *et al*., 1993) has underlined the importance of anatomical observation and morphometric analysis to systematics. Rice (1998, p. 4) stated that the “Initial faith in the near-infallibility of . . . molecular studies has now been tempered by a more sober appraisal of their strengths and weaknesses . . . Unlike morphological data, nucleotide sequence data generate only gene-phylogenies, not species-phylogenies. In any given clade, gene-phylogenies are not necessarily congruent with the species-phylogeny or with each other, so that cladograms derived from different kinds of molecular data are frequently contradictory.”

To gain a comprehensive understanding of the biodiversity of otariids, it is essential to observe not only inter-specific relationships, but also morphological variations *within* species. Recent work has been completed on this topic, which shows that variation in skull morphology is observed between most allopatric populations of otariids (Brunner, 2000; Brunner *et al*., 2002). Previous studies on geographic variation of otariids have been undertaken, such as genetic investigations for populations of *Z. c. californianus* (Maldonado *et al*., 1995) and *E. jubatus* (Bickham *et al*., 1996, 1998), blood transferrin types in *A. p. pusillus* and *A. p. doriferus* (Shaughnessy, 1982), cranial morphology of *A. forsteri* and *A. pusillus* (Brunner, 1998*b*), mean adult body size in populations of *A. tropicalis* (Bester & Van Jaarsveld, 1994), variation in mtDNA of *A. philippii* (Goldsworthy *et al*., 2000), and geographic variation in skulls of otariid seals (Brunner, 2000; Brunner *et al*., 2002).

Finally, and most importantly, a taxonomic review based on cranial morphometrics requires extensive familiarity with the morphology of skulls for each species and for each sex, particularly when dealing with groups of similar appearance (e.g. *Arctocephalus*). Sivertsen (1954) noted that two of the problems in dealing with the systematics of otariids are the enormous sexual differences in size and the very large individual variation. The effects of these on species identification become much reduced when only fully mature adults are used for taxonomic study (Brunner, 1998*b*, 2000, submitted). To this end, a significant number of crania were identified to genus, species, subspecies (where appropriate), sex and relative age, then measured and the data analysed. This synopsis provides a detailed description of the skull for males and females of each species of otariid, and a review of the current taxonomy of the family, using morphometric techniques applied to a large series of skulls. The identification of species includes quantitative and qualitative morphological descriptions for skulls (for both sexes), summaries of univariate and multivariate statistics, and photographic reference plates. Morphological variation in skulls for taxa that comprise current subspecific delineations are also discussed. These are: *Z. californianus* (*Z. c. californianus*, *Z. c. wollebaeki* and *Z. c. japonicus*), *A. australis* (*A. a. australis* and *A. a. gracilis*) and *A. pusillus* (*A. p. pusillus* and *A. p. doriferus*). Morphological relationships between species of the Otariidae are then described, the report concluding with summary recommendations for taxonomic revision of the family.

Materials and methods

Data collection and preparation

I examined and measured 2345 specimens representing all species of otariids in museums and other institutions, worldwide (Table 1). Skulls were photographed from dorsal, ventral and lateral perspectives. Summary details of each specimen used in this study are listed in Appendix I.

Specimens were grouped into categories of species, sex and relative age (Brunner, 1998*a*). Relative age was estimated by applying a suture-ageing index (Doutt, 1942; Sivertsen, 1954). For each skull, nine cranial sutures were assigned a value between 1–4, according to degree of closure (1 = suture fully open; 2 = less than half-fused; 3 = more than half-fused;

Code	Museum	Country
AM	Australian Museum, Sydney	Australia
AMNH	American Museum of Natural History, New York	USA
ASD	Asahi University, Gifu Prefecture	Japan
BMNH	British Museum of Natural History, London	England
CAS	California Academy of Sciences, San Francisco	USA
DMNH	Denver Museum of Natural History, Denver	USA
FMNH	Field Museum of Natural History, Chicago	USA
HU	Hokkaido University, Hakodate	Japan
HMH	Historical Museum of Hokkaido, Sapporo	Japan
HMJH	Historical Museum of Japanese History, Tokyo	Japan
LACM	Los Angeles County Museum, Los Angeles	USA
MNHN	Museum Nationale d'Histoire Naturelle, Paris	France
MVZ	Museum of Vertebrate Zoology, Berkeley	USA
NMML	National Marine Mammal Laboratory, Seattle	USA
NMNH	National Museum of Natural History, Washington DC	USA
NMNZ	National Museum of New Zealand, Wellington	New Zealand
MV	Museum of Victoria, Melbourne	Australia
NRM	Museum of Natural History, Stockholm	Sweden
PEM	Port Elizabeth Museum, Port Elizabeth	South Africa
SAM(1)	South Australian Museum, Adelaide	Australia
SAM(2)	South African Museum, Cape Town	South Africa
SDNHM	San Diego Natural History Museum, San Diego	USA
UAM	University of Alaska Museum, Fairbanks	USA
UMZC	University Museum of Zoology, Cambridge	England
WAM	Western Australian Museum, Perth	Australia
ZMB	Zoological Museum of Berlin, Berlin	Germany

Table 1 Collection localities specimens used in this study.

and 4 = suture fused completely) (Brunner, 1998*a*). These values were then added to provide an overall suture index (SI), ranging from 9–36.

Adult specimens only were used for taxonomic review to avoid age-related bias. Thus, a total of 1100 were used for taxonomic analyses. Growth curves were applied initially to specimens of each species and for each sex (Brunner, 2000; Brunner *et al.*, submitted), to identify the stage at which skulls reached physical maturity (i.e. condylobasal length no longer increases and, in males, a sagittal crest is present). Relative age of mature adults was at SI 21–24 for males and SI 17–19 for females, depending on the species (Brunner, 2000, submitted). Although this technique is not widely applied outside the work of pinniped morphology, it is an effective technique used successfully by the author in previous studies (Brunner, 1998*a*, *b*, 2000, 2002). Forty-one measurements were then recorded for each skull, using Mitotoyo digital callipers, and were mostly those from Sivertsen (1954) (Table 2, Fig. 1).

Analyses

Univariate statistics were computed with SYSTAT 8.0. Student's *t*-test was applied to test for significant differences in single measurements between various groups (interspecific, intersexual and population comparisons).

Principal Components Analysis (PCA) was applied using SYSTAT 8.0 to investigate variation within each group by extracting independent facets of variation from a matrix measuring dispersion. Components were ordered in terms of magnitude of their variances (*i*th principal component having the *i*th largest variance). The values for the original variables were initially standardized to *z*-scores, so that each variable had equal weighting.

Only adult specimens for which no data points were missing were used for multivariate analyses, thus reducing the possibility for bias. Factor matrices of product-moment correlation coefficients, indicating the character loadings for the first three components and the percentage of variation accounted for by each component, were computed (Brunner, 1998*b*, 2000; Jolicoeur & Mosimann, 1960; Pimentel, 1979). All variables were tested initially, then those which contributed little to the variance of the data (identified by low coefficient scores) were discarded.

Discriminant analyses using SYSTAT 8.0 were applied to examine relationships between groups. Methods comprised multivariate analysis of variance (MANOVA) followed by either two-group or multi-group discriminant function analysis (Pimentel, 1979).

Hierarchical cluster analyses were applied to adult male Otariidae, using single linkage R-squared distances to illustrate relationships between species. Ten skulls from the brown bear, *Ursus arctos*, as used by Berta & Sumich (1999) in their phylogenetic study, were used for comparison with otariid specimens in this study.

Results

The typical skull morphology of otariids can be described as supporting two general characteristics: a short, mesocephalic skull observed primarily, but not exclusively, in the fur seals and a more dolichocephalic form common in most sea lions. With the exception of *A. pusillus* (large fur seal) and *Z. c. wollebaeki* (small sea lion), the sea lions were the larger representatives of the Otariidae. Skulls of adult *E. jubatus* were the largest of the otariids and were relatively dolichocephalic,

Variable No.	Parameter
1	Condylobasal length, from gnathion to posterior of basion
2	Gnathion–middle of occipital crest
3	Gnathion–posterior end of nasals
4	Breadth of nares, from interior of nares at widest point
5	Greatest length of nasals, from anterior margin of nasal to posterior margin
6	Breadth at preorbital processes
7	Interorbital constriction
8	Breadth at supraorbital processes, measured at widest point
9	Breadth of braincase, measured dorsally at coronal suture
10	Occipital crest–mastoid, from mid-occipital crest to ventral margin of mastoid
11	Palatal notch–incisors, from anterior point of palatal notch to posterior edge of central incisor alveoli; where a palatal cleft was present, measurement was taken from palatal notch at margin of, but excluding, cleft
12	Distance behind border of canines, from posterior margin of canine alveolus to posterior margin of postcanine 6 alveolus
13	Rostral width, at widest point of rostrum
14	Gnathion–posterior end of maxilla (palatal)
15	Breadth of zygomatic root of maxilla, maximal breadth anteroposterior, from ventral perspective
16	Breadth of palate between postcanines 3 and 4, between postcanines 3 and 4 alveoli
17	Breadth of palate between postcanines 4 and 5, between postcanines 4 and 5 alveoli
18	Breadth of palate at postcanine 5, from proximal margin of postcanine 5 alveoli
19	Gnathion–caudal border postglenoid process
20	Zygomatic breadth, at widest point of zygomatic arch, from posterior of squamosals
21	Basion–zygomatic root of maxilla, ventral perspective, from anterior of basion to anterior of zygomatic root
22	Auditory breadth, greatest distance at auditory bullae
23	Mastoid breadth
24	Basion–bend of pterygoid, from anterior of basion to anterior of pterygoid
25	Height of canine above alveolus, a straight line from the posterior margin of alveolus to the tip of the canine
26	Gnathion–foramen infraorbitale, from gnathion to anterior of foramen infraorbitale
27	Height of skull at supraorbital processes, from base of skull at postcanine 6 alveolus to dorsal margin of skull at supraorbital processes
28	Height of skull at ventral margin of mastoid, dorsoventrally, from skull at base of sagittal crest to ventral margin of mastoid
29	Height of sagittal crest, dorsoventrally, from highest point of crest to skull at base of crest
30	Mesiodistal diameter of postcanines, at root of postcanine above alveolus
31	Length of mandible, from posterior margin of condyle to anterior margin of dentary
32	Length of mandibular teeth row (inclusive of canines), from anterior margin of canine alveolus to posterior margin of postcanine 6 alveolus
33	Mesiodistal diameter of canines, across base of canine at alveolus
34	Length of lower postcanine row, from anterior margin of postcanine 1 alveolus to posterior margin of postcanine 6 alveolus
35	Height of mandible at meatus, from dorsal margin of angularis at meatus to dorsal margin of coronoid process
36	Angularis–coronoideus, from ventral margin of angularis to dorsal margin of coronoid process
37	Length of masseteric fossa, from anterior margin of fossa to posterior margin of coronoid process
38	Breadth of masseteric fossa, dorsoventrally through centre of fossa
39	Gnathion–caudal border of preorbital process, from gnathion to posterior margin of preorbital process
40	Length of orbit–from ventral margin of postglenoid process to dorsal margin of the base of orbit
41	Breadth of orbit–mesiodistal from inside margin of orbit

Table 2 Measurements taken from otariid skulls used in this study.

while those of *O. byronia* were by far the most robust and possessed a mesocephalic skull type. Those of *C. ursinus* and *Arctocephalus* spp. (excluding *A. townsendi* and *A. philippii*) were relatively short and robust, also showing mesocephalic morphology. The remaining otariids, *Z. californianus*, *A. townsendi*, *A. philippii*, *A. p. pusillus* and *A. p. doriferus* had dolichocephalic proportions including a longer, tapering rostrum, narrower palatal regions and a longer, less curvaceous zygomatic arch.

Description of species: sea lions

There are currently five monotypic species of sea lions. Only one, *Zalophus californianus*, is separated into three subspecies. The following are summary descriptions for each species or subspecies of sea lions, outlining morphological characteristics that are constant within each species and those that express sexual dimorphism. Results from PCA are described, many of which show low resolution as may be expected when analysing variation within a single species. Results from PCA are summarized in Table 3. Univariate statistics are listed in Appendix II (http://curator.museum.uaf.edu/brunner/appendices/).

Steller sea lion – *Eumetopias jubatus* (Schreber, 1776)

General morphology

Specimens of *E. jubatus* were the largest of the family Otariidae. The rostrum was elongate, tapered and broad in males; in females, it was narrower at the canines than in males and broader than males at the posterior of the maxilla. Breadth at preorbital processes was greater than rostral width, in males. The orbit was elongate dorsoventrally (length of orbit was generally greater than its breadth); whereas, the zygomatic arch

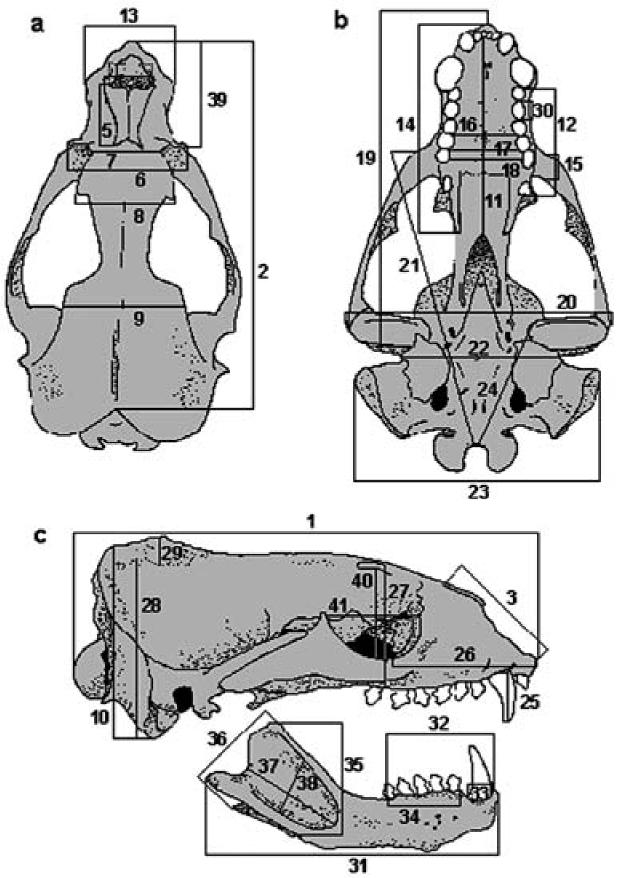


Figure 1 Measurements taken from otariid skulls used in this study, showing dorsal (a), ventral (b) and right lateral (c) perspectives (from Brunner 2002).

was long and narrow at the jugal-squamosal margins, and was less dense in females than in males. For most male *E. jubatus*, a convex rise was present at the frontal immediately behind the supraorbital processes. The frontal was long in both sexes. Supraorbital processes were quadrate, set close to the interorbital constriction and preorbital processes, and were smaller in females than in males. Sagittal and occipital crests were exaggerated in adult males, with heavy and rugose bone deposition around the cresting. The palate was broad and long, terminating squarely at its posterior. The canines were large in males, particularly at the roots, and less so in females. The auditory bullae were large and rounded with a pointed rise towards their inside edge. The bullae in older specimens possessed spur-like extensions at their posterior. The mastoid processes were thick and lengthened with age, particularly in males. The mandible was long and the angle between the dentary and coronoid process was large. The masseteric fossa was deep, especially in older specimens, and long. Postcanines were unicuspid, with posterior angling of PC 5 and a large diastema between PCs 4–5 (Plate 1).

Measured variables

Means for variables relating to length of skull, when observed relative to CBL, showed that males were larger than females in all but one characteristic: basion – bend of pterygoid. Relative to CBL, *E. jubatus* expressed sexual dimorphism (males larger than females) in all variables relating to robustness, excluding: breadth of braincase, and length and breadth of orbit. Ranges for three variables relating to the braincase and orbit overlapped between males and females (actual measurements). As a percentage of CBL, most variables relating to the mandible and teeth were larger in male *E. jubatus* than they were in females, excluding: distance behind border of upper canines, length of lower PC row and breadth of masseteric fossa.

Multivariate analyses

Principal components analysis for adult female *E. jubatus* was based on standardized data for 12 variables. The greatest within-sex variation in cranial morphology for female *E. jubatus* was one of size, observed in Component 1, and accounted for over half the total variance (54.6%). The most significant variables for Component 1 related primarily to dimensions of cranial length including CBL, gnathion–middle of occipital crest, gnathion–caudal border of postglenoid process and rostral width. Component 2 was influenced by shape, as seen by both positive and negative coefficients, and contributed another 16.6% to the total variance. In Component 2, there was an increase in palatal, condylobasal and rostral dimensions, compared with those for nasal and aural characteristics which decreased in magnitude. Length of nasals (coefficient: −0.653) and gnathion–posterior margin of nasals (−0.612) were the most significant variables for this component. Component 3 was also influenced by shape, and contributed a further 6.7% to the total variance. Variation was emphasized primarily in nasal and frontal dimensions, the most significant being length of nasals and gnathion–posterior margin of nasals which were positive (0.683 and 0.440, respectively). These two variables showed an increase in magnitude relative to interorbital constriction in Component 3, breadth of skull at supraorbital processes and auditory breadth which all possessed negative.

As with adult female *E. jubatus*, Component 1 described over half the total observed variance for adult males of this species (57.4%). Condylobasal length and gnathion–caudal border of postglenoid process in male *E. jubatus* showed both high and positive coefficients (0.917 and 0.924, respectively). Male *E. jubatus* expressed greater size variation than females in rostral width and zygomatic breadth which, in males, also had high, positive coefficients (0.835 and 0.895, respectively). Component 2, also influenced by shape, contributed another 14.4% to the total variance and was emphasized primarily by breadth of palate at PCs 4–5 (−0.755) and 5 (−0.775). Breadth of skull at supraorbital processes (−0.709) contributed the most variance to Component 3, decreasing in magnitude compared with length of nasals and gnathion–posterior margin of nasals. Condylobasal length, gnathion–caudal border of postglenoid process, rostral width, zygomatic breadth and basion–zygomatic root (anterior), contributed little to the total variance of Component 3, in adult male *E. jubatus*.

Variable	Component 1	Component 2	Component 3
(a) *Eumetopias jubatus*			
Females (n = 27)			
Length of nasals	0.200	−0.653	0.683
Gnathion–posterior margin of nasals	0.606	−0.612	0.440
Interorbital constriction	0.625	−0.570	−0.435
Breadth of skull at supraorbital processes	0.607	−0.531	−0.409
Auditory breadth	0.709	−0.121	−0.380
Breadth of palate at postcanines 4–5	0.715	0.360	0.369
Breadth of palate at postcanines 3–4	0.801	0.408	0.168
Gnathion–middle of occipital crest	0.895	0.009	−0.112
Gnathion–caudal border of postglenoid process	0.909	0.160	0.112
Palatal notch–incisors	0.774	0.474	−0.035
Condylobasal length	0.910	0.145	0.019
Rostral width	0.821	0.037	−0.005
Percentage of total variance	54.6	16.6	11.3
Eigenvalues	6.6	2.0	1.4
Males (n = 34)			
Breadth of palate at postcanine 5	0.489	−0.775	0.174
Breadth of palate at postcanines 4–5	0.606	−0.755	0.038
Breadth of skull at supraorbital processes	0.435	0.133	−0.709
Gnathion–middle of occipital crest	0.206	0.258	−0.587
Length of nasals	0.432	0.281	0.521
Gnathion–posterior margin of nasals	0.675	0.345	0.439
Breadth of skull at preorbital processes	0.686	0.011	−0.395
Distance behind border of upper canines	0.574	0.426	0.375
Mastoid breadth	0.764	0.212	−0.350
Condylobasal length	0.917	0.223	0.107
Gnathion–caudal border of postglenoid process	0.924	0.167	0.084
Rostral width	0.835	−0.212	0.080
Zygomatic breadth	0.895	0.038	−0.078
Breadth of palate at postcanines 3–4	0.726	−0.588	−0.032
Basion–zygomatic root (anterior)	0.837	0.202	−0.032
Percentage of total variance	57.4	14.4	9.5
Eigenvalues	6.3	1.5	1.0
(b) *Otaria byronia*			
Females (n = 37)			
Breadth of palate at postcanine 5	0.700	−0.679	0.010
Auditory breadth	0.787	0.056	0.434
Gnathion–caudal border of preorbital process	0.843	0.005	−0.432
Zygomatic breadth	0.828	−0.028	0.413
Gnathion–posterior margin of nasals	0.791	0.033	−0.401
Gnathion–middle of occipital crest	0.902	0.178	−0.241
Gnathion–caudal border of postglenoid process	0.885	0.314	0.192
Breadth of palate at postcanines 4–5	0.753	−0.622	0.048
Palatal notch–incisors	0.725	0.570	0.044
Basion–zygomatic root (anterior)	0.888	0.216	−0.020
Condylobasal length	0.905	0.342	−0.006
Breadth of palate at postcanines 3–4	0.789	−0.584	−0.006
Percentage of total variance	67.1	15.5	6.7
Eigenvalues	8.1	1.8	0.8
Males male (n = 49)			
Breadth of palate at postcanine 5	0.640	−0.729	0.095
Breadth of palate at postcanines 4–5	0.694	−0.696	0.123
Gnathion–posterior margin of nasals	0.683	0.263	0.611
Gnathion–caudal border of preorbital process	0.714	0.237	0.573
Mastoid breadth	0.869	0.227	−0.322
Auditory breadth	0.895	−0.001	−0.264
Height of skull at ventral margin of mastoid	0.861	0.039	−0.248
Occipital crest–mastoid	0.887	0.308	−0.231
Zygomatic breadth	0.907	−0.051	−0.155
Condylobasal length	0.843	0.398	0.134
Basion–zygomatic root (anterior)	0.869	0.299	−0.058
Breadth of palate at postcanines 3–4	0.762	−0.593	0.054

Table 3 Factor matrices from principal component analyses for specimens of adult male and female otariids, showing character loadings on the first three components.

Variable	Component 1	Component 2	Component 3
Percentage of total variance	65.2	15.8	8.9
Eigenvalues	7.8	1.9	1.1
(c) *Neophoca cinerea*			
Females (n = 34)			
Breadth of skull at supraorbital processes	0.695	0.642	0.225
Breadth of skull at preorbital processes	0.754	0.526	−0.108
Mastoid breadth	0.837	0.030	−0.455
Occipital crest–mastoid	0.807	−0.206	−0.439
Palatal notch–incisors	0.871	0.050	0.416
Auditory breadth	0.845	0.220	−0.241
Condylobasal length	0.926	−0.232	0.224
Gnathion–caudal border of postglenoid process	0.939	−0.236	0.180
Gnathion–caudal border of preorbital process	0.872	−0.259	0.098
Basion–zygomatic root (anterior)	0.898	−0.300	0.045
Percentage of total variance	71.9	10.5	7.9
Eigenvalues	7.2	1.1	0.8
Males (n = 58)			
Breadth of palate at postcanines 3–4	0.685	−0.601	0.288
Zygomatic breadth	0.754	−0.476	−0.333
Gnathion–caudal border of preorbital process	0.844	0.210	−0.323
Condylobasal length	0.893	0.146	0.230
Gnathion–caudal border of postglenoid process	0.951	0.066	0.128
Gnathion–posterior of maxilla (palatal)	0.817	0.448	0.097
Gnathion–middle of occipital crest	0.908	0.036	−0.088
Percentage of total variance	70.6	12.3	5.5
Eigenvalues	4.9	0.9	0.4
(d) *Phocarctos hookeri*			
Females (n = 32)			
Height of skull at supraorbital processes	0.508	−0.818	0.240
Gnathion–middle of occipital crest	0.817	−0.333	−0.446
Basion–zygomatic root (anterior)	0.899	0.207	0.312
Palatal notch–incisors	0.870	0.316	−0.070
Condylobasal length	0.952	0.203	0.022
Gnathion–caudal border of postglenoid process	0.952	0.034	0.003
Percentage of total variance	71.1	16.1	6.0
Eigenvalues	4.3	1.0	0.4
Males (n = 25)			
Height of skull at supraorbital processes	0.841	0.314	−0.354
Gnathion–caudal border of preorbital process	0.890	0.127	0.295
Gnathion–middle of occipital crest	0.938	0.084	0.236
Palatal notch–incisors	0.885	−0.289	−0.167
Gnathion–posterior margin of nasals	0.922	0.043	0.155
Height of sagittal crest	0.794	0.516	−0.147
Basion–zygomatic root (anterior)	0.876	−0.396	−0.111
Rostral width	0.888	0.175	0.044
Gnathion–caudal border of postglenoid process	0.904	−0.392	−0.039
Occipital crest–mastoid	0.861	0.305	0.031
Condylobasal length	0.897	−0.408	0.004
Percentage of total variance	77.8	9.8	3.3
Eigenvalues	8.6	1.1	0.4
(e) *Zalophus californianus californianus*			
Females (n = 42)			
Height of skull at ventral margin of mastoid	0.698	−0.647	−0.003
Occipital crest–mastoid	0.770	−0.532	0.032
Gnathion–posterior margin of nasals	0.687	0.175	−0.702
Basion–zygomatic root (anterior)	0.842	0.354	0.244
Condylobasal length	0.948	0.251	0.133
Gnathion–caudal border of postglenoid process	0.921	0.243	0.083
Gnathion–middle of occipital crest	0.878	−0.021	0.059
Percentage of total variance	68.3	14.0	8.3
Eigenvalues	4.8	1.0	0.6
Males (n = 61)			
Height of sagittal crest	0.667	−0.578	0.448

Table 3 *Continued.*

Variable	Component 1	Component 2	Component 3
Mastoid breadth	0.876	−0.328	−0.255
Auditory breadth	0.885	−0.255	−0.238
Gnathion–middle of occipital crest	0.939	0.123	0.149
Occipital crest–mastoid	0.879	−0.346	−0.109
Gnathion–posterior margin of nasals	0.798	0.508	0.078
Gnathion–caudal border of preorbital process	0.756	0.565	0.031
Condylobasal length	0.896	0.284	0.005
Percentage of total variance	70.8	16.2	4.5
Eigenvalues	5.7	1.3	0.4
(f) *Zalophus californianus wollebaeki*			
Males (n = 27)			
Palatal notch–incisors	0.806	−0.463	0.314
Rostral width	0.796	0.389	0.432
Mastoid breadth	0.896	0.129	−0.254
Zygomatic breadth	0.919	0.197	−0.238
Condylobasal length	0.870	−0.322	−0.176
Gnathion–middle of occipital crest	0.923	0.052	0.002
Percentage of total variance	75.7	8.8	7.3
Eigenvalues	4.5	0.5	0.4
(g) *Callorhinus ursinus*			
Females (n = 131)			
Breadth of palate at postcanines 4–5	0.623	−0.748	0.045
Gnathion–posterior margin of nasals	0.739	0.214	−0.523
Occipital crest–mastoid	0.645	0.066	0.390
Gnathion–caudal border of preorbital process	0.828	0.209	−0.373
Basion–zygomatic root (anterior)	0.777	0.404	0.250
Condylobasal length	0.856	0.389	0.148
Gnathion–caudal border of postglenoid process	0.840	0.392	0.109
Breadth of palate at postcanine 5	0.654	−0.685	0.063
Breadth of palate at postcanines 3–4	0.652	−0.671	−0.059
Percentage of total variance	54.8	22.7	7.5
Eigenvalues	4.9	2.0	0.7
Males (n = 49)			
Gnathion–caudal border of preorbital process	0.815	0.404	0.199
Height of skull at ventral margin of mastoid	0.807	−0.387	−0.312
Zygomatic breadth	0.843	−0.304	0.285
Height of skull at supraorbital processes	0.867	0.159	0.283
Condylobasal length	0.933	0.173	−0.249
Auditory breadth	0.887	−0.092	0.195
Gnathion–middle of occipital crest	0.889	0.239	−0.187
Basion–zygomatic root (anterior)	0.897	0.021	−0.168
Gnathion–caudal border of postglenoid process	0.946	0.064	−0.142
Mastoid breadth	0.870	−0.310	0.132
Percentage of total variance	76.8	6.3	5.0
Eigenvalues	7.7	0.6	0.5
(h) *Arctocephalus gazella*			
Females (n = 30)			
Zygomatic breadth	0.555	−0.306	−0.568
Gnathion–caudal border of preorbital process	0.279	0.568	−0.483
Basion–bend of pterygoid	0.572	0.247	0.371
Breadth of palate at postcanines 3–4	0.641	−0.562	0.329
Breadth of palate at postcanine 5	0.774	−0.443	−0.227
Breadth of skull at supraorbital processes	0.598	0.643	0.178
Breadth of palate at postcanines 4–5	0.787	−0.466	0.128
Interorbital constriction	0.615	0.546	0.118
Breadth of skull at preorbital processes	0.807	0.273	−0.095
Percentage of total variance	41.4	22.1	10.3
Eigenvalues	3.7	2.0	0.9
Males (n = 52)			
Gnathion–posterior margin of nasals	0.273	0.021	−0.851
Gnathion–caudal border of preorbital process	0.346	0.226	−0.804
Auditory breadth	0.598	−0.573	0.327
Gnathion–middle of occipital crest	0.474	−0.557	−0.215
Breadth of palate at postcanines 3–4	0.676	0.538	0.215

Table 3 *Continued.*

Variable	Component 1	Component 2	Component 3
Breadth of palate at postcanine 5	0.639	0.643	0.175
Breadth of palate at postcanines 4–5	0.731	0.576	0.124
Zygomatic breadth	0.821	−0.394	0.089
Rostral width	0.626	−0.557	−0.006
Percentage of total variance	36.0	24.3	18.0
Eigenvalues	3.2	2.2	1.6
(i) *Arctocephalus tropicalis*			
Females (n = 12)			
Breadth of palate at postcanines 3–4	0.229	0.800	−0.500
Breadth of skull at supraorbital processes	0.482	−0.695	−0.375
Interorbital constriction	0.299	−0.584	−0.682
Breadth of skull at preorbital processes	0.699	−0.314	0.600
Breadth of zygomatic root of maxilla	0.725	0.388	−0.333
Zygomatic breadth	0.855	0.224	0.307
Gnathion–middle of occipital crest	0.833	0.161	−0.275
Distance behind border of upper canines	0.877	0.104	0.215
Palatal notch–incisors	0.959	−0.048	0.147
Gnathion–caudal border of preorbital process	0.871	−0.156	−0.109
Gnathion–posterior of maxilla (palatal)	0.934	−0.000	−0.064
Basion–zygomatic root (anterior)	0.967	0.091	0.045
Condylobasal length	0.979	0.022	0.039
Gnathion–caudal border of postglenoid process	0.981	−0.081	0.033
Percentage of total variance	64.2	13.2	11.3
Eigenvalues	9.0	1.8	1.6
Males (n = 43)			
Breadth of palate at postcanine 5	0.419	0.871	−0.082
Breadth of palate at postcanines 4–5	0.517	0.809	0.088
Basion–bend of pterygoid	0.637	−0.213	−0.695
Occipital crest–mastoid	0.716	−0.275	0.415
Gnathion–caudal border of preorbital process	0.870	0.056	0.132
Height of skull at supraorbital processes	0.858	0.021	−0.121
Condylobasal length	0.892	−0.288	0.116
Basion–zygomatic root (anterior)	0.873	−0.298	0.021
Percentage of total variance	55.2	21.4	8.9
Eigenvalues	4.4	1.7	0.7
(j) *Arctocephalus forsteri*			
Females (n = 15)			
Breadth of zygomatic root of maxilla	0.206	0.965	−0.046
Gnathion–foramen infraorbitale	0.807	0.036	−0.518
Gnathion–caudal border of preorbital process	0.859	0.016	−0.320
Occipital crest–mastoid	0.892	0.104	0.310
Palatal notch–incisors	0.922	0.052	0.279
Gnathion–caudal border of postglenoid process	0.973	0.004	0.126
Basion–bend of pterygoid	0.850	−0.371	−0.110
Gnathion–posterior of maxilla (palatal)	0.929	0.063	0.100
Condylobasal length	0.972	−0.147	0.090
Gnathion–middle of occipital crest	0.931	0.149	−0.067
Basion–zygomatic root (anterior)	0.957	−0.130	0.023
Percentage of total variance	75.8	10.4	5.4
Eigenvalues	8.3	1.2	0.6
Males (n = 53)			
Length of nasals	0.602	0.626	−0.436
Auditory breadth	0.677	−0.575	−0.356
Condylobasal length	0.921	−0.015	0.250
Gnathion–posterior of maxilla (palatal)	0.791	0.220	0.245
Basion–zygomatic root (anterior)	0.872	−0.153	0.244
Gnathion–caudal border of postglenoid process	0.899	0.063	0.236
Zygomatic breadth	0.725	−0.545	−0.230
Gnathion–posterior margin of nasals	0.827	0.392	−0.216
Percentage of total variance	63.4	15.6	8.2
Eigenvalues	5.1	1.3	0.6
(k) *Arctocephalus pusillus pusillus*			
Females (n = 43)			
Auditory breadth	0.832	−0.429	0.242
Height of skull at supraorbital processes	0.809	−0.253	−0.517

Table 3 *Continued.*

Variable	Component 1	Component 2	Component 3
Zygomatic breadth	0.881	−0.196	0.152
Gnathion–middle of occipital crest	0.961	0.115	−0.091
Occipital crest–mastoid	0.839	−0.394	0.052
Condylobasal length	0.953	0.242	0.044
Gnathion–posterior of maxilla (palatal)	0.940	0.212	0.039
Gnathion–caudal border of postglenoid process	0.956	0.231	0.030
Basion–zygomatic root (anterior)	0.887	0.342	0.022
Percentage of total variance	80.5	8.1	4.0
Eigenvalues	7.2	0.7	0.4
Males (n = 37)			
Mastoid breadth	0.715	−0.660	0.095
Occipital crest–mastoid	0.741	−0.619	0.098
Gnathion–foramen infraorbitale	0.743	0.451	0.477
Gnathion–caudal border of preorbital process	0.863	0.194	−0.266
Gnathion–middle of occipital crest	0.880	−0.002	−0.180
Condylobasal length	0.896	0.310	−0.144
Gnathion–caudal border of postglenoid process	0.943	0.161	0.023
Percentage of total variance	68.9	16.9	5.3
Eigenvalues	4.8	1.2	0.4
(l) *Arctocephalus pusillus doriferus*			
Females (n = 42)			
Mastoid breadth	0.854	−0.471	0.110
Gnathion–middle of occipital crest	0.890	0.121	−0.383
Gnathion–posterior of maxilla (palatal)	0.890	0.165	0.301
Gnathion–caudal border of preorbital process	0.901	0.237	−0.188
Basion–zygomatic root (anterior)	0.925	0.132	0.139
Zygomatic breadth	0.901	−0.308	−0.104
Condylobasal length	0.953	0.223	0.075
Gnathion–caudal border of postglenoid process	0.955	0.209	0.073
Auditory breadth	0.911	−0.356	−0.030
Percentage of total variance	82.7	7.2	3.6
Eigenvalues	7.4	0.6	0.3
Males (n = 45)			
Zygomatic breadth	0.747	−0.482	0.312
Auditory breadth	0.756	−0.466	0.245
Basion–bend of pterygoid	0.824	−0.222	−0.413
Basion–zygomatic root (anterior)	0.899	−0.118	−0.352
Gnathion–caudal border of preorbital process	0.811	0.419	0.241
Gnathion–posterior of maxilla (palatal)	0.837	0.292	0.184
Condylobasal length	0.945	0.171	−0.179
Gnathion–middle of occipital crest	0.915	0.108	0.062
Gnathion–caudal border of postglenoid process	0.926	0.171	0.003
Percentage of total variance	72.9	9.4	6.4
Eigenvalues	6.6	0.8	0.6
(m) *Arctocephalus australis*			
Females (n = 24)			
Basion–zygomatic root (anterior)	0.643	−0.733	0.092
Occipital crest–mastoid	0.847	0.040	−0.474
Breadth of palate at postcanines 4–5	0.947	0.129	0.247
Zygomatic breadth	0.883	−0.165	−0.237
Breadth of palate at postcanines 3–4	0.953	0.097	0.221
Breadth of palate at postcanine 5	0.959	0.087	0.164
Rostral width	0.842	0.339	−0.059
Percentage of total variance	76.3	10.2	6.1
Eigenvalues	5.6	0.6	0.4
Males (n = 26)			
Breadth of skull at supraorbital processes	0.439	−0.694	0.555
Length of nasals	0.501	−0.681	−0.458
Occipital crest–mastoid	0.874	0.001	−0.262
Breadth of zygomatic root of maxilla	0.785	0.367	0.228
Auditory breadth	0.916	−0.036	0.054
Mastoid breadth	0.906	0.298	−0.039
Zygomatic breadth	0.929	0.129	0.024
Percentage of total variance	62.1	16.9	11.6
Eigenvalues	4.5	1.4	0.9

Table 3 *Continued.*

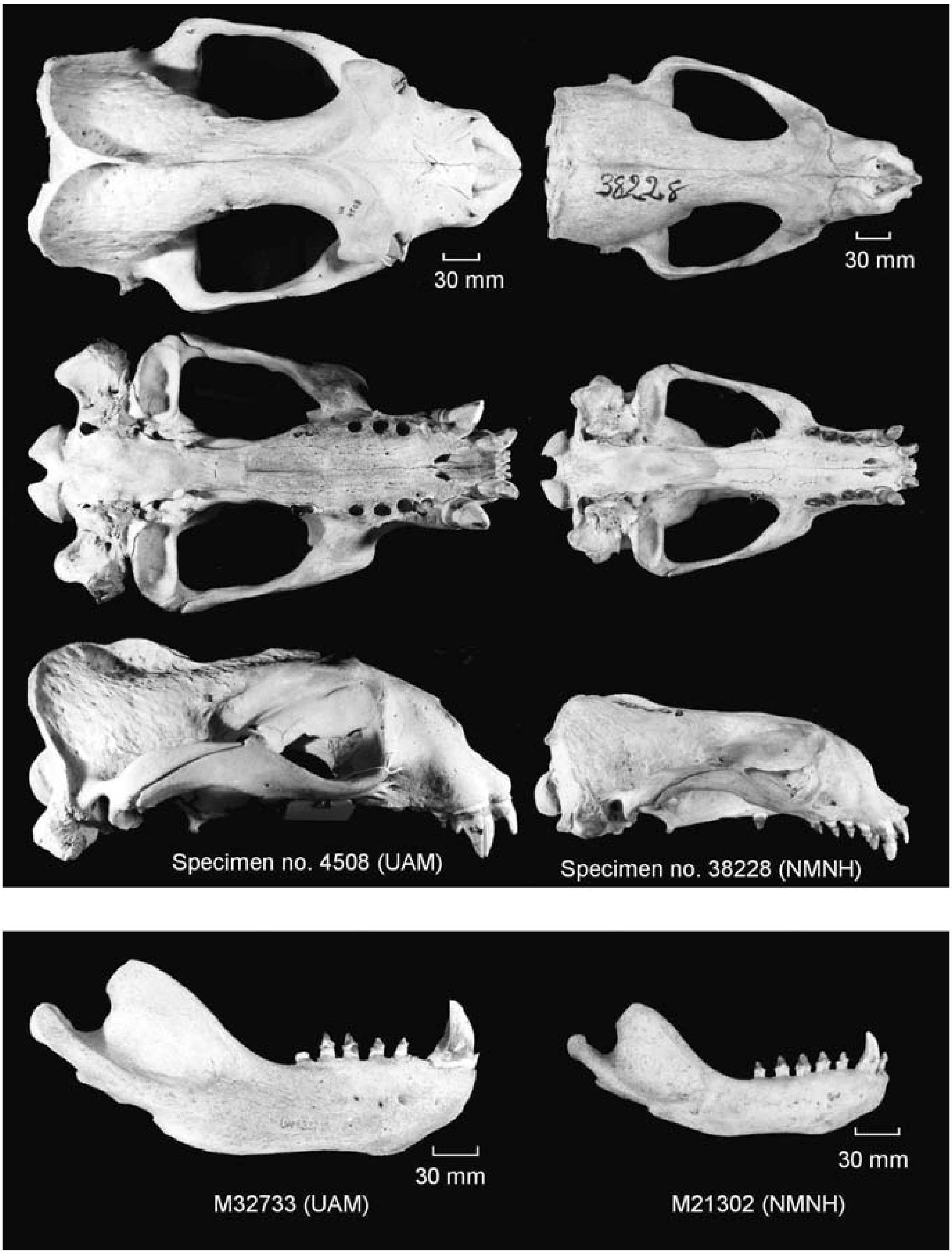
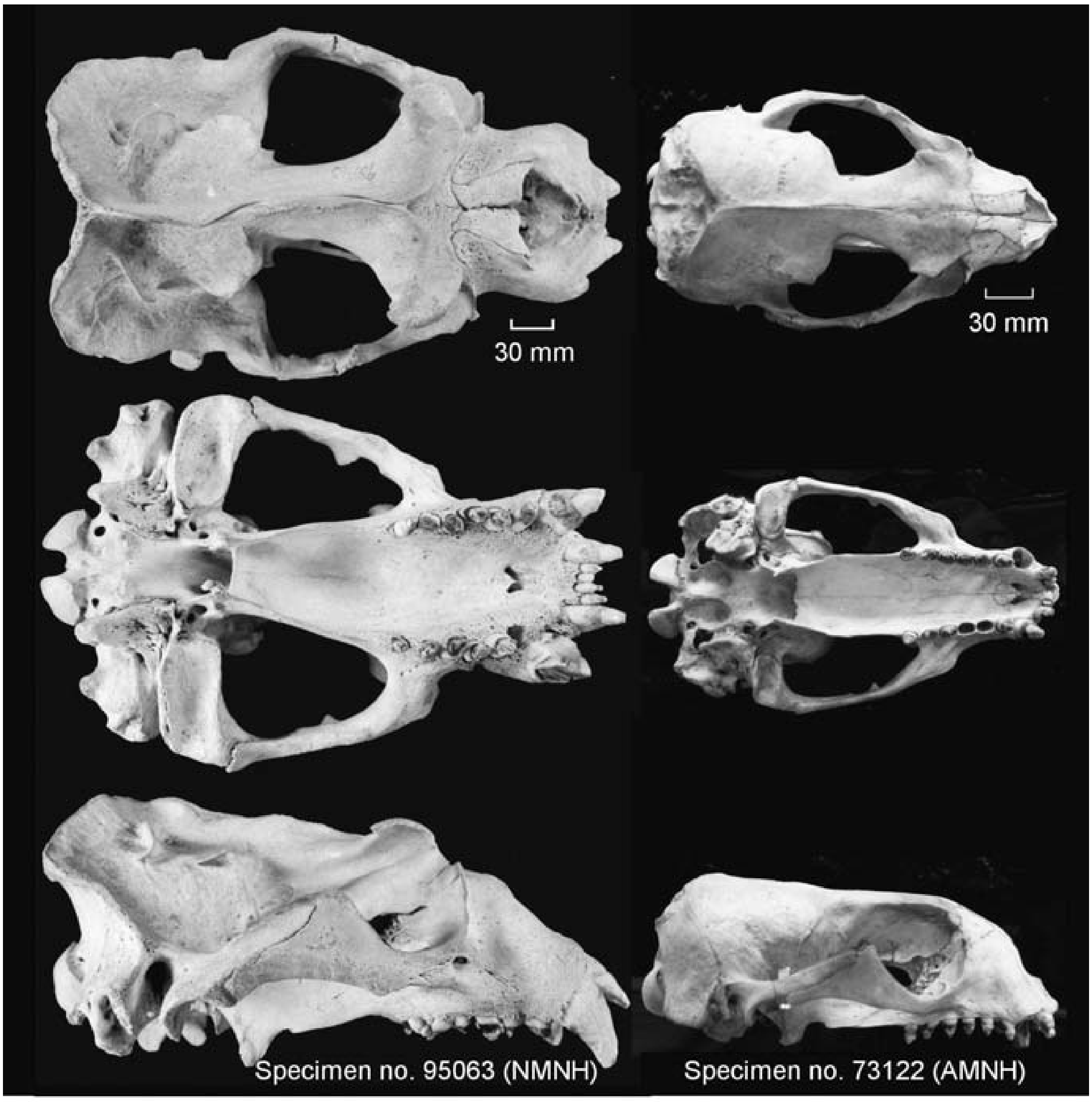


Plate 1 *Eumetopias jubatus* – adult male (left), adult female (right).

Southern sea lion – *Otaria byronia* (de Blainville, 1820)

General morphology

Skulls of adult *O. byronia* are by far the most robust of all the otariids. The rostrum in males was sloped and extremely broad, particularly at the canines, with mean rostral width 30% of total skull length in males and 22% in females. The nasals were short and broad, as were the preorbital processes. Interorbital constriction was wide, and the supraorbital processes heavy and rounded-to-quadrate, particularly in males. The palate was long, almost reaching the hamular process of the pterygoid, and wide with its lateral edges curved ventrally. The posterior border of the palate was virtually straight, unique to *O. byronia*. Zygomatic breadth was large, especially in adult males, and the zygomatic arch wide, dorsoventrally, at the squamoso-jugular margin. The mastoids were heavy and long in adult males but more reduced in females. The canines were large, robust, widely spaced and often splayed outwards. The sagittal crest



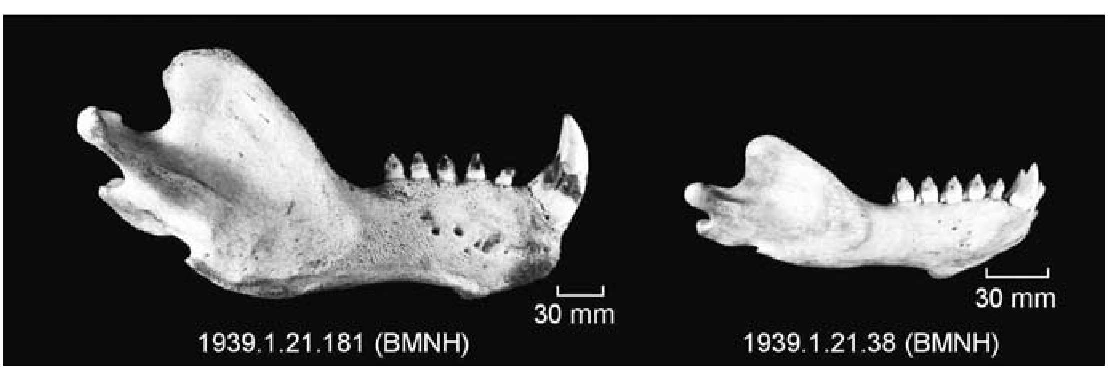


Plate 2 *Otaria byronia* – adult male (left), adult female (right).

in adult males was pronounced, rising along the entire frontal and increasing in height until it joined the occipital crest. The occipital crest in male *O. byronia* was the most robust of all the otariids, flaring dorsolaterally from the posterior margins of the sagittal crest. The mandible was heavy, particularly at the canine roots, the coronoid process possessing a deep and long masseteric fossa (Plate 2).

Measured variables

Condylobasal length was significantly larger in males than in females. Means for the remaining ten variables relating to length of skull, when observed relative to CBL, showed males were larger than females, or equal to them, in all but one characteristic: basion – bend of pterygoid. Relative to CBL, *O. byronia* expressed marked sexual dimorphism (males larger than females) in all variables relating to robustness, excluding four whose means were smaller in males: breadth of braincase, height of skull at ventral margin of mastoid, and length and breadth of orbit. Ranges for three variables relating to the braincase and orbit overlapped significantly when compared in actual measurements. As a percentage of CBL, most variables relating to mandible and teeth were also larger in male *O. byronia* than they were in females, excluding: distance behind border of upper canines and length of lower PC row.

Multivariate analyses

The greatest within-sex variation in cranial morphology for female *O. byronia* was observed in Component 1, and accounted for 67.1% of the total variance. The most significant variables for Component 1 were those related to length of skull, including CBL, gnathion–middle of occipital crest, gnathion–caudal border of postglenoid process and basion–zygomatic root (anterior). The second was a shape component and contributed another 15.1% to the total variance. Breadth of palate at PC 4–5 (−0.622) and 5 (−0.679) and palatal notch–incisors (0.570) were the most significant variables for this component which showed a decrease in magnitude compared with variables relating to palatal length. Component 3 contributed a further 6.7% to the total variance and was influenced mainly by auditory breadth (0.434) and gnathion–caudal border of preorbital processes (−0.432).

In adult male *O. byronia*, within-sex variation in cranial morphology was observed primarily in Component 1, accounting for 65.2% of the total variance with large, positive coefficients for most variables. Component 2 in adult male *O. byronia* was influenced strongly by breadth of palate at PCs 4–5 (−0.696) and 5 (−0.729) which were reduced in magnitude compared with other variables, and contributed a further 15.8% to the total variance. Component 3 added another 8.9% to the total variance and was influenced primarily by gnathion–posterior margin of nasals and gnathion–caudal border of preorbital processes (0.611 and 0.573, respectively).

Australian sea lion – *Neophoca cinerea* (Péron, 1816)

General morphology

Skulls of *N. cinerea* were smaller and less robust than those of *E. jubatus* and *O. byronia*. Cranial morphology was similar to that of *P. hookeri* and, to a lesser degree, *A. p. doriferus*. The rostrum of *N. cinerea* was long, sloping and narrow with wide nasals that flared anteriorly. The preorbital processes were broad in both sexes but more so in males. Interorbital constriction was wide in males, less so in females. Supraorbital processes in males were robust, angular and flared ventrolaterally. In females, the supraorbital processes were similar to males, but reduced. The frontal was broad and convex, especially in males. The sagittal crest was prominent in males, rising along the frontal from the posterior of the supraorbital processes, becoming pronounced ventrally where it joins the occipital crest. The occipital crest was exaggerated in males, and was present but reduced in females. The zygomatic arch curved at the jugal-squamosal joint (particularly at jugal). The canines in males were robust, especially at their roots. The palate was long and deep at the anterior, particularly so at canines. The auditory bullae were triangular with lateral and posterior spurs in older specimens, which were less obvious in females. The mastoids in males were robust and longer in older specimens of both sexes. The PCs (usually five upper) were broad with lateral cusps. The mandible was heavy at the ramus with a deep masseteric fossa in older specimens (Plate 3).

Measured variables

Relative to CBL, variables relating to length of skull shows male *N. cinerea* were similar to females in basion–bend of pterygoid, and basion–zygomatic root of maxilla (palatal), and were larger in the remaining variables relating to length. For variables relating to breadth of skull, breadth of orbit was similar in both sexes. Breadth of braincase, length of orbit, and height of skull at ventral margin of mastoid were proportionately larger in female *N. cinerea* than in males. The remaining variables related to breadth of skull were proportionately larger in males. Distance behind border of upper canines and length of lower PC row were proportionately smaller in male *N. cinerea* than in females. Relative to CBL, length of mandibular tooth row was similar for both sexes, whereas the remaining characteristics for mandible and teeth were all larger in males.

Multivariate analyses

Principal components analysis for adult female *N. cinerea* was based on standardized data for 10 variables. Component 1 was a size component with all large and positive coefficients from variables relating predominantly to length of skull, and accounted for 71.9% of the total variance. Component 2 was a shape component that accounted for a further 10.5% of the total variance, influenced primarily by breadth of skull at preorbital (0.526) and supraorbital (0.642) processes. Component 3 accounted for another 7.9% of the total variance. Mastoid breadth and occipital crest–mastoid (−0.455 and −0.439, respectively) were reduced in magnitude compared with palatal notch–incisors (0.416), which increased in magnitude.

Component 1 for adult male *N. cinerea*, described 70.6% of the total variance and was influenced strongly by size of measurements related to length of skull. These were primarily CBL, gnathion–caudal border of postglenoid process, gnathion–posterior of maxilla (palatal) and gnathion–middle of occipital crest. Component 2 described a further 12.3% of the total variance and showed breadth of palate at PCs 3–4 contributed significantly (−0.601). Component 3 expressed only small coefficient values and contributed 5.5% to the total variance. Zygomatic breadth and gnathion–caudal border of preorbital process were reduced in magnitude (−0.333 and −0.323, respectively) for this Component, compared with those variables related to length of skull.

Hooker's sea lion – *Phocarctos hookeri* (Gray, 1844)

General morphology

Skulls of adult male and female *P. hookeri* were morphologically similar to those of *N. cinerea*. As with all otariids, specimens of *P. hookeri* were significantly sexually dimorphic in size; adult males attained a mean CBL of 317 mm and females 261 mm. Skulls of adult male *P. hookeri* had pronounced

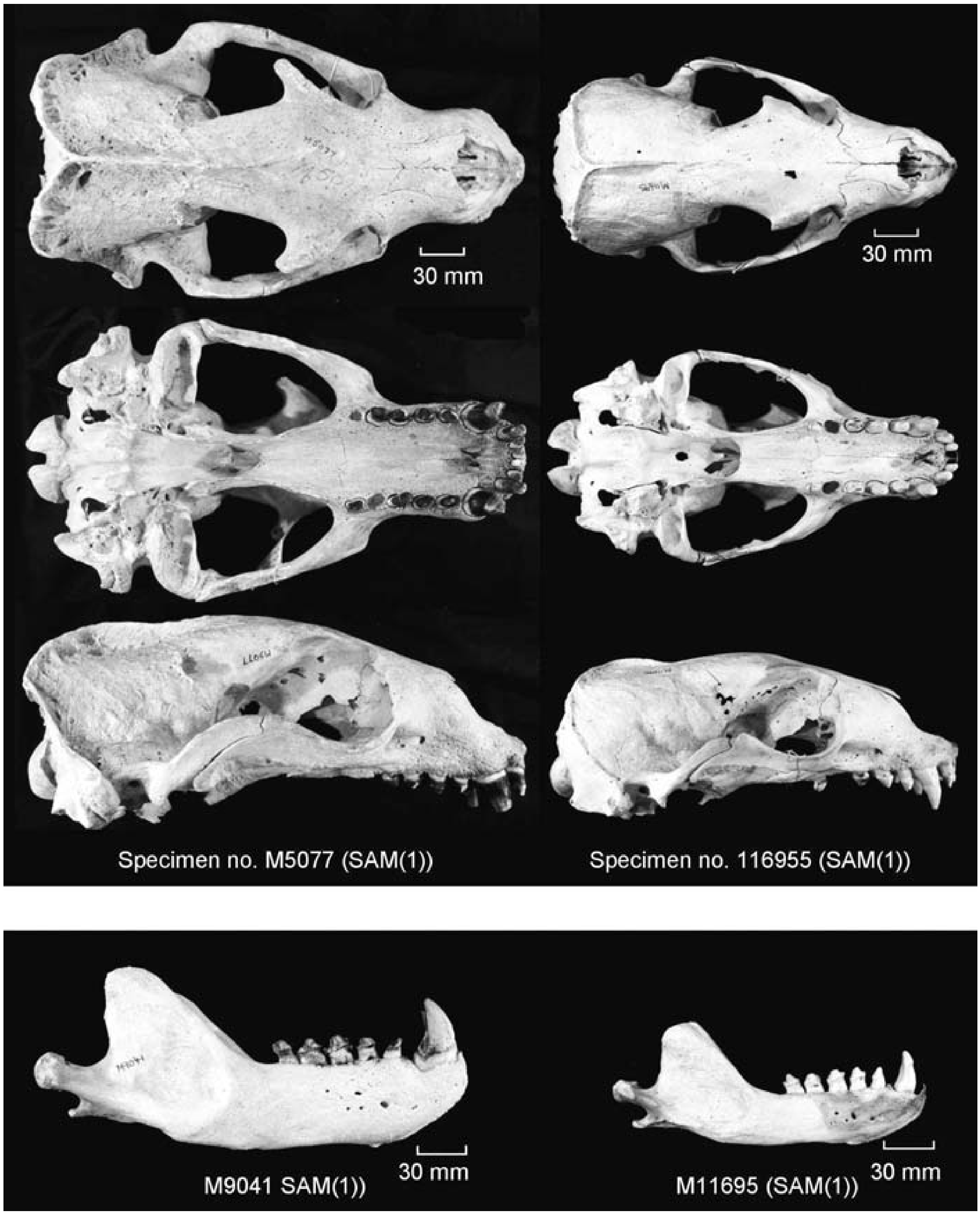


Plate 3 *Neophoca cinerea* – adult male (left), adult female (right).

sagittal crests, with a bone surface that was particularly rugose at the paraoccipital crest. The rostrum was elongated and convex. The zygomatic arch was long, with reduced curvature at the jugal-squamosal joint. The palate was long, broad and deep at the canines. The auditory bullae were small and flattened with prominent posterior spurs in older specimens. The mastoids were large, particularly in older males, and set close behind the pterygoid. The anterior of the zygomatic arch was narrow. The preorbital processes were long and often notched distally. Interorbital constriction was broad, especially in older males. The supraorbital processes were large in males, ventrolaterally angled and occasionally asymmetric. The upper PCs in skulls of *P. hookeri* varied in number between five and six but were usually found to have six. The mandible was robust in males, with a deep masseteric fossa in older specimens. Postcanines were unicuspid with small accessory cusps (Plate 4).

Measured variables

Adult male *P. hookeri* were similar to females in only one characteristic relating to length of skull (basion–bend of pterygoid), and were larger in the remaining ten length variables.

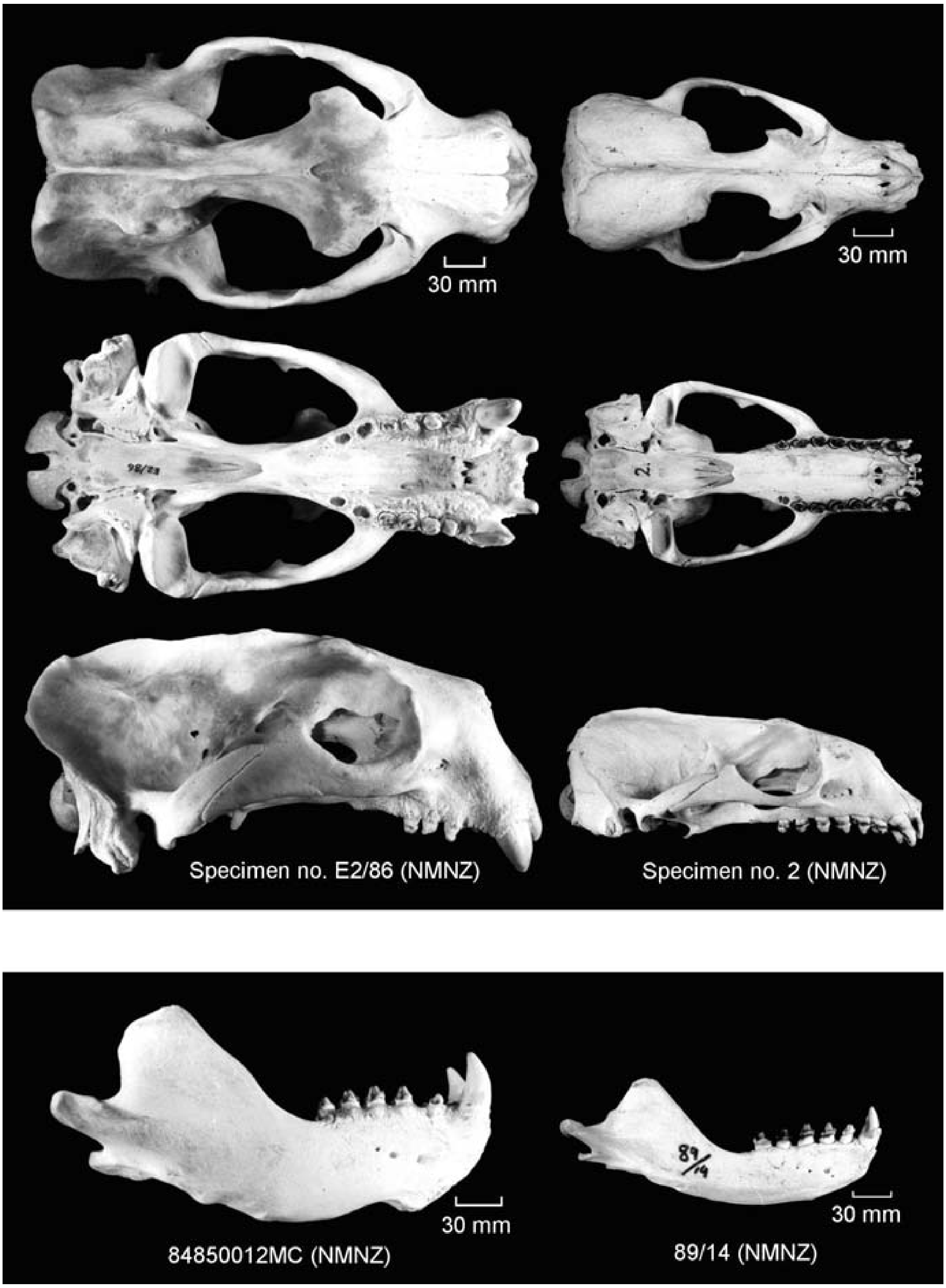


Plate 4 *Phocarctos hookeri* – adult male (left), adult female (right).

Four characteristics relating to breadth of skull were similar in both sexes: breadth of nares, breadth of zygomatic root of maxilla, breadth of orbit and height of skull at ventral margin of mastoid. Breadth of braincase, and length and breadth of orbit were proportionately larger in females than in males, although these overlapped considerably when observed in mm. The remaining variables relating to breadth of skull were proportionately larger in males than in females. Distance behind border of upper canines and length of lower PC row, were marginally smaller in males than in females. Relative to CBL, the remaining characteristics relating to mandible and teeth were all larger in male *P. hookeri* than in females.

Multivariate analyses

The greatest within-sex variation in cranial morphology for female *P. hookeri* was one of size, observed in Component 1, and accounted for 71.7% of the total variance. Most measurements for Component 1 described length of skull, contributing another 16.1% to the total variance. Height of skull at supraorbital processes (−0.818) was the most significant variable for Component 2 (a shape component) and the only measurement related to breadth, or robustness, of skull for female *P. hookeri*. Component 3 contributed a further 6.0% to the total variance and was influenced mainly by gnathion–middle of occipital crest (−0.446) and Basion–zygomatic root (anterior) (0.312).

Within-sex variation in cranial morphology for adult male *P. hookeri* was also described primarily by Component 1, accounting for 77.8% of the total variance with large, positive coefficients for most variables relating mostly to length of skull. The four measurements relating to robustness of skull (height of skull at supraorbital processes, height of sagittal crest, rostral width and occipital crest–mastoid) expressed lower coefficient values. Component 2 in adult male *P. hookeri* was influenced strongly by height of sagittal crest (0.516) and CBL (−0.408), contributing a further 9.8% to the total variance. Component 3 added another 3.3% to the total variance and was influenced primarily by height of skull at supraorbital processes (−0.354).

California sea lion – *Zalophus californianus californianus* (Lesson, 1828)

General morphology

Condylobasal length was greater in male *Z. c. californianus* (mean 282 mm) than in females (mean 231 mm). The rostrum was elongate and narrow, the nasals long, slender and expanded anteriorly. Preorbital processes were long, especially in adult males. Interorbital constriction was broad in males, less so in females. The supraorbital processes were pronounced and angular, extending just posterior from the interorbital constriction. The sagittal crest was prominent in males, rising abruptly at the supraorbital processes and forming a high convex ridge along the dorsal surface of the frontal through to the occipital crest. The occipital crest was curved and pronounced in males. For adult females, sagittal and occipital crests were also present but reduced. The zygomatic arch was elongate. The palate was long, narrow compared with other sea lions and deep at the anterior. The auditory bullae were bulbous with reduced posterior spurs in older, predominantly male, specimens. The mastoids were robust, longer in older specimens and were usually set further back from the pterygoid than for other sea lions. The PCs were of moderate size with reduced anterior and posterior accessory cusps, and were frequently asymmetric in number. The frontal was long and narrow. The mandible was long, with a large angle between the dentary and coronoid processes. Both maxillary and mandibular canines were robust in males, less so in females, and often splayed outwards from the vertical in both sexes. The third upper incisors were enlarged in both sexes (Plate 5).

Measured variables

Variables relating to length of skull (in actual and relative measurements) were mostly larger in male *Z. c. californianus* than in females. Length of nasals, and gnathion–posterior of maxilla (palatal) were of similar size in both sexes. The mean value for basion–bend of pterygoid, when compared relative to CBL, was smaller in male *Z. c. californianus* than in females. *Zalophus c. californianus* expressed marked sexual dimorphism in all but four variables relating to robustness: breadth of nares and breadth of orbit were of similar size in both sexes, whereas breadth of braincase and length of orbit were smaller in males than in females. The ranges for breadth of braincase overlapped significantly between males and females of this species (actual measurements). As a percentage of CBL, most variables relating to the mandible and teeth were larger in male *Z. c. californianus* than in females, excluding length of mandibular tooth row, which was the same for both sexes. Distance behind border of upper canines and length of lower PC row were smaller in males of this species than in females.

Multivariate analyses

Principal components analysis for adult female *Z. c. californianus* was based on standardized data for seven variables. Component 1 was influenced by size, with most variables relating to length of skull; these were basion–zygomatic root (anterior), CBL, gnathion–caudal border of postglenoid process and gnathion–middle of occipital crest. The first Component accounted for 68.3% of the total variance, whereas the second accounted for a further 14.0% and was described by shape. Component 2 was affected primarily by variables related to breadth of skull (height of skull at ventral margin of mastoid (−0.647) and occipital crest–mastoid (−0.532)), that possessed large negative coefficients. The third Component explained another 8.3% of the total variance in which gnathion–posterior margin of nasals was the most influential variable, with a coefficient of −0.702.

Component 1 in adult male *Z. c. californianus* explained 70.8% of the total variance, again showing large, positive coefficients. Component 2 in adult males explained a further 16.2% of the total variance, influenced primarily by variables relating to the rostral region and sagittal crest. These included gnathion–caudal border of preorbital process, height of sagittal crest and gnathion–posterior margin of nasals (0.565, −0.578 and 0.508, respectively. Component 3 expressed only small coefficient values and contributed 4.5% to the total variance. It was influenced primarily by height of sagittal crest (0.448), which increased in magnitude for this component, compared with mastoid and auditory breadth.

Galapagos sea lion – *Zalophus californianus wollebaeki* (Sivertsen, 1953)

General morphology

As with *Z. c. californianus*, the rostrum was elongate and narrow in *Z. c. wollebaeki*. The nasals were long, slender and broadened at the anterior. Preorbital processes were moderately long, more so in males than in females. Interorbital constriction was broad in males, less so in females. Supraorbital processes were pronounced and angular, extending posterior

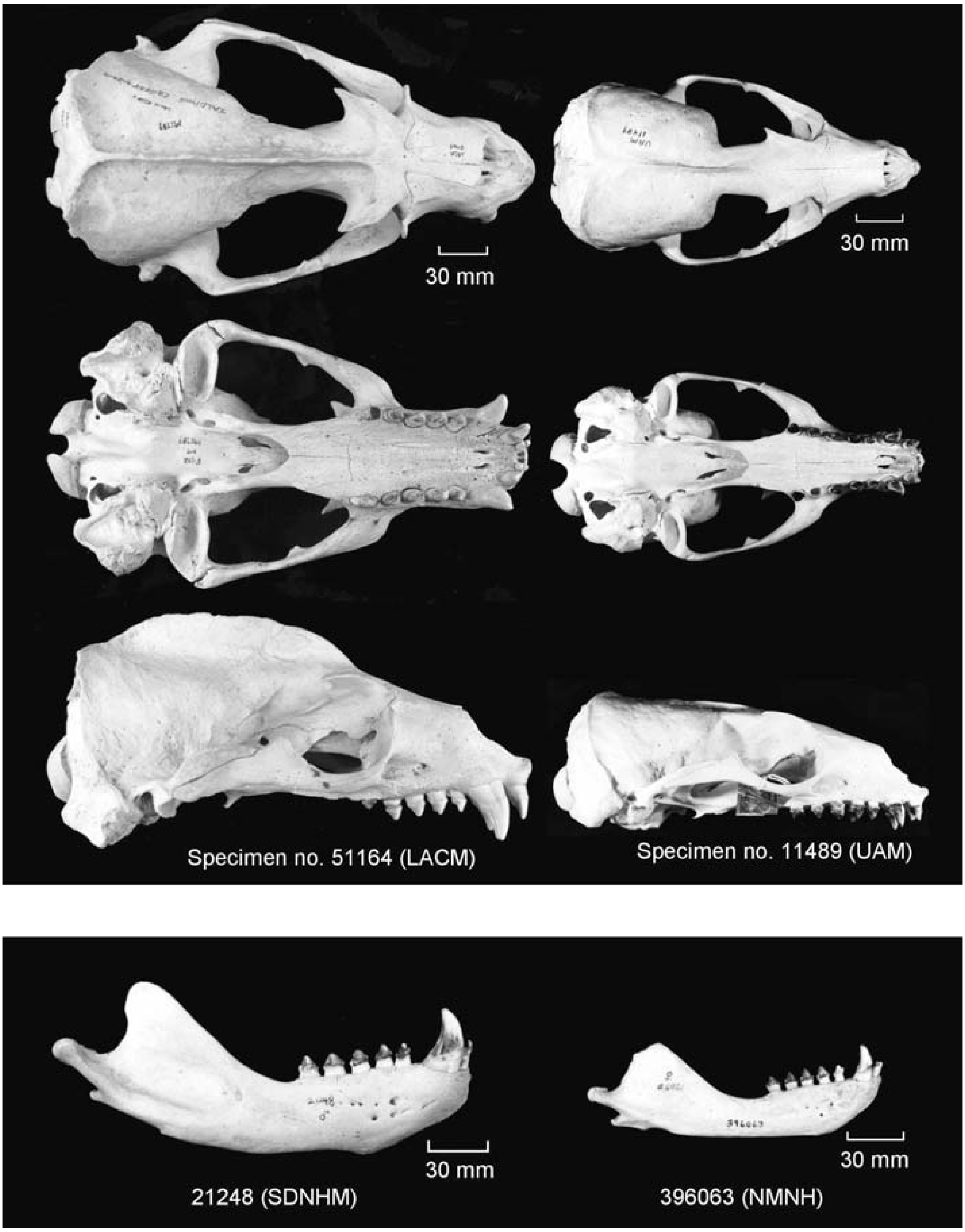
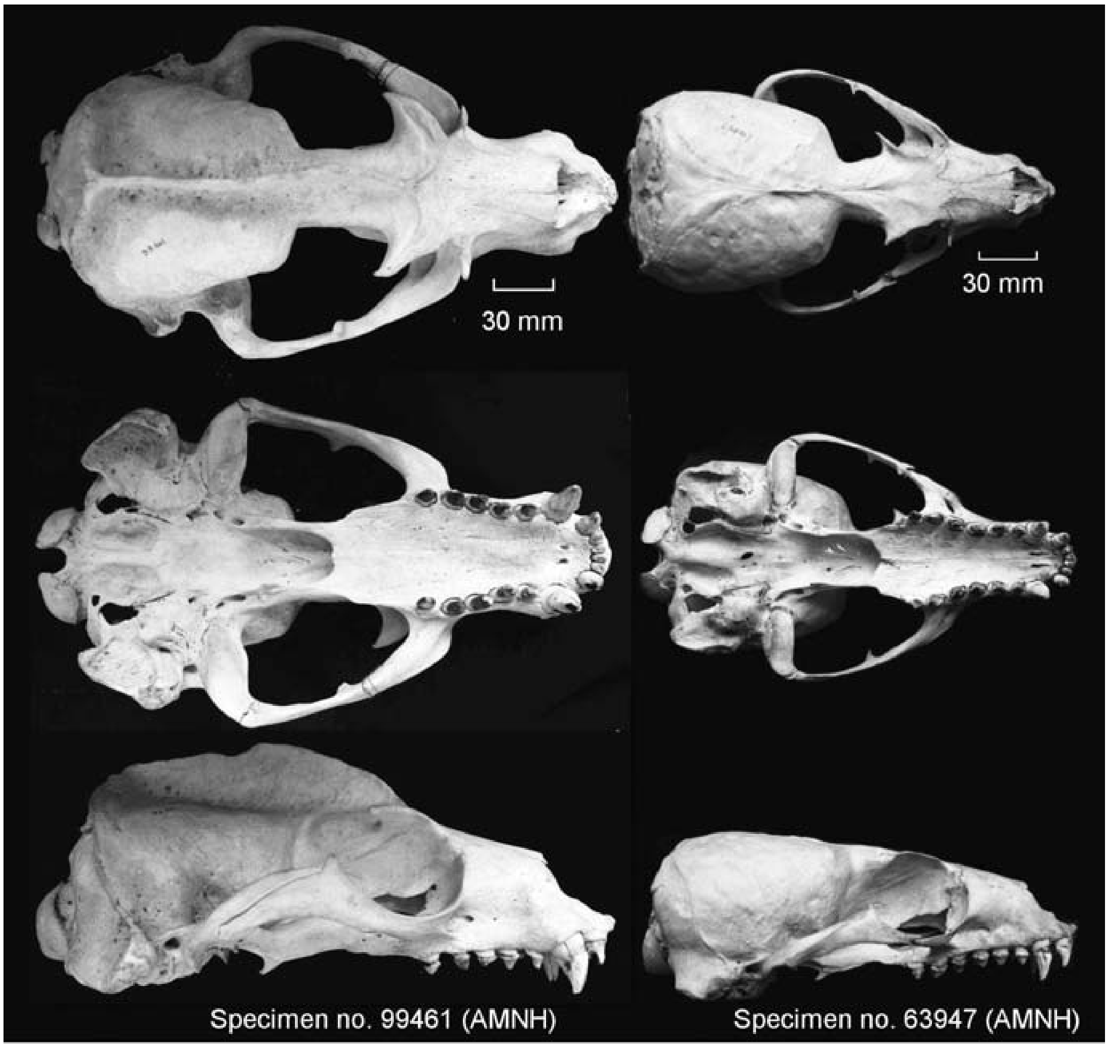


Plate 5 *Zalophus californianus californianus* – adult male (left), adult female (right).

from the interorbital constriction. The sagittal crest was prominent in males, similar to that of *Z. c. californianus* but generally not as high. The occipital crest was curved and pronounced in males, and in adult females both sagittal and occipital crests were present but reduced. The zygomatic arch was elongate, and the palate long, narrow and deep at the anterior in many specimens. The mastoids were large and longer in older specimens and, as with *Z. c. californianus*, were usually set further back from the pterygoid than for other sea lions. The PCs were small compared to other sea lions, with reduced anterior and posterior accessory cusps with frequent asymmetry in numbers. The frontal was long and narrow. The mandible was slender, with a large angle between the dentary and coronoid process. Both maxillary and mandibular canines were robust in males, less so in females. The third upper incisors were enlarged in both sexes (Plate 6).



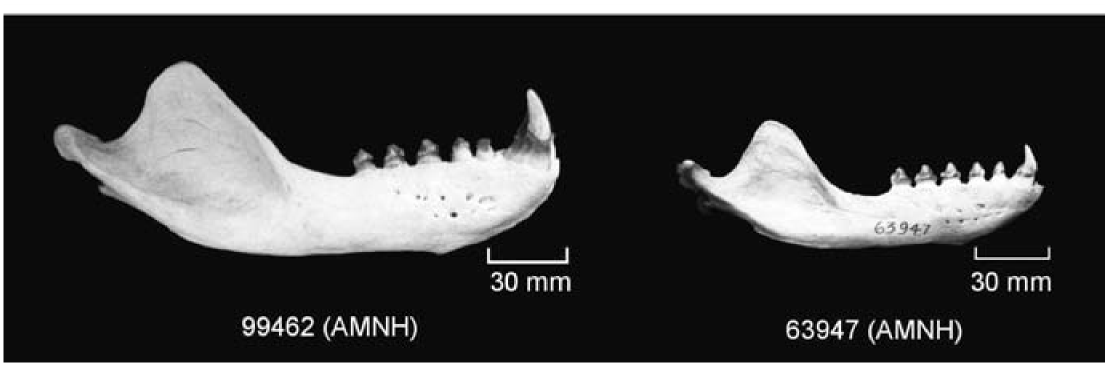


Plate 6 *Zalophus californianus wollebaeki* – adult male (left), adult female (right).

Measured variables

Relative to CBL, means for all but basion–bend of pterygoid were greater in males than in females. *Zalophus c. wollebaeki* expressed marked sexual dimorphism in all but six variables relating to robustness. Breadth of palate at PC 5 was similar in both sexes, whereas the remaining variables were smaller in males than in females (breadth of braincase, breadth of palate at PCs 3–4 and 4–5, and length and breadth of orbit). As a percentage of CBL, most variables relating to the mandible and teeth were larger in male *Z. c. wollebaeki*; exceptions were distance behind border of upper canines and length of lower PC row.

Multivariate analyses

Adult female *Z. c. wollebaeki* were not available for PCA analyses, due to insufficient numbers. Component 1 in adult males of this species expressed high loadings for most variables, contributing 75.7% to the total variance. Palatal notch–incisors and rostral width were influential in both Components 2 and 3. In the second component, palatal notch–incisors decreased in magnitude compared with rostral width, whereas both increased in magnitude for the third. These two contributed a further 8.8% and 7.3% respectively, to the total variance.

Japanese sea lion – *Zalophus californianus japonicus* (Peters, 1866)

General morphology

Skulls of the subspecies *Z. c. japonicus* were the largest in the genus *Zalophus*, with a mean CBL for adult males of 312 mm. Only one adult female *Z. c. japonicus* was available for data collection, which had a CBL of 242 mm. The rostrum of adult male *Z. c. japonicus* was elongate and broader than that of *Z. c. californianus* and *Z. c. wollebaeki*. The nasals were long and slender. Preorbital processes were broad and long. The interorbital constriction was broad, followed by triangulate supraorbital processes that extended dorsoventrally. The sagittal crest was prominent in all males and was the largest of all the *Zalophus*. The occipital crest was curved and pronounced. The zygomatic arch was elongate and wide at the squamoso-jugular margin. The palate was long, broader than that found in *Z. c. californianus* and *Z. c. wollebaeki* at PCs 3–4, and deeper at the anterior. The auditory bullae were bulbous with posterior spurs. The mastoids were robust and long. The PCs that were not worn possessed reduced anterior and posterior accessory cusps, and showed asymmetry in numbers of PCs. The frontal was long and narrow. The mandible was long, with a large angle between the dentary and the coronoid process. Both maxillary and mandibular canines were robust in males. The third upper incisors were enlarged (Plate 7).

Measured variables

Comparison of measurements between male and female skulls should be considered with caution, as there was only one adult female specimen of *Z. c. japonicus* available. Nevertheless, means for variables relating to length of skull, when observed relative to CBL, showed males were smaller than the female in basion–bend of pterygoid. Relative to CBL, *Z. c. japonicus* expressed marked sexual dimorphism in all but three variables relating to robustness which were smaller in males: breadth of braincase, and length and breadth of orbit. The ranges for these three variables overlapped significantly when observed in mm, whereas breadth of palate at PC 5 was the same for both sexes. As a percentage of CBL, most variables relating to the mandible and teeth were larger in male *Z. c. japonicus*, excluding distance behind border of upper canines.

Principal components analyses could not be completed for *Z. c. japonicus* due to insufficient representative samples.

Description of species: fur seals

The fur seals currently comprise two genera: the monotypic northern fur seal, *Callorhinus ursinus*, and eight species of southern fur seals of the genus *Arctocephalus*. The following are summary descriptions for each, outlining morphological characteristics that are constant within each species and those that express sexual dimorphism. Summary statistics are provided in Appendix II (http://curator.museum.uaf.edu/brunner/appendices/).

Northern fur seal – *Callorhinus ursinus* (Linnaeus, 1758)

General morphology

Specimens of *C. ursinus* were distinguished readily from skulls of the genus *Arctocephalus* primarily by characteristics relating to the rostral region. Rostral length was significantly reduced compared with those of the *Arctocephalus*, terminating abruptly and possessing a ‘sawn-off’ appearance. Rostral width varied in males more so than in females, but was generally broad with some males attaining widths up to 60.5 mm. The nasals were wide and curved downward at the premaxilla. The breadth of skull at preorbital processes varied, mainly between males, but was primarily broad. The preorbital processes were reduced in both sexes. Interorbital constriction, relative to CBL, was wide although less so in female *C. ursinus*. Supraorbital processes were small and robust in males and were often developed immediately posterior to, or over the top of, the interorbital constriction. Many male *C. ursinus* possessed a pronounced convex frontal at the supraorbital processes. Supraorbital processes for females were similar in structure to males but not as large and lacked the convex dimensions of the frontal. Sagittal and occipital crests were developed in adult males, whereas in females no sagittal crests were observed. The anterior of the zygomatic arch was narrow in both sexes. The upper canines were angled downward almost vertically and were approximately twice as large in males than in females. PCs were small and unicuspid, with pc 6 possessing a small posterior accessory cusp. The auditory bullae were flattened, triangular, with small posterior spurs found in older specimens. The zygomatic arch was thick and curved, particularly at the jugal-squamosal joint, and was again less robust in females. The palate was short and wide, and occasionally appeared with some posterior clefting. The mandible was robust at the anterior of the dentary, with heavy bone deposition at the canine roots in males. The masseteric fossa was deep, particularly in males and more so in older specimens (Plate 8).

Measured variables

Means for variables relating to length of skull, when observed relative to CBL, showed males were smaller than females in basion–bend of pterygoid, and of a similar size in palatal notch–incisors, gnathion–posterior of maxilla (palatal), and basion–zygomatic root. Relative to CBL, male *C. ursinus* were larger than females in all but breadth of braincase, and length and breadth of orbit, measurements that overlapped significantly when observed in mm. As a percentage of CBL, most variables relating to mandible and teeth were larger in male *C. ursinus* than in females, excluding mesiodistal diameter of PCs, distance behind border of upper canines and length of lower PC row.

Multivariate analyses

The greatest variation in cranial morphology for female *C. ursinus* was observed in Component 1 and accounted for just over half the total variance explained (54.8%), in which

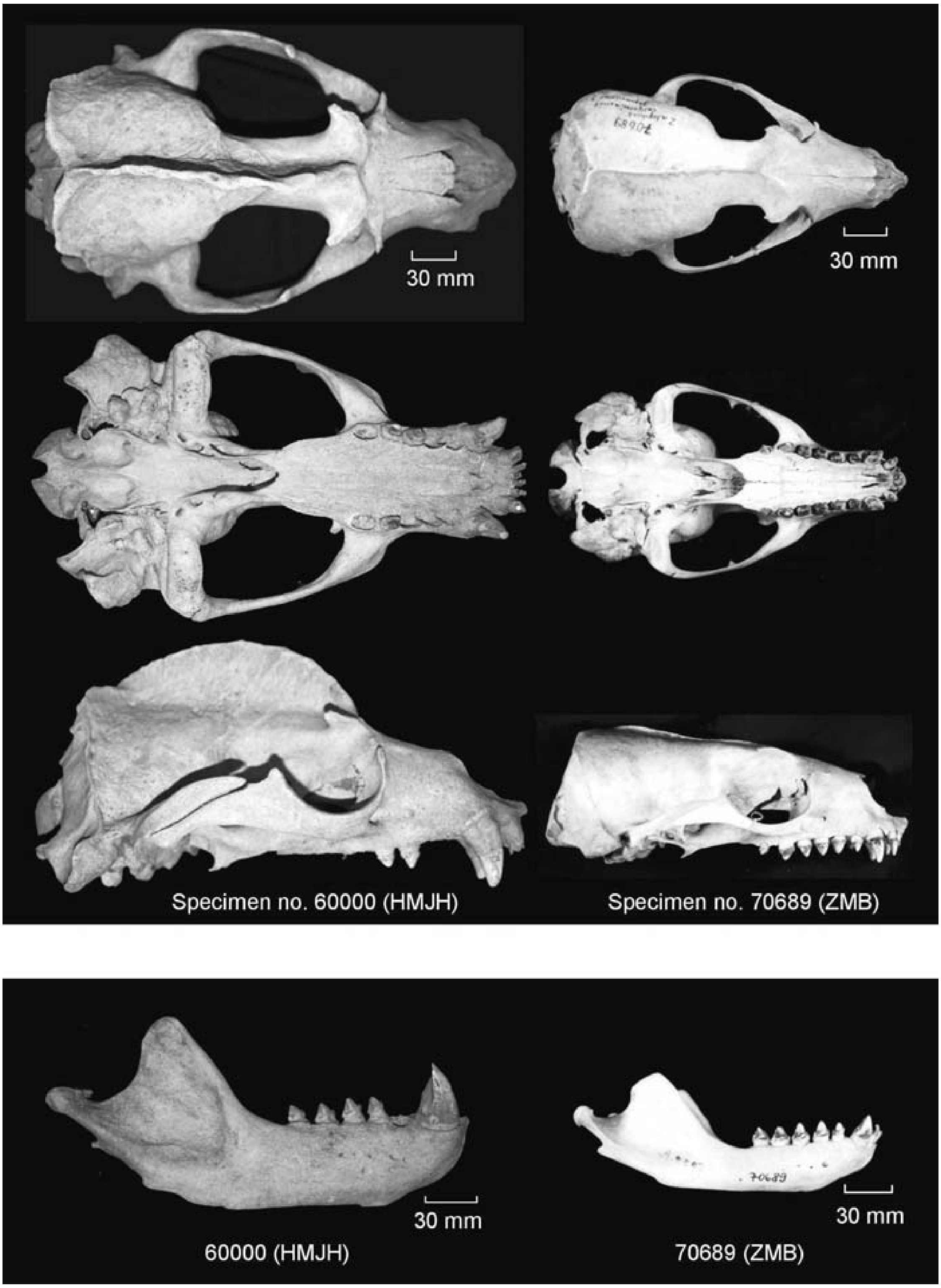
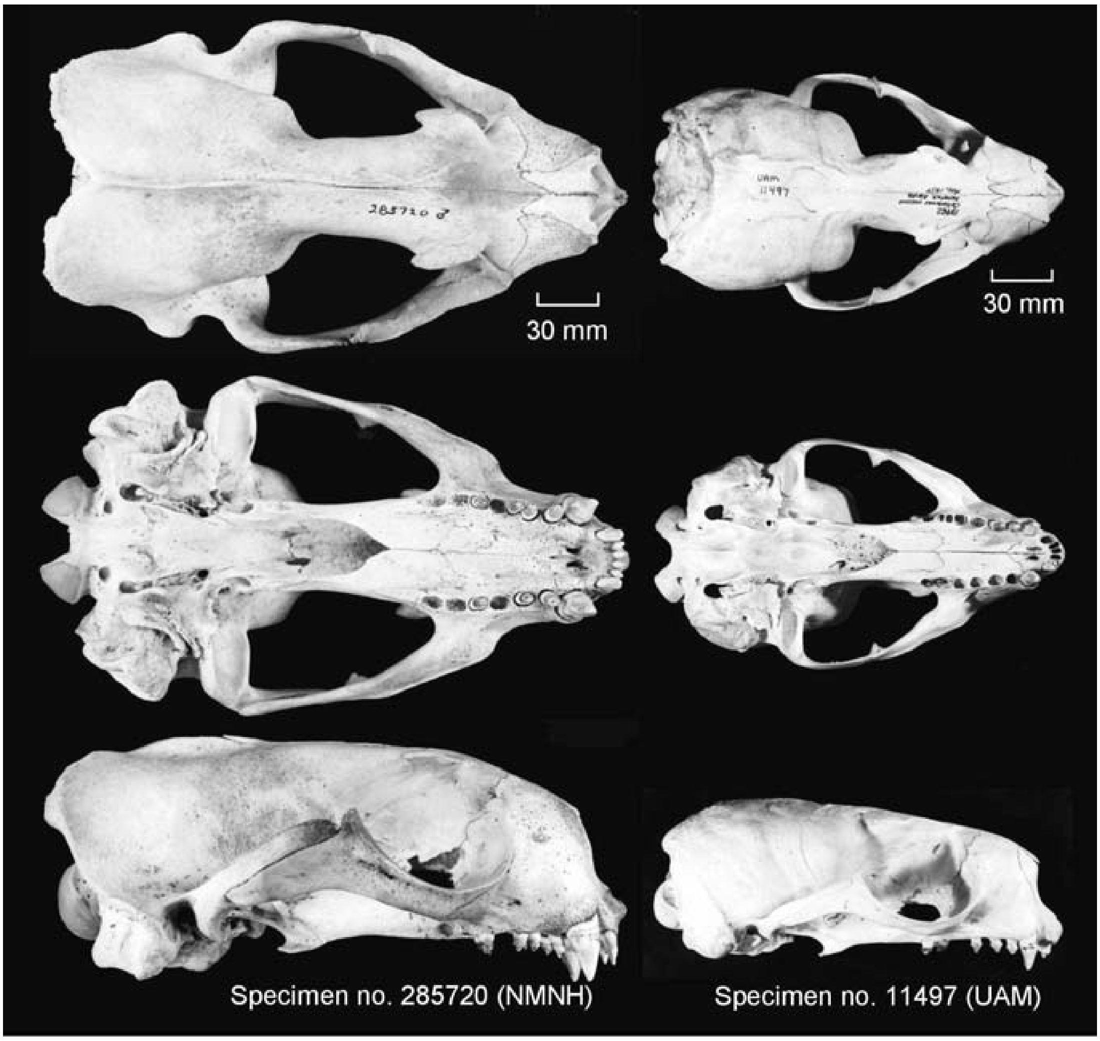


Plate 7 *Zalophus californianus japonicus* – adult male (left), adult female (right).

measurements relating to length of skull contributed significantly. Component 2 was a shape component and described another 22.7% to the total variance. Breadth of palate at PCs 3–4, 4–5 and 5 were the most significant variables for this component, all expressing large negative coefficients (−0.671, −0.748 and −0.685, respectively). Component 3 contributed a further 7.5% to the total variance; gnathion–posterior margin of nasals (−0.523) was the most influential measurement, decreasing in magnitude with gnathion–caudal border of preorbital process (−0.373).



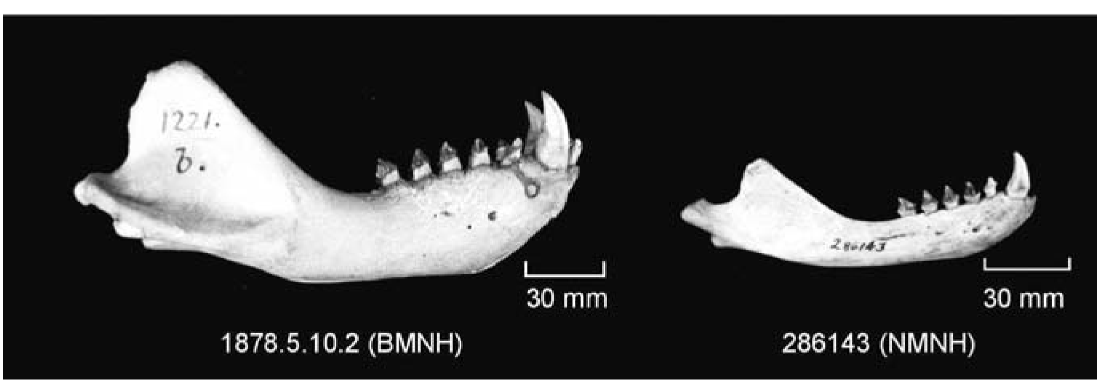


Plate 8 *Callorhinus ursinus* – adult male (left), adult female (right).

For adult male *C. ursinus*, Component 1 described 76.8% of the total variance, over 20% more than that observed for adult female *C. ursinus*. Measurements with the largest coefficients were those relating primarily to length of skull, including CBL (0.933), gnathion–caudal border of postglenoid process (0.946) and basion–zygomatic root (anterior) (0.897). Component 2 contributed another 14.4% to the total variance. Gnathion–caudal border of preorbital process increased in magnitude (0.404) compared with variables relating to breadth of skull, such as height of skull at ventral margin of mastoid, mastoid breadth and zygomatic breadth. The latter three measurements all possessed negative coefficients (−0.387, −0.310 and −0.304, respectively). Height of skull at ventral margin of mastoid (−0.312) contributed the most variance to Component 3, which added 5.0% to the total variance explained.

Antarctic fur seal – *Arctocephalus gazella* (Peters, 1875)

General morphology

Skulls of adult male *A. gazella* were the most robust of the genus *Arctocephalus*, relative to CBL. The rostral region for this species was short and robust in males but less so in females. The palate was generally wide and shallow, particularly at pc 5. The auditory bullae were small, flat and triangulate. Mastoid processes were set close to the pterygoid and were longer in older specimens, extending ventrally. The zygomatic arch was short, curved significantly and was wide, dorso-ventrally at the jugul-squamosal margin. The supraorbital processes extended posteriorly and were larger in males than in females. The sagittal and occipital crests were well developed in male *A. gazella*, especially in older specimens but were reduced, or not present, in females. The anterior nares were wide and the nasals generally sloped downward in a continuation of the convex curve of the frontal. The nasals were often fused posteriorly. Most PCs were unicuspid, with pcs 5 and 6 reduced to 'nubs'. Interorbital constriction was broad, especially in males (Plate 9).

Measured variables

Variables relating to length of skull (%CBL) showed male *A. gazella* were shorter than females in basion–bend of pterygoid, were similar in basion–zygomatic root and length of nasals, and were longer in the remaining seven variables. For characteristics relating to breadth of skull, breadth of nares was the same for both sexes. Breadth of braincase, and length and breadth of orbit were proportionately larger in females than in males although they overlapped considerably when observed in mm. The remaining 15 variables relating to breadth of skull were proportionately larger in male *A. gazella* than in females. For variables relating to the mandible and teeth, distance behind border of upper canines and length of lower PC row were smaller in males than in females; the remaining variables were larger in males.

Multivariate analyses

The greatest within-sex variation in cranial morphology for female *A. gazella* was observed in Component 1 but accounted for less than half the total variance explained (41.4%). Coefficients for this Component were all positive, yet were significantly lower than those found in other species. Measurements explaining most of the variance in Component 1 for female *A. gazella* related primarily to breadth of skull. Component 2 was a shape component and contributed another 22.1% to the total variance. Breadth of skull at supraorbital processes (0.643), breadth of palate at PCs 3–4 (−0.562) and gnathion–caudal border of preorbital process (0.568) were the most significant variables. Component 3 contributed a further 10.3% to the total variance explained and was influenced mainly by zygomatic breadth (−0.568) and, as with Component 2, gnathion–caudal border of preorbital processes (−0.483).

In adult male *A. gazella*, variation was observed primarily in Component 1, although it accounted for only 36.0% of the total variance explained. Coefficients for Component 1 were all positive yet, as with adult female *A. gazella*, were significantly lower than those found in other otariids. Component 2 in adult males contributed 24.3% to the total variance explained, and was influenced strongly by palatal breadth at PCs 3–4, 4–5 and 5 which all expressed strongly negative coefficients. Component 3 also described a large proportion of the total variance explained (18.0%) and was influenced primarily by gnathion–posterior margin of nasals and gnathion–caudal border of preorbital process (−0.851 and −0.804, respectively).

Subantarctic fur seal – *Arctocephalus tropicalis* (Gray, 1872)

General morphology

Skulls of *A. tropicalis* were generally smaller than those of other *Arctocephalus*, excluding *A. galapagoensis*. The rostral region was narrow, usually with a small, well-defined gnathion. The rostrum in females was narrower than in males when compared in actual size and relative to CBL. The palate was long and deep towards the anterior, particularly at PCs 1–2. The zygomatic arch was elongate and curved at the jugal-squamosal margin. The zygomatic arch was longer than those of other species of *Arctocephalus* when observed as a percentage of CBL. The sagittal and occipital crests were pronounced in males and usually absent in females. The interorbital constriction was narrow and the nasals were long, and wide at their anterior. Supraorbital processes were present but reduced, especially in females. The PCs were unicuspid and spaced, with maxillary PCs 4–6 often angled outward from the palate rather than extending vertically downwards. Specimens of *A. tropicalis* were less sexually dimorphic in size when compared with skulls of larger species of *Arctocephalus*, confirmed by the greater number of variables that expressed the same mean values when observed as a percentage of CBL (Plate 10).

Measured variables

Male *A. tropicalis* were larger than females (relative to CBL) in five variables relating to length of skull: palatal notch–incisors, gnathion–posterior of maxilla (palatal), Gnathion–caudal border postglenoid process, gnathion–foramen infraorbitale, and Gnathion–caudal border of preorbital process. Gnathion–mid occipital crest and length of nasals was similar in both sexes, whereas basion–zygomatic root and basion–bend of pterygoid were proportionately smaller in females. Skulls of male *A. tropicalis* were larger than those of females in breadth of nares, zygomatic breadth, height of skull at supraorbital processes and height of skull at ventral margin of mastoid. Females were comparatively larger than males in breadth of braincase, and length and breadth of orbit. As with other species of otariids, these three variables overlapped considerably between males and females in actual measurements. For variables relating to the mandible and teeth, skulls of male *A. tropicalis* were comparatively smaller than those of females in distance behind border of upper canines, and were similar to

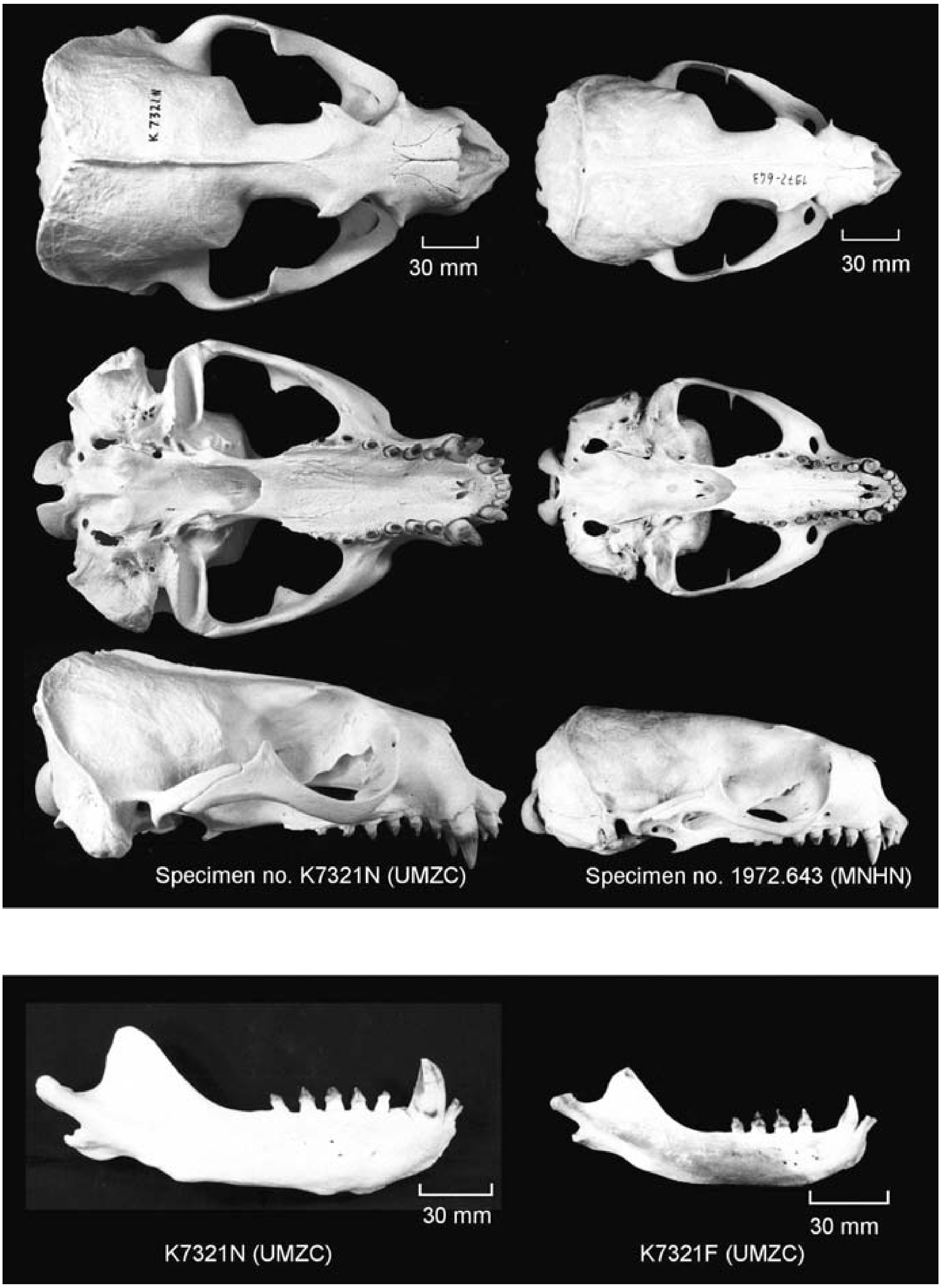
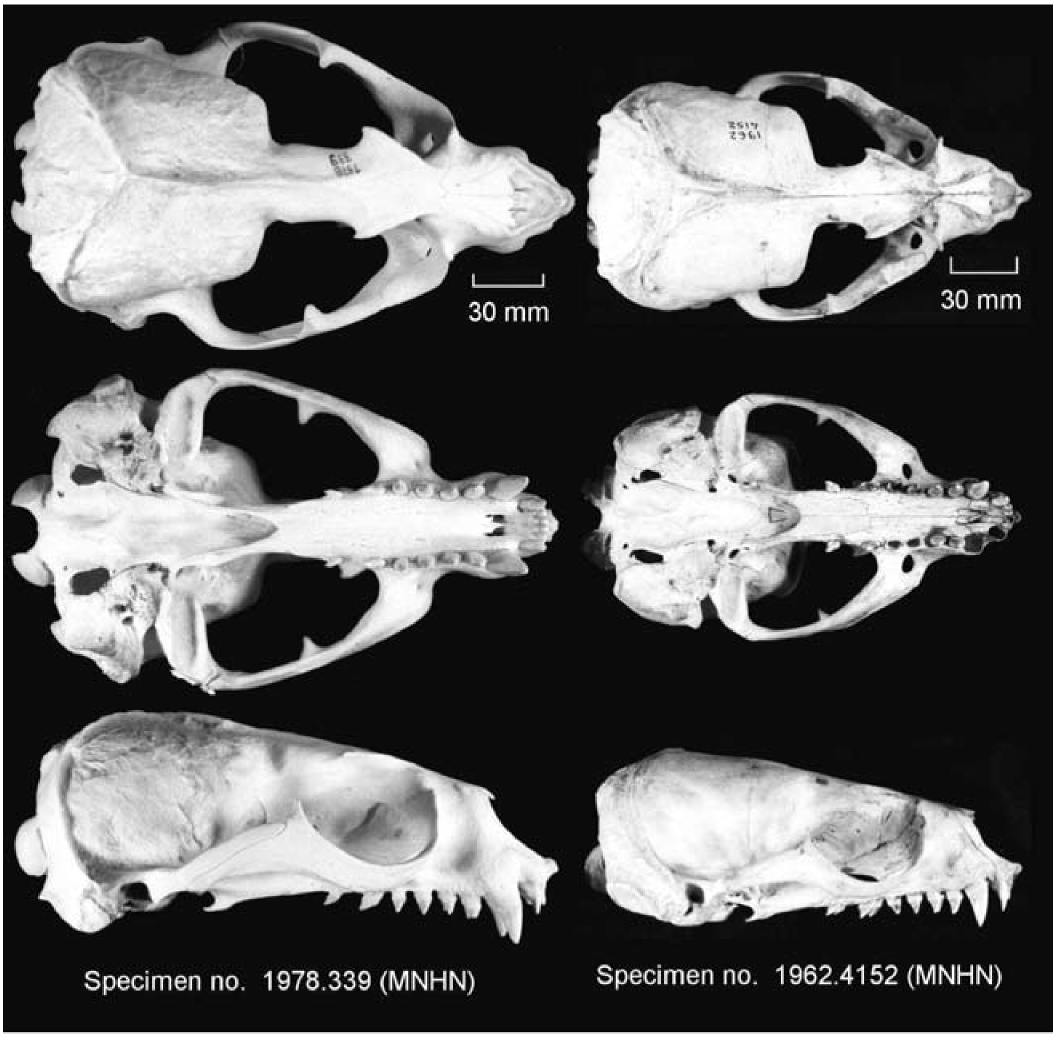


Plate 9 *Arctocephalus gazella* – adult male (left), adult female (right).

females in height of upper canines above alveolus, mesiodistal diameter of PCs and length of lower PC row.

Multivariate analyses

From the PCA, Component 1 for adult female *A. tropicalis* accounted for 64.2% of the total variance explained with predominantly large, positive coefficients, particularly for measurements relating to length of skull. Component 2 was a shape component and contributed another 13.2% to the total variance. Breadth of palate at PCs 3–4 increased in magnitude compared with breadth of skull at supraorbital processes (0.800 and −0.695, respectively). These were the most significant variables for Component 2. The third Component for adult female *A. tropicalis* was also influenced by shape and contributed



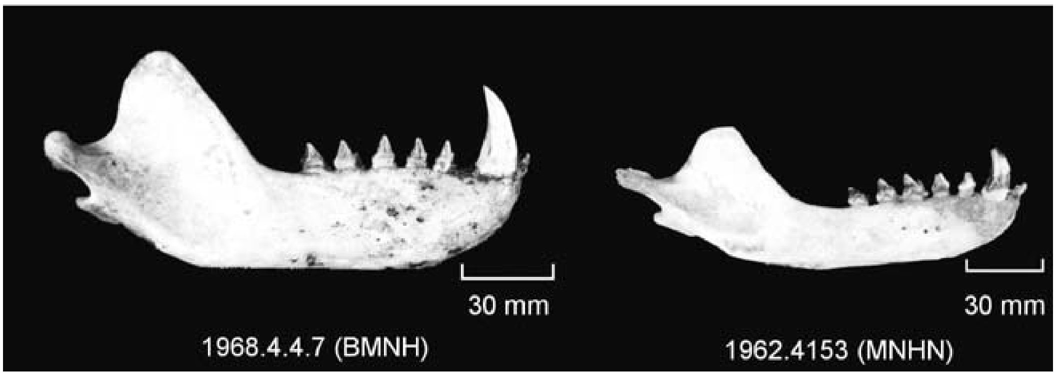


Plate 10 *Arctocephalus tropicalis* – adult male (left), adult female (right).

a further 11.3% to the total variance explained. It was influenced mainly by interorbital constriction and breadth of skull at preorbital processes, the former decreasing in magnitude compared with the latter in Component 3 (−0.682 and 0.600, respectively).

In adult male *A. tropicalis*, Component 1 described a little over half the total variance explained (55.2%) in which, as with adult females of this species, the measurements expressing the largest coefficients were those relating to length of skull. Component 2 contributed another 21.4% to the total variance explained, and was influenced primarily by breadth of palate at PCs 4–5 and 5 (0.871 and 0.809, respectively). For Component 3, basion–bend of pterygoid (−0.695) decreased in magnitude compared with variables relating to length of skull, such as CBL (0.116) and gnathion–caudal border of preorbital process (0.132). The third component contributed a further 8.9% to the total variance explained for adult male *A. tropicalis*.

New Zealand fur seal – *Arctocephalus forsteri* (Lesson, 1828)

General morphology

Skulls of *A. forsteri* were morphologically similar to those of *A. australis*. The rostrum was moderate, narrow and well defined. The nasals flared anteriorly, were narrow at the junction with the frontal and usually showed no obvious continuation of curvature from the frontal. The interorbital constriction was narrow with well-defined supraorbital processes that extended posteriorly. The frontal was generally flat, or moderately convex in males, and usually flat in females. The anterior of the zygomatic arch was broad in both sexes. The zygomatic arch was short, with moderate curvature at the jugal-squamosal margin. Sagittal and occipital crests were pronounced in males, especially in older specimens. Females, predominantly older specimens, possessed reduced sagittal and occipital crests. The preorbital processes were narrow and well defined. Postcanines had anterior and posterior accessory cusps (unlike *A. tropicalis* which are unicuspid) and usually abutted each other to PC 5. The mandible was short with the masseteric fossa deeper in older specimens (Plate 11).

Measured variables

Condylobasal length was larger in males than in females, again reflecting pronounced sexual dimorphism. Means for the remaining ten variables relating to length of skull relative to CBL, showed that males were smaller than females in basion–bend of pterygoid, and of a similar size in length of nasals. Relative to CBL, *A. forsteri* expressed marked dimorphism in most variables relating to robustness, particularly: breadth at supraorbital processes, interorbital constriction, rostral width, zygomatic breadth, mastoid breadth and height of sagittal crest. Variables relating to the mandible and teeth were also proportionately larger in male *A. forsteri* than in females, excluding distance behind border of upper canines and length of lower PC row.

Multivariate analyses

In adult female *A. forsteri*, the greatest variation in cranial morphology was observed primarily in variables relating to length of skull in Component 1, describing 75.8% of the total variance explained. Component 2 was influenced by shape and added another 10.4% to the total variance explained. Breadth of zygomatic root of maxilla possessed a strongly positive coefficient (0.965) and increased in magnitude compared with all other variables for this component. The third component contributed a further 5.4% to the total variance explained and was influenced mainly by gnathion–middle of occipital crest with a coefficient of −0.518.

Component 1 for adult male *A. forsteri* accounted for 63.4% of the total variance explained with large, positive coefficients for most variables, particularly those relating to length of skull. Component 2 contributed a further 15.6% to the total variance and as with female *A. forsteri*, was influenced strongly by length of nasals, auditory breadth and zygomatic breadth (0.626, −0.575 and −0.545, respectively. Component 3 described another 8.2% of the total variance explained and was influenced primarily by length of nasals, with a coefficient of −0.436.

South African fur seal – *Arctocephalus pusillus pusillus* (Schreber, 1775)

General morphology

Specimens of *A. p. pusillus* were generally smaller than those of *A. p. doriferus*. Skulls of *A. p. pusillus* were narrow at the anterior of the zygomatic arch. The auditory bullae were large, rounded and bulbous. The rostrum was long and narrow. The nasals were elongate and often fused posteriorly. The preorbital processes were long, well defined, and larger in male *A. p. pusillus* than in females. Supraorbital processes were large in males, smaller in females, and often asymmetric in both sexes. The frontal was long, narrow, with the sagittal crest often developed to the supraorbital processes and was convex posterior to the interorbital constriction. Irregular ossifications were frequent on the cranium of male *A. p. pusillus*, located primarily towards the anterior of the parietal (these ossifications reached an extreme in *O. byronia*). The sagittal and occipital crests were large in males and possessed a rugose surface of bone surrounding the crests. The zygomatic arch was elongate and broad dorso-ventrally at the jugal-squamosal margin. The palate was long and deep at the canines through to PCs 1–2. Many specimens of *A. p. pusillus* expressed varying degrees of posterior palatal clefting or malformations. The auditory bullae were bulbous with small, spur-like posterior extensions in older specimens. The anterior of the zygomatic arch was narrow in both sexes of *A. p. pusillus*. The mandible was long with the angle of dentary and coronoid process larger than that of other *Arctocephalus* (e.g. *A. gazella*, *A. forsteri*). The PCs were large with significant anterior and posterior accessory cusps. Specimens of female *A. p. pusillus* (and *A. p. doriferus*) expressed the most masculine traits of all female *Arctocephalus*, usually with sagittal and occipital crests present (Plate 12).

Measured variables

When means are compared, relative to CBL, most variables were larger in adult male *A. p. pusillus* than in adult females, excluding four that were similar in both sexes (length of nasals, gnathion–posterior of maxilla (palatal), basion–zygomatic root, and height of upper canines above alveolus). Six variables were smaller in males than in females (basion–bend of pterygoid, breadth of braincase, length and breadth of orbit, and distance behind border of upper canines).

Multivariate analyses

From the PCA, Component 1 for adult female *A. p. pusillus* described 80.5% of the total variance explained and was influenced mainly by variables relating to length of skull. Component 2 contributed another 8.1% to the total variance, in which all variables relating to breadth of skull decreased in magnitude compared with those relating to length of skull. Component 3 added a further 4.0% to the total variance explained. It was influenced mainly by height of skull at supraorbital processes, with a coefficient of −0.517. The remaining

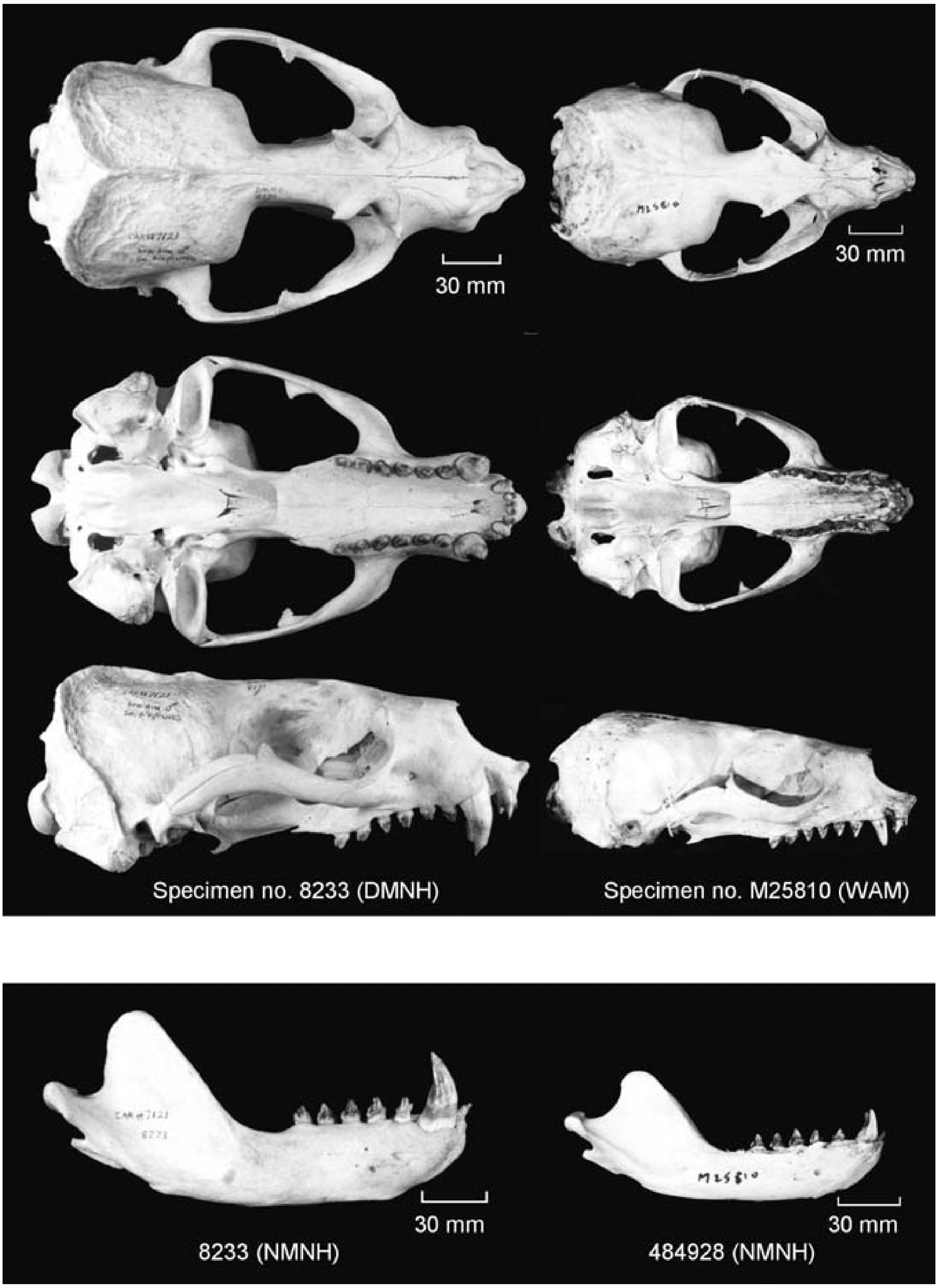


Plate 11 *Arctocephalus forsteri* – adult male (left), adult female (right).

variables for this component contributed little to the total variance explained.

Component 1 for adult male *A. p. pusillus* described 68.9% of the total variance and, as with adult females of this species, was influenced primarily by variables relating to length of skull including CBL (0.896) and gnathion–caudal border of postglenoid process (0.943). Mastoid breadth and occipital crest–mastoid (−0.660 and −0.619, respectively) were the most heavily weighted variables for Component 2, which decreased in magnitude compared with most variables relating to length of skull. Component 2 added a further 16.9% to the total variance explained. The third component contributed

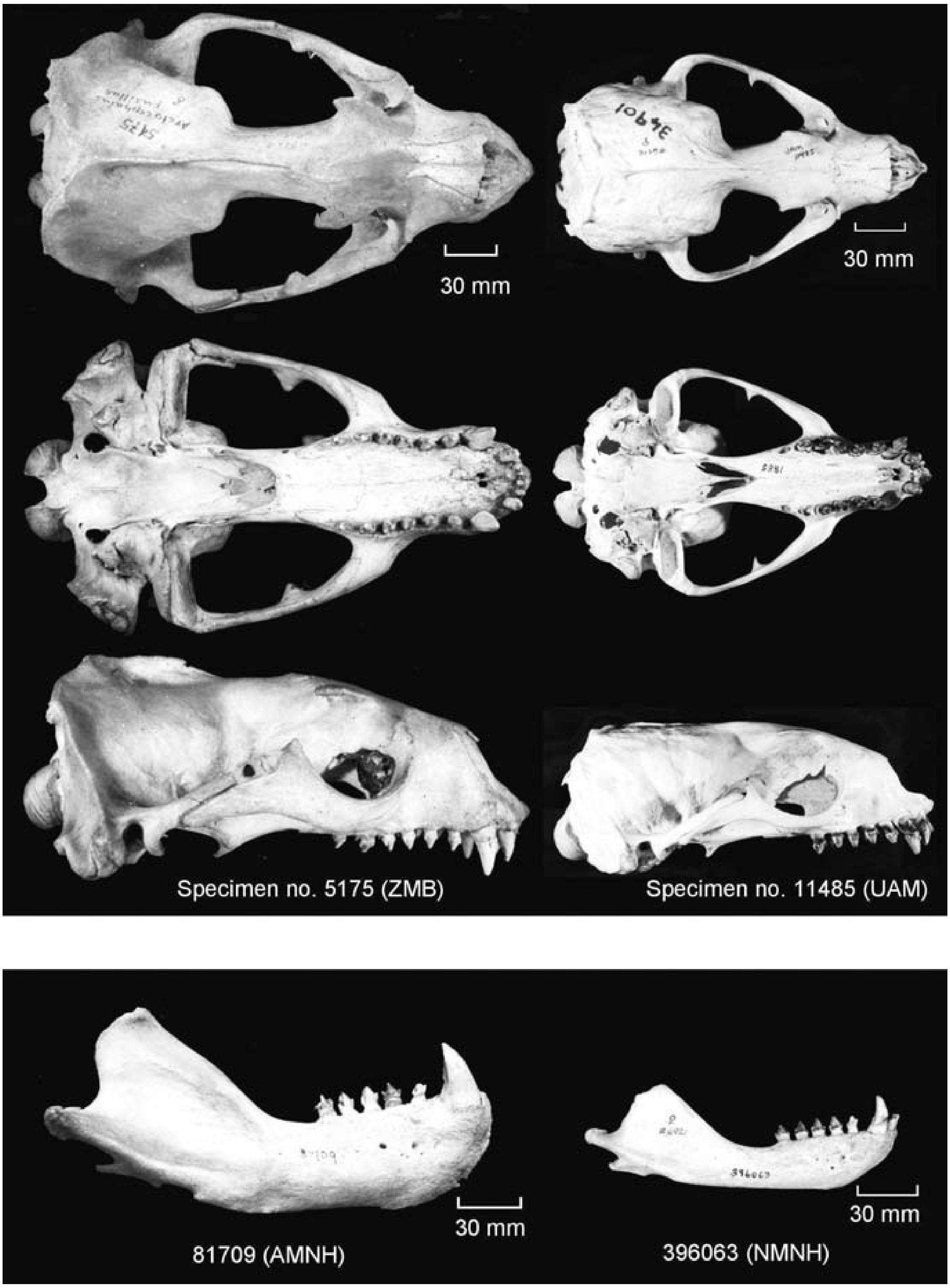


Plate 12 *Arctocephalus pusillus pusillus* – adult male (left), adult female (right).

another 5.3% to the total variance, in which gnathion–foramen infraorbitale (0.477) had the largest coefficient value.

Australian fur seal – *Arctocephalus pusillus doriferus* Wood Jones, 1925

General morphology

Skulls of the subspecies *A. p. doriferus* were the largest of the genus *Arctocephalus*. The rostrum was long and narrow, as for *A. p. pusillus*. The preorbital processes were prominent and well defined, particularly in males. The supraorbital processes were broad and, again, more pronounced in males than in females. The frontal was wide at the supraorbital processes, and became narrow at the anterior of the braincase. The sagittal crest was pronounced in males, less so in females and usually did not extend forward of the cranium. The occipital crest was large with a rugose surface on the braincase, especially

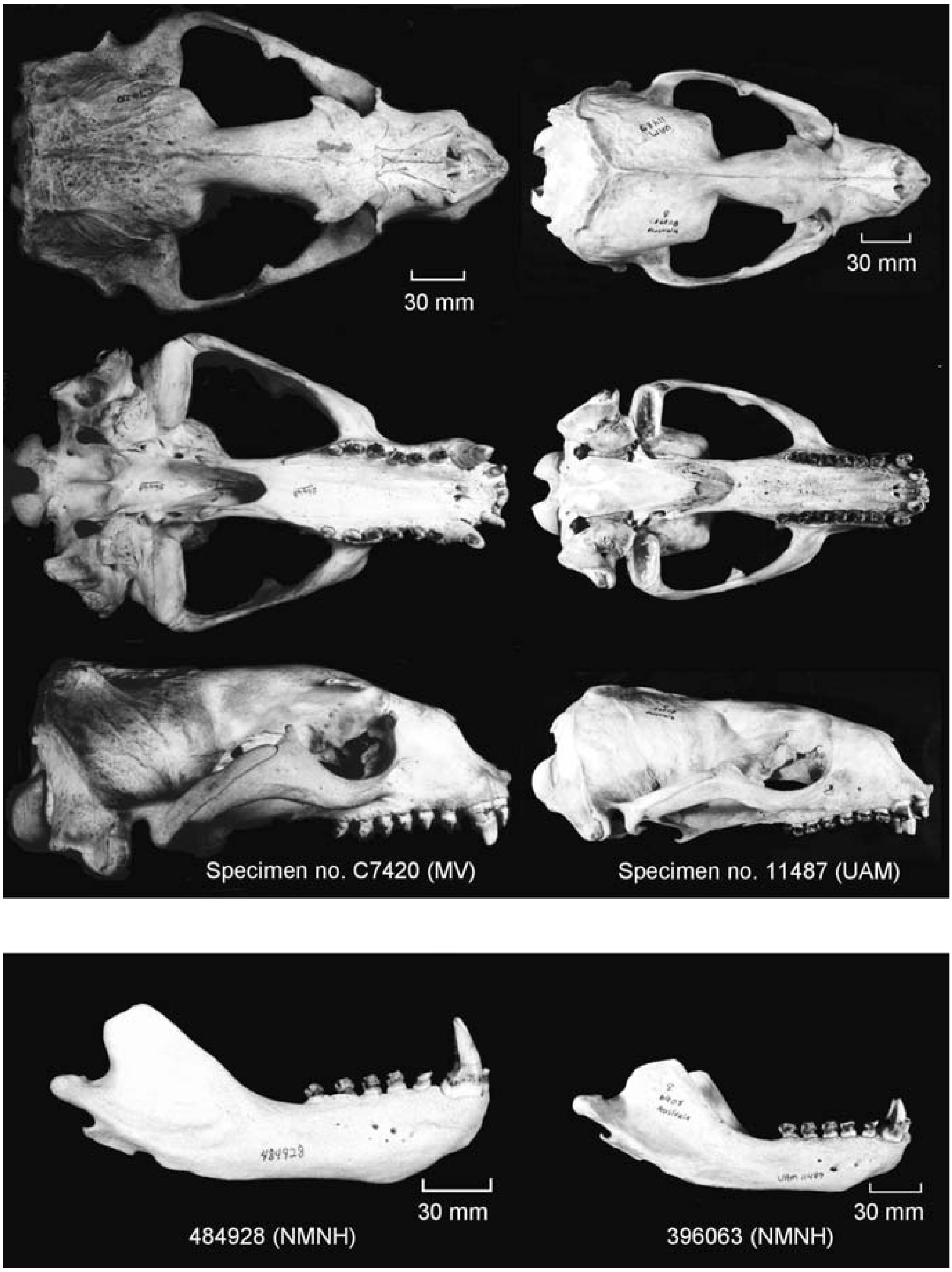


Plate 13 *Arctocephalus pusillus doriferus* – adult male (left), adult female (right).

near the occipital crest in male specimens. The zygomatic arch was long and curved at the jugal-squamosal margin, the anterior of which was narrow in both sexes. The palate was long, narrow and deep. As with *A. p. pusillus*, many specimens of *A. p. doriferus*, regardless of age or sex, possessed posterior clefting or malformation of the palate. The auditory bullae were rounded and bulbous. The mandible was long and the angle of the dentary and coronoid process was large. The masseteric fossa was long, and deeper in older specimens. The PCs were robust with large anterior and posterior accessory cusps. Some asymmetry was observed in the number of maxillary PCs, but was less common in PCs of the mandible (Plate 13).

Measured variables

Length of nasals, palatal notch–incisors, gnathion–posterior of maxilla (palatal), basion–zygomatic root, and basion–bend of pterygoid were proportionately similar in both sexes of *A. p. doriferus*. All variables relating to breadth of skull (excluding breadth of braincase) were significantly larger in males. Although adult female *A. p. doriferus* possessed reduced cresting and bone mass compared with that of males, skulls of older female *A. p. doriferus* had sagittal crests that were more prominent than those for most other female *Arctocephalus*. Female *A. p. doriferus* were proportionately larger than males in breadth of braincase, distance behind border of upper canines and length of lower PC row.

Multivariate analyses

Results from the PCA for adult female *A. p. doriferus* showed that Component 1 explained 82.7% of the total variance. This value was comparable with that found in adult female *A. p. pusillus*. Component 2 was a shape component and contributed another 7.2% to the total variance and, again similar to female *A. p. pusillus*, showed variables relating to breadth of skull decreased in magnitude while those relating to length of skull increased. Mastoid breadth (−0.471) was the most significant variable for this component. Component 3 was also a shape component and contributed a further 3.6% to the total variance. It was influenced mainly by gnathion–middle of occipital crest and gnathion–posterior of maxilla (palatal) (−0.383 and 0.301, respectively).

For adult male *A. p. doriferus*, Component 1 described 72.9% of the total variance and was comparable with that of Component 1 in adult male *A. p. pusillus*. Cranial characteristics relating to length of skull possessed the largest coefficients, particularly CBL (0.945), gnathion–middle of occipital crest (0.915) and gnathion–caudal border of postglenoid process (0.926). Component 2 contributed another 9.4% to the total variance, approximately half that observed for adult male *A. p. pusillus*. This component was influenced primarily by zygomatic breadth (−0.482), auditory breadth (−0.466) and gnathion–caudal border of preorbital process (0.419). Auditory and zygomatic breadth decreased in magnitude compared with variables relating to the rostral and frontal regions. Component 3 added another 6.4% to the total variance explained, in which basion–bend of pterygoid expressed the greatest negative coefficient (−0.413).

Guadalupe fur seal – *Arctocephalus townsendi* Merriam, 1897

General morphology

Cranial morphology of *A. townsendi* was similar to that of *A. philippii*, but the skulls of *A. townsendi* were generally smaller. The rostrum and preorbital processes were long and narrow in both sexes. The nasals were long, slender and flared anteriorly. The interorbital constriction was narrow. The supraorbital processes were narrow and angled ventrally. The frontal was long and comparatively slender. The palate was long, narrow and deep at the canines. The upper canine roots were larger in males than in females. The PCs were large, unicuspid and spaced apart. The zygomatic arch was long and thin at the jugal-squamosal margins. The auditory bullae were rounded. A sagittal crest was present in males, reduced in females, and rose from the posterior of the frontal to the occipital crest. The occipital crest was present in males. The mandible was elongate, usually with a narrow dentary and shallow masseteric fossa in both sexes (Plate 14).

Measured variables

Condylobasal length was significantly larger in. Measurements for the remaining ten variables relating to length of skull showed males were proportionately smaller than the female in basion–bend of pterygoid and proportionately similar to females in length of nasals. Relative to CBL, *A. townsendi* expressed marked dimorphism in most variables relating to robustness, particularly breadth at supraorbital processes, interorbital constriction, rostral width, zygomatic breadth, mastoid breadth, and height of sagittal crest. Variables relating to the mandible and teeth were also proportionately larger in male *A. townsendi* than in females, excluding distance behind border of upper canines and length of lower PC row.

Multivariate statistics were not applied to this species as too few adult specimens were available.

Galapagos fur seal – *Arctocephalus galapagoensis* Heller, 1904

General morphology

Skulls of *A. galapagoensis* were the smallest of all the otariids and, although smaller, were morphologically similar to *A. australis* and *A. forsteri*. *Arctocephalus galapagoensis* also showed the least sexual dimorphism for the Otariidae. The rostrum was short and broad. The nasals were moderate in length, flared anteriorly and were narrow at the junction with the frontal. The interorbital constriction was slender with small supraorbital processes that extended posteriorly. The frontal was generally flat, or moderately convex in males, and usually flat in females. The auditory bullae were small and triangulate. The zygomatic arch was short with moderate curvature at the jugal-squamosal margin, similar to that of *A. forsteri* but narrower at the anterior of the zygomatic arch as observed in *A. australis*. The sagittal and occipital crests were moderate in males, becoming larger in older specimens. Female *A. galapagoensis* showed little, if any, cresting. The preorbital processes were small and well defined. The PCs were large, with anterior and posterior accessory cusps that usually abutted against each other. The mandible was short and robust with the masseteric fossa deeper in older specimens (Plate 15).

Measured variables

Variables relating to length of skull were proportionately greater in males than in females, including gnathion–posterior end of nasals, palatal notch–incisors, basion–zygomatic root, gnathion–caudal border postglenoid process, and gnathion–caudal border of preorbital process. The remaining variables relating to length of skull were the same for both sexes, or proportionately smaller in males than in females. Male *A. galapagoensis* were larger than females in all but five variables relating to breadth of skull, in which males were proportionately smaller than females (breadth of skull at supraorbital processes, breadth of braincase, height of skull at ventral margin of mastoid, and length and breadth of orbit). For variables

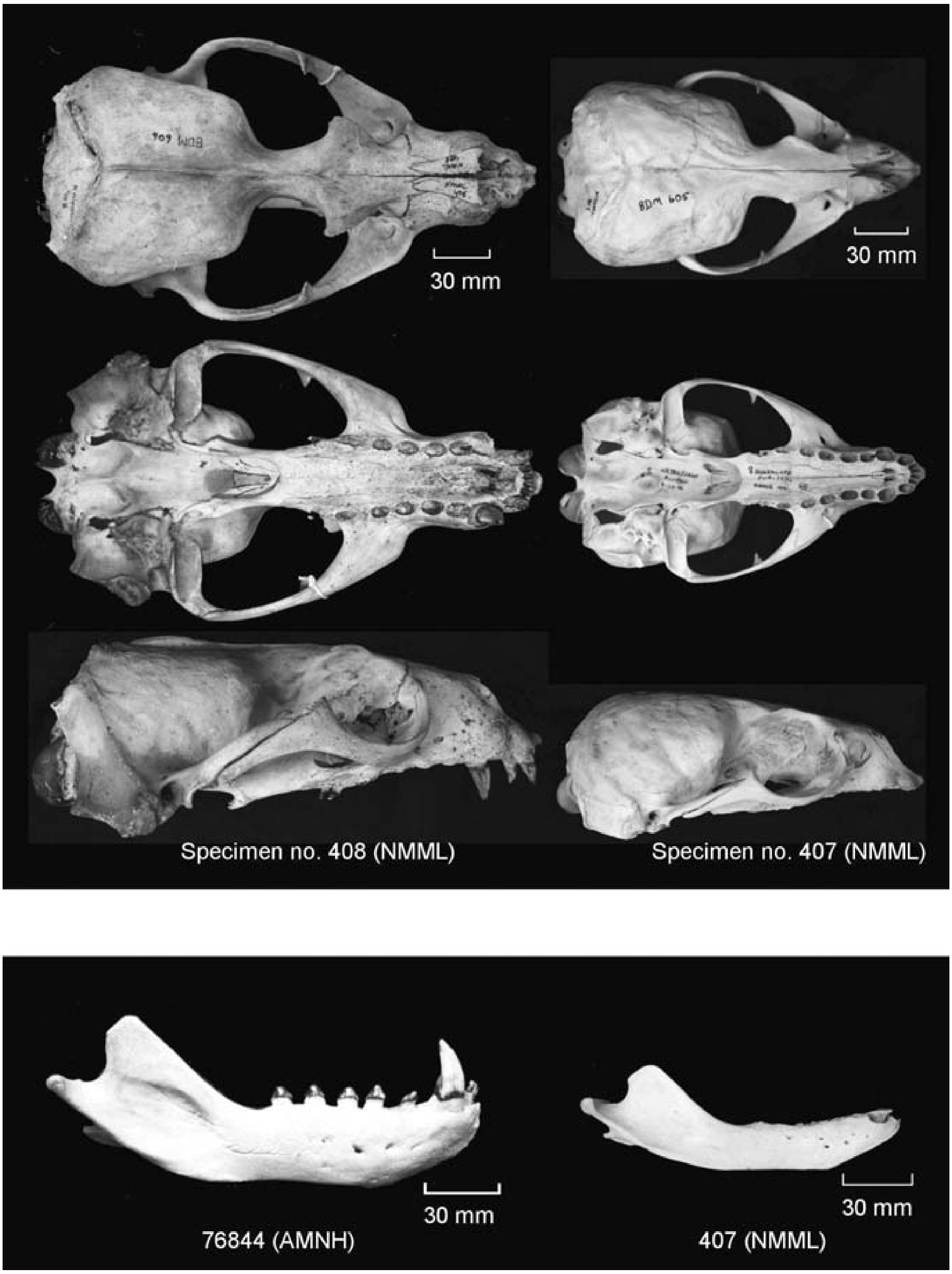


Plate 14 *Arctocephalus townsendi* – adult male (left), adult female (right).

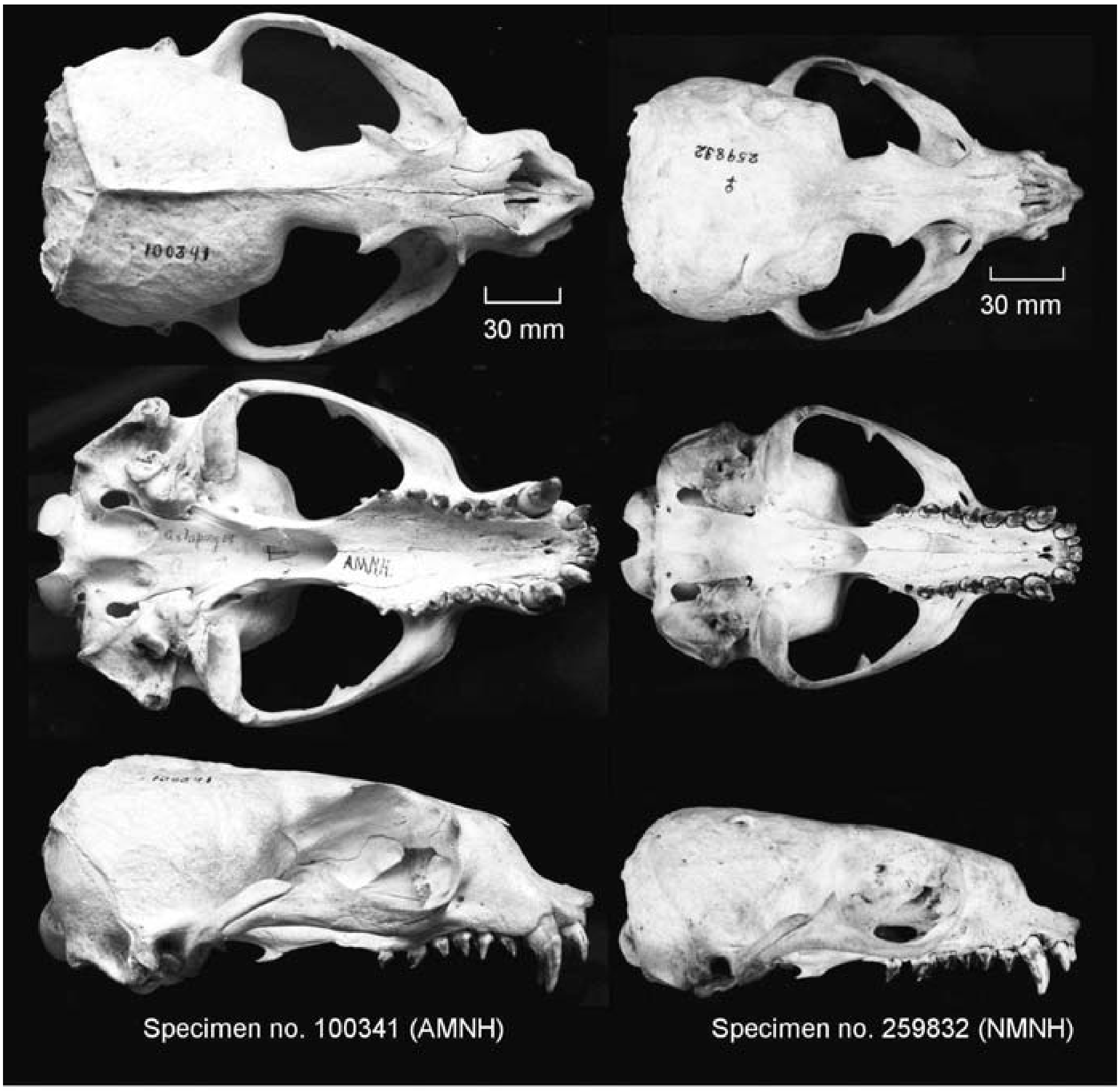
relating to the mandible and teeth, means relative to CBL showed males were smaller than females in mesiodistal diameter of PCs, distance behind border of upper canines, and length of lower PC row. Both sexes expressed the same means for breadth of masseteric fossa and length of mandibular tooth row. The remaining variables related to the mandible and teeth were proportionately larger in males.

Multivariate comparisons of male and female *A. galapagoensis* were not applied due to the small sample size of adult specimens (seven males and four females).

South American fur seal – *Arctocephalus australis* (Zimmerman, 1783)

General morphology

Specimens of *A. australis* were morphologically similar to those of *A. forsteri*. The rostrum was long, and narrow. The nasals were elongate and narrow at the junction with the frontal.



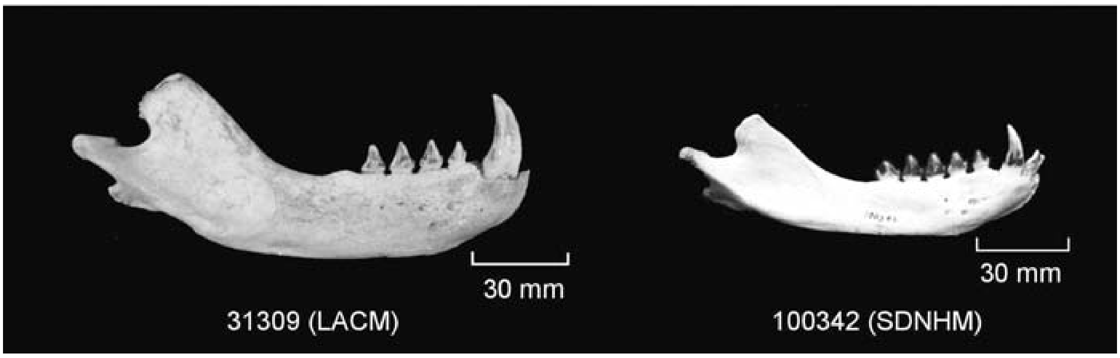


Plate 15 *Arctocephalus galapagoensis* – adult male (left), adult female (right).

The interorbital constriction was slender with well-defined supraorbital processes that extended posteriorly. As with *A. forsteri*, the frontal was generally flat or moderately convex in males, and usually flat in females. The auditory bullae were small and triangulate. The zygomatic arch was short with moderate curvature at the jugal-squamosal margin, similar to that of *A. forsteri* but narrower at the anterior of the zygomatic arch. The sagittal and occipital crests were well developed in males. Females, predominantly older specimens, possessed reduced sagittal and occipital crests. The preorbital processes were small and well defined. Structure of the PCs varied somewhat in the size of the anterior and posterior accessory cusps (some specimens had larger cusps, some smaller), but all showed the PCs abutting against each other. The mandible was

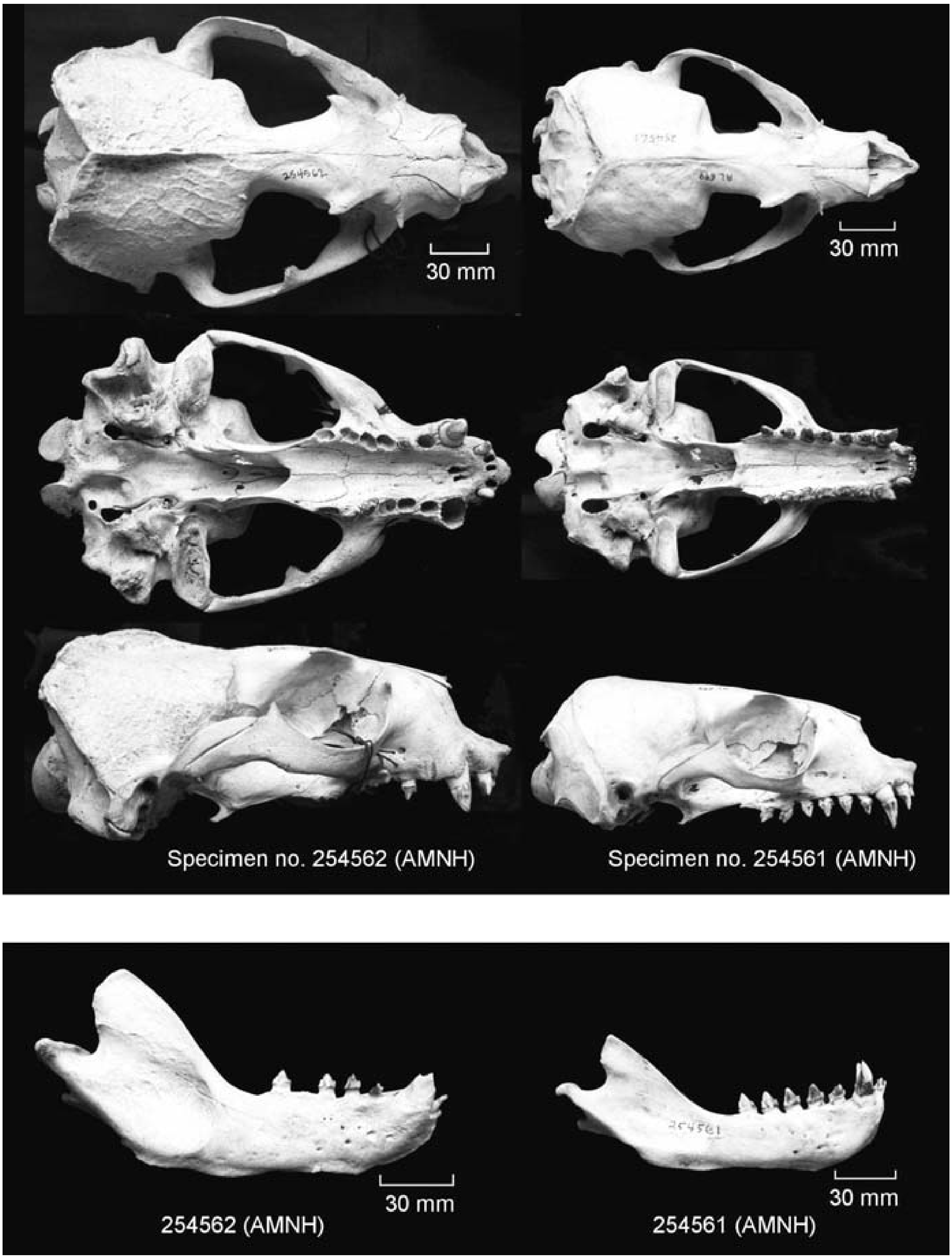


Plate 16 *Arctocephalus australis* – adult male (left), adult female (right).

relatively short with the masseteric fossa deeper in older specimens (Plate 16).

Measured variables

Male *A. australis* were proportionately larger than females in variables relating to length of skull, excluding three with the same means for both sexes (length of nasals, palatal notch–incisors, and gnathion–posterior of maxilla (palatal)). Males were comparatively smaller than females in basion–bend of pterygoid. For variables relating to breadth of skull, breadth of zygomatic root of maxilla, and height of skull at supraorbital processes showed the same mean values for both sexes, and three variables were comparatively smaller in males (breadth of braincase, and length and breadth of orbit). Means for the remaining 14 variables relating to breadth of skull were all greater for male *A. australis*, than for females. For variables relating to the mandible and teeth, males were proportionately smaller than females in height of canines above alveolus, distance behind border of upper canines and height of mandible at meatus. Both sexes showed the same mean values for length of lower PC row.

Multivariate analyses

Component 1 for adult female *A. australis* was influenced mainly by size of variables relating to breadth, or robustness, of skull and accounted for 76.3% of the total variance explained. Breadth of palate at PCs 3–4, 4–5 and 5 contributed the most variation showing large, positive coefficients. Component 2, a shape component, contributed another 10.2% to the total variance and was influenced primarily by basion–zygomatic root of maxilla (anterior) (−0.733), the only measurement in the analysis that related to length of skull. Component 3 was also a shape component and described a further 6.1% to the total variance. Occipital crest–mastoid (−0.474) contributed most to the variation described in Component 3.

The greatest within-sex variation for adult male *A. australis* was observed in Component 1 and accounted for 62.1% of the total variance. As with adult female *A. australis*, the most significant variables for adult males described by Component 1 were those related to breadth of skull, particularly auditory, mastoid and zygomatic breadth. Component 2 contributed another 16.9% to the total variance and was influenced primarily by breadth of skull at supraorbital processes and length of nasals, which were both reduced in magnitude (−0.694 and −0.681, respectively). Both of these measurements also contributed most to the variation described in Component 3.

Juan Fernandez fur seal – *Arctocephalus philippii* (Peters, 1866)

General morphology

Cranial morphology of *A. philippii* was similar to that of *A. townsendi*, but the skulls of *A. philippii* were the larger. The rostrum and nasals were long and narrow. The preorbital processes were long and larger in older specimens. Interorbital constriction and supraorbital processes were narrow, the latter angled ventrally. The frontal was long and slender, as was the palate which was deep at the canines. The upper canine roots were bulbous in male *A. philippii*, and the PCs were large, unicuspid and widely spaced, similar to those of *A. townsendi*. The zygomatic arch was long and thin at the squamoso-jugal margins. Auditory bullae were primarily rounded. A sagittal crest was present in subadult and adult males, and was reduced in females, rising from the posterior of the frontal to the occipital crest. An occipital crest was present in males. The mandible was elongate, usually with a narrow dentary and relatively shallow masseteric fossa (Plate 17).

Measured variables

Condylobasal length was considerably larger in male *A. philippii* than in females. Palatal notch–incisors and basion–zygomatic root were similar for both sexes of *A. philippii*, whereas the remaining measurements for variables relating to length of skull, relative to CBL, showed that male *A. philippii* were smaller than the female. Males expressed marked sexual dimorphism in most variables relating to robustness, excluding breadth of braincase, and length and breadth of orbit which were comparatively smaller in males than in females. Variables relating to the mandible and teeth were proportionately larger in male *A. philippii* than in females, excluding distance behind border of upper canines, length of mandibular tooth row and mesiodistal diameter of lower canines.

Multivariate statistics were not applied to this species as too few adult specimens were available (one male and one female).

A comparison of subspecies

The following describes variation of skull morphology within species of otariids that currently comprise subspecific groups; namely, *A. pusillus*, *Z. californianus* and *A. australis*.

Arctocephalus pusillus. Cranial characteristics for each sex were compared between adult *A. p. pusillus* and *A. p. doriferus*. Eight variables were used for maximum separation in two-group discriminant function analysis for males (Wilks' lambda = 0.18, $P < 0.0001$), and nine for females (Wilks' lambda = 0.34, $P < 0.0001$) (Fig. 2). Results showed that in both sexes the skull of *A. p. doriferus* was generally larger than that of *A. p. pusillus*. Male *A. p. doriferus* expressed the greatest intraspecific difference in CBL, with only moderate overlap with *A. p. pusillus* (Table 4). Relative to CBL, there was little difference in cranial morphology between *A. p. doriferus* and *A. p. pusillus*, which would be expected when comparing two closely related subspecies. Nevertheless, in absolute measurements (mm), the rostral region of *A. p. doriferus* was longer than that of *A. p. pusillus* (reflecting the greater CBL in the former subspecies) and the palate was wider.

Zalophus californianus. Variation in cranial morphology was also observed in specimens of adult *Z. c. californianus*, *Z. c. wollebaeki* and *Z. c. japonicus*. The 14 variables used in multi-group discriminant function analysis for males, and the 13 for females, provided maximum separation between groups (males: Wilks' lambda = 0.04, $P < 0.0001$; females: Wilks' lambda = 0.06, $P < 0.0001$). Figure 3 shows that skulls of *Z. c. californianus* and *Z. c. wollebaeki* grouped together with minor overlap, whereas those of *Z. c. japonicus* separated significantly from the other subspecies. Skulls of *Z. c. japonicus* were significantly larger than those of *Z. c. californianus* and *Z. c. wollebaeki*. Besides greater total skull length in *Z. c. japonicus*, other differences were observed. The sagittal crest in *Z. c. japonicus* was significantly larger and more rounded dorsally, than it was in *Z. c. californianus* and *Z. c. wollebaeki*; the zygomatic arch was thicker at the jugal-squamosal margin; the rostrum and palate were broader in *Z. c. japonicus*; the supraorbital processes were shorter and thicker; the angle between the dentary and the coronoid process was more acute; and, the dentary was broader dorso-ventrally. There were fewer significant differences found between *Z. c. californianus* and *Z. c. wollebaeki*, the main being that *Z. c. wollebaeki* was smaller (Table 5).

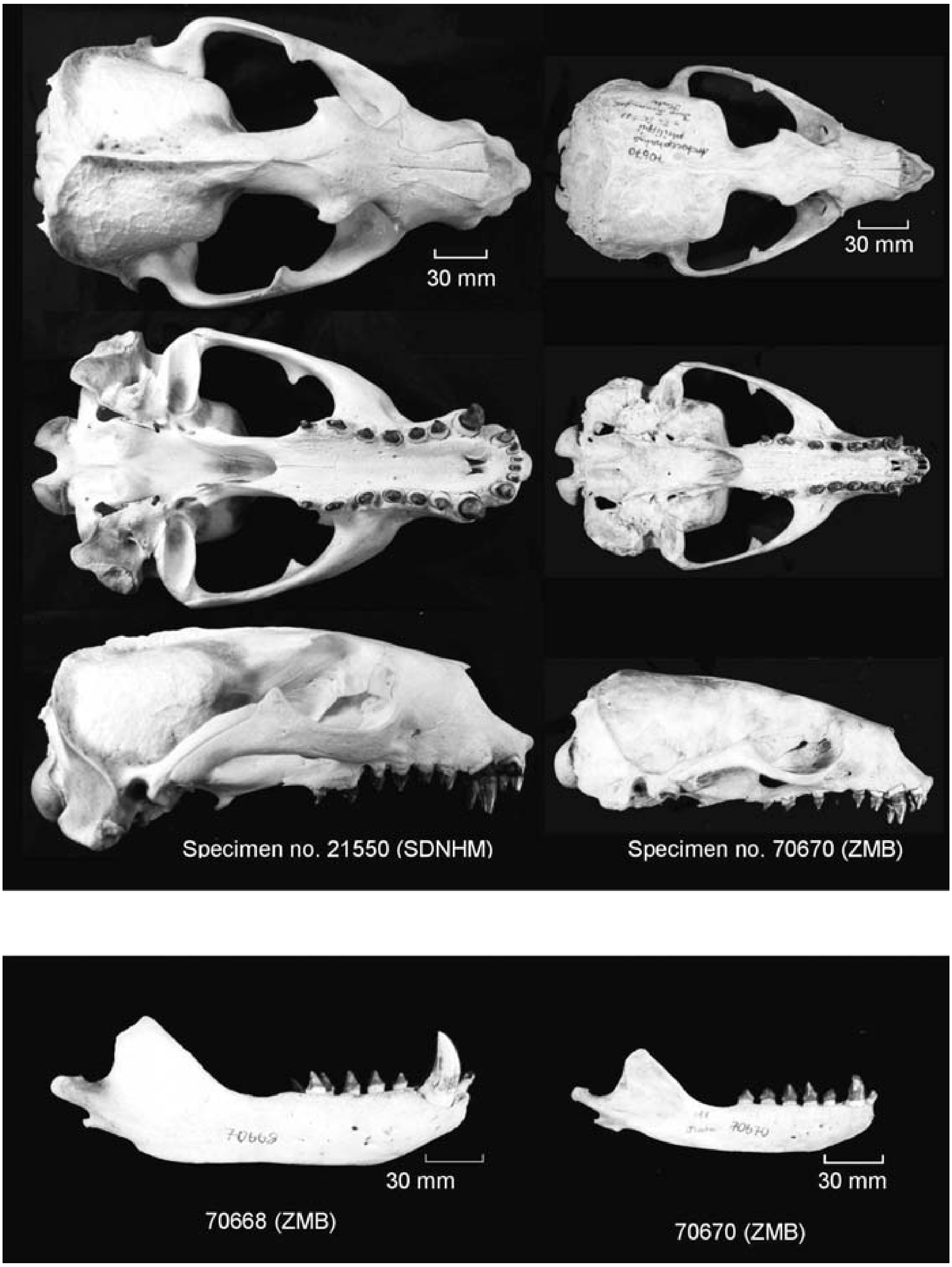


Plate 17 *Arctocephalus philippii* – adult male (left), adult female (right).

Arctocephalus australis. Fifteen variables were used for multi-group discriminant function analysis for male *A. australis* from Falkland Islands, Punta del Diablo, Argentina and San Juan, Peru. The scatterplot resulting from the discriminant function analysis shows specimens from the Falkland Islands and Punta del Diablo overlapped, while those from San Juan formed a separate group (Wilks' lambda $= 0.01$, $P = 0.001$) (Fig. 4a). Skulls from San Juan appeared to be shorter, yet more robust in mastoid and zygomatic breadth, than those from the Falkland Islands and Punta del Diablo. Separation of adult female *A. australis* into geographic groups (Punta del Diablo and San Juan) was also significant. Twelve variables used in the two-group discriminant function analysis provided maximum separation between the groups (Wilks' lambda $= 0.06$, $P = 0.003$) (Fig. 4b). Means for the 12 variables show that skulls of adult female *A. australis* from Punta del Diablo were

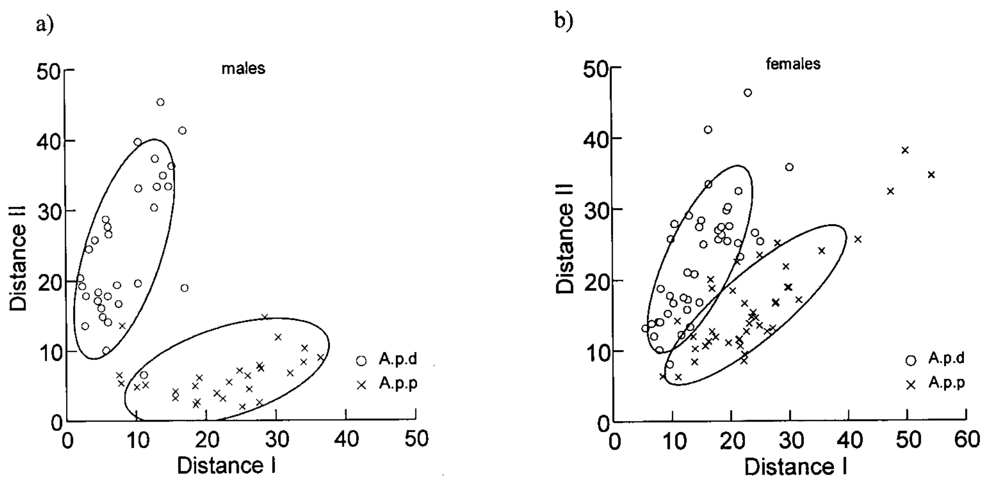


Figure 2 Mahalanobis distances with .95 confidence ellipses for adult male (a) and female (b) *Arctocephalus pusillus pusillus* (males: n = 34, females: n = 42) and *A. p. doriferus* (malaes: n = 44, females: n = 42).

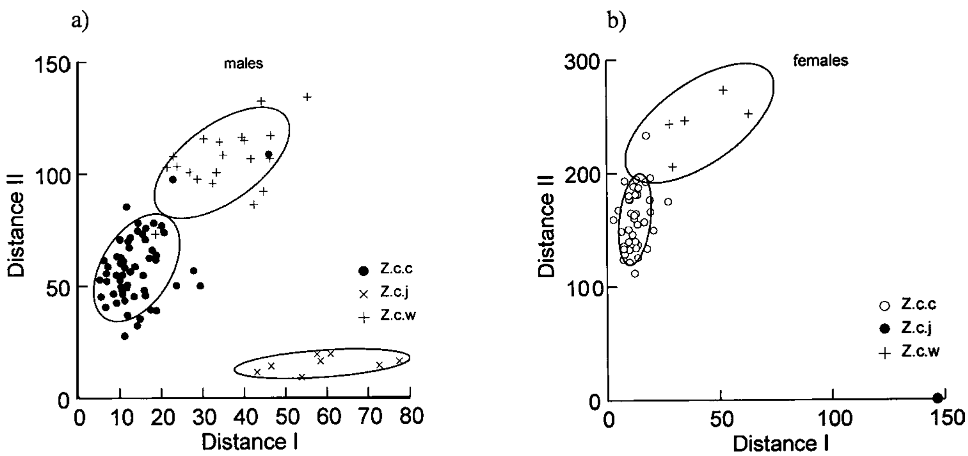


Figure 3 Mahalanobis distances with .95 confidence ellipses for adult male (a) and female (b) *Zalophus californianus californianus* (males: n = 57, females: n = 41), *Z. c. japonicus* (males: n = 8, females: n = 1) and *Z. c. wollebaeki* (males: n = 21, females: n = 5).

	A. p. doriferus **(mm)**			***A. p. pusillus*** **(mm)**		
Variable	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
Males						
Condylobasal length	282.02	7.60	265.77–302.15	269.67	6.44	254.86–280.50
Breadth of nares	37.34	2.13	32.75–43.60	33.96	3.47	25.21–41.16
Palatal notch–incisors	121.44	10.21	97.65–139.20	117.27	6.07	104.01–125.56
Gnathion–posterior of maxilla (palatal)	135.36	4.40	126.30–143.89	127.41	4.74	118.14–137.27
Basion–zygomatic root (anterior)	191.66	5.96	182.00–207.40	184.11	4.98	175.30–198.62
Gnathion–caudal border of preorbital process	94.96	3.96	84.33–101.65	91.69	3.42	83.83–98.00
Breadth of palate at postcanines 3–4	38.53	3.21	28.90–44.17	34.26	3.09	30.32–41.86
Breadth of palate at postcanines 4–5	42.77	3.35	36.07–48.37	37.09	3.87	25.73–45.16
Females						
Condylobasal length	226.22	6.88	207.52–238.41	217.41	9.27	196.54–235.19
Gnathion–middle of occipital crest	191.31	7.45	176.38–205.97	185.49	9.12	163.31–201.82
Breadth of skull at preorbital processes	56.42	2.99	49.57–63.50	55.78	3.50	48.44–67.76
Gnathion–posterior of maxilla (palatal)	107.64	4.38	96.04–117.04	101.92	5.76	86.35–112.52
Gnathion–caudal border postglenoid process	170.39	6.12	153.34–181.23	162.62	8.81	137.60–178.07
Basion–zygomatic root (anterior)	152.75	5.01	140.35–163.35	147.23	6.91	127.20–160.81
Basion–bend of pterygoid	70.51	2.53	63.70–77.61	68.47	3.05	61.42–73.39
Gnathion–foramen infraorbitale	69.57	2.87	63.41–77.02	68.15	4.39	58.43–78.91
Breadth of palate at postcanines 4–5	29.78	2.71	25.04–35.09	27.52	2.62	20.58–32.95

Table 4 Group means for adult male and female *Arctocephalus pusillus pusillus* (males: n = 34, females: (n = 42) and *A. p. doriferus* (males: n = 44, females: n = 42).

Variable	*Z. c. californianus* (mm) Mean	SD	Range	*Z. c. japonicus* (mm) Mean	SD	Range	*Z. c. wollebaeki* (mm) Mean	SD	Range
Males									
Condylobasal length	283.86	10.78	253.01–303.95	314.38	8.17	299.51–323.44	266.94	6.75	250.59–277.77
Breadth of nares	29.62	2.15	21.49–33.82	36.82	2.75	28.77–41.01	28.69	1.82	25.71–33.01
Breadth of skull at preorbital processes	82.56	5.21	70.63–93.26	95.75	4.97	85.06–102.88	70.41	3.74	62.59–78.27
Breadth of skull at supraorbital processes	69.14	7.20	52.14–87.08	80.62	5.02	70.22–86.93	68.44	5.78	60.27–81.28
Breadth of braincase	81.86	2.83	75.90–88.56	89.33	3.19	84.05–94.58	79.64	2.39	74.68–84.43
Occipital crest–mastoid	130.59	9.30	104.79–148.61	146.32	8.31	126.44–158.93	119.44	8.62	95.28–138.13
Zygomatic breadth	159.21	10.38	132.14–177.56	184.18	8.34	162.03–193.90	149.25	7.70	129.22–160.23
Basion–zygomatic root of maxilla (palatal)	189.35	6.42	115.78–143.76	210.90	7.27	137.13–160.84	175.01	5.53	109.68–132.43
Mastoid breadth	142.95	9.68	115.59–163.77	172.64	8.52	154.27–186.38	128.29	7.95	111.55–142.32
Basion – bend of pterygoid	81.25	4.03	73.54–89.28	93.83	5.89	84.76–108.49	78.82	4.61	70.97–93.26
Gnathion–caudal border of preorbital process	98.89	4.33	88.98–107.69	109.39	5.61	97.10–116.81	88.62	3.69	83.00–95.93
Height of skull at ventral margin of mastoid	106.64	7.16	90.84–121.90	120.07	6.77	108.51–134.32	97.89	5.67	84.33–110.93
Breadth of palate at postcanines 4–5	45.90	3.15	40.33–54.21	49.59	2.88	41.15–53.15	39.61	2.06	34.94–44.17
Breadth of palate at postcanine 5	45.01	3.37	38.69–52.85	46.83	3.21	38.96–53.12	40.03	2.17	35.06–46.23
Females									
Condylobasal length	231.31	6.05	221.30–247.77	242.00	–	–	231.77	6.47	223.73–239.17
Gnathion–middle of occipital crest	204.46	5.46	194.05–217.52	213.38	–	–	204.35	4.08	200.11–208.65
Breadth of skull at preorbital processes	58.65	2.77	53.07–66.52	66.49	–	–	54.40	1.96	52.00–57.47
Palatal notch–incisors	95.68	4.61	82.92–104.58	99.48	–	–	92.81	2.88	89.20–96.84
Distance behind border of upper canines	54.91	3.92	48.63–64.19	66.92	–	–	59.36	4.42	51.56–62.36
Gnathion–posterior of maxilla (palatal)	106.51	3.52	97.09–114.24	113.03	–	–	104.38	1.97	102.26–107.25
Breadth of zygomatic root of maxilla	11.74	1.22	8.95–14.28	14.79	–	–	11.69	1.09	10.70–13.45
Breadth of orbit	46.93	1.16	44.22–49.22	50.67	–	–	45.94	0.83	44.82–46.85
Auditory breadth	91.64	2.05	88.09–96.27	102.80	–	–	89.66	2.38	87.26–93.46
Basion–bend of pterygoid	67.44	2.55	62.50–73.88	78.79	–	–	71.25	6.53	64.05–81.56
Breadth of palate at postcanines 3–4	30.40	1.61	25.88–33.24	31.97	–	–	31.27	1.96	28.85–34.01
Breadth of palate at postcanines 4–5	34.06	1.85	30.39–37.75	37.12	–	–	35.99	1.32	34.81–37.52
Breadth of palate at postcanines 5	34.04	1.96	29.59–38.34	35.43	–	–	35.96	1.62	33.62–37.46

Table 5 Group mean, standard deviation and range for adult *Zalophus californianus californianus* (males: n = 57, females: n = 41), *Z. c. japonicus* (males: n = 8, females: n = 1) and *Z. c. wollebaeki* (males: n = 21, females: n = 5).

smaller in all but one variable (gnathion–foramen infraorbitale) than those from San Juan. In specimens of *A. australis*, females from Peru were larger than those from the Falkland Islands, whereas skulls of males from Peru appeared shorter but more robust than those from the Falkland Islands and Punta del Diablo (Table 6).

The Otariidae

Results from the hierarchical cluster analysis, using single linkage R-squared distances, indicate an initial grouping of the Otariidae from the brown bear, *Ursus arctos* (Fig. 5). Within the Otariidae, *O. byronia* separated from the remaining otariids. *Callorhinus ursinus* was separate from all the fur seals, whereas the cluster comprising *Arctocephalus*, *A. p. pusillus* and *A. p. doriferus* grouped together closely, as did *A. forsteri* and *A. australis*. *Arctocephalus tropicalis* and *A. galapagoensis* also remained within the genus *Arctocephalus*, as did *A. gazella* which, on the periphery of this cluster, was still included within the genus. Most notably, Figure 5 illustrates a close relationship between *A. philippii* and *A. townsendi*, yet did not incorporate them within the genus *Arctocephalus*. The genus *Zalophus* was placed closer to the fur seals than the sea lions, which indicates the 'Arctocephalinae' and 'Otariinae' may not be reciprocally monophyletic. *Arctocephalus townsendi* and *A. philippii* were the furthest removed from

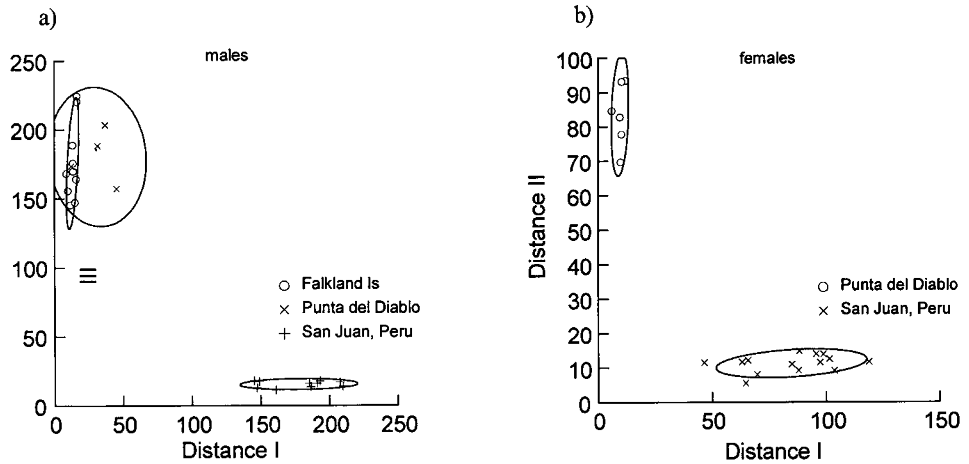


Figure 4 Mahalanobis distances with .95 confidence ellipses for adult male (a) and female (b) *A. australis* from Falkland Island (males: n = 9), Punta del Diablo, Argentina (males: n = 4, females: n = 6) and San Juan, Peru (males: n = 14, females: n = 10).

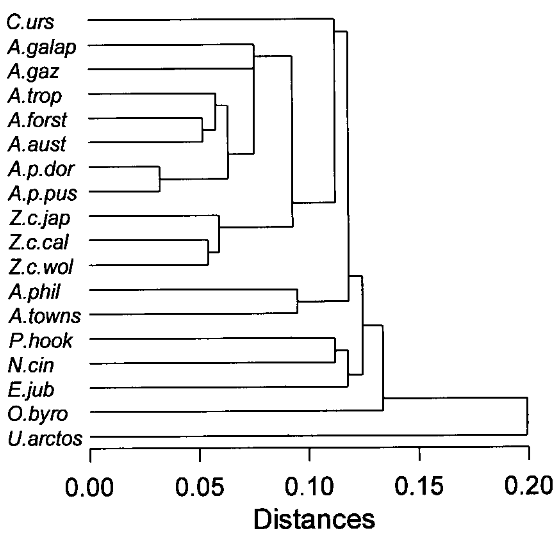


Figure 5 Hierarchical cluster tree for the family Otariidae with brown bear *Ursus arctos* as outgroup, based on skull measurements of adult males, using single-linkage R-squared distances. (*A. towns = Arctocephalus townsendi, A. phil = A. philippii, Z. c. woll = Z. c. wollebaeki, Z. c. c = Z. c. californianus, Z. c. j = Z. c. japonicus, A. gaz = A. gazella, A. p. pus = A. p. pusillus, A. p. dor = A. p. doriferus, A. a = A. australis, A forst = A. forsteri, A. trop = A. tropicalis, A. galap = A. galapagoensis, C. urs = Callorhinus ursinus, N. cin = Neophoca cinerea, P. hook = Phocarctos hookeri, E. jub = Eumetopias jubatus, O. byro = Otaria byronia*).

other species of *Arctocephalus*, close to the genus *Zalophus*, which again does not support subfamilial separation on phenetic grounds.

Discussion

The Pinnipedia are diagnosed systematically by a suite of derived morphological characters that distinguish them from terrestrial mammals and other marine mammals. Pinnipeds, including the Otariidae, possess cranial morphology that differs fundamentally from that of terrestrial mammals. As described by Berta & Sumich (1999), these include:

1 *Large orbit* – The orbit in pinnipeds is large, both in absolute size and relative to the body, compared with that of terrestrial mammals.
2 *Large infraorbital foramen* – The infraorbital foramen is large in pinnipeds contrasting with its small size in most terrestrial carnivores.
3 *Maxilla forms a significant part of the orbital wall* – The maxilla of pinnipeds forms part of the lateral and anterior walls of the orbit. In terrestrial carnivores, the maxilla is usually limited in its posterior extent by contact of the jugal, palatine, and/or lacrimal.
4 *Lacrimal absent or fusing early in ontogeny and does not contact the jugal* – The lacrimal is greatly reduced or absent in pinnipeds. In terrestrial carnivores, the lacrimal contacts the jugal or is separated from it by a thin sliver of the maxilla.

The overall shape of the skull in both sexes is unique within a given species of otariid. For instance, in skulls of *A. forsteri* both males and females exhibit the same general shape (e.g. broad anterior zygomatic arch, small triangular auditory bullae), yet the muscle-attaching components are always greater in males. The extreme sexual dimorphism in size of otariids is reflected in the skulls of all otariid species (Brunner, 2000; Brunner *et al.*, 2002).

Phylogenetic relationships

In a study of cytochrome *b* and 12SrRNA, Lento *et al.* (1995, 1997) revealed paraphyly among both fur seals and sea lions, although their studies did not include representatives of all species of otariids. A currently accepted phylogeny for the Otariidae described by Berta & Sumich (1999) indicates that *C. ursinus* diverged early (shortly after *Pithanotaria*), then a monophyletic *Arctocephalus* diverged, followed by the appearance of sea lions (*Zalophus* diverging first, then *Eumetopias*

	Falkland Island (mm)			Punta del Diablo (mm)			San Juan, Peru (mm)		
Variable	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Males									
Gnathion–middle of occipital crest	208.93	4.70	201.34–217.13	208.50	5.36	202.26–213.85	205.71	7.76	193.82–216.36
Breadth of nares	30.97	2.22	26.74–34.05	32.02	1.96	29.61–33.88	31.74	1.90	29.44–35.53
Interorbital constriction	34.29	3.73	29.76–41.05	34.89	3.26	30.69–37.80	34.42	3.40	30.51–41.67
Breadth of skull at supraorbital processes	52.14	4.56	44.94–59.96	55.60	4.48	50.71–61.43	50.22	5.06	40.87–57.03
Occipital crest–mastoid	109.54	6.61	99.90–121.18	111.66	7.97	103.41–122.43	111.23	5.09	102.28–115.96
Palatal notch–incisors	104.36	6.76	94.29–114.92	97.57	3.20	93.99–101.76	102.47	6.94	93.35–113.05
Distance behind border of upper canines	58.49	2.23	56.25–63.94	56.74	1.39	55.35–58.66	60.83	4.32	49.83–66.07
Zygomatic breadth	139.68	7.74	125.53–155.37	141.43	7.27	132.04–149.78	143.97	5.62	129.58–148.62
Basion–zygomatic root of maxilla (palatal)	166.15	5.92	156.38–173.00	160.75	5.03	156.26–167.94	167.18	6.22	153.77–176.09
Mastoid breadth	129.52	7.35	115.27–143.76	129.07	4.88	124.01–135.24	133.50	6.46	119.71–140.44
Gnathion–foramen infraorbitale	84.04	11.10	52.21–95.38	81.27	8.96	75.17–94.53	80.93	4.35	75.92–90.71
Gnathion–caudal border of preorbital process	77.79	1.80	74.50–80.82	77.45	1.84	74.90–79.23	78.14	2.69	72.30–82.10
Height of sagittal crest	8.19	3.13	3.58–12.77	10.10	2.12	7.56–12.53	8.30	2.72	5.64–13.88
Breadth of palate at postcanines 3–4	32.59	2.26	30.15–36.91	29.23	3.21	24.71–31.79	32.48	2.53	26.29–34.90
Breadth of palate at postcanines 4–5	35.75	2.97	31.44–40.99	32.41	2.23	29.71–35.12	36.65	2.75	32.02–40.20
Females									
Occipital crest–mastoid	–	–	–	86.19	4.09	80.10–90.93	89.77	4.05	81.68–97.13
Distance behind border of upper canines	–	–	–	51.66	3.94	45.27–56.15	53.43	2.66	46.26–56.21
Rostral width	–	–	–	33.99	2.06	30.26–36.60	38.58	2.52	34.40–41.59
Gnathion–posterior of maxilla (palatal)	–	–	–	93.61	5.96	85.16–101.28	97.55	3.29	91.20–103.16
Breadth of zygomatic root of maxilla	–	–	–	12.81	1.67	11.29–15.98	14.40	1.24	12.29–16.93
Gnathion–caudal border postglenoid process	–	–	–	145.33	8.91	130.45–156.00	154.50	3.39	149.43–160.82
Basion–bend of pterygoid	–	–	–	64.44	3.37	58.24–68.05	67.65	2.31	63.20–70.58
Gnathion–foramen infraorbitale	–	–	–	66.54	5.48	60.62–76.02	64.71	2.89	61.36–70.58
Gnathion–caudal border of preorbital process	–	–	–	61.23	3.69	54.83–65.04	62.27	2.33	57.45–65.81
Height of skull at supraorbital process	–	–	–	57.58	3.91	50.09–61.50	58.73	1.75	55.73–62.94
Height of skull at ventral margin of mastoid	–	–	–	73.76	3.73	69.16–79.38	74.48	3.72	69.98–84.13
Breadth of palate at postcanine 5	–	–	–	26.29	1.74	24.79–29.26	30.55	2.07	26.79–33.77

Table 6 Group means for adult *Arctocephalus australis* from the Falkland Islands (males: n = 10, females, n/a), Punta del Diablo, Argentina (males: n = 4, females, n = 6) and San Juan, Peru (males: n = 10, females: n = 10).

and finally *Otaria*). The dendogram based on cranial morphometrics from this study shows a different structure from that described by Berta & Sumich (1999), one that is more congruent with the recent genetic data of Wynen *et al*. (2001), with some exceptions. Results from the morphometric study described here show *Otaria* separate from all other otariids, the grouping of a sea lion complex comprising *E. jubatus*, *N. cinerea*, and *P. hookeri*, and another containing the remaining Otariidae. Within the latter, *A. philippii* and *A. townsendi* separated from the *Arctocphalus* complex, yet grouped with each other. *Callorhinus ursinus* was separate from the remaining *Arctocephalus*. *Zalophus* formed one group close to the *Arctocephalus* complex, whereas the remaining *Arctocphalus* formed the other. Within *Arctocephalus*, *A. forsteri* and *A. australis* formed a close group, as did *A. p. pusillus* and *A. p. doriferus*.

Berta & Wyss (1994) suggested the *Arctocephalus* were more closely related to sea lions than to *Callorhinus*. Indeed, from this study the *Arctocephalus* (excluding *A. philippii* and *A. townsendi*) appeared more closely related to *Zalophus* than they did to *C. ursinus*. Nevertheless, based on this morphometric study *C. ursinus* appears more closely related to the *Arctocephalus*–*Zalophus* complex than it does to the other sea lions.

Kim *et al*. (1975) suggested that *C. ursinus* is a specialized offshoot of the Arctocephaline stem, based on external parasites. Results from this study support their hypothesis, in that cranial morphology of *C. ursinus* is significantly different from that of other otariids, particularly at the rostrum and canines, but appears morphologically closer to *Arctocephalus* and *Zalophus* than to *A. philippii*, *A. townsendi* and the remaining otariids. Significant differences between skulls of the genera *Callorhinus* and *Arctocephalus* can be found primarily in the structure of the rostrum and the angle of the canines. The facial angle of *Callorhinus* is abrupt (less than 125°) whereas for *Arctocephalus* it is more than 125° (King, 1983). The canines of *Callorhinus* are angled vertically, compared with the more curved canines of *Arctocephalus*. The PCs of *C. ursinus*, although not as reduced as those of *A. gazella*, are small and reminiscent of this latter species.

Data from the hierarchical cluster analysis suggest *C. ursinus* may have diverged after *A. philippii* and *A. townsendi*. From a genetic perspective, Wynen *et al*. (2001) and Bininda-Emonds *et al*. (1999) found that *C. ursinus* was basal to the remaining fur seal and sea lion taxa; this was only partially reflected in the present morphological study, with *C. ursinus* appearing basal to the *Arctocephalus–Zalophus* group, but not to the remaining otariids.

Repenning *et al*. (1971) suggested that possibly all species of *Arctocephalus* have a relationship to, and perhaps an origin from, *A. australis* due to one common trait, the evolution of simplified PC structures. An extinct, ancient otariid, *Arctocephalus fischeri*, was described from a left mandible found in Miocene fossil beds, Province of Paraná, Argentina. The specimen resembled closely that of *A. australis* (Kellogg, 1922). Conversely, later work on the Miocene fossils *Thalassoleon* and *Pethanotaria*, which were shown to possess simple PCs, suggested that modern otariids with well-developed cusps such as *A. australis* and *A. pusillus*, are more advanced (Repenning & Tedford, 1977). Results from this study indicate a strong morphological link between at least three species of *Arctocephalus* (*A. australis*, *A. forsteri* and *A. galapagoensis*), supporting subspecific status described by Scheffer (1958) and King (1954), and genetic results of Wynen *et al*. (2001). Results from the hierarchical cluster analysis also support the late appearance of the genus *Arctocephalus* as indicated by Repenning & Tedford (1977).

Wynen *et al*. (2001) show *A. pusillus* falling well within the *Arctocephalus*, again congruent with the morphometric data within this study. Repenning *et al*. (1971), Stirling & Warneke (1971), Trillmich & Majluf (1981), and Goldsworthy *et al*. (1997) stated that *A. pusillus* is phenotypically intermediate between fur seals and sea lions. Nevertheless, results from Wynen *et al*. (2001) and data from this study do not reflect a close phylogenetic affinity with any sea lion lineage; they appear to be well within the genus *Arctocephalus*.

Systematics and taxonomy

Division of the Otariidae into subfamilies on the basis of abundant underfur has long been considered dubious (e.g. Repenning & Tedford, 1977), particularly since that character may have evolved more than once among the otariids (Repenning *et al*., 1971; Lento *et al*., 1995). Lento *et al*. (1995) noted that genetic evidence of more than one appearance of underhair was supported by a study of three mtDNA genes in an extended survey of otariine taxa. Results from this, and other, morphological and genetic studies indicate the separation between the 'subfamilies' Arctocephalinae and Otariinae, as frequently described, is redundant. At the time of writing, only one genetic review for the entire family Otariidae has been published (Wynen *et al*., 2001); they found no support for the recognition of the two subfamilies, based on analyses of mtDNA. Árnason *et al*. (1995) studied the molecular systematics of pinnipeds (including four species of otariids: *Z. californianus*, *E. jubatus*, *A. gazella* and *A. forsteri*) and found the two otariid subfamilies separated but the bootstrap value for the Otariinae was low (51), as were nucleotide differences between subfamilies, approximately 8.5% (sea lions – 5.0%, fur seals – 6.1%).

As with the change in use of subfamily delineations within the Otariidae, the current taxonomic structure of genera also requires amendment. For instance, atypical *Arctocephalus* morphology is observed in skulls of *A. philippii* and *A. townsendi*. Primarily, both species possess a narrower, more elongated skull, than observed in other species of *Arctocephalus*. The rostrum is significantly longer, and the PCs are without accessory cusps and spaced apart, unlike those in *A. forsteri*, *A. australis*, *A. galapagoensis*, *A. p. pusillus* and *A. p. doriferus* (refer Repenning *et al*., 1971). Also, zygomatic breadth is narrower in *A. philippii* and *A. townsendi* than it is in other species of *Arctocephalus*. Few morphological differences between *A. philippii* and *A. townsendi* are apparent, yet both exhibit marked structural differences from other species of the genus. *Arctocephalus townsendi* is generally smaller than *A. philippii* (e.g. body length of *A. townsendi* males = 180 cm, females = 120 cm; *A. philippii* males = 200 cm, females = 140 cm) (Bonner, 1994). The significantly elongated rostrum in both species is accentuated by a bulbous terminal rhinarium and ventrally angled nostrils, a trait found in no other species of *Arctocephalus* (Repenning *et al*., 1971). Wynen *et al*. (2001) found the divergence of mtDNA between *A. philippii* and *A. townsendi* to be very low ($D_a = 0.004$) and questioned the retention of these as separate species. They also described a significant divergence between the *A. townsendi*/*A. philippii* group and the remaining *Arctocephalus*, showing congruence with morphometric data presented here.

Scheffer (1958), King (1954) and others considered *A. philippii* and *A. townsendi* to be subspecies of *A. philippii* because of their morphological similarities. Sivertsen (1954) also considered both species as a separate genus, *Arctophoca*, because the skulls of *A. townsendi* and *A. philippii* are exceptionally narrow compared with those of *Arctocephalus*. The distance from the middle of the occipital crest to the mastoid processes in *A. philippii* and *A. townsendi* is very short, the condyles of the mandible are 'particularly narrow', and the diastema between PCs is large, compared with that of *Arctocephalus*. Conversely, Repenning *et al*. (1971) noted '. . . the *philippii-townsendi* complex is in some ways distinctive, but classing these two species in a separate genus, *Arctophoca*, seems unwarranted'. Repenning *et al*. (1971) analysed a small sample size[1] of skulls of mixed age and sex, basing their conclusions on these. Since Repenning *et al*. (1971), there has not been another taxonomic revision of these seals, with most researchers accepting unquestioningly the species as part of the genus *Arctocephalus*.

Both *A. philippii* and *A. townsendi* possess relatively docile dispositions (King, 1983) and appear to have similar habits, including hauling out on lava rock at the base of cliffs (Hubbs & Norris, 1971). Also, only *A. townsendi* approaches *A. philippii* in the duration of its foraging cycle (Francis & Boness, 1998) which is approximately 11.5 days at sea and 5.0 days on land (Figueroa, 1994). Both species occur in the western Pacific, off the coasts of America (*A. townsendi* to the north, primarily at Guadalupe Island, *A. philippii* to the south, primarily at Juan Fernandez Island). Thus, both species at one point may have occurred sympatrically.

There are few morphological differences between skulls of *A. philippii* and *A. townsendi* other than size, which indicates strongly that separation into species is not warranted. The difference in size may perhaps reflect an adaptation to environmental factors such as water temperature and primary productivity. *Arctocephalus philippii* inhabits more cold-temperate latitudes than *A. townsendi* and thus may have become larger, as is the trend in other otariids (Brunner, 2000, 2002). Results from this study, and data from genetic, behavioural and other morphological research indicate that both species should, in fact, be considered subspecies and form a genus separate from the remaining species of *Arctocephalus*, as *Arctophoca philippii philippii* and *Arctophoca philippii townsendi*.

From the analyses, *O. byronia* grouped separately from the remaining otariids, rather than falling within a monotypic group of otariines, as would be expected from two distinct subfamilies. *Otaria byronia* is by far the most robust of the Otariidae, with unique and instantly recognizable cranial morphology. Particularly, the palate of this species is unlike that of any other otariid, and is reminiscent of the palate found in the walrus, *Odobenus rosmarus*. Results from this study conflict with those of previous genetic and phylogenetic research, and should be considered with caution. Further studies on the origins of *O. bryonia* would be beneficial.

The sea lions *E. jubatus*, *N. cinerea* and *P. hookeri* formed a separate morphological group within the Otariidae, indicating relatively close similarities and, with particular regard to *N. cinerea* and *P. hookeri*, probably a close ancestral link. In pelage appearance, female *P. hookeri* are virtually identical to female *N. cinerea*, silvery-grey dorsally and creamy ventrally. Male *N. cinerea* and *P. hookeri* are similar in size, are light coloured when first moulted from their natal coat, and both darken with age (Marlow, 1975; Bonner, 1994). Both *N. cinerea* and *P. hookeri* were once considered to be within the genus *Neophoca* (Sivertsen, 1954; Scheffer, 1958). Scheffer (1958) believed the differences between *N. cinerea* and *P. hookeri* were not of generic importance, but that they should retain the specific names *cinerea* and *hookeri* in order to identify the two populations. Although the geographic proximity of *Neophoca cinerea* and *Phocarctos hookeri* would suggest a close relationship, Wynen *et al*. (2001) found no genetic evidence of this in their data, although they did describe a close intergeneric relationship, as did Bininda-Emonds *et al*. (1999). A major biological difference between these species is that *N. cinerea* experiences a unique 18 month breeding cycle, whereas the breeding season for *P. hookeri* is yearly, beginning in December (Ling & Walker, 1978). There are also major differences in breeding behaviour, in that male *P. hookeri* possess a more ritualized defence of territory, whereas male *N. cinerea* are more aggressive but will desert a chosen territory if no females appear (Marlow, 1975). Marlow (1975, p. 227) stated that "... the considerable differences in behaviour which exist between *Neophoca cinerea* and *Phocarctos hookeri* leave no doubt whatsoever that they are different species ... Moreover, these differences are sufficiently great to make it doubtful that any advantage could be gained by combining them in one genus". Results from this study highlight the morphological similarities of the skull of *N. cinerea* and *P. hookeri*, yet they vary sufficiently in other biological respects for them not to be considered congeneric.

Interestingly, specimens of *E. jubatus* fell within the cluster containing *N. cinerea* and *P. hookeri*. Proportions of the skull, relative to CBL, are similar between these genera, although *E. jubatus* is by far the largest. Besides size, the most conspicuous differences between *E. jubatus* and the latter genera include the shape and position of the PCs, dimensions of the auditory bullae and palatal breadth. The PCs in *E. jubatus* are large, unicuspid and possess a significant diastema between maxillary PCs four and five. Postcanines of *N. cinerea* and *P. hookeri* are smaller, have anterior and posterior accessory cusps and show no obvious diastema. Other than these features, *E. jubatus* resembled similar structural morphology as *N. cinerea* and *P. hookeri*.

Arctocephalus australis was recognized as two subspecies by King (1954) and subsequently by Rice (1998) and others who based their assumptions on King's (1954) research. King (1954) suggested *A. australis* should be classified into two subspecies, a 'larger' form, *A. a. gracilis*, found on the Falkland Islands and a 'smaller' form, *A. a. australis*, from the mainland. Subsequently, Bonner (1981) found that three skulls of *A. galapagoensis* were included in King's mainland sample of 11 specimens, thus casting doubt upon King's analysis. Results from this study, using significantly larger sample sizes and accurate species identification, supports King's subspecific separation, although specimens from Punta del Diablo were morphologically closer to *A. a. australis* than to *A. a. gracilis*, thus should also be included in the former group. Results from this study support conclusions of King (1954) in that there are significant differences between *A. australis* from the Falkland Islands (*A. a. australis*) and those from Peru on the mainland of South America (*A. a. gracilis*) although the patterns in skull size differ between males and females.

From multivariate analyses, specimens of *A. australis* clustered closely with those of *A. forsteri*. Cranial morphology

[1] Skulls from *A. philippii*: three adult males, one subadult male and one immature male, plus one possible female. Skulls from *A. townsendi*: two adult males (plus three partial crania), two subadult males plus one subadult female, two juvenile males plus one juvenile female.

for these two species differed little; both multivariate and bivariate analyses expressed similarities to an extent found when comparing subspecies such as *A. p. pusillus* and *A. p. doriferus*. For instance, when comparing *A. forsteri* and *A. australis*, results from the *t*-tests showed 51% of measured variables in males and 56% in females showed no significant differences. When comparing *A. p. pusillus* and *A. p. doriferus*, 44% of measured variables for both males and females showed no significant differences. Nevertheless, the anterior of the zygomatic arch was broader in *A. forsteri* than in *A. australis*. Male *A. forsteri* had a mean CBL approximately 5 mm less than that for male *A. australis*. There was no significant difference in CBL between females of both groups.

Repenning *et al*. (1971, p. 21) stated that although the shape of PCs varies in *A. australis* (with some specimens possessing PCs with prominent anterior and posterior accessory cusps), some specimens "... have postcanines that consist almost entirely of a single main cusp, with only a slight suggestion of anterior accessory cusp, and that are very similar to the postcanines of some specimens of *A. forsteri* ...". Morphological data from this study confirm the similarities in structure of the PCs for both species, as described by Repenning *et al*. (1971). Striking morphological similarities between *A. forsteri* and *A. australis* were also apparent in other cranial characteristics. These include CBL, length and curvature of the zygomatic arch, rostral width, length of the palate, shape and size of the auditory bullae, size of canines, length of nasals, height of skull at supraorbital processes, shape and angle of the mastoid processes, and size and shape of sagittal and occipital crests.

There are other biological similarities between *A. australis* and *A. forsteri*, including breeding and behavioural characteristics. The breeding season for *A. australis* begins in November, the males are polygynous, but do not gather females into harems (King, 1983). Pups are born in November and December weighing 3–5 kg at birth, after which adults mate in late November and December, approximately 6–8 days post-parturition, and breeding groups begin to break up by the beginning of January (King, 1983). For *A. forsteri*, breeding occurs mainly through November and December, pups are born between late November and mid-January, with a peak in mid-December (King, 1983). Most copulations are in December (New Zealand) and January (Australia). During January, there is a general breakdown of the harem system as the males depart to sea. At birth, the pups weigh about 3.5 kg (King, 1983). The primary conclusion drawn from this study for these two species, in combination with other biological factors described by previous researchers, is that *A. australis* and *A. forsteri* are similar enough to be considered subspecies.

King (1954) considered *A. galapagoensis* conspecific with *A. australis*, and Scheffer (1958), too, treated it as a subspecies of the latter. Data from this study confirm that cranial morphology of *A. galapagoensis* is similar in most respects to that of *A. australis* and *A. forsteri*, when compared as a proportion of CBL. When skull characters of *A. galapagoensis* and *A. australis* were compared relative to CBL, 67% in males and 56% in females showed no significant differences. These results describe less variation than what is found in closely related subspecies such as *A. p. pusillus* and *A. p. doriferus* (Brunner, 2000). The PCs for *A. galapagoensis* were described previously by Repenning *et al*. (1971); although they had small sample sizes (and the fact that the structure of PCs varies somewhat within species of otariids), the most common PC shape for *A. galapagoensis* is similar to that of *A. australis* and *A. forsteri*. Wynen *et al*. (2001) described a close genetic relationship between *A. australis*, *A. forsteri* and *A. galapagoensis*, which is congruent with the morphometric results described here. Thus, it appears strongly that *A. galapagoensis* is morphologically and genetically similar enough to be considered a subspecies of *A. australis*.

Arctocephalus p. pusillus and *A. p. doriferus* were once considered separate species, primarily because of the great geographic separation between both, until Repenning *et al*. (1971) reviewed the taxonomy and found no characteristics to sharply differentiate one from the other. Warneke & Shaughnessy (1985), King (1983) and others later confirmed their conspecific status. Cruwys & Friday (1995) suggested *A. p. pusillus* and *A. p. doriferus* be considered separate species because *A. p. doriferus* displays a greater degree of sexual dimorphism in CBL than does *A. p. pusillus*. Results from the cluster analyses in this study, and multivariate analyses in previous research (Brunner, 1998*b*), support *A. p. pusillus* and *A. p. doriferus* as subspecies and indicate few significant differences between them that would warrant specific separation. *Arctocephalus pusillus* appears to be a large species of the genus *Arctocephalus* rather than a morphometric simile of any other otariid genera, and should remain within the genus *Arctocephalus*.

The difference in skull size may have evolved as a consequence of variation in water temperature between Eastern Cape waters of South Africa, and Australia. The mean surface water temperature at Algoa Bay was recorded at 19 °C (Ross, 1984), while that of the southern coasts of Victoria and Tasmania was 14–15 °C (Ross & Cockroft, 1990). Variation of size was also found within the subspecies *A. p. pusillus* (Brunner *et al*., in press), in that skulls of males from south-east South Africa were smaller than those from Namibia and south-west South Africa. This may indicate variation in climate and resources, and suggests restricted movement of individuals between groups. A difference in size has been observed previously in skulls of *A. p. pusillus* and *A. p. doriferus*, although a smaller sample size of *A. p. pusillus* was utilized (Brunner, 1998*b*). Shaughnessy (1982) found that blood transferrin types A and C were common to both *A. p. pusillus* at False Bay, South Africa and *A. p. doriferus* but a third transferrin type, P, was absent from a series of 53 *A. p. doriferus*.

Nevertheless, *A. p. pusillus* and *A. p. doriferus* possess a more dolichocephalic skull than that observed for other species of *Arctocephalus*. Both subspecies have more elongated rostral and palatal regions compared with species such as *A. forsteri* or *A. gazella*, and show a strong morphological similarity to *N. cinerea*. This may be partly attributed to the greater total skull length of *A. pusillus* compared with other *Arctocephalus*. The zygomatic arch for both subspecies of *A. pusillus* is long, yet the dimensions of the orbit are similar to those of other species within the genus. Thus, due to the greater condylobasal length in *A. pusillus*, the squamosal appears extended more posteriorly to accommodate the greater length of skull for this species. Although closest to the *Arctocephalus* in cranial morphology, skull length and elongation of the zygomatic arch in *A. pusillus* are similar to those found in other large otariids such as *N. cinerea* and *P. hookeri*, and contribute to the skull's 'sea lion-like' appearance.

Although not the largest, skulls of *A. gazella* are the most robust within the genus *Arctocephalus*. They are identified readily by the structure of PCs 5 and (particularly) 6, which are reduced significantly to small nubs. The rostral width of *A. gazella* is the broadest for the genus. Cranial morphology of *C. ursinus* is also instantly recognizable. The rostrum for this species is significantly shorter than that observed in *Arctocephalus*, terminating abruptly and enhanced by vertically angled canines.

Arctocephalus gazella and *A. tropicalis* were considered subspecies for some time (King, 1959*a*, *b*), whereas Scheffer (1958) and Sivertsen (1954) thought they were the same animal and only recently were they considered separate species (e.g. Repenning *et al.*, 1971; King, 1983). In this morphometric study, both *A. tropicalis* and *A. gazella* grouped with other species of *Arctocephalus*, yet *A. gazella* remained on the periphery of the main group of *Arctocephalus* and was removed from *A. tropicalis*. Although both *A. gazella* and *A. tropicalis* are known to interbreed (e.g. Kerley & Robinson, 1987; Shaughnessy *et al.*, 1998; Brunner, 1998*b*), interspecific morphological differences are obvious. Of all the species of *Arctocephalus*, skulls of *A. gazella* are the most robust, and possess PC structures not seen in any other otariid. Conversely, skulls of *A. tropicalis* express more typical *Arctocephalus* morphology, including a less robust skull than *A. gazella*, a more slender rostrum, and more narrow supraorbital processes and interorbital constriction. A significant characteristic of *A. tropicalis* is its small, unicuspid PCs, unlike those of *A. forsteri*, *A. australis*, *A. galapagoensis* and *A. pusillus*. In *A. tropicalis*, these splay outwards at PCs 4–6 and are similar in structure to those of *A. townsendi* and *A. philippii*.

From the analyses, all three subspecies of *Z. californianus* clustered together. Itoo (1985) suggested *Z. c. japonicus* should be considered a separate species based primarily on greater CBL and variation in the number of PCs, and Rice (1998) considered them all as separate species. Results from this study indicate the number of PCs varied significantly within all subspecies of *Z. californianus*, thus cannot be used definitively as a separating characteristic. Besides greater total skull length, other differences were observed between *Z. c. japonicus* and the other two subspecies of *Z. californianus*. The sagittal crest in *Z. c. japonicus* was larger and more rounded dorsally, the zygomatic arch was thicker at the jugal-squamosal margin, the rostrum and palate were broader, the supraorbital processes were shorter and more robust, the angle between the dentary and coronoid process was more acute, and the dentary was broader dorso-ventrally. There are fewer significant differences between skulls of the two subspecies *Z. c. californianus* and *Z. c. wollebaeki*, the main distinction being *Z. c. wollebaeki* is smaller. Results from this study support the recognition of *Z. c. japonicus* as a distinct species of *Zalophus*; further, *Z. c. californianus* and *Z. c. wollebaeki* should remain subspecies.

Conclusion

Considering the results presented in this study, combined with findings from previous morphological and genetic research, summary recommendations to amend the current taxonomy of the family Otariidae, are as follows.

(i) Separation of the otariids into the subfamilies Otariinae and Arctocephalinae should no longer be recognized. The family Otariidae should be separated into genus, species and subspecies only.
(ii) *Arctocephalus townsendi* and *A. philippii* should be excluded from the genus *Artctocephalus* and form a separate group, the previously recognized *Arctophoca philippii philippii* and *Arctophoca philippii townsendi*.
(iii) *Arctocephalus p. pusillus* and *A. p. doriferus* should remain subspecies and stay within the genus *Arctocephalus*.
(iv) The subspecific split of *A. a. australis* and *A. a. gracilis* should remain, but should include within *A. a. australis* specimens from Punta del Diablo.
(v) *Arctocephalus forsteri* should be considered a subspecies of *A. australis*, as *A. a. forsteri*.
(vi) *Arctocephalus galapagoensis* appears to be a dwarf of the species *A. australis*, and should be considered subspecific with this group, as *A. a. galapagoensis*.
(vii) *Z. c. japonicus* should be considered a separate species of *Zalophus* and not a subspecies of *Z. californianus*.

With this in mind, the recommended revised nomenclature for the family Otariidae, comprises:

***Otaria* Péron, 1816**
  byronia (de Blainville, 1820)
***Eumetopias* Gill, 1866**
  jubatus (Schreber, 1776)
***Neophoca* Gray, 1866**
  cinerea (Péron, 1816)
***Phocarctos* Gray, 1844**
  hookeri (Gray, 1844)
***Zalophus* Gill, 1866**
  californianus (Lesson, 1828)
    californianus (Lesson, 1828)
    wollebaeki (Sivertsen, 1953)
  japonicus (Peters, 1866)
***Callorhinus* Gray, 1859**
  ursinus (Linnaeus, 1758)
***Arctocephalus* Geoffroy Saint-Hilaire and Cuvier, 1824**
  gazella (Peters, 1875)
  tropicalis (Gray, 1872)
  pusillus (Schreber, 1775)
    pusillus (Schreber, 1776)
    doriferus (Wood Jones, 1925)
  australis (Zimmerman, 1783)
    australis (Zimmerman, 1783)
    gracilis (Nehring, 1887)

forsteri (Lesson, 1828)
galapagoensis Heller, 1904
***Arctophoca* Peters, 1866**
philippii (Peters, 1866)
philippii (Peters, 1866)
townsendi (Merriam, 1897)

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Appendix I

Summary of adult specimens of otariid skulls used for this study.

Abbreviations for museums:

AM	Australian Museum, Sydney	MVZ	Museum of Vertebrate Zoology, Berkeley
AMNH	American Museum of Natural History, New York	NRM	Natural History Museum, Stockholm
ASD	Asahi School of Dentistry, Gifu	NMML	National Marine Mammal Laboratory, Seattle
BMNH	British Museum of Natural History, London	NMNH	National Museum of Natural History, Washington, DC
CAS	California Academy of Sciences, San Francisco	NMNZ	National Museum of New Zealand, Wellington
DNHM	Denver Natural History Museum, Colorado	PEM	Port Elizabeth Museum, Port Elizabeth
FMNH	Field Museum of Natural History, Chicago	SAM	South Australian Museum, Adelaide
HMH	Historical Museum of Hokkaido, Sapporo	SAM(2)	South African Museum, Cape Town
HMJH	Historical Museum of Japanese History, Tokyo	SDNHM	San Diego Natural History Museum, San Diego
HU	Hokkaido University, Hakodate	UAM	University of Alaska Museum, Fairbanks
LACM	Los Angeles County Museum, Los Angeles	UMZC	University Museum of Zoology, Cambridge
MNHN	Museum of Natural History, Paris	WAM	Western Australian Museum, Perth
MV	Museum of Victoria, Melbourne	ZMB	Zoolgical Museum of Berlin, Berlin

Species	Location collected	Accession no.	Sex	SI	Date collected	Museum
A.a	Peru	84.910	f	19	–	BMNH
A.a	Punta del Diablo	254567	f	19	31/01/74	AMNH
A.a	Punta del Diablo	504896	f	19	1971	NMNH
A.a	–	501067	f	19	–	NMNH
A.a	San Juan, Peru	84.965	f	22	1983	BMNH
A.a	San Juan, Peru	84.922	f	22	–	BMNH
A.a	Punta del Diablo	501120	f	23	4/01/73	NMNH
A.a	San Juan, Peru	84.916	f	26	22/03/83	BMNH
A.a	San Juan, Peru	1984.917	f	26	22/3/83	BMNH
A.a	San Juan, Peru	84.925	f	27	–	BMNH
A.a	San Juan, Peru	84.938	f	28	30476	BMNH
A.a	San Juan, Peru	84.974	f	28	–	BMNH
A.a	San Juan, Peru	84.968	f	28	–	BMNH
A.a	Punta del Diablo	484935	f	28	1971	NMNH
A.a	Punta del Diablo	484934	f	28	1971	NMNH
A.a	San Juan, Peru	84.937	f	29	–	BMNH
A.a	Peru	84.970	f	29	–	BMNH
A.a	Str of Magellan	1879.8.21.5	f	29	–	BMNH
A.a	San Juan, Peru	84.915	f	30	–	BMNH
A.a	San Juan, Peru	84.94	f	30	9/06/83	BMNH
A.a	San Juan, Peru	84.957	f	30	–	BMNH
A.a	Punta del Diablo	254568	f	30	30/01/74	AMNH
A.a	San Dernando, Peru	84.967	f	31	23/03/83	BMNH
A.a	Punta del Barco	254561	f	33	–	AMNH
A.a	San Juan, Peru	84.919	f	35	22/3/83	BMNH
A.a	San Juan, Peru	84.914	f	35	–	BMNH
A.a	Peru	84.911	m	24	–	BMNH
A.a	San Juan, Peru	1984.942	m	24	15/7/83	BMNH
A.a	Falkland Is	1949.3.17.17	m	24	–	BMNH
A.a	San Juan, Peru	84.926	m	25	–	BMNH
A.a	Cape Curbelo, Uruguay	205917	m	25	25/05/63	AMNH
A.a	Isla de Lobos, Uruguay	205918	m	25	12/11/58	AMNH
A.a	Falkland Is	1949.3.17.10	m	26	–	BMNH
A.a	Peru	84.918	m	26	–	BMNH
A.a	Punta del Diablo	504895	m	26	1971	NMNH

Species	Location collected	Accession no.	Sex	SI	Date collected	Museum
A.a	Falkland Is	1949.3.17.11	m	27	–	BMNH
A.a	Falkland Is	1949.3.17.8	m	28	–	BMNH
A.a	San Juan, Peru	84.930	m	28	1983	BMNH
A.a	San Juan, Peru	84.923	m	28	1983	BMNH
A.a	Falkland Is	1949.3.17.6	m	28	–	BMNH
A.a	–	36664	m	28	–	NMNH
A.a	Falkland Is	1949.3.17.7	m	29	–	BMNH
A.a	San Juan, Peru	84.931	m	29	–	BMNH
A.a	San Juan, Peru	1984.934	m	29	5/83	BMNH
A.a	San Juan, Peru	1984.92	m	29	22/3/83	BMNH
A.a	San Juan, Peru	1984.973	m	29	–	BMNH
A.a	Falkland Is	1949.3.17.5	m	30	–	BMNH
A.a	Falkland Is	1949.3.17.1	m	30	–	BMNH
A.a	Punta del Diablo	254562	m	30	20/01/73	AMNH
A.a	Punta del Diablo	254564	m	30	25/01/73	AMNH
A.a	Punta del Diablo	254565	m	30	25/01/73	AMNH
A.a	Paracas Penin, Peru	8228	m	30	20/07/70	DMNH
A.a	Falkland Is	1949.3.17.2	m	31	–	BMNH
A.a	Peru	84.933	m	31	–	BMNH
A.a	San Juan, Peru	1984.927	m	31	26/3/83	BMNH
A.a	Isla de Lobos, Uruguay	239140	m	31	–	NMNH
A.a	Falkland Is	1949.3.17.4	m	33	–	BMNH
A.a	San Juan, Peru	84.932	m	33	1983	BMNH
A.a	Cape Curbelo, Uruguay	205916	m	33	25/05/63	AMNH
A.a	Peru	84.924	m	35	–	BMNH
A.a	Falkland Is	1949.3.17.3	m	36	–	BMNH
A.a	Peru	84.978	m	36	–	BMNH
A.a	Isla la Vieja, Peru	23616	m	36	18/06/57	SDNHM
A. f	Constant Bay, N.Z.	DM1415	f	19	14/11/59	NMNZ
A. f	Preservation Inlt, N.Z.	MA62	f	19	–	NMNZ
A. f	Recherche	m25810	f	20	–	WAM
A. f	Breaksea Sound	DM729	f	20	11/11/43	NMNZ
A. f	South Neptune Is	M15480	f	22	11/01/63	SAM
A. f	Waratah Bay, Vic	C07535	f	24	13/10/21	MV
A. f	South Neptune Is	M15489	f	24	11/06/63	SAM
A. f	East Franklin Is	M16330	f	25	19/2/91	SAM
A. f	Ohiro Bay, N.Z.	MM1681	f	25	?/5/73	NMNZ
A. f	UNKNOWN	"1590"	f	25	1994	NMNZ
A. f	South Neptune Is	M15482	f	27	11/02/63	SAM
A. f	South Neptune Is	M15469	f	28	26/11/67	SAM
A. f	UNKNOWN	DM1495	f	28	–	NMNZ
A. f	Kangaroo Is	M16520	f	30	?/1/89	SAM
A. f	South Neptune Is	M15477	f	30	?/11/67	SAM
A. f	Aldinga Bch, S. Aust.	M16248	f	32	21/7/90	SAM
A. f	Campbell Is, N.Z.	DM1494	f	32	–	NMNZ
A. f	Pukerua Bay, NZ	504891	f	33	14/05/76	NMNH
A. f	Cape Saunders, N.Z.	DM1445	m	24	31/07/58	NMNZ
A. f	Breaksea Sound	DM733	m	24	15/12/47	NMNZ
A. f	Macquarie Is	M23684	m	24	17/2/89	AM
A. f	N.Z.	1879.260	m	25	–	MNHN
A. f	South Neptune Is	M15486	m	25	11/04/63	SAM
A. f	Recherche Arch. WA	1968.9.26.6	m	26	–	BMNH
A. f	Cape Foulwind, NZ	1876.2.16.5	m	26	–	BMNH
A. f	S. Neptune Is, S. Aust.	8233	m	26	–	DMNH
A. f	Kangaroo Is	M16521	m	26	?/1/89	SAM
A. f	Island Bay, Wellington	DM1509	m	26	17/6/63	NMNZ
A. f	Pearson Is, S. Aust.	M16522	m	27	1/01/87	SAM
A. f	Red Rocks, Wellington	MM1918	m	27	?/6/86	NMNZ
A. f	Aukland Is, N.Z.	DM1054	m	27	1/03/40	NMNZ
A. f	Snares Is	DM746	m	27	11/04/43	NMNZ
A. f	Macquarie Is	M17992	m	27	27/8/87	AM
A. f	Recherche Arch. WA	1968.9.26.9	m	28	–	BMNH
A. f	Tasman Sea, NZ	396921	m	28	–	NMNH
A. f	Macquarie Is	C25816	m	28	?/3/68	MV

Species	Location collected	Accession no.	Sex	SI	Date collected	Museum
A. f	Macquarie Is	C06190	m	28	1/06/60	MV
A. f	Casuarina Islet	C01993	m	28	?/4/36	MV
A. f	South Neptune Is	M15481	m	28	11/01/63	SAM
A. f	Kangaroo Is	M16803	m	28	27/4/91	SAM
A. f	Cape Saunders, N.Z.	DM1443	m	28	31/07/58	NMNZ
A. f	Macquarie Is	M17991	m	28	21/10/87	AM
A. f	Macquarie Is	M18039	m	28	30/11/83	AM
A. f	Macquarie Is	M18034	m	28	27/8/87	AM
A. f	Macquarie Is	M12823	m	28	4/08/78	AM
A. f	South Neptune Is	M15475	m	29	29/11/67	SAM
A. f	Kangaroo Is	M16519	m	29	?/1/89	SAM
A. f	5 Fingers Penn.	DM731	m	29	11/11/43	NMNZ
A. f	Wellington, N.Z.	NM1724	m	29	1965	NMNZ
A. f	Macquarie Is	M18036	m	29	27/8/87	AM
A. f	Macquarie Is	M18035	m	29	28/10/87	AM
A. f	Str of Magellan	23331	m	30	–	NMNH
A. f	Daw Is, W.A.	C29733	m	30	1986	MV
A. f	Kangaroo Is	M16477	m	30	30/1/91	SAM
A. f	Macquarie Is	M15441	m	30	2/10/63	SAM
A. f	Kangaroo Is	M17675	m	30	11/12/89	SAM
A. f	Cape Saunders, N.Z.	DM1446	m	30	31/07/58	NMNZ
A. f	Sinclair Head, N.Z.	DM1326	m	30	19/5/58	NMNZ
A. f	South Is, NZ	8229	m	31	–	DMNH
A. f	Red Rocks, Wellington	MM1919	m	31	?/8/85	NMNZ
A. f	Chalky Inlet, N.Z.	DM1492	m	31	19/7/48	NMNZ
A. f	Macquarie Is	M17990	m	31	11/11/84	AM
A. f	Macquarie Is	M17994	m	31	27/8/87	AM
A. f	Kangaroo Is	M16398	m	32	16/4/88	SAM
A. f	Macquarie Is	M15448	m	32	2/04/64	SAM
A. f	UNKNOWN	MM2168	m	32	–	NMNZ
A. f	Palliser Bay, N.Z.	DM1416	m	32	24/1/60	NMNZ
A. f	Campbell Is, N.Z.	DM1345	m	32	28/8/44	NMNZ
A. f	South Neptune Is	M15485	m	33	11/03/63	SAM
A. f	Macquarie Is	M15444	m	33	7/10/62	SAM
A. f	Cape Turakirae, N.Z.	MM1793	m	33	?/8/76	NMNZ
A. f	Napies Beach, N.Z.	DM1617	m	33	1969	NMNZ
A. f	Kaikoura, N.Z.	NMNZ1929	m	33	–	NMNZ
A. f	Macquarie Is	M17993	m	33	22/10/87	AM
A. f	N.Z.	1879.261	m	34	–	MNHN
A. f	Enderby Is	SAB89.90	m	34	1990	NMNZ
A. f	South Neptune Is	M15483	m	34	11/02/63	SAM
A. f	South Neptune Is	M15468	m	34	26/11/67	SAM
A. f	Island Bay, Wellington	DM1580	m	34	5/12/59	NMNZ
A. f	Otaga Harbour, N.Z.	DM778	m	34	?/2/52	NMNZ
A. f	Macquarie Is	MP.B7	m	34	?/11/83	AM
A. f	South Neptune Is	M15473	m	35	28/11/67	SAM
A. f	Macquarie Is	M15445	m	35	7/10/62	SAM
A. f	Red Rocks, Wellington	MM1934	m	35	?/6/86	NMNZ
A. f	Macquarie Is	M18037	m	35	?/11/83	AM
A. f	Coffin Bay, S. Aust.	M15368	m	36	~1974	SAM
A. f	–	m12449	m	21	–	WAM
A. f	Recherche	m39962	m	30	5/91	WAM
A. f	Two People Bay, WA	m41185	m	32	–	WAM
A. f	Recherche	m3813	m	36	14/02/60	WAM
A.galap	–	100342	f	19	–	AMNH
A.galap	Galapagos	100319	f	22	13/03/33	AMNH
A.galap	Galapagos	1962.116	f	26	10/61	MNHN
A.galap	Tower Is, Galapagos.	259832	f	31	22/09/35	NMNH
A.galap	Fernandina, Galapagos	1991.2	f	30	20/8/79	BMNH
A.galap	Tower Is, Galapagos	lacm31309	m	24	15/03/57	LACM
A.galap	Fernandina, Galapagos. Is	1991.1	m	27	22/11/77	BMNH
A.galap	Galapagos	1962.115	m	28	7/1960	MNHN
A.galap	Galapagos	100341	m	28	–	AMNH
A.galap	Galapagos	1962.1153	m	32	10/61	MNHN

Species	Location collected	Accession no.	Sex	SI	Date collected	Museum
A.galap	Fernandina, Galapagos. Is	1991.3	m	34	17/9/79	BMNH
A.galap	Galapagos	(Type) 20829	m	35	1899	CAS
A.gaz	Bird Is	1960.8.10.7	f	19	1/12/58	BMNH
A.gaz	Bird Is	1960.8.10.39	f	19	1960	BMNH
A.gaz	Bird Is	1960.8.10.14	f	19	13/12/58	BMNH
A.gaz	Bird Is	1960.8.10.19	f	19	–	BMNH
A.gaz	Bird Is	1960.8.10.32	f	19	1960	BMNH
A.gaz	Bird Is	1958.7.8.13	f	20	–	BMNH
A.gaz	Bird Is	1958.7.8.10	f	20	–	BMNH
A.gaz	Bird Is	1960.8.10.31	f	20	1960	BMNH
A.gaz	Bird Is	K7321A	f	20	15/02/93	UMZC
A.gaz	Bird Is	1960.8.10.41	f	21	–	BMNH
A.gaz	Bird Is	1960.8.10.13	f	21	–	BMNH
A.gaz	Bird Is	1960.8.10.33	f	21	1960	BMNH
A.gaz	Bird Is	K7321I	f	21	15/02/93	UMZC
A.gaz	Bird Is	1958.4.24.4	f	22	–	BMNH
A.gaz	Bird Is	K7321D	f	23	15/02/93	UMZC
A.gaz	Bird Is	K7321H	f	23	15/02/93	UMZC
A.gaz	Bird Is	K7321E	f	24	15/02/93	UMZC
A.gaz	Macquarie Is	M25464	f	25	?/12/91	AM
A.gaz	Bird Is	K7321J	f	25	15/02/93	UMZC
A.gaz	Bird Is	K7321F	f	25	15/02/93	UMZC
A.gaz	Bird Is	1960.8.10.5	f	26	1/12/58	BMNH
A.gaz	Bird Is	1960.8.10.34	f	26	1960	BMNH
A.gaz	Crozet Is	1972.643	f	26	10/08/71	MNHN
A.gaz	Bird Is	8234	f	26	–	DMNH
A.gaz	Bird Is	1960.8.10.29	f	27	1960	BMNH
A.gaz	Bird Is	1962.6.14.13	f	28	3/1/60	BMNH
A.gaz	Macquarie Is	m25464	f	29	12/91	AM
A.gaz	Bird Is	1960.8.20.36	f	30	1960	BMNH
A.gaz	Bird Is	1960.8.10.30	f	30	1960	BMNH
A.gaz	Marion Is	1955.3.14.5	f	30	22/4/52	BMNH
A.gaz	Bird Is	1960.8.10.38	f	32	1960	BMNH
A.gaz	Bird Is	1962.6.14.15	f	33	1960	BMNH
A.gaz	Bird Is	1962.6.14.14	f	34	1960	BMNH
A.gaz	Bird Is	1960.8.10.37	f	34	1960	BMNH
A.gaz	Heard Is	hs85/83	m	24	–	AM
A.gaz	Bird Is	1960.8.10.43	m	24	–	BMNH
A.gaz	Bird Is	1960.8.10.50	m	25	–	BMNH
A.gaz	Bouvet Id	1964.9.22.2	m	25	–	BMNH
A.gaz	Bird Is	1958.7.8.14	m	25	–	BMNH
A.gaz	Bird Is	1960.8.10.45	m	25	–	BMNH
A.gaz	Bird Is	K7321O	m	25	15/02/93	UMZC
A.gaz	Heard Is	hs85/82	m	26	–	AM
A.gaz	Bird Is	1960.8.10.55	m	26	–	BMNH
A.gaz	Bird Is	1958.7.8.15	m	27	–	BMNH
A.gaz	Bird Is	1960.8.10.57	m	27	–	BMNH
A.gaz	Bird Is	1960.8.10.2	m	27	–	BMNH
A.gaz	Bird Is	1960.8.10.20	m	27	–	BMNH
A.gaz	S.Shetland Is	1960.8.4.3	m	28	–	BMNH
A.gaz	Bird Is	1960.8.10.51	m	29	–	BMNH
A.gaz	S. Georgia	1981.125	m	29	–	BMNH
A.gaz	Bird Is	1960.8.10.27	m	29	–	BMNH
A.gaz	Bird Is	1960.8.10.24	m	29	–	BMNH
A.gaz	Heard Is	hs85/85	m	30	–	AM
A.gaz	Bird Is	1962.6.14.5	m	30	–	BMNH
A.gaz	Bird Is	1960.8.10.48	m	30	–	BMNH
A.gaz	Bird Is	1960.8.10.49	m	30	–	BMNH
A.gaz	Heard Is	M28910	m	31	–	AM
A.gaz	Heard Is	M28912	m	31	4/03/88	AM
A.gaz	Heard Is	hs85/86	m	31	–	AM
A.gaz	Heard Is	hs85/73	m	31	–	AM
A.gaz	Heard Is	hs85/81	m	31	–	AM
A.gaz	Heard Is	hs85/39	m	31	–	AM

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A.gaz	Bird Is	1960.8.10.21	m	31	–	BMNH
A.gaz	Bird Is	1960.8.10.18	m	31	19/12/58	BMNH
A.gaz	Heard Is	M29113	m	32	4/09/88	AM
A.gaz	Heard Is	hs85/46	m	32	–	AM
A.gaz	Heard Is	hs85/47	m	32	–	AM
A.gaz	Heard Is	hs85/76	m	32	–	AM
A.gaz	Heard Is	hs85/77	m	32	–	AM
A.gaz	Bird Is	1960.8.10.53	m	32	–	BMNH
A.gaz	Heard Is	M28913	m	33	?/11/92	AM
A.gaz	Heard Is	M28915	m	33	10/12/48	AM
A.gaz	Heard Is	M28909	m	33	18/3/92	AM
A.gaz	Heard Is	M28911	m	33	4/03/88	AM
A.gaz	Heard Is	hs85/01	m	33	–	AM
A.gaz	Bird Is	1960.8.10.46	m	33	–	BMNH
A.gaz	Sth Orkney Is	392266	m	33	10/02/66	NMNH
A.gaz	Heard Is	M29122	m	34	4/03/88	AM
A.gaz	Heard Is	M29117	m	34	9/06/88	AM
A.gaz	Heard Is	hs85/89	m	34	–	AM
A.gaz	Heard Is	hs85/51	m	34	–	AM
A.gaz	Heard Is	hs85/42	m	34	–	AM
A.gaz	S. Sandwich Is	1964.9.22.1	m	34	–	BMNH
A.gaz	Bird Is	1962.6.14.6	m	34	–	BMNH
A.gaz	Bird Is	Dec, 1963*	m	34	12/63	BMNH
A.gaz	S. Orkney Is	1960.8.4.4	m	34	–	BMNH
A.gaz	Bird Is	K7321N	m	34	15/02/93	UMZC
A.gaz	Heard Is	M29111	m	35	4/09/88	AM
A.gaz	Heard Is	M29109	m	35	4/03/88	AM
A.gaz	Heard Is	M29119	m	35	10/11/88	AM
A.gaz	Heard Is	M29120	m	35	4/09/88	AM
A.gaz	Heard Is	hs85/3	m	35	–	AM
A.gaz	Heard Is	hs85/40	m	35	–	AM
A.gaz	Heard Is	hs85/53	m	35	–	AM
A.gaz	Heard Is	hs85/8	m	35	–	AM
A.gaz	Marion Is	mfs117	m	35	7/12/81	PEM
A.gaz	Bird Is	1960.8.10.6	m	35	–	BMNH
A.gaz	Heard Is	M29112	m	36	21/7/92	AM
A.gaz	Heard Is	M28914	m	36	?/2/93	AM
A.gaz	Heard Is	hs85/37	m	36	–	AM
A.gaz	Heard Is	hs85/75	m	36	–	AM
A.gaz	Bird Is	1962.6.14.7	m	36	–	BMNH
A.p.d	Seal Rocks	C29639	f	19	8/09/78	MV
A.p.d	Seal Rocks	C29130	f	19	30/09/66	MV
A.p.d	Seal Rocks	C29152	f	19	19/8/70	MV
A.p.d	Seal Rocks	C29124	f	19	23/11/69	MV
A.p.d	Julia Percy Is	M2973	f	19	?/6/21	AM
A.p.d	Seal Rocks	C29406	f	20	18/4/72	MV
A.p.d	Seal Rocks	C29148	f	20	18/8/70	MV
A.p.d	Julia Percy Is	M15505	f	20	16/01/64	SAM
A.p.d	Seal Rocks	C29271	f	21	22/7/71	MV
A.p.d	Lady Julia Percy Is	C01997	f	21	?/?/34	MV
A.p.d	Phillip Is, Vic	C28918	f	22	24/09/68	MV
A.p.d	Julia Percy Is	M15508	f	22	17/01/64	SAM
A.p.d	Seal Rocks	C29635	f	23	8/10/78	MV
A.p.d	Seal Rocks	C29275	f	23	23/7/71	MV
A.p.d	Seal Rocks	C29140	f	23	20/6/70	MV
A.p.d	Seal Rocks	C29161	f	23	14/9/70	MV
A.p.d	Julia Percy Is	M15491	f	23	11/01/64	SAM
A.p.d	Julia Percy Is	M15499	f	24	15/01/64	SAM
A.p.d	Seal Rocks	C29359	f	25	23/2/72	MV
A.p.d	Seal Rocks	C29081	f	25	11/11/64	MV
A.p.d	Julia Percy Is	M15494	f	25	14/01/64	SAM
A.p.d	Julia Percy Is	M15506	f	26	16/01/64	SAM
A.p.d	Bass Strait	11487	f	27	–	UAM
A.p.d	Seal Rocks	C29103	f	27	17/7/69	MV

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A.p.d	Seal Rocks	C29358	f	28	23/2/72	MV
A.p.d	Seal Rocks	C29227	f	28	19/5/71	MV
A.p.d	Seal Rocks	C29129	f	29	30/09/66	MV
A.p.d	Seal Rocks	C29110	f	29	29/7/69	MV
A.p.d	Seal Rocks	C29076	f	30	21/11/68	MV
A.p.d	Tenth Is. Tas.	M15409	f	30	13/10/65	SAM
A.p.d	Seal Rocks	C29415	f	31	22/4/72	MV
A.p.d	Australia	8238	f	32	–	DMNH
A.p.d	Seal Rocks	C29352	f	32	15/1/72	MV
A.p.d	Julia Percy Is	M15504	f	32	16/01/64	SAM
A.p.d	Julia Percy Is	M15510	f	32	18/01/64	SAM
A.p.d	Lady Julia Percy Is	C25574	f	33	30/1/74	MV
A.p.d	Portland, Vic	C01990	f	33	?/4/36	MV
A.p.d	Seal Rocks	C29435	f	33	21/6/72	MV
A.p.d	Seal Rocks	C29268	f	34	22/7/71	MV
A.p.d	Seal Rocks	C29180	f	34	27/11/70	MV
A.p.d	Tenth Is. Tas.	M15408	f	35	13/10/65	SAM
A.p.d	Tenth Is. Tas.	M15406	f	35	13/10/65	SAM
A.p.d	Seal Rocks	C29177	m	25	18/11/70	MV
A.p.d	Rushcutters Bay, NSW	M17844	m	25	14/6/69	AM
A.p.d	Deal Is, Bass Strait	C14520	m	27	5/11/71	MV
A.p.d	Melbourne Zoo	C29647	m	27	19/3/76	MV
A.p.d	N. Casuarina Islet	M15965	m	27	5/02/86	SAM
A.p.d	Tenth Is. Tas.	M15411	m	27	13/10/65	SAM
A.p.d	Seal Rocks	C29165	m	28	?/9/70	MV
A.p.d	Seal Rocks	C29342	m	28	16/12/71	MV
A.p.d	Seal Rocks	C29126	m	29	?/12/69	MV
A.p.d	Julia Percy Is	M15502	m	29	15/01/64	SAM
A.p.d	Julia Percy Is	M15513	m	29	18/01/64	SAM
A.p.d	Julia Percy Is	M15517	m	29	21/01/64	SAM
A.p.d	Vic. Aust	484928	m	30	–	NMNH
A.p.d	Discovery Bay	C25072	m	30	19/7/81	MV
A.p.d	King Is	C01991	m	30	1936	MV
A.p.d	Seal Rocks	C29123	m	30	18/11/69	MV
A.p.d	Seal Rocks	C28953	m	30	14/11/67	MV
A.p.d	Julia Percy Is	M15512	m	30	18/01/64	SAM
A.p.d	Robe, S. Aust.	M14040	m	30	15/1/86	SAM
A.p.d	Cape Jaffa, S. Aust.	M15297	m	30	28/02/85	SAM
A.p.d	Point Cook, Vic	C29027	m	31	22/5/68	MV
A.p.d	Seal Rocks	C29095	m	31	18/4/69	MV
A.p.d	Montague Is	S1656	m	31	1924	AM
A.p.d	Seal Rocks	C29334	m	32	22/10/71	MV
A.p.d	Lady Julia Percy Is	C25531	m	32	?/2/73	MV
A.p.d	Seal Rocks	C29179	m	32	26/11/70	MV
A.p.d	Seal Rocks	C29122	m	32	14/11/69	MV
A.p.d	Julia Percy Is	M15503	m	32	16/01/64	SAM
A.p.d	N. Casuarina Islet	M15966	m	32	1/02/86	SAM
A.p.d	Tenth Is. Tas.	M15410	m	32	13/10/65	SAM
A.p.d	Tenth Is, Tas	M15404	m	32	13/10/65	SAM
A.p.d	Montague Is	M3714	m	32	?/9/25	AM
A.p.d	Lady Julia Percy Is	C25537	m	33	30/1/74	MV
A.p.d	Portland, Vic	C07420	m	33	12/1895	MV
A.p.d	Lady Julia Percy Is	C01988	m	33	1936	MV
A.p.d	Skerries, Wingham Inl	C05731	m	34	?/5/50	MV
A.p.d	Julia Percy Is	M15514	m	34	18/01/64	SAM
A.p.d	N. Casuarina Islet	M15967	m	34	5/02/86	SAM
A.p.d	Julia Percy Is	M15493	m	34	12/01/64	SAM
A.p.d	Tenth Is. Tas.	M15407	m	34	13/10/65	SAM
A.p.d	Montague Is	M4750	m	34	22/9/29	AM
A.p.d	S. Aust.	M16246	m	35	?/12/79	SAM
A.p.d	Wilsons Prom, Vic	C10911	m	35	10/06/67	MV
A.p.d	Julia Percy Is	M15501	m	35	15/01/64	SAM
A.p.d	Julia Percy Is	M15511	m	35	18/01/64	SAM
A.p.p	Sinclairs Is	zm32724	f	19	20/01/48	SAM(2)

Species	Location collected	Accession no.	Sex	SI	Date collected	Museum
A.p.p	Sinclairs Is	zm34861	f	19	23/02/48	SAM(2)
A.p.p	Algoa Bay	32100	f	20	–	ZMB
A.p.p	S. Africa	100045	f	20	30/07/30	AMNH
A.p.p	Sinclairs Is	zm34860	f	21	23/02/48	SAM(2)
A.p.p	E. London Aquarium	pemn1898	f	21	5/08/92	PEM
A.p.p	Sinclair Is, sw Afr.	396063	f	21	1948	NMNH
A.p.p	Van Reenan Bay, Nam.	M10106	f	21	?/2/78	SAM
A.p.p	Sinclairs Is	zm34726	f	22	–	SAM(2)
A.p.p	–	zm34863	f	22	–	SAM(2)
A.p.p	Sinclairs Is	zm34862	f	23	–	SAM(2)
A.p.p	Sinclairs Is	zm34725	f	25	–	SAM(2)
A.p.p	Sinclairs Is	zm34740	f	26	18/09/47	SAM(2)
A.p.p	Sinclairs Is	zm35008	f	27	28/02/48	SAM(2)
A.p.p	Sinclairs Is	11485	f	28	12/09/47	UAM
A.p.p	Van Reenen Bay, Nam.	M10105	f	28	1/02/74	SAM
A.p.p	Cape of Good Hope	K7362	f	29	–	UMZC
A.p.p	Sinclairs Is	zm34857	f	30	24/03/48	SAM(2)
A.p.p	Sinclairs Is	zm34873	f	30	25/03/48	SAM(2)
A.p.p	Sinclairs Is	zm34872	f	31	9/02/49	SAM(2)
A.p.p	Sinclairs Is	zm34727	f	32	10/12/48	SAM(2)
A.p.p	Sinclairs Is	zm34874	f	32	–	SAM(2)
A.p.p	Sinclairs Is	zm34871	f	32	11/11/46	SAM(2)
A.p.p	Sinclairs Is	zm34870	f	32	2/11/46	SAM(2)
A.p.p	Sardinia Bay	pemn930	f	32	4/03/83	PEM
A.p.p	Sinclairs Is	zm34737	f	33	3/02/48	SAM(2)
A.p.p	Wilderness	pemn931	f	33	3/83	PEM
A.p.p	Walvis Bay	pemn632	f	33	12/70	PEM
A.p.p	PE Harbour	pemn596	f	33	3/09/70	PEM
A.p.p	Van Reenen Bay, Nam.	M10107	f	33	1/02/74	SAM
A.p.p	Van Reenen Bay, Nam.	M10108	f	33	1/02/74	SAM
A.p.p	Sinclairs Is	zm34741	f	34	–	SAM(2)
A.p.p	Cape Recife	pemn929	f	35	14/03/83	PEM
A.p.p	Sundays River Mouth	pemn819	f	35	8/03/82	PEM
A.p.p	Walvis Bay	pemn636	f	35	12/70	PEM
A.p.p	Woody Cape	pemn818	f	36	8/03/82	PEM
A.p.p	Goukamma	pemn821	f	36	16/03/82	PEM
A.p.p	Algoa Bay	pemn881	f	36	10/82	PEM
A.p.p	False Bay	zm34667	f	19	20/11/50	SAM(2)
A.p.p	False Bay	zm34664	f	20	14/11/50	SAM(2)
A.p.p	False Bay	zm34671	f	24	–	SAM(2)
A.p.p	False Bay	zm34672	f	24	–	SAM(2)
A.p.p	False Bay	zm34670	f	25	26/04/50	SAM(2)
A.p.p	Sinclairs Is	zm34702	m	24	19/11/48	SAM(2)
A.p.p	–	zm34704	m	24	–	SAM(2)
A.p.p	–	zm34705	m	24	–	SAM(2)
A.p.p	–	5175	m	25	–	ZMB
A.p.p	Sinclairs Is	zm34682	m	26	28/10/46	SAM(2)
A.p.p	Sinclairs is	zm34736	m	27	17/11/47	SAM(2)
A.p.p	Walvis Bay	pemn645	m	27	12/70	PEM
A.p.p	sw Africa	81701	m	27	–	AMNH
A.p.p	South Africa	N2004	m	27	25/7/92	PEM
A.p.p	Sinclairs Is	zm34681	m	28	18/11/47	SAM(2)
A.p.p	Sinclairs Is	zm34711	m	28	–	SAM(2)
A.p.p	Sinclairs Is	zm34660	m	28	12/11/47	SAM(2)
A.p.p	Sinclairs Is	zm34659	m	29	11/47	SAM(2)
A.p.p	Walvis Bay, Namibia	pemn633	m	29	17/12/80	PEM
A.p.p	Algoa Bay	pemn614	m	29	1/69	PEM
A.p.p	sw Africa	81705	m	31	–	AMNH
A.p.p	False Bay	zm39248	m	32	2/79	SAM(2)
A.p.p	Nortkhock Bay PE	pemn787	m	32	30/12/81	PEM
A.p.p	Pollock Bch, PE	pemn886	m	32	23/10/82	PEM
A.p.p	Woody Cape	pemn620	m	32	10/05/70	PEM
A.p.p	Oyster Bay	pemn618	m	32	15/11/68	PEM
A.p.p	Walvis Bay	pemn642	m	32	12/70	PEM

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A.p.p	Algoa Bay	pemn691	m	32	4/03/81	PEM
A.p.p	Luderitz, Namibia	M10104	m	32	?/1/77	SAM
A.p.p	Walvis Bay	pemn648	m	33	12/70	PEM
A.p.p	Sinclairs Is	zm34706	m	34	8/11/46	SAM(2)
A.p.p	Sinclairs Is	zm34742	m	34	17/11/48	SAM(2)
A.p.p	Walvis Bay	pemn646	m	34	12/70	PEM
A.p.p	–	pemn601	m	34	–	PEM
A.p.p	Devils Isle	zm34834	m	35	2/11/46	SAM(2)
A.p.p	Walvis Bay	pemn635	m	35	12/70	PEM
A.p.p	Walvis Bay	pemn634	m	35	12/70	PEM
A.p.p	Port Alfred	pemn619	m	35	5/02/77	PEM
A.p.p	sw Africa	81709	m	35	–	AMNH
A.p.p	sw Africa	81706	m	35	–	AMNH
A.p.p	sw Africa	81707	m	35	–	AMNH
A.p.p	Sinclairs Is	11486	m	35	10/09/47	UAM
A.p.p	sw Africa	81708	m	36	–	AMNH
A.phil	Juan Fernandez	70670	f	34	1888	ZMB
A.phil	Juan Fernandes Is	21550	m	34	6/11/68	SDNHM
A.town	Guadalupe Is	407	f	17	19/07/76	NMML
A.town	Ano Nuevo Is	24791	f	28	3/6/98	CAS
A.town	Guadalupe Is	76844	m	24	–	AMNH
A.town	Guadalupe Is	408	m	30	24/06/77	NMML
A.tr	Braemer Bay	–	m	35	2/09/87	WAM
A.tr	Marion Is	1968.4.4.2	f	20	15/3/52	BMNH
A.tr	Mutton Bird Bch, WA	m19129	f	24	–	WAM
A.tr	Marion Is	1955.3.14.8	f	25	24/3/52	BMNH
A.tr	Ile Amsterdam	1986.72	f	26	1986	MNHN
A.tr	Port Elizabeth	pemn1452	f	29	17/12/87	PEM
A.tr	Gough Is	zm41242	f	30	24/09/87	SAM(2)
A.tr	Marion Is	1968.4.4.1	f	30	22/04/52	BMNH
A.tr	Maitland River Mouth	pemn576	f	31	9/09/70	PEM
A.tr	Southern Natal	pemn2241	f	31	1994	PEM
A.tr	Marion Is	1955.3.14.7	f	32	15/2/52	BMNH
A.tr	Cape Recife	pemn1893	f	33	27/07/92	PEM
A.tr	Durban	pemn616	f	35	11/07/77	PEM
A.tr	Ile Amsterdam	1962.415	f	36	30/12/55	MNHN
A.tr	Marion Is	mfs125	m	24	–	PEM
A.tr	Gough Is	gfs8	m	25	21/11/77	PEM
A.tr	Gough Is	zm36964	m	26	10/73	SAM(2)
A.tr	–	zm40481	m	26	–	SAM(2)
A.tr	Marion Is	mfs136	m	26	–	PEM
A.tr	Ile Amsterdam	1972.644	m	26	6/03/71	MNHN
A.tr	Guano Isds	zm39210	m	27	–	SAM(2)
A.tr	Gough Is	gfs219	m	27	21/08/78	PEM
A.tr	Gough Is	gfs196	m	27	21/08/78	PEM
A.tr	Marion Is	mfs129	m	27	–	PEM
A.tr	Gough Is	zm36959	m	29	10/73	SAM(2)
A.tr	Ile Amsterdam	1971.119	m	29	16/03/69	MNHN
A.tr	Gough Is	zm40838	m	30	16/10/89	SAM(2)
A.tr	Gough Is	zm40839	m	30	16/10/89	SAM(2)
A.tr	Gough Is	gfs140	m	30	6/05/78	PEM
A.tr	Gough Is	gfs44	m	31	13/01/78	PEM
A.tr	Marion Is	mfs106	m	31	8/01/81	PEM
A.tr	Sunset bch, Sea Pt	zm38753	m	32	29/12/74	SAM(2)
A.tr	Ile Amsterdam	1978.334	m	32	1/72	MNHN
A.tr	Gough Is	zm36961	m	33	8/11/73	SAM(2)
A.tr	Gough Is	zm41238	m	33	24/09/87	SAM(2)
A.tr	Lamberts Bay	zm40624	m	34	12/84	SAM(2)
A.tr	Buffalo Bay, Knysna	pemn887	m	34	1/11/82	PEM
A.tr	Gough Is	gfs141	m	34	6/05/78	PEM
A.tr	Marion Is	mfs133	m	34	–	PEM
A.tr	Marion Is	mfs110	m	34	21/01/81	PEM
A.tr	Marion Is	mfs104	m	34	18/12/80	PEM
A.tr	Amsterdam Is	1957.8.1.1	m	34	24/11/55	BMNH

Species	Location collected	Accession no.	Sex	SI	Date collected	Museum
A.tr	Ile Amsterdam	1971.118	m	34	12/02/70	MNHN
A.tr	Nth. Wollongong	M18108	m	34	26/7/80	AM
A.tr	Marion Is	mfs111	m	35	3/02/81	PEM
A.tr	Ile Amsterdam	1978.339	m	35	19/09/72	MNHN
A.tr	Ile Amsterdam	1962.415	m	35	23/12/55	MNHN
A.tr	Gough Is	zm41236	m	36	24/09/87	SAM(2)
A.tr	Marion Is	mfs130	m	36	–	PEM
A.tr	Ile Amsterdam	1986.70	m	36	1986	MNHN
A.tr	Marion Is	1968.4.4.7	m	24	20/12/51	BMNH
A.tr	Cape Reclife, S. Africa	m17672	m	25	15/06/92	SAM
A.tr	Marion Is	zm34895	m	26	11/04/52	SAM(2)
A.tr	Marion Is	fs38	m	34	14/01/75	PEM
A.tr	Marion Is	fs02	m	34	5/02/74	PEM
A.tr	Goolwa, S. Aust.	m18395	m	35	21/08/94	SAM
A.tr	Marion Is	fs32	m	36	9/01/75	PEM
C.urs	Miyagi Pref	286186	f	19	30/03/50	NMNH
C.urs	Miyagi Pref	286211	f	19	9/04/50	NMNH
C.urs	Miyagi Pref	286225	f	19	19/04/50	NMNH
C.urs	Miyagi Pref	286211	f	19	9/04/50	NMNH
C.urs	Miyagi Pref	286240	f	19	27/04/50	NMNH
C.urs	Iwate Pref	286256	f	19	28/04/50	NMNH
C.urs	Iwate Pref	286254	f	19	28/04/50	NMNH
C.urs	Iwate Pref	286248	f	19	27/04/50	NMNH
C.urs	Iwate Pref	286299	f	19	9/05/50	NMNH
C.urs	Iwate Pref	286300	f	19	9/05/50	NMNH
C.urs	Iwate Pref	286320	f	19	12/05/50	NMNH
C.urs	Iwate Pref	286342	f	19	12/05/50	NMNH
C.urs	Iwate Pref	286346	f	19	12/05/50	NMNH
C.urs	Iwate Pref	286349	f	19	13/05/50	NMNH
C.urs	Iwate Pref	286352	f	19	13/05/50	NMNH
C.urs	Miyagi Pref	286158	f	20	24/03/50	NMNH
C.urs	Miyagi Pref	286233	f	20	19/04/50	NMNH
C.urs	Miyagi Pref	286238	f	20	27/04/50	NMNH
C.urs	Iwate Pref	286274	f	20	1/05/50	NMNH
C.urs	Iwate Pref	286323	f	20	12/05/50	NMNH
C.urs	Iwate Pref	286327	f	20	12/05/50	NMNH
C.urs	Iwate Pref	286330	f	20	12/05/50	NMNH
C.urs	Sitka, Alaska	286061	f	20	20/01/51	NMNH
C.urs	Sitka, Alaska	286093	f	20	25/01/51	NMNH
C.urs	Sitka, Alaska	286095	f	20	25/01/51	NMNH
C.urs	Sitka, Alaska	286097	f	20	25/01/51	NMNH
C.urs	St Paul Is	11492	f	20	–	UAM
C.urs	Miyagi Pref	286173	f	21	29/03/50	NMNH
C.urs	Miyagi Pref	286194	f	21	30/03/50	NMNH
C.urs	Miyagi Pref	286239	f	21	27/04/50	NMNH
C.urs	Iwate Pref	286258	f	21	28/04/50	NMNH
C.urs	Iwate Pref	286319	f	21	12/05/50	NMNH
C.urs	Sitka, Alaska	286047	f	21	18/01/51	NMNH
C.urs	Sitka, Alaska	286052	f	21	18/01/51	NMNH
C.urs	Sitka, Alaska	286055	f	21	19/01/51	NMNH
C.urs	Sitka, Alaska	286056	f	21	19/01/51	NMNH
C.urs	Sitka, Alaska	286079	f	21	24/01/51	NMNH
C.urs	Sitka, Alaska	286086	f	21	25/01/51	NMNH
C.urs	Sitka, Alaska	286094	f	21	25/01/51	NMNH
C.urs	St Paul Is	11493	f	21	–	UAM
C.urs	Pribilof Is	5648	f	22	–	ZMB
C.urs	Miyagi Pref	286143	f	22	24/03/50	NMNH
C.urs	Miyagi Pref	286207	f	22	9/04/50	NMNH
C.urs	Miyagi Pref	286212	f	22	9/04/50	NMNH
C.urs	Iwate Pref	286264	f	22	28/04/50	NMNH
C.urs	Iwate Pref	286266	f	22	28/04/50	NMNH
C.urs	Miyagi Pref	286284	f	22	8/05/50	NMNH
C.urs	Iwate Pref	286337	f	22	12/05/50	NMNH
C.urs	Sitka, Alaska	286041	f	22	16/01/51	NMNH

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C.urs	Iwate Pref	286351	f	22	13/05/50	NMNH
C.urs	Sitka, Alaska	286070	f	22	23/01/51	NMNH
C.urs	Sitka, Alaska	286081	f	22	24/01/51	NMNH
C.urs	Miyagi Pref	286152	f	23	24/03/50	NMNH
C.urs	Miyagi Pref	286190	f	23	30/03/50	NMNH
C.urs	Miyagi Pref	286226	f	23	19/04/50	NMNH
C.urs	Miyagi Pref	286212	f	23	9/04/50	NMNH
C.urs	Miyagi Pref	286237	f	23	24/04/50	NMNH
C.urs	Iwate Pref	286247	f	23	27/04/50	NMNH
C.urs	Iwate Pref	286269	f	23	28/04/50	NMNH
C.urs	Iwate Pref	286273	f	23	1/05/50	NMNH
C.urs	Miyagi Pref	286291	f	23	8/05/50	NMNH
C.urs	Miyagi Pref	286298	f	23	8/05/50	NMNH
C.urs	Iwate Pref	286303	f	23	9/05/50	NMNH
C.urs	Iwate Pref	286306	f	23	9/05/50	NMNH
C.urs	Sitka, Alaska	286046	f	23	18/01/51	NMNH
C.urs	Sitka, Alaska	286054	f	23	18/01/51	NMNH
C.urs	Sitka, Alaska	286071	f	23	23/01/51	NMNH
C.urs	Sitka, Alaska	286074	f	23	23/01/51	NMNH
C.urs	Sitka, Alaska	286083	f	23	24/01/51	NMNH
C.urs	Iwate Pref	286259	f	24	28/04/50	NMNH
C.urs	Iwate Pref	286261	f	24	28/04/50	NMNH
C.urs	Iwate Pref	286309	f	24	9/05/50	NMNH
C.urs	Iwate Pref	286314	f	24	9/05/50	NMNH
C.urs	Iwate Pref	286321	f	24	12/05/50	NMNH
C.urs	Iwate Pref	286324	f	24	12/05/50	NMNH
C.urs	Iwate Pref	286331	f	24	12/05/50	NMNH
C.urs	Iwate Pref	286341	f	24	12/05/50	NMNH
C.urs	Iwate Pref	286340	f	24	12/05/50	NMNH
C.urs	Sitka, Alaska	286044	f	24	17/01/51	NMNH
C.urs	Sitka, Alaska	286053	f	24	18/01/51	NMNH
C.urs	Sitka, Alaska	286050	f	24	18/01/51	NMNH
C.urs	Sitka, Alaska	286060	f	24	20/01/51	NMNH
C.urs	Sitka, Alaska	286072	f	24	23/01/51	NMNH
C.urs	Sitka, Alaska	286075	f	24	23/01/51	NMNH
C.urs	Sitka, Alaska	286077	f	24	24/01/51	NMNH
C.urs	Sitka, Alaska	286082	f	24	24/01/51	NMNH
C.urs	Sitka, Alaska	286080	f	24	24/01/51	NMNH
C.urs	Sitka, Alaska	286105	f	24	26/01/51	NMNH
C.urs	Miyagi Pref	286171	f	25	29/03/50	NMNH
C.urs	Iwate Pref	286253	f	25	28/04/50	NMNH
C.urs	Iwate Pref	286307	f	25	9/05/50	NMNH
C.urs	Sitka, Alaska	286039	f	25	16/01/51	NMNH
C.urs	Sitka, Alaska	286048	f	25	18/01/51	NMNH
C.urs	Sitka, Alaska	286064	f	25	23/01/51	NMNH
C.urs	Sitka, Alaska	286063	f	25	23/01/51	NMNH
C.urs	Sitka, Alaska	286073	f	25	23/01/51	NMNH
C.urs	Sitka, Alaska	286087	f	25	25/01/51	NMNH
C.urs	Sitka, Alaska	286089	f	25	25/01/51	NMNH
C.urs	Portage Bay, Alaska	11497	f	25	5/54	UAM
C.urs	St Paul Is	1891.12.18.10	f	26	–	BMNH
C.urs	Miyagi Pref	286244	f	26	27/04/50	NMNH
C.urs	Miyagi Pref	286283	f	26	8/05/50	NMNH
C.urs	Iwate Pref	286310	f	26	9/05/50	NMNH
C.urs	Iwate Pref	286334	f	26	12/05/50	NMNH
C.urs	Sitka, Alaska	286059	f	26	19/01/51	NMNH
C.urs	Sitka, Alaska	286068	f	26	23/01/51	NMNH
C.urs	Miyagi Pref	286162	f	27	25/03/50	NMNH
C.urs	Miyagi Pref	286193	f	27	30/03/50	NMNH
C.urs	Iwate Pref	286279	f	27	2/05/50	NMNH
C.urs	Iwate Pref	286335	f	27	12/05/50	NMNH
C.urs	Sitka, Alaska	286049	f	27	18/01/51	NMNH
C.urs	Sitka, Alaska	286057	f	27	19/01/51	NMNH
C.urs	Miyagi Pref	286217	f	28	11/04/50	NMNH

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C.urs	Miyagi Pref	286215	f	28	11/04/50	NMNH
C.urs	Miyagi Pref	286220	f	28	19/04/50	NMNH
C.urs	Miyagi Pref	286215	f	28	11/04/50	NMNH
C.urs	Miyagi Pref	286217	f	28	11/04/50	NMNH
C.urs	Iwate Pref	286312	f	28	9/05/50	NMNH
C.urs	Sitka, Alaska	286040	f	28	16/01/51	NMNH
C.urs	Sitka, Alaska	286065	f	28	23/01/51	NMNH
C.urs	Sitka, Alaska	286078	f	28	24/01/51	NMNH
C.urs	Commander Is	1928.4.21.63	f	29	–	BMNH
C.urs	–	74328	f	29	–	ZMB
C.urs	Miyagi Pref	286209	f	29	9/04/50	NMNH
C.urs	Miyagi Pref	286282	f	29	8/05/50	NMNH
C.urs	Iwate Pref	286302	f	29	9/05/50	NMNH
C.urs	Iwate Pref	286313	f	29	9/05/50	NMNH
C.urs	Sitka, Alaska	286062	f	29	22/01/51	NMNH
C.urs	Sitka, Alaska	286066	f	29	23/01/51	NMNH
C.urs	Sitka, Alaska	286069	f	30	23/01/51	NMNH
C.urs	Yedo, Japan	F5942	f	10	1880	ZMB
C.urs	Fukishima	286130	f	29	16/03/50	NMNH
C.urs	Pribilof Is	1878.5.10.2	m	24	–	BMNH
C.urs	Bering Is	21328	m	24	1883	NMNH
C.urs	Bering Is	47102	m	24	3/6/1892	NMNH
C.urs	St Paul Is	285656	m	24	16/07/48	NMNH
C.urs	St Paul Is	285716	m	25	31/08/49	NMNH
C.urs	St Paul Is	285720	m	25	8/07/46	NMNH
C.urs	St Paul Is	285724	m	25	31/07/48	NMNH
C.urs	St Paul Is	285723	m	25	29/07/46	NMNH
C.urs	St Paul Is	285690	m	25	5/08/49	NMNH
C.urs	St Paul Is	285652	m	25	8/07/48	NMNH
C.urs	St Paul Is	285664	m	25	3/08/48	NMNH
C.urs	St Paul Is	285634	m	25	14/07/47	NMNH
C.urs	Bering Is	1928.4.21.60	m	26	–	BMNH
C.urs	St Paul Is	285710	m	26	13/08/49	NMNH
C.urs	St Paul Is	285727	m	26	2/08/46	NMNH
C.urs	St Paul Is	285699	m	26	13/08/49	NMNH
C.urs	St Paul Is	285651	m	26	6/07/48	NMNH
C.urs	St Paul Is	285632	m	26	11/07/47	NMNH
C.urs	St Paul Is	1891.12.18.9	m	27	–	BMNH
C.urs	St Paul Is	K7228	m	27	–	UMZC
C.urs	Bering Is	47101	m	27	3/6/1892	NMNH
C.urs	Bering Is	21325	m	28	5/1892	NMNH
C.urs	St Paul Is	285704	m	28	13/08/49	NMNH
C.urs	St Paul Is	219836	m	28	1917	NMNH
C.urs	St Paul Is	285649	m	28	30/06/48	NMNH
C.urs	St Paul Is	285653	m	28	9/07/48	NMNH
C.urs	St Paul Is	11494	m	28	17/08/52	UAM
C.urs	–	10/11/1899	m	29	11/1899	ZMB
C.urs	St Paul Is	285700	m	29	13/08/49	NMNH
C.urs	St Paul Is	285666	m	29	9/08/48	NMNH
C.urs	St Paul Is	285658	m	29	18/07/48	NMNH
C.urs	St Paul Is	285665	m	30	3/08/48	NMNH
C.urs	St Paul Is	285677	m	30	28/06/49	NMNH
C.urs	St Paul Is	285684	m	31	31/07/49	NMNH
C.urs	Bering Is	1928.4.21.61	m	32	–	BMNH
C.urs	St Paul Is	285685	m	32	1/08/49	NMNH
C.urs	St Paul Is	285663	m	32	30/07/48	NMNH
C.urs	St Paul Is	285709	m	32	13/08/49	NMNH
C.urs	St Paul Is	285706	m	33	13/08/49	NMNH
C.urs	St Paul Is	285715	m	33	9/07/40	NMNH
C.urs	St Paul Is	285726	m	33	2/08/46	NMNH
C.urs	St Paul Is	285667	m	33	11/08/48	NMNH
C.urs	St Paul Is	285657	m	33	18/07/48	NMNH
C.urs	St Paul Is	285644	m	33	7/47	NMNH
C.urs	St Paul Is	285695	m	34	6/08/49	NMNH

Species	Location collected	Accession no.	Sex	SI	Date collected	Museum
C.urs	St Paul Is	285687	m	34	1/08/49	NMNH
C.urs	St Paul Is	285660	m	34	27/07/48	NMNH
C.urs	St Paul Is	285640	m	34	7/47	NMNH
C.urs	Bering Is	1928.4.21.59	m	35	–	BMNH
C.urs	St Paul Is	285650	m	35	4/07/48	NMNH
E.jub	Barren Is, AK	18552	f	19	12/04/78	UAM
E.jub	Galena Bay	31904	f	19	1995	UAM
E.jub	Ano Nuevo Is, CA	lacm52313	f	19	27/06/15	LACM
E.jub	–	lacm51173	f	19	–	LACM
E.jub	Rausu, east Hokkaido	97012	f	19	1997	HU
E.jub	Rausu, east Hokkaido	95014	f	19	1995	HU
E.jub	St George Is	1897.1.18.7	f	20	–	BMNH
E.jub	Ano Nuevo Is, CA	1950.7.21.5	f	20	–	BMNH
E.jub	–	lacm52316	f	20	–	LACM
E.jub	Rausu, east Hokkaido	99013	f	20	1999	HU
E.jub	Rausu, east Hokkaido	94023	f	20	1994	HU
E.jub	Bering Is	47104	f	21	3/6/1892	NMNH
E.jub	Ano Nuevo Is, CA	lacm620	f	21	3/07/21	LACM
E.jub	Rausu, east Hokkaido	99008	f	21	1999	HU
E.jub	Rausu, east Hokkaido	98011	f	21	1998	HU
E.jub	Rausu, east Hokkaido	95015	f	21	1995	HU
E.jub	Tuleni Is, Okhotsk Sea	21302	f	22	1883	NMNH
E.jub	Tuleni Is, Okhotsk Sea	21309	f	22	–	NMNH
E.jub	Rausu, east Hokkaido	95016	f	22	1995	HU
E.jub	Rausu, east Hokkaido	98022	f	23	1998	HU
E.jub	Rausu, east Hokkaido	95019	f	23	1995	HU
E.jub	St Paul Is	31916	f	24	23/05/94	UAM
E.jub	St George Is	8162	f	25	–	NMNH
E.jub	Bering Str	8163	f	25	1840	NMNH
E.jub	–	267995	f	25	–	NMNH
E.jub	Rausu, east Hokkaido	94017	f	25	1994	HU
E.jub	Ano Nuevo Is, CA	1950.7.21.6	f	26	–	BMNH
E.jub	Tuleni Is, Okhotsk Sea	38220	f	26	1883	NMNH
E.jub	St Paul Is	188982	f	26	8/1892	NMNH
E.jub	Ano Nuevo Is, CA	lacm52311	f	26	27/06/15	LACM
E.jub	Kodiak Is	256492	f	27	1930	NMNH
E.jub	Rausu, east Hokkaido	94026	f	27	1994	HU
E.jub	Bering Sea	5210	f	28	–	UAM
E.jub	Hokkaido	97305	f	28	1997	HU
E.jub	Hokkaido	97309	f	28	1997	HU
E.jub	Hokkaido	97307	f	28	1997	HU
E.jub	Rausu, east Hokkaido	95011	f	28	1995	HU
E.jub	Ano Nuevo Is, CA	2744	f	29	6/24	DMNH
E.jub	Hokkaido	14	f	29	?	HU
E.jub	Unalaska Is	15861	f	30	1876	NMNH
E.jub	Tuleni Is, Okhotsk Sea	38228	f	30	1883	NMNH
E.jub	Hokkaido	98NT1	f	30	1998	HU
E.jub	Rausu, east Hokkaido	94020	f	30	1994	HU
E.jub	Rebun Island	99204	f	30	1999	HU
E.jub	Rausu, east Hokkaido	95018	f	30	1995	HU
E.jub	Rausu, east Hokkaido	94022	f	30	1994	HU
E.jub	Point Pinos, CA	159964	f	31	22/06/09	NMNH
E.jub	Chehalis County, Washington	188980	f	31	10/1885	NMNH
E.jub	St Paul Is	276209	f	31	12/07/48	NMNH
E.jub	Rausu, east Hokkaido	94014	f	31	1994	HU
E.jub	Rebun Island	98201	f	31	1998	HU
E.jub	Rausu, east Hokkaido	98009	f	31	1998	HU
E.jub	Rausu, east Hokkaido	95021	f	31	1995	HU
E.jub	Hokkaido	98301	f	31	1998	HU
E.jub	Rebun Island	97203	f	32	1997	HU
E.jub	Rausu, east Hokkaido	94021	f	33	1994	HU
E.jub	Farallones Is, CA	23457	f	24	–	NMNH
E.jub	Farallones Is, CA	21523	f	31	9/1884	NMNH
E.jub	Farallones Is, CA	21537	f	33	9/1884	NMNH

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E.jub	St George Is	32733	m	24	5/05/94	UAM
E.jub	Rebun Island	1325	m	24	1968	ASD
E.jub	Tuleni Is, Okhotsk Sea	21303	m	25	1883	NMNH
E.jub	Bering Is	22072	m	26	–	NMNH
E.jub	Bering Is	22071	m	26	–	NMNH
E.jub	St Paul Is	83887	m	26	1897	NMNH
E.jub	Pribilof Is	114830	m	26	?/7/1902	NMNH
E.jub	Ano Nuevo Is, CA	lacm616	m	26	4/07/21	LACM
E.jub	Rebun Island	1033	m	26	?/02/1969	ASD
E.jub	Rebun Island	75K6	m	26	30/12/1975	ASD
E.jub	Rebun Island	75K20	m	26	1976	ASD
E.jub	Hokkaido	97302	m	26	1997	HU
E.jub	Shakotan, Hokkaido	98105	m	26	1998	HU
E.jub	Shakotan, Hokkaido	99104	m	26	1999	HU
E.jub	Hokkaido	94	m	26	1994	HU
E.jub	Hokkaido	929/29	m	26	1992	HU
E.jub	St Paul Is	72815	m	27	1872	ZMB
E.jub	St Paul Is	7140	m	27	–	NMNH
E.jub	Otter Is, Bering Sea	11470	m	27	10/07/74	UAM
E.jub	Rebun Island	75K3	m	27	1975	ASD
E.jub	Hokaido	870524	m	27	1987	HU
E.jub	–	1992.272	m	28	–	BMNH
E.jub	Farallone Is, CA	13217	m	28	–	NMNH
E.jub	Aleutian Is	261229	m	28	1936	NMNH
E.jub	St George Is	43370	m	28	16/05/96	UAM
E.jub	Bristol Bay, Bering Sea	5216	m	28	–	UAM
E.jub	St Paul Is	AF19493	m	28	1997	UAM
E.jub	Rebun Island	75K16	m	28	1976	ASD
E.jub	Hokkaido	98CH02	m	28	1998	HU
E.jub	St Paul Is	188981	m	29	4/8/1891	NMNH
E.jub	Bristol Bay, Bering Sea	5217	m	29	–	UAM
E.jub	St Paul Is	43367	m	29	25/02/96	UAM
E.jub	St Paul Is	43367	m	29	25/02/96	UAM
E.jub	–	lacm52314	m	29	–	LACM
E.jub	Rebun Island	75K1	m	29	1975	ASD
E.jub	Hokkaido	97304	m	29	1997	HU
E.jub	Shakotan, Hokkaido	99105	m	29	1999	HU
E.jub	St Paul Is	1950.3.29.12	m	30	–	BMNH
E.jub	St Paul Is	49730	m	30	–	NMNH
E.jub	–	152135	m	30	?/8/08	NMNH
E.jub	St Paul Is	276031	m	30	7/07/46	NMNH
E.jub	St Paul Is	276354	m	30	7/07/48	NMNH
E.jub	–	–	m	30	–	UAM
E.jub	Shakotan, Hokkaido	99106	m	30	1999	HU
E.jub	Rausu, east Hokkaido	98029	m	30	1998	HU
E.jub	Hokkaido	98ST01	m	30	1998	HU
E.jub	St George Is	1950.3.29.11	m	31	–	BMNH
E.jub	Aleutian Is	267526	m	31	1937	NMNH
E.jub	Lynn Canal, AK	246499	m	31	6/02/25	NMNH
E.jub	Tahola, Washington	276032	m	31	13/06/42	NMNH
E.jub	Rebun Island	75K13	m	31	1976	ASD
E.jub	San Francisco Bay	4702	m	32	7/1834	NMNH
E.jub	St Paul Is	285509	m	32	22/06/49	NMNH
E.jub	St Paul Is	43365	m	32	22/04/96	UAM
E.jub	Rishiri Island	1323	m	32	14/04/69	ASD
E.jub	Rebun Island	75K24	m	32	1976	ASD
E.jub	Farralones Is, CA	4701	m	33	7/1856	NMNH
E.jub	Unalaska Is	15359	m	33	–	NMNH
E.jub	Dall Is, AK	8655	m	33	1960	DMNH
E.jub	Monterey, CA	6906	m	28	–	NMNH
E.jub	Massett, BC	21108	m	31	7/1883	NMNH
E.jub	Monterey, CA	3631	m	32	–	NMNH
N.cin	Australia	A3568	f	20	1839	MNHN
N.cin	Olive Is, S. Aust.	m11964	f	20	7/07/78	SAM

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N.cin	Cape Jervis, S. Aust.	m17681	f	20	7/02/92	SAM
N.cin	Israelite Bay, WA	m23975	f	21	25/01/85	WAM
N.cin	Margaret Cove, WA	m16288	f	21	10/07/82	WAM
N.cin	Victor Harbor, S. Aust.	m19788	f	21	23/10/95	SAM
N.cin	Port Lincoln, S. Aust.	m19790	f	21	28/03/96	SAM
N.cin	Kangaroo Is, S. Aust.	m19787	f	22	9/11/97	SAM
N.cin	West coast, S. Aust.	m16227	f	22	<1991	SAM
N.cin	Sussex Mill, WA	m19204	f	23	19/05/78	WAM
N.cin	Recherche	m7678	f	24	1967	WAM
N.cin	Doubtful Isles, WA	m15366	f	24	3/77	WAM
N.cin	Green Islets, WA	1968.9.26.29	f	25	28/11/56	BMNH
N.cin	Dangerous Reef, S. Aust.	m11705	f	26	–	SAM
N.cin	Coffin Bay, S. Aust.	m19272	f	26	1980's	SAM
N.cin	Houtman Abrolhos	m6224	f	27	28/06/64	WAM
N.cin	Coffin bay, S. Aust.	m12959	f	27	1977	SAM
N.cin	Bald Is, WA	m21197	f	28	1976	WAM
N.cin	Port Lincoln, S. Aust.	m19791	f	28	28/03/96	SAM
N.cin	–	m7877	f	29	–	WAM
N.cin	Spencer Gulf, S. Aust.	m11701	f	29	1975	SAM
N.cin	Seal Bay, KI	1968.9.26.27	f	30	–	BMNH
N.cin	Cabot's Bch, S. Aust.	m12963	f	30	5/08/85	SAM
N.cin	Port Lincoln, S. Aust.	m19792	f	30	28/03/98	SAM
N.cin	Greenly Is, S. Aust.	m18665	f	30	1976	SAM
N.cin	Beagle Is, WA	m16837	f	31	11/79	WAM
N.cin	Parson's Bch, S. Aust.	m11215	f	31	17/08/82	SAM
N.cin	Little English Is, S. Aust.	m7471	f	31	18/11/65	SAM
N.cin	Coompana Tan, S. Aust.	m18394	f	31	21/09/94	SAM
N.cin	Purdie Is, S. Aust.	m11962	f	32	14/05/78	SAM
N.cin	Thistle Is, S. Aust.	m11700	f	32	4/01/76	SAM
N.cin	Port Lincoln, S. Aust.	m18234	f	32	30/09/94	SAM
N.cin	Kangaroo Is, S. Aust.	m18401	f	32	18/02/95	SAM
N.cin	Port Elliott, S. Aust.	m17680	f	33	27/12/93	SAM
N.cin	Fisherman Is, WA	m16839	f	30	11/79	WAM
N.cin	Franklin Is, S. Aust.	m11695	f	30	4/82	SAM
N.cin	S Neptune Is, S. Aust.	11482	m	25	1970	UAM
N.cin	S Neptune Is, S. Aust.	571463	m	29	6/70	NMNH
N.cin	S. Neptune Is, S. Aust.	8249	m	30	–	DMNH
N.cin	Spencer Gulf, S. Aust.	1968.9.26.25	m	31	–	BMNH
N.cin	Neptune Is, S. Aust.	1897.10.10.5	m	32	–	BMNH
N.cin	NW Aust.	337.e	m	36	–	BMNH
N.cin	Kangaroo Is, S. Aust.	m8674	m	24	2/08/69	SAM
N.cin	Kangaroo Is, S. Aust.	m9041	m	24	15/08/70	SAM
N.cin	Rivoli Bay, S. Aust.	m2480	m	24	–	SAM
N.cin	Recherche	m8331	m	25	27/10/70	WAM
N.cin	–	m6163	m	25	–	SAM
N.cin	Pearson Is, S. Aust.	m2477	m	25	–	SAM
N.cin	Kangaroo Is, S. Aust.	m19786	m	25	16/04/97	SAM
N.cin	Cape Bouger, S. Aust.	m11963	m	26	6/06/77	SAM
N.cin	S Neptune Is, S. Aust.	m15459	m	26	1967	SAM
N.cin	Lake Preston, WA	m3323	m	27	27/02/58	WAM
N.cin	Greenhead, WA	m25807	m	27	6/11/74	WAM
N.cin	Recherche	m7677	m	28	1967	WAM
N.cin	Recherche	m3810	m	28	15/02/60	WAM
N.cin	Kangaroo Is, S. Aust.	m11710	m	28	3/02/78	SAM
N.cin	Spencer Gulf, S. Aust.	m11203	m	28	4/12/83	SAM
N.cin	–	m13379	m	28	–	SAM
N.cin	Recherche	m7676	m	29	1967	WAM
N.cin	Pt Turton, S. Aust.	m15964	m	29	3/07/89	SAM
N.cin	Olive Is, S. Aust.	m11702	m	30	7/07/78	SAM
N.cin	Snake Park, S. Aust.	m5077	m	30	24/02/41	SAM
N.cin	S. Aust. coast	m1263	m	30	1922	SAM
N.cin	Victor Harbor, S. Aust.	m19789	m	30	8/10/95	SAM
N.cin	Greenly Is, S. Aust.	m18648	m	30	1976	SAM
N.cin	Wirrina Resort, S. Aust.	m16395	m	30	22/02/91	SAM

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N.cin	recherche	m3811	m	31	12/02/60	WAM
N.cin	Doubtful Isles, WA	m15367	m	31	3/77	WAM
N.cin	Hopetown/Braemer Bay, WA	m6090	m	31	16/02/64	WAM
N.cin	Yanchep, WA	m7866	m	31	27/07/68	WAM
N.cin	Recherche	m3809	m	31	14/02/60	WAM
N.cin	Western Aust.	m25809	m	31	–	WAM
N.cin	Kangaroo Is, S. Aust.	m11711	m	31	14/01/75	SAM
N.cin	Marino Rocks, S. Aust.	m11223	m	31	2/05/83	SAM
N.cin	Victor Harbor, S. Aust.	m6263	m	31	10/08/57	SAM
N.cin	Pearson Is, S. Aust.	m2003	m	31	1923	SAM
N.cin	Goolwa, S. Aust.	m3219	m	31	1931	SAM
N.cin	Kangaroo Is, S. Aust.	m16981	m	31	12/08/91	SAM
N.cin	Pearson Is, S. Aust.	m16592	m	31	1/02/91	SAM
N.cin	Largs Bay, S. Aust.	m12788	m	32	1/06/84	SAM
N.cin	Pearson Is, S. Aust.	m9545	m	32	2/74	SAM
N.cin	Victor Harbor, S. Aust.	m16980	m	32	28/01/92	SAM
N.cin	Coffin Bay, S. Aust.	m19270	m	32	1980's	SAM
N.cin	Kangaroo Is, S. Aust.	m19785	m	32	25/01/93	SAM
N.cin	S Neptune Is, S. Aust.	m15462	m	32	1967	SAM
N.cin	Kangaroo Is, S. Aust.	m11708	m	33	24/06/75	SAM
N.cin	Kangaroo Is, S. Aust.	m11704	m	33	30/01/78	SAM
N.cin	Nuyts Archip. S. Aust.	m11703	m	33	28/10/77	SAM
N.cin	Eyre Peninsula, S. Aust.	m9040	m	33	1922	SAM
N.cin	Israelite Bay, WA	m23974	m	34	25/01/85	WAM
N.cin	Hummocks, S. Aust.	m4942	m	34	1939	SAM
N.cin	Port Willunga, S. Aust.	m15963	m	34	11/04/90	SAM
N.cin	Kangaroo Is, S. Aust.	m11636	m	35	14/07/84	SAM
N.cin	S Neptune Is, S. Aust.	m15748	m	35	12/06/90	SAM
O.byro	Chancay, Peru	1900.5.7.10	f	19	–	BMNH
O.byro	–		f	22	–	ZMB
O.byro	Santa Cruz, Argentina	2382	f	24	31/03/26	DMNH
O.byro	Peru	84.983	f	26	8/5/83	BMNH
O.byro	Chincha Is, Peru	77800	f	26	1919	AMNH
O.byro	Sta Cruz, Argentina	73122	f	27	25/03/26	AMNH
O.byro	–	1959.12.4.7	f	27	–	BMNH
O.byro	Peru	84.985	f	27	8/05/83	BMNH
O.byro	Peru	84.991	f	27	8/05/83	BMNH
O.byro	San Juan, Peru	84.984	f	27	4/83	BMNH
O.byro	Lobos Is, Uruguay	239138	f	27	1923	NMNH
O.byro	San Juan, Peru	84.980	f	28	9/6/83	BMNH
O.byro	Peru	84.981	f	28	–	BMNH
O.byro	Isla Chiloe, Chile	23360	f	28	2/06/70	SDNHM
O.byro	San Juan, Peru	285141	f	30	15/01/49	NMNH
O.byro	Falkland Is	1939.1.21.112	f	19	–	BMNH
O.byro	Falkland Is	1939.1.21.83	f	20	–	BMNH
O.byro	Falkland Is	1939.1.21.77	f	20	–	BMNH
O.byro	Falkland Is	1939.1.21.98	f	20	–	BMNH
O.byro	Falkland Is	1949.3.17.83	f	24	–	BMNH
O.byro	Falkland Is	1939.1.21.108	f	24	–	BMNH
O.byro	Falkland Is	1939.1.21.119	f	24	–	BMNH
O.byro	Falkland Is	1939.1.21.117	f	25	–	BMNH
O.byro	Falkland Is	1939.1.21.115	f	25	–	BMNH
O.byro	Falkland Is	1939.1.21.113	f	25	–	BMNH
O.byro	Falkland Is	1939.1.21.116	f	26	–	BMNH
O.byro	Falkland Is	1939.1.21.121	f	26	–	BMNH
O.byro	Falkland Is	1939.1.21.106	f	26	–	BMNH
O.byro	Falkland Is	1939.1.21.120	f	27	–	BMNH
O.byro	Falkland Is	1939.1.21.104	f	27	–	BMNH
O.byro	Falkland Is	1939.1.21.107	f	27	–	BMNH
O.byro	Falkland Is	1939.1.21.110	f	27	–	BMNH
O.byro	Falkland Is	1939.1.21.101	f	27	–	BMNH
O.byro	Falkland Is	1939.1.21.114	f	28	–	BMNH
O.byro	Falkland Is	1939.1.21.109	f	28	–	BMNH
O.byro	Falkland Is	1939.1.21.118	f	29	–	BMNH

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O.byro	Falkland Is	1939.1.21.105	f	30	–	BMNH
O.byro	Falkland Is	1951.3.6.1	m	24	–	BMNH
O.byro	Falkland Is	1939.1.21.179	m	24	–	BMNH
O.byro	Lobos de Tierra, Peru	153566	m	24	2/04/07	NMNH
O.byro	Isla Lobos, Chile	22407	m	24	21/05/70	SDNHM
O.byro	Falkland Is	8253	m	24	2/65	DMNH
O.byro	Falkland Is	1939.1.21.172	m	24	–	BMNH
O.byro	Falkland Is	1939.1.21.165	m	25	–	BMNH
O.byro	Tierra del Fuego, Argentina	482156	m	25	20/04/71	NMNH
O.byro	La Gunilla, Peru	lacm72456	m	25	–	LACM
O.byro	Falkland Is	1939.1.21.176	m	25	–	BMNH
O.byro	Falkland Is	ws479	m	26	–	BMNH
O.byro	Sth America	335.d	m	26	–	BMNH
O.byro	Falkland Is	1939.1.21.164	m	26	–	BMNH
O.byro	Falkland Is	K7029	m	26	–	UMZC
O.byro	–	B	m	26	–	ZMB
O.byro	–	1959.12.4.6	m	26	–	BMNH
O.byro	Falkland Is	1869.8.10.1	m	27	–	BMNH
O.byro	Falkland Is	1950.11.6.1	m	27	–	BMNH
O.byro	Falkland Is	1914.7.4.1	m	27	–	BMNH
O.byro	Str of Magellan	1880.7.28.6	m	27	–	BMNH
O.byro	Falkland Is	b2*	m	27	–	BMNH
O.byro	Tierra del Fuego, Argentina	482157	m	27	20/04/71	NMNH
O.byro	Punta Piramides, Argentina	484912	m	27	31/01/73	NMNH
O.byro	Falkland Is	1B*	m	28	–	BMNH
O.byro	Coquimbo Bay, Chile	1887.6.18.2	m	28	–	BMNH
O.byro	Falkland Is	1939.1.21.163	m	28	–	BMNH
O.byro	Torres	33881	m	28	–	ZMB
O.byro	Falkland Is	1939.1.21.173	m	28	–	BMNH
O.byro	Falkland Is	335.0	m	29	–	BMNH
O.byro	Falkland Is	1939.1.21.177	m	29	–	BMNH
O.byro	Falkland Is	1939.1.21.182	m	29	–	BMNH
O.byro	Falkland Is	K7024	m	29	12/1875	UMZC
O.byro	Chile	K7028	m	29	1876	UMZC
O.byro	Peru	72817	m	29	–	ZMB
O.byro	–	550227	m	29	–	NMNH
O.byro	Santa Cruz, Argentina	2380	m	29	29/03/26	DMNH
O.byro	Falkland Is	1939.1.21.166	m	29	–	BMNH
O.byro	Sth America	1851.5.5.1	m	30	–	BMNH
O.byro	Ils St Maria	C	m	30	–	ZMB
O.byro	Isla de los Viejas, Peru	504394	m	30	27/08/66	NMNH
O.byro	of Ost Cat?	335.m	m	31	–	BMNH
O.byro	Falkland Is	1869.2.24.1	m	31	–	BMNH
O.byro	–	72822	m	31	1902	ZMB
O.byro	–	550142	m	31	–	NMNH
O.byro	Falkland Is	1939.1.21.183	m	31	24/7/35	BMNH
O.byro	Falkland Is	1886.12.13.1	m	32	–	BMNH
O.byro	Sth America	46494	m	32	–	ZMB
O.byro	Buenos Aires, Argentina	172782	m	32	1910	NMNH
O.byro	Lobos de Tierra, Peru	153567	m	32	2/04/07	NMNH
O.byro	Falkland Is	1925.12.17.1	m	34	–	BMNH
O.byro	Cp Fairweather, Patagonia	95063	m	34	1896	NMNH
O.byro	Cerros de Illesces	550307	m	34	19/12/82	NMNH
O.byro	Isla Chiloe, Chile	23345	m	34	2/06/70	SDNHM
O.byro	Montevideo	70695	m	27	–	ZMB
O.byro	Mar del Plata, Argentina	172781	m	30	1910	NMNH
O.byro?	Falkland Is	1939.1.21.99	f	19	–	BMNH
P.hook	Enderby Is	310/39	f	19	–	NMNZ
P.hook	Enderby Is	e17/8081	f	19	1981	NMNZ
P.hook	–	m17822	f	19	–	AM
P.hook	Enderby Is	88/8182	f	20	1982	NMNZ
P.hook	Enderby Is	89/14	f	21	1989	NMNZ
P.hook	Enderby Is	e15/8081	f	22	1981	NMNZ
P.hook	Enderby Is	46/8182	f	22	1982	NMNZ

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P.hook	Enderby Is	89/13	f	22	1989	NMNZ
P.hook	Enderby Is	May-82	f	23	1982	NMNZ
P.hook	Auckland Is	m12606	f	23	14/02/73	AM
P.hook	Auckland Is	1926.389	f	24	1926	MNHN
P.hook	Auckland Is	344983	f	24	18/01/67	NMNH
P.hook	Enderby Is	e10/80.81	f	24	1981	NMNZ
P.hook	Enderby Is	e17/8081	f	24	1981	NMNZ
P.hook	Enderby Is	13/8182	f	24	1982	NMNZ
P.hook	Enderby Is	03FFV	f	24	–	NMNZ
P.hook	Enderby Is	e4/86	f	25	1986	NMNZ
P.hook	Enderby Is	e2/8081	f	25	1981	NMNZ
P.hook	Enderby Is	8485/0007MC	f	25	1985	NMNZ
P.hook	Enderby Is	2	f	25	–	NMNZ
P.hook	–	m17824	f	25	–	AM
P.hook	Auckland Is	344986	f	26	18/01/64	NMNH
P.hook	Enderby Is	89/15	f	26	1990	NMNZ
P.hook	Enderby Is	5	f	26	–	NMNZ
P.hook	–	m17823	f	26	–	AM
P.hook	Enderby Is	310/38II	f	27	–	NMNZ
P.hook	Enderby Is	e1/80	f	27	1980	NMNZ
P.hook	Enderby Is	e1/8586	f	27	1986	NMNZ
P.hook	Enderby Is	89/16	f	28	1989	NMNZ
P.hook	Auckland Is	m17848	f	29	–	AM
P.hook	Enderby Is	8485/0005MC	f	30	1985	NMNZ
P.hook	Enderby Is	FFV02/82	f	23	1982	NMNZ
P.hook	–	NMNZ1663	m	24	–	NMNZ
P.hook	Auckland Is	NMNZ2297	m	25	–	NMNZ
P.hook	Enderby Is	8485/0002MC	m	25	1985	NMNZ
P.hook	–	NMNZ1034	m	26	–	NMNZ
P.hook	Auckland Is	344982	m	27	18/01/64	NMNH
P.hook	Enderby Is	8485/0012MC	m	27	1985	NMNZ
P.hook	Enderby Is	Jul-82	m	27	1982	NMNZ
P.hook	Enderby Is	e5/8081	m	27	1981	NMNZ
P.hook	–	NMNZ1033	m	27	–	NMNZ
P.hook	Snares Is, N.Z.	8256	m	28	5/02/71	DMNH
P.hook	Enderby Is	Apr-81	m	29	1981	NMNZ
P.hook	Enderby Is	NMNZ1644	m	31	–	NMNZ
P.hook	N.Z.	8254	m	31	–	DMNH
P.hook	Campbell Is	1875.509	m	32	–	MNHN
P.hook	Snares Is, N.Z.	344981	m	33	13/01/64	NMNH
P.hook	Auckland Is	m33573	m	24	–	AM
P.hook	Auckland Is	m17849	m	25	–	AM
P.hook	Auckland Is	m11816	m	26	1/73	AM
P.hook	Auckland Is	m11813	m	27	1/73	AM
P.hook	Auckland Is	m11811	m	27	1/73	AM
P.hook	Auckland Is	m11812	m	29	1/73	AM
P.hook	Auckland Is	m11815	m	29	1/73	AM
P.hook	Auckland Is	m11819	m	29	1/73	AM
P.hook	N.Z.	m663	m	32	–	SAM
P.hook	Enderby Is	e2/86	m	33	1986	NMNZ
P.hook	Auckland Is	m11818	m	33	1/73	AM
Z.c.c	Baja Calif, ME	21241	f	23	22/11/53	SDNHM
Z.c.c	San Benito Is, ME	35383	f	24	–	NMNH
Z.c.c	North Bch, LI	16888	f	25	5/07/01	AMNH
Z.c.c	Baja Calif, ME	lacm22999	f	25	13/09/53	LACM
Z.c.c	Isla Natividad, ME	396915	f	26	4/69	NMNH
Z.c.c	Baja Calif, ME	22983	f	26	27/02/74	SDNHM
Z.c.c	Baja Calif, ME	19393	f	27	19/04/63	SDNHM
Z.c.c	Baja Calif, ME	21240	f	27	20/11/53	SDNHM
Z.c.c	San Martin, CA	180457	f	28	8/03/57	AMNH
Z.c.c	Baja Calif, ME	lacm51195	f	28	1/07/64	LACM
Z.c.c	Baja Calif, ME	lacm51188	f	28	2/11/63	LACM
Z.c.c	San Martin Is, ME	180452	f	29	8/03/57	AMNH
Z.c.c	San Martin Is, ME	180453	f	29	8/03/57	AMNH

Species	Location collected	Accession no.	Sex	SI	Date collected	Museum
Z.c.c	San Martin Is, ME	180454	f	29	8/03/57	AMNH
Z.c.c	San Benitas Is, ME	27135	f	29	–	NMNH
Z.c.c	Benita Is, ME	21737	f	29	–	NMNH
Z.c.c	Isla Natividad, ME	395725	f	29	24/04/68	NMNH
Z.c.c	San Miguel Is, CA	11489	f	29	8/69	UAM
Z.c.c	N. Pacific	lacm91761	f	29	23/09/92	LACM
Z.c.c	San Jorge Is, ME	lacm8584	f	29	20/01/50	LACM
Z.c.c	San Nicolas Is, CA	lacm51228	f	29	10/09/60	LACM
Z.c.c	N. Pacific	lacm91326	f	29	21/04/93	LACM
Z.c.c	Baja Calif, ME	22979	f	29	1/71	SDNHM
Z.c.c	Baja Calif, ME	23340	f	29	28/02/75	SDNHM
Z.c.c	Baja Calif, ME	22863	f	29	9/02/73	SDNHM
Z.c.c	Baja Calif	22825	f	29	25/01/72	SDNHM
Z.c.c	Baja Calif, ME	22823	f	29	25/01/72	SDNHM
Z.c.c	San Clemente Is, CA	2365	f	29	27/06/28	DMNH
Z.c.c	San Martin Is, CA	180461	f	30	8/03/57	AMNH
Z.c.c	San Martin Is, CA	180459	f	30	8/03/57	AMNH
Z.c.c	Benita Is, ME	21736	f	30	11/1884	NMNH
Z.c.c	La Jolla, CA	276052	f	30	23/10/43	NMNH
Z.c.c	San Pedro, CA	276054	f	30	5/12/46	NMNH
Z.c.c	–	504203	f	30	–	NMNH
Z.c.c	N. Pacific	lacm91889	f	30	30/09/94	LACM
Z.c.c	Baja Calif, ME	lacm23000	f	30	13/09/53	LACM
Z.c.c	Bluff Cove, CA	lacm86035	f	30	26/11/82	LACM
Z.c.c	Baja Calif, ME	22984	f	30	28/02/74	SDNHM
Z.c.c	Baja Calif, ME	19397	f	30	16/04/63	SDNHM
Z.c.c	N. Pacific	lacm91334	f	31	18/06/93	LACM
Z.c.c	Santa Barbara coast, CA	lacm51184	f	31	3/03/69	LACM
Z.c.c	San Miguel Is, CA	8267	f	31	–	DMNH
Z.c.c	Sonora, ME	514663	m	24	1969	NMNH
Z.c.c	Huntington Bch, CA	lacm51171	m	24	1/12/59	LACM
Z.c.c	Baja Calif, ME	23342	m	24	27/02/77	SDNHM
Z.c.c	Baja Calif, ME	21248	m	24	17/06/56	SDNHM
Z.c.c	Baja Calif, ME	19396	m	24	19/04/63	SDNHM
Z.c.c	San Miguel Is, CA	21245	m	24	18/09/54	SDNHM
Z.c.c	San Martin Is, CA	180458	m	25	8/03/57	AMNH
Z.c.c	Santa Cruz Is, CA	131897	m	25	–	NMNH
Z.c.c	San Benito Is, ME	259651	m	25	5/35	NMNH
Z.c.c	San Nicolas Is, CA	lacm51175	m	25	13/04/60	LACM
Z.c.c	Coronado Is, CA	260216	m	26	21/03/36	NMNH
Z.c.c	San Benito Is, ME	259654	m	26	5/35	NMNH
Z.c.c	San Benito Is, ME	259653	m	26	5/35	NMNH
Z.c.c	Baja Calif, ME	19155	m	26	7/04/62	SDNHM
Z.c.c	Ano Nuevo Is, CA	8265	m	26	–	DMNH
Z.c.c	Baja Calif, ME	21249	m	27	17/06/56	SDNHM
Z.c.c	Puerto Refugia, ME	19152	m	27	16/03/62	SDNHM
Z.c.c	Puerto Refugio, ME	19153	m	27	16/03/62	SDNHM
Z.c.c	Georges Is, Sonora, ME	261318	m	28	25/03/37	NMNH
Z.c.c	Sonora, ME	514664	m	28	1969	NMNH
Z.c.c	San Nicolas Is, CA	lacm9337	m	28	19/05/51	LACM
Z.c.c	San Nicholas Is	15254	m	30	–	NMNH
Z.c.c	S. vincente River, ME	504928	m	31	7/12/54	NMNH
Z.c.c	Ano Nuevo Is, CA	11474	m	31	9/67	UAM
Z.c.c	San Miguel Is, CA	lacm51192	m	31	7/09/60	LACM
Z.c.c	Baja Calif, ME	lacm43456	m	31	25/04/73	LACM
Z.c.c	Baja Calif, ME	19156	m	31	18/04/62	SDNHM
Z.c.c	Puerto Refugio, ME	18663	m	31	26/04/53	SDNHM
Z.c.c	San Miguel Is, CA	21244	m	31	18/09/54	SDNHM
Z.c.c	Baja Calif, ME	22859	m	31	9/02/73	SDNHM
Z.c.c	Torrey Pines Cliffs, CA	21246	m	31	28/12/55	SDNHM
Z.c.c	Baja Calif, ME	19158	m	31	21/04/62	SDNHM
Z.c.c	Baja Calif, ME	2594	m	31	–	SDNHM
Z.c.c	San Benito Is, ME	259655	m	32	5/35	NMNH
Z.c.c	CA	11490	m	32	–	UAM

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Z.c.c	Baja Calif, ME	lacm43482	m	32	26/06/73	LACM
Z.c.c	San Diego Co, CA	lacm85974	m	32	16/08/90	LACM
Z.c.c	Baja Calif, ME	10586	m	32	–	SDNHM
Z.c.c	Coronados Is	180667	m	33	7/05/57	AMNH
Z.c.c	Sta Margarita Is	180515	m	33	19/03/57	AMNH
Z.c.c	Isla Tiburon	514030	m	33	8/10/76	NMNH
Z.c.c	Anoo Nuevo Is, CA	35200	m	33	10/68	UAM
Z.c.c	Baja Calif, ME	lacm43455	m	33	25/04/73	LACM
Z.c.c	Santa Cruz, CA	lacm39665	m	33	14/03/70	LACM
Z.c.c	San Pedro, CA	lacm54590	m	33	29/09/78	LACM
Z.c.c	Isla San Pedro Martir, ME	19154	m	33	21/05/62	SDNHM
Z.c.c	Ano Nuevo Is, CA	8263	m	33	–	DMNH
Z.c.c	Baja Calif, ME		m	34	–	UAM
Z.c.c	La Jolla, CA	11404	m	34	–	SDNHM
Z.c.c	San Clemente Is, CA	2364	m	34	27/06/28	DMNH
Z.c.c	San Benito Is, ME	259652	m	35	5/35	NMNH
Z.c.c	Isla Natividad, ME	395724	m	35	24/04/68	NMNH
Z.c.c	Ano Nuevo Point, CA	lacm39666	m	35	24/03/70	LACM
Z.c.c	San Nicolas Is, CA	lacm31360	m	35	9/04/60	LACM
Z.c.c	Baja Calif, ME	2589	m	35	–	SDNHM
Z.c.c	Baja Calif, ME	20686	m	35	26/04/66	SDNHM
Z.c.c	Isla de la Guarda, ME	8268	m	35	–	DMNH
Z.c.c	Coast of CA	14410	m	36	–	NMNH
Z.c.c	San Miguel Is, CA	11491	m	36	8/69	UAM
Z.c.c	San Nicolas Is, CA	lacm51164	m	36	11/04/60	LACM
Z.c.c	Marineland Pier, CA	lacm54624	m	29	6/07/70	LACM
Z.c.c	Moss Landing, CA	lacm39663	m	30	19/10/69	LACM
Z.c.c	Magdalena Is	180502	m	32	14/03/57	AMNH
Z.c.c	Ano Nuevo Is, CA	lacm39655	m	33	26/05/68	LACM
Z.c.c	Moss Landing, CA	lacm39662	m	33	19/10/62	LACM
Z.c.j	Japan	70689	f	27	–	ZMB
Z.c.j	Japan	1873.3.12.1	m	33	1862	BMNH
Z.c.j.	Rebun Island	"ID#3"	m	28	28-8/98	HMJH
Z.c.j.	Rebun Island	"I-001"	m	28	4-6/98	HMJH
Z.c.j.	Rebun Island	"ID#1226"	m	30	8-8/89	HMJH
Z.c.j.	Rebun Island	"ID#1"	m	31	–	HMJH
Z.c.j.	Aonae, Okushiri Island	2	m	33	1950	HMH
Z.c.j.	Aonae, Okushiri Island	7	m	33	1950	HMH
Z.c.j.	Aonae, Okushiri Island	6	m	33	1950	HMH
Z.c.j.	Aonae, Okushiri Island	4	m	35	1950	HMH
Z.c.j.	Aonae, Okushiri Island	1	m	35	1950	HMH
Z.c.j.	Aonae, Okushiri Island	3	m	36	1950	HMH
Z.c.j.	Aonae, Okushiri Island	5	m	36	1950	HMH
Z.c.j.	Rebun Island	"ID#60000"	m	36	1-8/97	HMJH
Z.c.j.	Rebun Island	132	m	24+	29-7/93	HMJH
Z.c.j.	Rebun Island	142	m	26+	29-8/90	HMJH
Z.c.j.	Rebun Island	136	m	28+	26-7/93	HMJH
Z.c.j.	Rebun Island	1248	m	28+	4-9/90	HMJH
Z.c.j.	Rebun Island	"24"	m	29+	14-8/90	HMJH
Z.c.j.	Rebun Island	"ID#23"	m	30+	11-8/90	HMJH
Z.c.j.	Rebun Island	"I-002"	m	30+	9-9/98	HMJH
Z.c.j.	Rebun Island	"I-003"	m	30+	21-10/98	HMJH
Z.c.w	Hood Is, Galapagos	22869	f	22	2/06/73	SDNHM
Z.c.w	Galapagos	1962.116	f	30	1/62	MNHN
Z.c.w	Hood Is, Galapagos	51748	f	32	11/02/41	FMNH
Z.c.w	Hood Is, Galapagos	23278	f	33	7/4/1888	NMNH
Z.c.w	Galapagos	1962.116	f	34	6/60	MNHN
Z.c.w	Galapagos	3761	m	26	1853	NRM
Z.c.w	Santiago Is, Galapagos	214780	m	27	12/03/71	AMNH
Z.c.w	Str of Magellan	23332	m	27	1/1888	NMNH
Z.c.w	Floreana Is, Galapagos	214781	m	28	17/03/71	AMNH
Z.c.w	Seymor Is, Galapagos	99462	m	28	14/03/35	AMNH
Z.c.w	Hood Is, Galapagos	23277	m	28	7/4/1888	NMNH
Z.c.w	Hood Is, Galapagos	23279	m	28	7/4/1888	NMNH

Species	Location collected	Accession no.	Sex	SI	Date collected	Museum
Z.c.w	Galapagos	1962.115	m	29	6/60	MNHN
Z.c.w	Seymor Is, Galapagos	99463	m	30	14/03/35	AMNH
Z.c.w	Galapagos	51758	m	30	31/01/41	FMNH
Z.c.w	Galapagos	3760	m	31	1853	NRM
Z.c.w	Galapagos	63946	m	32	4/23	AMNH
Z.c.w	Hood Is, Galapagos	23280	m	32	7/4/1888	NMNH
Z.c.w	Hood Is, Galapagos	23281	m	32	7/4/1888	NMNH
Z.c.w	Isbela Is, Galapagos	396917	m	32	–	NMNH
Z.c.w	Santa Cruz	1962.114	m	34	1962	MNHN
Z.c.w	Santiago, Galapagos	1973.293	m	35	1968	MNHN
Z.c.w	Galapagos	3758	m	35	1853	NRM
Z.c.w	Galapagos	3766	m	35	1853	NRM
Z.c.w	Santa Cruz	1962.114	m	36	1/01/62	MNHN
Z.c.w	Galapagos	1962.115	m	36	2/60	MNHN
Z.c.w	Galapagos	1962.115	m	36	2/60	MNHN
Z.c.w	Galapagos	1962.115	m	36	2/62	MNHN
Z.c.w	Galapagos	1962.114	m	36	10/61	MNHN
Z.c.w	Seymor Is, Galapagos	99461	m	36	14/03/98	AMNH
Z.c.w	Hood Is, Galapagos	23276	m	36	7/4/1888	NMNH
Z.c.w	Galapagos	3762	m	36	1853	NRM
Z.c.w	Galapagos	3763	m	36	1853	NRM
Z.c.w	Galapagos	3765	m	36	1853	NRM
Z.c.w	Galapagos	51759	m	36	3/02/41	FMNH
Z.c.w	Charles Id, Galapagos	51760	m	36	3/02/41	FMNH

Appendix II

Summary statistics for adult male and female otariids.

Table 1 *Eumetopias jubatus*

Variable	Sex	n	Mean		SD		Range		CV		P	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	56	313.60	1.00	9.22	–	293.55–330.85	–	0.03	–	0.000	0.000
	m	71	385.82	1.00	10.91	–	358.83–413.31	–	0.03	–		
Gnathion – mid-occipital crest	f	56	273.73	0.87	8.53	0.01	257.88–291.00	0.84–0.91	0.03	0.02	0.000	0.000
	m	71	346.67	0.91	16.51	0.02	253.27–382.51	0.86–0.96	0.05	0.02		
Gnathion – posterior end of nasals	f	55	109.83	0.35	5.56	0.01	94.75–121.96	0.32–0.37	0.05	0.04	0.000	0.000
	m	71	144.40	0.37	6.36	0.01	129.43–158.58	0.33–0.41	0.04	0.04		
Length of nasals	f	53	47.70	0.15	4.60	0.01	37.67–56.39	0.12–0.17	0.10	0.09	0.000	0.055
	m	68	60.19	0.16	4.89	0.01	48.56–69.35	0.13–0.18	0.08	0.08		
Palatal notch – incisors	f	56	148.64	0.47	5.71	0.01	135.17–159.71	0.45–0.50	0.04	0.02	0.000	0.000
	m	71	194.92	0.51	7.37	0.01	179.82–214.84	0.48–0.53	0.04	0.02		
Gnathion – posterior of maxilla (palatal)	f	56	153.57	0.49	6.42	0.01	130.10–164.71	0.44–0.52	0.04	0.03	0.000	0.002
	m	71	191.05	0.50	7.30	0.01	174.30–214.76	0.47–0.52	0.04	0.02		
Basion – zygomatic root	f	54	211.83	0.68	7.82	0.01	195.78–227.67	0.65–0.70	0.04	0.02	0.000	0.077
	m	71	262.77	0.69	14.22	0.01	176.81–283.68	0.66–0.72	0.05	0.02		
Basion – bend of pterygoid	f	54	90.56	0.29	5.38	0.02	80.80–116.74	0.26–0.38	0.06	0.06	0.000	0.086
	m	68	109.06	0.28	5.18	0.01	91.99–123.63	0.23–0.31	0.05	0.04		
Gnathion – caudal border postglenoid process	f	56	241.19	0.77	7.48	0.01	223.87–254.85	0.75–0.79	0.03	0.01	0.000	0.000
	m	71	302.05	0.78	10.11	0.01	279.01–330.10	0.76–0.80	0.03	0.01		
Gnathion – foramen infraorbitale	f	54	105.16	0.33	4.85	0.01	90.00–113.68	0.29–0.35	0.05	0.04	0.000	0.000
	m	66	134.90	0.35	6.70	0.02	115.36–152.27	0.30–0.39	0.05	0.05		
Gnathion – caudal border of preorbital process	f	56	107.30	0.34	4.11	0.01	98.08–115.50	0.32–0.36	0.04	0.03	0.000	0.000
	m	70	136.97	0.36	4.91	0.01	124.99–151.02	0.33–0.37	0.04	0.03		
Breadth of skull												
Breadth of nares	f	55	40.71	0.13	2.64	0.01	35.07–47.79	0.11–0.15	0.07	0.07	0.000	0.000
	m	71	57.37	0.15	3.57	0.01	47.95–67.47	0.13–0.17	0.06	0.07		
Breadth at preorbital processes	f	55	93.24	0.30	5.30	0.01	82.23–108.96	0.27–0.34	0.06	0.05	0.000	0.000
	m	70	134.70	0.35	7.19	0.02	116.03–151.69	0.30–0.39	0.05	0.05		
Interorbital constriction	f	56	61.85	0.20	4.91	0.01	51.27–74.73	0.17–0.24	0.08	0.07	0.000	0.000
	m	71	93.92	0.25	5.42	0.02	79.05–104.83	0.21–0.29	0.06	0.06		
Breadth at supraorbital processes	f	55	86.95	0.28	6.62	0.02	75.63–105.52	0.25–0.33	0.08	0.07	0.000	0.000
	m	70	130.37	0.34	8.34	0.02	102.55–149.06	0.27–0.39	0.06	0.06		
Breadth of braincase	f	56	88.86	0.28	2.69	0.01	80.26–93.94	0.26–0.31	0.03	0.04	0.000	0.000
	m	67	93.29	0.24	3.54	0.01	85.98–99.64	0.22–0.27	0.04	0.05		
Occipital crest – mastoid	f	56	126.30	0.40	5.17	0.01	116.16–138.99	0.38–0.43	0.04	0.03	0.000	0.000
	m	70	176.61	0.46	8.45	0.02	161.23–196.22	0.41–0.50	0.05	0.04		
Rostral width	f	54	61.87	0.20	3.57	0.01	54.10–69.32	0.18–0.22	0.06	0.05	0.000	0.000
	m	68	100.79	0.26	5.47	0.01	89.21–115.68	0.24–0.29	0.05	0.05		
Breadth of zygomatic root of maxilla	f	56	22.88	0.07	2.06	0.01	19.21–28.39	0.06–0.09	0.09	0.09	0.000	0.000
	m	71	32.35	0.08	3.25	0.01	25.91–39.61	0.07–0.10	0.10	0.09		
Zygomatic breadth	f	55	175.55	0.56	8.34	0.02	159.37–194.63	0.51–0.61	0.05	0.04	0.000	0.000
	m	68	237.71	0.62	9.82	0.02	215.59–256.00	0.57–0.65	0.04	0.03		

Auditory breadth	f	55	131.83	0.42	4.75	0.02	123.49–142.91	0.39–0.45	0.04	0.04	0.000	0.000
	m	68	189.03	0.49	9.78	0.02	166.42–206.35	0.44–0.53	0.05	0.04		
Mastoid breadth	f	50	154.12	0.49	7.30	0.02	139.38–169.37	0.46–0.52	0.05	0.03	0.000	0.000
	m	66	223.65	0.58	10.39	0.02	203.22–246.63	0.54–0.64	0.05	0.04		
Height of skull at supraorbital processes	f	56	80.78	0.26	4.66	0.01	70.12–90.64	0.23–0.29	0.06	0.05	0.000	0.000
	m	71	117.84	0.31	6.89	0.02	95.28–131.59	0.26–0.34	0.06	0.06		
Height of skull at ventral margin of mastoid	f	56	113.46	0.36	6.44	0.02	96.64–130.16	0.32–0.41	0.06	0.06	0.000	0.043
	m	71	142.65	0.37	8.13	0.02	121.50–161.24	0.32–0.41	0.06	0.05		
Height of sagittal crest	f	54	5.48	0.02	3.06	0.01	0.00–11.56	0.00–0.04	0.56	0.57	0.000	0.000
	m	68	28.07	0.07	5.83	0.02	8.35–43.45	0.02–0.11	0.21	0.22		
Breadth of palate at postcanines 3–4	f	56	46.80	0.15	3.20	0.01	39.33–53.60	0.13–0.17	0.07	0.06	0.000	0.000
	m	70	64.85	0.17	4.87	0.01	53.94–77.84	0.14–0.20	0.08	0.07		
Breadth of palate at postcanines 4–5	f	55	48.51	0.16	3.36	0.01	40.76–58.13	0.14–0.18	0.07	0.06	0.000	0.000
	m	70	62.17	0.16	4.67	0.01	53.01–74.08	0.14–0.19	0.08	0.07		
Breadth of palate at postcanine 5	f	54	42.12	0.13	2.40	0.01	36.80–47.82	0.12–0.15	0.06	0.06	0.000	0.000
	m	69	55.97	0.15	4.21	0.01	47.89–66.29	0.12–0.17	0.08	0.07		
Length of orbit	f	56	65.40	0.21	2.37	0.01	61.03–71.72	0.19–0.22	0.04	0.04	0.000	0.000
	m	71	73.75	0.19	2.74	0.01	68.44–79.35	0.18–0.21	0.04	0.04		
Breadth of orbit	f	56	58.08	0.19	2.26	0.01	53.13–65.78	0.17–0.21	0.04	0.04	0.000	0.168
	m	71	70.68	0.18	2.76	0.01	65.95–77.06	0.17–0.20	0.04	0.05		
Mandible and teeth												
Length of mandible	f	52	222.91	0.71	6.64	0.01	211.17–236.65	0.68–0.74	0.03	0.02	0.000	0.000
	m	63	289.30	0.75	9.60	0.02	272.38–309.41	0.72–0.79	0.03	0.02		
Length of mandibular tooth row	f	52	94.93	0.30	4.01	0.01	81.04–104.41	0.25–0.33	0.04	0.04	0.000	0.000
	m	63	121.99	0.32	4.69	0.01	111.82–131.05	0.29–0.34	0.04	0.03		
Mesiodistal diameter of lower canines	f	51	15.62	0.05	1.40	0.01	12.40–18.54	0.04–0.06	0.09	0.11	0.000	0.000
	m	58	30.84	0.08	2.08	0.01	25.65–34.95	0.07–0.09	0.07	0.07		
Distance becaudal border of upper canines	f	55	94.88	0.30	13.31	0.01	81.99–187.45	0.27–0.32	0.14	0.04	0.000	0.000
	m	71	108.51	0.28	9.46	0.02	69.46–121.91	0.18–0.30	0.09	0.06		
Height of upper canines above alveolus	f	53	32.13	0.10	4.09	0.01	24.62–43.88	0.08–0.14	0.13	0.13	0.000	0.000
	m	64	43.22	0.11	4.99	0.01	31.67–65.29	0.08–0.17	0.12	0.11		
Mesiodistal diameter of postcanines	f	30	10.53	–	0.47	–	9.21–11.78	–	0.05	–	0.000	0.000
	m	34	12.15	–	0.78	–	10.90–14.77	–	0.07	–		
Length of lower postcanine row	f	51	66.28	0.21	4.31	0.01	50.07–75.30	0.16–0.23	0.07	0.06	0.000	0.000
	m	63	77.08	0.20	3.65	0.01	66.44–84.16	0.17–0.22	0.05	0.05		
Height of mandible at meatus	f	52	67.91	0.22	3.78	0.01	62.37–77.35	0.20–0.25	0.06	0.05	0.000	0.000
	m	63	100.64	0.26	5.10	0.01	90.22–114.24	0.23–0.28	0.05	0.05		
Angularis–coronoideus	f	52	69.12	0.22	4.49	0.01	59.68–78.66	0.19–0.25	0.07	0.06	0.000	0.000
	m	63	96.47	0.25	4.86	0.01	85.98–109.98	0.23–0.28	0.05	0.04		
Length of masseteric fossa	f	52	72.60	0.23	5.04	0.02	62.76–83.85	0.20–0.27	0.07	0.07	0.000	0.000
	m	63	99.37	0.26	6.71	0.02	87.62–117.60	0.22–0.30	0.07	0.06		
Breadth of masseteric fossa	f	52	45.72	0.15	3.36	0.01	38.15–52.07	0.12–0.17	0.07	0.07	0.000	0.601
	m	63	55.38	0.14	5.33	0.01	44.19–66.94	0.12–0.17	0.10	0.10		

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 1 Summary statistics for skull measurements – adult male and female *Eumetopias jubatus*.

Table 2 *Otaria byronia*

Variable	Sex	n	Mean		SD		Range		CV		*P*	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	37	263.05	–	8.82	–	246.27–282.72	–	0.03	–	0.000	0.000
	m	55	342.33	–	17.17	–	312.82–393.30	–	0.05	–		
Gnathion – mid-occipital crest	f	37	223.92	0.85	10.40	0.02	197.54–245.72	0.80–0.90	0.05	0.03	0.000	0.000
	m	55	303.76	0.89	21.26	0.05	214.73–345.79	0.60–0.95	0.07	0.05		
Gnathion – posterior end of nasals	f	37	92.84	0.35	5.87	0.02	82.63–103.71	0.32–0.39	0.06	0.05	0.000	0.000
	m	55	129.20	0.38	8.94	0.02	114.33–153.89	0.34–0.42	0.07	0.05		
Length of nasals	f	33	43.17	0.17	4.78	0.02	33.17–51.92	0.13–0.20	0.11	0.10	0.000	0.925
	m	48	56.26	0.17	5.46	0.02	44.75–69.85	0.13–0.21	0.10	0.10		
Palatal notch – incisors	f	37	152.19	0.58	6.37	0.01	140.77–163.81	0.56–0.60	0.04	0.02	0.000	0.000
	m	54	212.44	0.62	14.33	0.02	179.62–267.07	0.57–0.68	0.07	0.03		
Gnathion – posterior of maxilla (palatal)	f	37	138.44	0.53	5.60	0.01	127.01–151.71	0.50–0.56	0.04	0.02	0.000	0.000
	m	55	187.40	0.55	11.73	0.02	161.90–231.93	0.49–0.59	0.06	0.03		
Basion – zygomatic root	f	37	181.89	0.69	7.26	0.01	165.69–201.66	0.66–0.72	0.04	0.02	0.000	0.000
	m	55	241.55	0.71	13.20	0.01	218.51–267.53	0.68–0.73	0.06	0.02		
Basion – bend of pterygoid	f	37	83.62	0.32	5.47	0.02	68.74–92.20	0.27–0.34	0.07	0.06	0.000	0.001
	m	55	103.81	0.30	6.45	0.02	90.62–114.34	0.27–0.35	0.06	0.06		
Gnathion – caudal border postglenoid process	f	37	198.69	0.76	8.26	0.01	181.97–221.77	0.74–0.78	0.04	0.02	0.000	0.000
	m	55	270.88	0.79	17.92	0.04	225.32–304.90	0.59–0.82	0.07	0.05		
Gnathion – foramen infraorbitale	f	37	92.58	0.35	6.40	0.02	78.25–107.93	0.30–0.39	0.07	0.06	0.000	0.000
	m	55	134.23	0.39	12.09	0.02	110.77–182.91	0.35–0.47	0.09	0.06		
Gnathion – caudal border of preorbital process	f	37	87.15	0.33	4.27	0.01	78.34–96.17	0.30–0.36	0.05	0.03	0.000	0.000
	m	55	120.40	0.35	9.39	0.02	102.34–155.24	0.32–0.39	0.08	0.05		
Breadth of skull												
Breadth of nares	f	36	33.10	0.13	2.48	0.01	28.36–39.13	0.11–0.14	0.08	0.07	0.000	0.000
	m	55	47.52	0.14	5.16	0.01	37.43–60.72	0.10–0.18	0.11	0.09		
Breadth at preorbital processes	f	36	76.80	0.29	5.70	0.02	63.08–87.19	0.24–0.34	0.07	0.06	0.000	0.000
	m	53	119.05	0.34	9.63	0.05	95.16–144.14	0.07–0.42	0.08	0.13		
Interorbital constriction	f	37	49.08	0.19	5.29	0.02	37.82–59.26	0.15–0.22	0.11	0.10	0.000	0.000
	m	55	76.87	0.23	8.79	0.02	58.03–98.49	0.18–0.28	0.11	0.10		
Breadth at supraorbital processes	f	37	72.32	0.28	7.48	0.03	57.86–91.23	0.22–0.34	0.10	0.09	0.000	0.000
	m	48	116.50	0.34	12.75	0.03	94.56–151.36	0.27–0.42	0.11	0.10		
Breadth of braincase	f	34	80.23	0.31	2.49	0.01	74.69–84.49	0.28–0.34	0.03	0.05	0.000	0.000
	m	52	84.97	0.25	4.75	0.02	74.77–95.28	0.20–0.28	0.06	0.08		
Occipital crest – mastoid	f	37	109.40	0.42	4.46	0.01	97.77–119.49	0.39–0.44	0.04	0.03	0.000	0.000
	m	55	173.56	0.51	15.63	0.03	145.94–211.37	0.45–0.56	0.09	0.06		
Rostral width	f	37	57.78	0.22	4.68	0.01	47.19–67.06	0.19–0.25	0.08	0.06	0.000	0.000
	m	51	101.15	0.30	10.14	0.02	83.13–135.01	0.26–0.34	0.10	0.07		
Breadth of zygomatic root of maxilla	f	37	19.20	0.07	1.98	0.01	15.56–23.16	0.06–0.09	0.10	0.10	0.000	0.000
	m	55	27.56	0.08	3.53	0.01	21.48–38.65	0./06–0.10	0.13	0.10		
Zygomatic breadth	f	37	150.59	0.57	7.91	0.02	135.28–173.59	0.53–0.61	0.05	0.04	0.000	0.000
	m	55	218.22	0.64	14.70	0.03	185.14–249.49	0.58–0.70	0.07	0.05		

Auditory breadth	f	37	114.29	0.44	4.94	0.02	104.10–129.82	0.40–0.46	0.04	0.03	0.000	0.001
	m	52	155.61	0.46	21.83	0.05	70.30–185.32	0.18–0.55	0.14	0.11		
Mastoid breadth	f	37	127.49	0.49	5.69	0.02	114.63–141.86	0.45–0.52	0.05	0.03	0.000	0.000
	m	54	194.91	0.57	18.17	0.04	164.70–240.30	0.49–0.64	0.09	0.06		
Height of skull at supraorbital processes	f	37	77.82	0.30	4.23	0.01	69.14–89.85	0.27–0.32	0.05	0.04	0.000	0.016
	m	55	104.06	0.30	7.88	0.02	86.00–122.50	0.26–0.34	0.08	0.06		
Height of skull at ventral margin of mastoid	f	37	96.68	0.37	3.86	0.02	89.78–104.83	0.34–0.39	0.04	0.04	0.000	0.016
	m	55	121.80	0.36	14.29	0.03	94.64–151.55	0.28–0.42	0.12	0.09		
Height of sagittal crest	f	36	3.42	0.01	2.87	0.01	0.00–9.54	0.00–0.04	0.84	0.86	0.000	0.000
	m	55	28.89	0.08	8.93	0.02	11.20–52.75	0.03–0.15	0.31	0.29		
Breadth of palate at postcanines 3–4	f	37	39.21	0.15	3.42	0.01	31.81–48.31	0.13–0.18	0.09	0.08	0.000	0.000
	m	54	60.29	0.18	6.40	0.02	48.93–77.22	0.14–0.23	0.11	0.10		
Breadth of palate at postcanines 4–5	f	37	41.94	0.16	3.52	0.01	34.50–51.23	0.13–0.19	0.08	0.07	0.000	0.000
	m	55	62.64	0.18	5.90	0.02	50.15–77.71	0.15–0.23	0.09	0.09		
Breadth of palate at postcanine 5	f	37	42.52	0.16	3.58	0.01	34.49–51.74	0.13–0.19	0.08	0.07	0.000	0.000
	m	55	62.16	0.18	5.71	0.02	48.40–75.49	0.14–0.22	0.09	0.09		
Length of orbit	f	37	56.11	0.21	2.53	0.01	52.23–60.52	0.20–0.23	0.05	0.04	0.000	0.000
	m	54	65.56	0.19	3.64	0.01	59.44–74.64	0.17–0.21	0.06	0.05		
Breadth of orbit	f	37	54.89	0.21	2.46	0.01	50.76–60.71	0.19–0.23	0.05	0.04	0.000	0.012
	m	54	69.00	0.20	4.88	0.01	59.47–79.45	0.17–0.24	0.07	0.07		
Mandible and teeth												
Length of mandible	f	31	184.62	0.70	9.60	0.03	170.36–209.83	0.66–0.77	0.05	0.04	0.000	0.000
	m	37	261.30	0.76	22.30	0.04	218.46–302.87	0.66–0.84	0.09	0.05		
Length of mandibular tooth row	f	31	72.52	0.28	4.17	0.01	62.95–80.66	0.25–0.30	0.06	0.05	0.000	0.001
	m	38	98.10	0.29	5.86	0.01	86.12–109.00	0.27–0.32	0.06	0.41		
Mesiodistal diameter of lower canines	f	31	12.15	0.05	1.37	0.01	9.80–15.61	0.04–0.06	0.11	0.11	0.000	0.000
	m	38	28.82	0.09	2.60	0.01	23.55–34.29	0.07–0.10	0.09	0.10		
Distance becaudal border of upper canines	f	37	68.16	0.26	3.70	0.01	62.50–78.11	0.24–0.29	0.05	0.05	0.000	0.000
	m	55	84.10	0.25	5.03	0.01	71.37–96.42	0.22–0.27	0.06	0.05		
Height of upper canines above alveolus	f	32	27.31	0.10	3.99	0.02	16.17–36.55	0.06–0.14	0.15	0.15	0.000	0.000
	m	35	41.45	0.12	4.83	0.01	32.33–51.03	0.10–0.15	0.12	0.11		
Mesiodistal diameter of postcanines	f	32	7.87	–	0.42	–	7.19–8.73	–	0.05	–	0.000	–
	m	32	9.00	–	0.59	–	7.29–10.60	–	0.07	–		
Length of lower postcanine row	f	31	51.47	0.20	3.54	0.01	42.84–59.69	0.17–0.22	0.07	0.06	0.000	0.000
	m	38	63.48	0.19	3.19	0.01	57.05–70.02	0.17–0.20	0.05	0.04		
Height of mandible at meatus	f	31	64.14	0.24	3.99	0.01	55.44–72.18	0.22–0.27	0.06	0.04	0.000	0.000
	m	37	104.05	0.30	10.11	0.02	85.21–122.61	0.26–0.35	0.10	0.08		
Angularis – coronoideus	f	31	68.23	0.26	4.03	0.01	59.04–79.84	0.24–0.28	0.06	0.04	0.000	0.000
	m	37	101.71	0.30	9.12	0.02	85.54–120.94	0.27–0.34	0.09	0.06		
Length of masseteric fossa	f	31	68.80	0.26	8.09	0.03	53.48–83.17	0.21–0.31	0.12	0.11	0.000	0.000
	m	38	117.92	0.34	12.46	0.03	89.73–141.82	0.28–0.40	0.11	0.08		
Breadth of masseteric fossa	f	31	43.37	0.16	3.88	0.01	33.47–48.32	0.13–0.18	0.09	0.09	0.000	0.008
	m	38	59.13	0.17	5.90	0.02	46.75–75.87	0.14–0.22	0.10	0.09		

SD = standard deviation, CV = coefficient of variation, P = probability values derived from students t-test.

Table 2 Summary statistics for skull measurements – adult male and female *Otaria byronia*.

Table 3 *Neophoca cinerea*

			Mean		SD		Range		CV		*P*	
Variable	**Sex**	**n**	**Actual (mm)**	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual**	**Relative to CBL**	**Actual**	**Relative to CBL**
Length of skull												
Condylobasal length (CBL)	f	36	243.51	1.00	8.43	–	228.55–264.51	–	0.04	–	0.000	0.000
	m	58	293.44	1.00	8.85	–	277.79–315.38	–	0.03	–		
Gnathion – mid-occipital crest	f	36	217.94	0.90	7.89	0.02	195.45–238.66	0.84–0.93	0.04	0.02	0.000	0.000
	m	58	275.10	0.94	8.98	0.02	257.42–291.41	0.90–1.00	0.03	0.02		
Gnathion – posterior end of nasals	f	36	85.86	0.35	3.98	0.01	77.89–97.43	0.33–0.37	0.05	0.03	0.000	0.000
	m	58	114.48	0.39	5.18	0.01	104.31–125.32	0.36–0.42	0.05	0.03		
Length of nasals	f	30	40.80	0.17	2.43	0.01	36.30–45.87	0.15–0.18	0.06	0.05	0.000	0.000
	m	45	53.09	0.18	3.68	0.01	45.49–60.43	0.16–0.20	0.07	0.06		
Palatal notch – incisors	f	36	114.56	0.47	6.21	0.01	104.32–127.08	0.44–0.49	0.05	0.03	0.000	0.000
	m	58	142.47	0.49	6.77	0.02	121.55–159.49	0.44–0.51	0.05	0.03		
Gnathion – posterior of maxilla (palatal)	f	36	114.39	0.47	4.30	0.01	106.20–124.98	0.45–0.48	0.04	0.02	0.000	0.000
	m	58	140.56	0.48	6.21	0.02	122.49–156.75	0.42–0.52	0.04	0.03		
Basion – zygomatic root	f	36	158.97	0.65	6.40	0.01	148.63–172.73	0.63–0.67	0.04	0.02	0.000	0.766
	m	58	191.57	0.65	6.69	0.01	178.08–206.84	0.63–0.68	0.04	0.02		
Basion – bend of pterygoid	f	36	69.04	0.28	4.08	0.01	62.42–78.44	0.26–0.32	0.06	0.05	0.000	0.266
	m	58	82.18	0.28	4.78	0.01	71.27–95.56	0.25–0.31	0.06	0.05		
Gnathion – caudal border postglenoid process	f	36	182.39	0.75	6.73	0.01	169.56–197.42	0.73–0.76	0.04	0.01	0.000	0.000
	m	58	226.10	0.77	7.62	0.01	208.64–245.70	0.74–0.79	0.03	0.02		
Gnathion – foramen infraorbitale	f	36	82.56	0.34	6.70	0.03	51.46–91.39	0.21–0.38	0.08	0.08	0.000	0.000
	m	58	105.29	0.36	5.86	0.02	92.45–116.27	0.31–0.40	0.06	0.05		
Gnathion – caudal border of preorbital process	f	36	86.21	0.35	3.38	0.01	80.35–96.29	0.34–0.37	0.04	0.02	0.000	0.000
	m	58	112.36	0.38	4.91	0.01	101.52–123.97	0.35–0.41	0.04	0.03		
Breadth of skull												
Breadth of nares	f	36	31.43	0.13	2.38	0.01	25.84–36.32	0.11–0.15	0.08	0.07	0.000	0.000
	m	57	41.37	0.14	3.91	0.01	31.94–51.16	0.11–0.17	0.10	0.10		
Breadth at preorbital processes	f	36	65.57	0.27	4.66	0.02	55.77–75.24	0.24–0.29	0.07	0.06	0.000	0.000
	m	57	90.38	0.31	6.31	0.02	76.71–108.10	0.27–0.36	0.07	0.06		
Interorbital constriction	f	36	43.39	0.18	3.02	0.01	37.98–49.38	0.15–0.19	0.07	0.06	0.000	0.000
	m	57	61.62	0.21	5.78	0.02	49.76–79.53	0.18–0.26	0.09	0.08		
Breadth at supraorbital processes	f	34	73.33	0.30	4.94	0.02	63.10–84.31	0.27–0.33	0.07	0.06	0.000	0.000
	m	53	100.40	0.34	10.30	0.03	57.95–131.60	0.19–0.43	0.10	0.10		
Breadth of braincase	f	35	79.87	0.33	2.53	0.01	72.89–83.71	0.30–0.35	0.03	0.04	0.000	0.000
	m	58	84.25	0.29	2.79	0.01	77.90–91.40	0.26–0.31	0.03	0.04		
Occipital crest – mastoid	f	36	101.11	0.42	4.34	0.01	91.73–111.40	0.38–0.44	0.04	0.03	0.000	0.000
	m	58	131.10	0.45	5.86	0.02	119.81–145.36	0.42–0.49	0.05	0.04		
Rostral width	f	36	48.63	0.20	3.54	0.01	40.33–54.75	0.17–0.23	0.07	0.07	0.000	0.000
	m	57	74.87	0.25	4.97	0.02	62.64–85.98	0.22–0.29	0.07	0.06		
Breadth of zygomatic root of maxilla	f	36	13.12	0.05	1.43	0.01	10.31–16.08	0.04–0.06	0.11	0.11	0.000	0.000
	m	58	18.19	0.06	1.27	0.01	14.97–21.41	0.05–0.70	0.07	0.08		
Zygomatic breadth	f	36	129.96	0.53	5.25	0.02	115.52–144.98	0.50–0.56	0.04	0.03	0.000	0.000
	m	58	167.92	0.57	7.16	0.02	152.99–186.07	0.52–0.62	0.04	0.03		

Auditory breadth	f	36	97.55	0.40	4.00	0.01	88.83–107.91	0.38–0.43	0.04	0.03	0.000	0.000
	m	l8	125.12	0.43	6.09	0.02	113.80–141.59	0.38–0.48	0.05	0.05		
Mastoid breadth	f	36	117.43	0.48	4.87	0.02	106.74–130.33	0.45–0.51	0.04	0.03	0.000	0.000
	m	57	155.56	0.53	7.64	0.02	142.32–180.69	0.49–0.59	0.05	0.04		
Height of skull at supraorbital processes	f	36	69.06	0.28	3.64	0.01	63.46–79.75	0.27–0.31	0.05	0.04	0.000	0.000
	m	58	87.32	0.30	5.66	0.02	76.56–100.75	0.26–0.33	0.07	0.06		
Height of skull at ventral margin of mastoid	f	36	89.56	0.37	4.12	0.01	80.51–101.52	0.35–0.39	0.05	0.03	0.000	0.150
	m	58	106.80	0.36	4.90	0.02	93.42–118.55	0.33–0.40	0.05	0.05		
Height of sagittal crest	f	36	4.15	0.02	2.02	0.01	0.00–8.61	0.00–0.04	0.49	0.52	0.000	0.000
	m	57	15.46	0.05	4.11	0.01	8.43–27.90	0.03–0.09	0.27	0.27		
Breadth of palate at postcanines 3–4	f	36	30.75	0.13	2.43	0.01	25.14–35.43	0.11–0.14	0.08	0.07	0.000	0.000
	m	58	41.85	0.14	3.11	0.01	34.74–48.78	0.12–0.16	0.07	0.07		
Breadth of palate at postcanines 4–5	f	36	32.76	0.13	2.48	0.01	26.25–37.19	0.11–0.15	0.08	0.07	0.000	0.000
	m	58	43.40	0.15	3.32	0.01	36.16–51.81	0.13–0.17	0.08	0.07		
Breadth of palate at postcanine 5	f	36	31.62	0.13	2.24	0.01	26.91–36.25	0.11–0.14	0.07	0.06	0.000	0.000
	m	58	41.78	0.14	3.48	0.01	35.07–51.64	0.12–0.17	0.08	0.07		
Length of orbit	f	36	52.01	0.21	2.31	0.01	47.17–57.44	0.20–0.23	0.04	0.04	0.000	0.000
	m	57	58.01	0.20	3.44	0.01	52.48–74.33	0.18–0.26	0.06	0.07		
Breadth of orbit	f	36	49.42	0.20	1.96	0.01	46.11–53.66	0.19–0.22	0.04	0.04	0.000	0.004
	m	58	57.89	0.20	2.43	0.01	53.76–65.29	0.18–0.22	0.04	0.04		
Mandible and teeth												
Length of mandible	f	23	167.25	0.68	9.55	0.03	139.68–184.91	0.57–0.71	0.06	0.04	0.000	0.000
	m	41	209.05	0.71	7.54	0.02	194.52–229.03	0.68–0.74	0.04	0.02		
Length of mandibular tooth row	f	23	75.23	0.31	4.23	0.01	66.98–84.32	0.27–0.32	0.06	0.04	0.000	0.069
	m	41	92.03	0.31	4.85	0.01	81.48–105.26	0.27–0.34	0.05	0.05		
Mesiodistal diameter of lower canines	f	23	10.79	0.04	1.10	0.01	8.70–12.81	0.04–0.05	0.10	0.11	0.000	0.000
	m	39	20.50	0.07	1.40	0.01	17.65–23.12	0.06–0.08	0.07	0.09		
Distance becaudal border of upper canines	f	36	62.56	0.26	5.57	0.02	55.34–73.19	0.23–0.30	0.09	0.09	0.000	0.000
	m	58	69.22	0.24	5.61	0.02	61.27–80.69	0.21–0.29	0.08	0.09		
Height of upper canines above alveolus	f	32	19.58	0.08	4.62	0.02	8.58–28.60	0.03–0.12	0.24	0.24	0.000	0.000
	m	43	29.56	0.10	3.47	0.01	22.17–38.80	0.07–0.13	0.12	0.12		
Mesiodistal diameter of postcanines	f	21	9.44	–	0.75	–	7.87–10.70	–	0.08	–	0.000	–
	m	33	10.99	–	0.70	–	9.93–12.35	–	0.06	–		
Length of lower postcanine row	f	23	55.54	0.23	3.07	0.01	49.87–61.71	0.20–0.24	0.06	0.04	0.000	0.000
	m	41	62.95	0.21	3.38	0.01	55.94–71.28	0.19–0.24	0.05	0.05		
Height of mandible at meatus	f	23	53.49	0.22	5.28	0.02	45.19–64.09	0.19–0.24	0.10	0.07	0.000	0.000
	m	41	79.51	0.27	4.76	0.02	69.51–91.18	0.24–0.30	0.06	0.06		
Angularis – coronoideus	f	23	62.07	0.25	4.38	0.01	54.25–72.93	0.24–0.28	0.07	0.04	0.000	0.000
	m	41	81.16	0.28	4.20	0.01	72.67–93.93	0.25–0.31	0.05	0.05		
Length of masseteric fossa	f	23	53.12	0.22	4.68	0.01	46.60–64.11	0.20–0.25	0.09	0.07	0.000	0.000
	m	41	69.39	0.24	5.06	0.01	58.89–81.85	0.20–0.26	0.07	0.06		
Breadth of masseteric fossa	f	23	37.17	0.15	3.65	0.01	28.80–46.34	0.12–0.18	0.10	0.09	0.000	0.000
	m	41	49.19	0.17	4.69	0.02	38.90–59.77	0.14–0.20	0.10	0.10		

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 3 Summary statistics for skull measurements – adult male and female *Neophoca cinerea*.

Table 4 *Phocarctos hookeri*

Variable	Sex	n	Mean		SD		Range		CV		*P*	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	32	261.66	–	6.24	–	251.86–275.97	–	0.02	–	0.000	0.000
	m	26	317.09	–	13.16	–	290.63–345.90	–	0.04	–		
Gnathion – mid-occipital crest	f	32	232.45	0.89	5.82	0.02	223.70–244.74	0.84–0.92	0.03	0.02	0.000	0.000
	m	26	298.02	0.94	12.78	0.02	276.52–328.16	0.88–0.97	0.04	0.03		
Gnathion – posterior end of nasals	f	32	94.14	0.36	3.88	0.01	87.63–102.95	0.33–0.38	0.04	0.03	0.000	0.000
	m	26	131.21	0.41	8.18	0.02	108.42–146.70	0.36–0.44	0.06	0.04		
Length of nasals	f	26	49.05	0.19	3.18	0.01	43.59–56.31	0.17–0.22	0.07	0.06	0.000	0.000
	m	25	68.24	0.22	6.58	0.02	48.09–84.38	0.16–0.26	0.10	0.09		
Palatal notch – incisors	f	32	123.42	0.47	4.39	0.01	115.77–133.82	0.45–0.48	0.04	0.02	0.000	0.000
	m	26	156.37	0.49	8.62	0.01	135.94–175.28	0.47–0.52	0.06	0.03		
Gnathion – posterior of maxilla (palatal)	f	32	120.80	0.46	3.86	0.01	114.01–127.87	0.44–0.49	0.03	0.02	0.000	0.055
	m	25	148.20	0.47	6.47	0.01	131.37–161.44	0.45–0.48	0.04	0.02		
Basion – zygomatic root	f	32	177.26	0.68	5.16	0.01	166.55–189.56	0.65–0.69	0.03	0.01	0.000	0.001
	m	26	218.34	0.69	11.56	0.01	198.08–239.99	0.66–0.71	0.05	0.02		
Basion – bend of pterygoid	f	32	67.65	0.26	3.25	0.01	62.23–79.35	0.24–0.29	0.05	0.04	0.000	0.386
	m	25	81.31	0.26	4.81	0.01	71.20–89.76	0.24–0.28	0.06	0.05		
Gnathion – caudal border postglenoid process	f	32	200.33	0.77	5.66	0.01	190.47–212.65	0.75–0.78	0.03	0.01	0.000	0.000
	m	26	249.91	0.79	11.23	0.01	224.94–277.80	0.77–0.80	0.05	0.01		
Gnathion – foramen infraorbitale	f	32	90.41	0.35	5.73	0.02	80.23–100.93	0.31–0.38	0.06	0.06	0.000	0.001
	m	26	114.63	0.36	7.20	0.02	99.03–129.50	0.32–0.38	0.06	0.05		
Gnathion – caudal border of preorbital process	f	32	88.64	0.34	3.21	0.01	82.72–97.70	0.32–0.36	0.04	0.03	0.000	0.000
	m	26	118.72	0.38	6.31	0.01	109.07–137.01	0.35–0.40	0.05	0.04		
Breadth of skull												
Breadth of nares	f	32	30.24	0.12	1.64	0.01	26.53–33.37	0.10–0.13	0.05	0.07	0.000	0.023
	m	26	38.10	0.12	3.11	0.01	34.13–46.09	0.11–0.14	0.08	0.07		
Breadth at preorbital processes	f	32	73.01	0.28	5.70	0.02	64.45–99.36	0.25–0.39	0.08	0.09	0.000	0.000
	m	26	100.03	0.32	8.80	0.03	82.52–122.71	0.27–0.37	0.09	0.08		
Interorbital constriction	f	32	39.81	0.15	2.49	0.01	36.22–46.90	0.14–0.18	0.06	0.07	0.000	0.000
	m	26	57.31	0.18	4.15	0.02	48.62–65.52	0.15–0.21	0.07	0.08		
Breadth at supraorbital processes	f	30	57.64	0.22	4.75	0.02	51.23–69.13	0.20–0.27	0.08	0.08	0.000	0.000
	m	25	85.95	0.27	8.71	0.03	72.55–103.45	0.23–0.33	0.10	0.11		
Breadth of braincase	f	32	77.57	0.30	2.51	0.01	72.61–82.80	0.28–0.32	0.03	0.04	0.000	0.000
	m	26	82.18	0.26	2.89	0.01	76.18–88.55	0.23–0.29	0.04	0.05		
Occipital crest – mastoid	f	32	102.18	0.39	2.73	0.01	97.05–107.70	0.37–0.41	0.03	0.03	0.000	0.000
	m	26	132.72	0.42	6.93	0.02	121.43–147.71	0.39–0.45	0.05	0.04		
Rostral width	f	31	49.82	0.19	2.94	0.01	44.94–54.87	0.17–0.22	0.06	0.06	0.000	0.000
	m	26	82.55	0.26	7.15	0.02	72.50–95.20	0.23–0.30	0.09	0.07		
Breadth of zygomatic root of maxilla	f	32	14.44	0.06	1.51	0.01	11.44–18.01	0.04–0.07	0.10	0.11	0.000	0.000
	m	26	20.33	0.06	2.02	0.01	16.17–23.17	0.05–0.08	0.10	0.11		
Zygomatic breadth	f	32	135.52	0.52	4.89	0.02	123.76–144.00	0.47–0.56	0.04	0.04	0.000	0.000
	m	26	180.23	0.57	9.63	0.03	167.13–200.62	0.53–0.62	0.05	0.04		

Auditory breadth	f	32	104.38	0.40	2.87	0.01	100.84–110.57	0.38–0.43	0.03	0.03	0.000	0.000
	m	26	135.74	0.43	6.74	0.02	124.27–149.81	0.39–0.46	0.05	0.04		
Mastoid breadth	f	32	114.34	0.44	3.61	0.01	106.70–121.68	0.42–0.47	0.03	0.03	0.000	0.000
	m	25	154.21	0.49	8.62	0.02	142.23–172.91	0.43–0.53	0.06	0.05		
Height of skull at supraorbital processes	f	32	71.62	0.27	2.74	0.01	66.78–77.66	0.25–0.31	0.04	0.04	0.000	0.000
	m	25	97.83	0.31	4.39	0.01	90.01–107.19	0.29–0.33	0.05	0.04		
Height of skull at ventral margin of mastoid	f	32	89.04	0.34	2.77	0.01	82.94–94.30	0.32–0.36	0.03	0.03	0.000	0.870
	m	26	107.80	0.34	4.83	0.02	96.28–115.01	0.31–0.38	0.05	0.05		
Height of sagittal crest	f	32	4.39	0.02	1.93	0.01	0.00–8.80	0.00–0.03	0.44	0.48	0.000	0.000
	m	26	17.42	0.06	3.65	0.01	11.90–25.18	0.04–0.08	0.21	0.20		
Breadth of palate at postcanines 3–4	f	32	37.90	0.15	2.03	0.01	34.25–41.16	0.13–0.16	0.05	0.06	0.000	0.000
	m	25	52.64	0.17	4.78	0.01	43.28–60.71	0.13–0.19	0.09	0.08		
Breadth of palate at postcanines 4–5	f	32	38.56	0.15	1.71	0.01	35.33–42.22	0.14–0.16	0.04	0.05	0.000	0.000
	m	25	51.85	0.16	4.68	0.01	43.01–60.15	0.14–0.19	0.09	0.08		
Breadth of palate at postcanine 5	f	32	36.04	0.14	1.76	0.01	33.04–39.51	0.12–0.15	0.05	0.05	0.000	0.003
	m	25	47.61	0.15	4.72	0.02	40.43–56.29	0.12–0.18	0.10	0.11		
Length of orbit	f	32	60.28	0.23	1.74	0.01	57.63–64.97	0.22–0.25	0.03	0.03	0.000	0.000
	m	25	65.94	0.21	4.29	0.01	57.38–72.56	0.18–0.23	0.07	0.06		
Breadth of orbit	f	32	52.53	0.20	1.57	0.01	49.84–56.07	0.19–0.22	0.03	0.04	0.000	0.301
	m	25	64.56	0.20	3.21	0.01	57.97–72.26	0.18–0.22	0.05	0.05		
Mandible and teeth												
Length of mandible	f	26	182.80	0.70	5.65	0.02	173.24–193.87	0.67–0.73	0.03	0.02	0.000	0.000
	m	15	238.42	0.75	12.86	0.02	214.22–261.15	0.71–0.78	0.05	0.02		
Length of mandibular tooth row	f	26	77.95	0.30	3.18	0.01	71.14–83.77	0.28–0.32	0.04	0.04	0.000	0.136
	m	15	97.17	0.31	5.45	0.02	87.82–108.50	0.27–0.33	0.06	0.05		
Mesiodistal diameter of lower canines	f	23	9.79	0.04	0.84	0.01	8.47–11.51	0.03–0.04	0.09	0.13	0.000	0.000
	m	13	23.42	0.07	3.19	0.01	18.19–27.83	0.06–0.09	0.14	0.15		
Distance becaudal border of upper canines	f	32	72.64	0.28	3.61	0.01	62.37–79.27	0.24–0.30	0.05	0.02	0.000	0.000
	m	26	83.46	0.26	4.41	0.01	72.77–91.86	0.24–0.29	0.05	0.05		
Height of upper canines above alveolus	f	23	24.61	0.09	2.64	0.01	20.82–32.96	0.08–0.12	0.11	0.11	0.000	0.287
	m	13	31.97	0.10	5.38	0.02	20.67–40.11	0.07–0.13	0.17	0.17		
Mesiodistal diameter of postcanines	f	25	8.99	–	0.57	–	7.55–9.99	–	0.06	–	0.001	–
	m	6	9.87	–	0.36	–	9.37–10.37	–	0.04	–		
Length of lower postcanine row	f	26	60.92	0.23	2.04	0.01	57.32–64.07	0.21–0.25	0.03	0.04	0.000	0.000
	m	15	66.49	0.21	3.59	0.02	61.68–74.76	0.18–0.23	0.05	0.07		
Height of mandible at meatus	f	26	52.57	0.20	2.79	0.01	48.50–57.62	0.19–0.22	0.05	0.05	0.000	0.000
	m	15	82.49	0.26	5.70	0.02	70.56–91.70	0.22–0.28	0.07	0.07		
Angularis – coronoideus	f	26	61.34	0.24	3.33	0.01	53.69–66.48	0.20–0.25	0.05	0.06	0.000	0.000
	m	15	87.30	0.27	6.64	0.02	76.64–97.47	0.24–0.30	0.08	0.06		
Length of masseteric fossa	f	26	62.30	0.24	5.85	0.02	48.89–69.61	0.19–0.27	0.09	0.09	0.000	0.000
	m	15	90.46	0.28	7.79	0.02	68.01–101.07	0.23–0.31	0.09	0.06		
Breadth of masseteric fossa	f	26	36.02	0.14	3.88	0.01	26.77–41.28	0.10–0.16	0.11	0.10	0.000	0.000
	m	15	50.71	0.16	5.46	0.01	40.07–60.43	0.13–0.18	0.11	0.09		

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 4 Summary statistics for skull measurements – adult male and female *Phocarctos hookeri*.

Table 5 *Zalophus californianus californianus*

Variable	Sex	n	Mean		SD		Range		CV		*P*	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	42	231.41	1.00	6.00	–	221.30–247.77	–	0.03	–	0.000	0.000
	m	65	283.91	1.00	11.09	–	253.01–303.95	–	0.04	–		
Gnathion – mid-occipital crest	f	42	204.50	0.88	5.40	0.01	194.05–217.52	0.85–0.91	0.03	0.02	0.000	0.000
	m	65	256.97	0.91	12.40	0.02	223.55–280.81	0.85–0.94	0.05	0.02		
Gnathion – posterior end of nasals	f	42	78.07	0.34	3.17	0.01	70.25–82.82	0.31–0.36	0.04	0.03	0.000	0.000
	m	64	103.35	0.37	5.60	0.05	90.95–114.61	0.34–0.72	0.05	0.13		
Length of nasals	f	34	43.01	0.19	2.64	0.01	38.06–47.95	0.17–0.21	0.06	0.06	0.000	0.000
	m	62	55.08	0.19	4.69	0.02	40.90–65.31	0.15–0.23	0.09	0.08		
Palatal notch – incisors	f	42	95.78	0.41	4.59	0.02	82.92–104.58	0.37–0.45	0.05	0.04	0.000	0.000
	m	65	122.43	0.43	7.49	0.02	104.95–144.82	0.39–0.49	0.06	0.04		
Gnathion – posterior of maxilla (palatal)	f	42	106.50	0.46	3.48	0.01	97.09–114.24	0.44–0.48	0.03	0.02	0.000	0.000
	m	65	130.95	0.46	6.54	0.05	115.78–143.76	0.45–0.50	0.05	0.12		
Basion – zygomatic root	f	42	150.67	0.65	4.27	0.01	141.51–159.62	0.64–0.67	0.03	0.01	0.000	0.766
	m	65	189.10	0.66	8.52	0.05	163.58–207.04	0.40–0.74	0.05	0.07		
Basion – bend of pterygoid	f	42	67.42	0.29	2.52	0.01	62.50–73.88	0.27–0.32	0.04	0.03	0.000	0.266
	m	65	81.24	0.28	4.08	0.03	73.54–89.85	0.20–0.32	0.05	0.09		
Gnathion – caudal border postglenoid process	f	42	170.25	0.74	4.72	0.01	162.87–184.99	0.72–0.75	0.03	0.01	0.000	0.000
	m	65	214.07	0.75	12.79	0.04	149.43–234.31	0.50–0.81	0.06	0.05		
Gnathion – foramen infraorbitale	f	40	73.65	0.31	3.27	0.04	66.93–80.74	0.28–0.34	0.04	0.13	0.000	0.000
	m	62	93.35	0.33	7.13	0.02	76.15–106.08	0.28–0.37	0.08	0.06		
Gnathion – caudal border of preorbital process	f	42	77.38	0.34	2.67	0.01	71.74–83.53	0.32–0.36	0.04	0.03	0.000	0.000
	m	65	98.92	0.35	4.44	0.01	88.98–107.69	0.28–0.38	0.05	0.04		
Breadth of skull												
Breadth of nares	f	41	22.46	0.10	1.02	0.01	20.69–25.02	0.09–0.11	0.05	0.06	0.000	0.000
	m	64	29.66	0.10	2.14	0.01	21.49–33.82	0.08–0.12	0.07	0.07		
Breadth at preorbital processes	f	42	58.67	0.25	2.74	0.01	53.07–66.52	0.23–0.30	0.05	0.05	0.000	0.000
	m	65	82.62	0.29	5.24	0.02	70.63–93.26	0.26–0.33	0.06	0.06		
Interorbital constriction	f	42	33.09	0.14	1.77	0.01	29.59–37.57	0.13–0.17	0.05	0.06	0.000	0.000
	m	65	45.96	0.16	3.22	0.01	38.51–52.49	0.13–0.18	0.07	0.07		
Breadth at supraorbital processes	f	40	49.66	0.22	3.75	0.02	40.75–61.03	0.18–0.25	0.08	0.07	0.000	0.000
	m	64	68.87	0.24	7.10	0.02	52.14–87.08	0.20–0.29	0.10	0.09		
Breadth of braincase	f	41	78.13	0.34	1.90	0.01	74.55–82.87	0.30–0.36	0.02	0.04	0.000	0.000
	m	65	81.71	0.29	2.80	0.01	75.90–88.56	0.26–0.32	0.03	0.05		
Occipital crest – mastoid	f	42	92.91	0.40	3.47	0.01	86.68–100.97	0.37–0.43	0.04	0.03	0.000	0.000
	m	65	130.16	0.46	9.21	0.03	104.79–148.61	0.39–0.51	0.07	0.05		
Rostral width	f	40	36.76	0.16	1.48	0.02	32.84–39.56	0.04–0.17	0.04	0.13	0.000	0.000
	m	63	59.20	0.21	4.04	0.04	49.60–68.71	0.18–0.47	0.07	0.16		
Breadth of zygomatic root of maxilla	f	42	11.72	0.05	1.21	0.01	8.95–14.28	0.04–0.06	0.10	0.11	0.000	0.000
	m	65	15.97	0.06	1.72	0.02	12.07–20.15	0.05–0.20	0.11	0.32		
Zygomatic breadth	f	41	119.09	0.52	3.31	0.02	113.37–128.20	0.48–0.55	0.03	0.03	0.000	0.000
	m	65	158.85	0.56	10.13	0.03	132.14–177.56	0.48–0.65	0.06	0.05		

Auditory breadth	f	42	91.50	0.40	2.21	0.01	85.81–96.27	0.37–0.42	0.02	0.03	0.000	0.000
	m	65	123.21	0.44	8.01	0.02	104.78–141.58	0.39–0.53	0.07	0.05		
Mastoid breadth	f	42	101.55	0.44	2.78	0.01	96.29–106.42	0.41–0.46	0.03	0.03	0.000	0.000
	m	64	142.83	0.50	9.71	0.04	115.59–163.77	0.29–0.56	0.07	0.08		
Height of skull at supraorbital processes	f	42	58.75	0.26	2.67	0.01	54.00–64.53	0.23–0.28	0.05	0.05	0.000	0.000
	m	65	77.11	0.27	4.33	0.02	67.91–86.89	0.25–0.41	0.06	0.08		
Height of skull at ventral margin of mastoid	f	42	82.28	0.36	3.05	0.01	76.91–88.62	0.32–0.38	0.04	0.04	0.000	0.150
	m	65	106.62	0.37	7.11	0.04	90.84–121.90	0.14–0.43	0.07	0.10		
Height of sagittal crest	f	42	3.18	0.01	2.01	0.01	0.00–6.69	0.00–0.03	0.63	0.65	0.000	0.000
	m	63	27.58	0.10	8.26	0.03	5.66–47.93	0.02–0.16	0.30	0.30		
Breadth of palate at postcanines 3–4	f	42	30.34	0.13	1.63	0.01	25.88–33.24	0.11–0.14	0.05	0.06	0.000	0.000
	m	65	41.32	0.15	3.04	0.01	34.76–50.49	0.13–0.17	0.07	0.07		
Breadth of palate at postcanines 4–5	f	42	34.01	0.15	1.85	0.01	30.39–37.75	0.13–0.16	0.05	0.06	0.000	0.000
	m	65	45.77	0.16	3.23	0.01	38.61–54.21	0.14–0.18	0.07	0.06		
Breadth of palate at postcanine 5	f	42	33.99	0.15	1.96	0.01	29.59–38.34	0.13–0.17	0.06	0.06	0.000	0.000
	m	65	44.97	0.16	3.44	0.01	38.69–52.85	0.13–0.19	0.08	0.07		
Length of orbit	f	41	51.86	0.23	1.74	0.01	48.40–55.82	0.21–0.24	0.03	0.03	0.000	0.000
	m	65	57.47	0.20	2.40	0.01	52.15–62.88	0.18–0.22	0.04	0.04		
Breadth of orbit	f	42	46.94	0.20	1.15	0.01	44.22–49.22	0.19–0.22	0.03	0.04	0.000	0.004
	m	65	55.20	0.20	2.51	0.07	46.80–61.43	0.18–0.76	0.05	0.35		
Mandible and teeth												
Length of mandible	f	33	152.03	0.66	3.97	0.01	140.36–161.30	0.62–0.68	0.03	0.02	0.000	0.000
	m	44	197.31	0.70	9.92	0.02	171.55–213.50	0.64–0.73	0.05	0.03		
Length of mandibular tooth row	f	33	66.02	0.29	1.75	0.01	61.10–69.67	0.27–0.31	0.03	0.04	0.000	0.069
	m	43	82.47	0.29	6.31	0.04	51.42–90.60	0.07–0.32	0.08	0.14		
Mesiodistal diameter of lower canines	f	32	8.51	0.04	0.57	0.00	6.68–9.82	0.03–0.04	0.07	0.10	0.000	0.000
	m	43	18.83	0.07	1.42	0.01	15.87–22.00	0.05–0.08	0.08	0.09		
Distance becaudal border of upper canines	f	42	55.09	0.24	4.04	0.02	48.63–64.19	0.21–0.28	0.07	0.08	0.000	0.000
	m	65	62.20	0.22	5.21	0.02	52.70–77.28	0.19–0.26	0.08	0.07		
Height of upper canines above alveolus	f	34	19.51	0.08	2.02	0.01	15.33–23.62	0.07–0.10	0.10	0.10	0.000	0.000
	m	47	28.58	0.10	3.39	0.01	22.00–36.13	0.08–0.13	0.12	0.12		
Mesiodistal diameter of postcanines	f	36	8.32	–	0.41	–	7.64–9.06	–	0.05	–	0.000	–
	m	38	9.42	–	0.47	–	8.60–10.52	–	0.05	–		
Length of lower postcanine row	f	34	48.62	0.21	1.55	0.01	44.95–51.82	0.20–0.23	0.03	0.04	0.000	0.000
	m	44	54.82	0.19	3.44	0.01	44.29–61.56	0.16–0.22	0.06	0.06		
Height of mandible at meatus	f	34	42.18	0.18	2.09	0.01	36.71–46.25	0.16–0.20	0.05	0.06	0.000	0.000
	m	44	66.59	0.23	6.86	0.02	53.12–83.47	0.19–0.28	0.10	0.09		
Angularis – coronoideus	f	34	46.18	0.20	2.71	0.01	39.85–52.81	0.18–0.22	0.06	0.05	0.000	0.000
	m	44	66.87	0.24	6.90	0.02	54.86–84.64	0.20–0.28	0.10	0.08		
Length of masseteric fossa	f	34	45.51	0.20	4.97	0.02	31.87–56.12	0.14–0.24	0.11	0.11	0.000	0.000
	m	43	65.16	0.23	6.01	0.04	45.87–74.26	0.02–0.25	0.09	0.16		
Breadth of masseteric fossa	f	34	28.45	0.12	2.93	0.01	22.11–34.90	0.10–0.15	0.10	0.10	0.000	0.000
	m	44	40.66	0.14	5.06	0.02	27.16–51.32	0.10–0.18	0.12	0.11		

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 5 Summary statistics for skull measurements – adult male and female *Zalophus californianus californianus*.

Table 6 *Z. c. wollebaeki*

			Mean		SD		Range		CV		*P*	
Variable	**Sex**	**n**	**Actual (mm)**	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual**	**Relative to CBL**	**Actual**	**Relative to CBL**
Length of skull												
Condylobasal length (CBL)	f	5	231.77	1.00	6.47	–	223.73–239.17	–	0.03	–	0.000	0.000
	m	31	264.64	1.00	6.75	–	250.59–277.77	–	0.03	–		
Gnathion – mid-occipital crest	f	5	204.35	0.88	4.08	0.02	200.11–208.65	0.86–0.91	0.02	0.02	0.000	0.000
	m	31	238.78	0.90	7.68	0.02	219.74–255.90	0.87–0.96	0.03	0.02		
Gnathion – posterior end of nasals	f	5	75.24	0.32	3.90	0.02	68.48–78.40	0.30–0.34	0.05	0.05	0.000	0.000
	m	30	91.98	0.35	4.74	0.02	81.48–99.85	0.31–0.38	0.05	0.05		
Length of nasals	f	5	39.18	0.17	3.60	0.02	34.04–42.40	0.15–0.19	0.09	0.11	0.000	0.000
	m	24	48.73	0.19	3.83	0.01	41.70–57.20	0.16–0.21	0.08	0.08		
Palatal notch – incisors	f	5	92.81	0.40	2.88	0.01	89.20–96.84	0.39–0.41	0.03	0.02	0.000	0.000
	m	31	112.46	0.43	4.33	0.01	103.21–120.72	0.40–0.45	0.04	0.03		
Gnathion – posterior of maxilla (palatal)	f	5	104.38	0.45	1.97	0.01	102.26–107.25	0.44–0.46	0.02	0.02	0.000	0.000
	m	31	121.92	0.46	5.53	0.02	109.68–132.43	0.40–0.49	0.05	0.04		
Basion – zygomatic root	f	5	151.18	0.65	6.19	0.01	142.32–158.32	0.64–0.66	0.04	0.01	0.000	0.766
	m	31	173.48	0.66	4.91	0.01	164.43–184.00	0.64–0.68	0.03	0.02		
Basion – bend of pterygoid	f	5	71.25	0.31	6.53	0.02	64.05–81.56	0.29–0.34	0.09	0.07	0.000	0.266
	m	31	78.87	0.30	4.61	0.02	70.97–93.26	0.27–0.34	0.06	0.05		
Gnathion – caudal border postglenoid process	f	5	170.13	0.73	4.77	0.01	163.99–176.31	0.72–0.75	0.03	0.02	0.000	0.000
	m	31	198.60	0.75	6.11	0.01	186.06–208.61	0.74–0.78	0.03	0.01		
Gnathion – foramen infraorbitale	f	4	72.26	0.31	3.71	0.02	68.14–75.77	0.29–0.33	0.05	0.06	0.000	0.000
	m	26	86.56	0.33	4.70	0.01	74.81–93.90	0.30–0.35	0.05	0.04		
Gnathion – caudal border of preorbital process	f	5	74.55	0.32	1.98	0.01	72.38–77.61	0.31–0.33	0.03	0.03	0.000	0.000
	m	30	88.17	0.33	3.69	0.01	83.00–95.93	0.31–0.35	0.04	0.03		
Breadth of skull												
Breadth of nares	f	5	22.95	0.10	2.09	0.01	20.14–25.04	0.09–0.11	0.09	0.09	0.000	0.000
	m	30	28.58	0.11	1.82	0.01	25.71–33.01	0.10–0.12	0.06	0.06		
Breadth at preorbital processes	f	5	54.40	0.23	1.96	0.01	52.00–57.47	0.23–0.24	0.04	0.02	0.000	0.000
	m	26	69.91	0.26	3.74	0.01	62.59–78.27	0.23–0.29	0.05	0.05		
Interorbital constriction	f	5	30.63	0.13	2.71	0.01	26.85–34.34	0.11–0.15	0.09	0.11	0.000	0.000
	m	29	40.74	0.15	2.79	0.01	34.91–48.89	0.14–0.19	0.07	0.07		
Breadth at supraorbital processes	f	4	52.99	0.23	4.92	0.02	47.78–58.59	0.20–0.25	0.09	0.10	0.000	0.000
	m	26	68.24	0.26	5.78	0.02	60.27–81.28	0.22–0.31	0.09	0.09		
Breadth of braincase	f	5	78.11	0.34	3.61	0.02	72.18–80.82	0.31–0.36	0.05	0.05	0.000	0.000
	m	31	79.76	0.30	2.39	0.01	74.68–84.43	0.28–0.32	0.03	0.03		
Occipital crest – mastoid	f	5	91.83	0.40	3.45	0.01	87.94–96.04	0.39–0.40	0.04	0.01	0.000	0.000
	m	31	117.31	0.44	8.62	0.03	95.28–138.13	0.38–0.51	0.07	0.06		
Rostral width	f	5	38.23	0.17	2.21	0.01	35.90–40.98	0.16–0.18	0.06	0.05	0.000	0.000
	m	30	54.38	0.21	3.48	0.01	48.37–61.66	0.19–0.23	0.06	0.06		
Breadth of zygomatic root of maxilla	f	5	11.69	0.05	1.09	0.00	10.70–13.45	0.05–0.06	0.09	0.09	0.000	0.000
	m	31	14.40	0.06	1.42	0.01	11.78–17.31	0.04–0.07	0.10	0.11		
Zygomatic breadth	f	5	121.72	0.53	4.67	0.01	116.50–128.71	0.51–0.54	0.04	0.02	0.000	0.000
	m	29	147.97	0.56	7.70	0.02	129.22–160.23	0.51–0.59	0.05	0.04		

Auditory breadth	f	5	89.66	0.39	2.38	0.01	87.26–93.46	0.38–0.40	0.03	0.02	0.000	0.000
	m	31	110.89	0.42	6.00	0.02	98.88–124.26	0.38–0.47	0.05	0.04		
Mastoid breadth	f	5	98.45	0.42	4.32	0.01	93.39–104.88	0.41–0.44	0.04	0.03	0.000	0.000
	m	30	127.04	0.48	7.95	0.02	111.55–142.32	0.43–0.53	0.06	0.05		
Height of skull at supraorbital processes	f	5	58.43	0.25	1.43	0.01	56.60–59.84	0.24–0.26	0.02	0.03	0.000	0.000
	m	30	69.61	0.26	4.12	0.01	61.68–80.23	0.24–0.29	0.06	0.04		
Height of skull at ventral margin of mastoid	f	5	81.98	0.35	3.58	0.02	78.16–85.96	0.33–0.38	0.04	0.06	0.000	0.150
	m	31	97.01	0.37	5.67	0.02	84.33–110.93	0.33–0.41	0.06	0.05		
Height of sagittal crest	f	5	1.50	0.01	0.50	0.01	0.00–3.27	0.00–0.01	1.00	0.91	0.000	0.000
	m	30	21.92	0.08	7.26	0.03	6.87–35.19	0.03–0.13	0.33	0.32		
Breadth of palate at postcanines 3–4	f	5	31.27	0.14	1.96	0.01	28.85–34.01	0.13–0.14	0.06	0.04	0.000	0.000
	m	30	35.35	0.13	2.52	0.01	30.25–39.39	0.11–0.16	0.07	0.08		
Breadth of palate at postcanines 4–5	f	5	35.99	0.16	1.32	0.01	34.81–37.52	0.15–0.16	0.04	0.04	0.000	0.000
	m	30	39.77	0.15	2.06	0.01	34.94–44.17	0.13–0.16	0.05	0.05		
Breadth of palate at postcanine 5	f	5	35.96	0.15	1.62	0.01	33.62–37.46	0.15–0.16	0.05	0.04	0.000	0.000
	m	30	39.96	0.15	2.17	0.01	35.06–46.23	0.14–0.17	0.05	0.05		
Length of orbit	f	5	53.52	0.23	1.57	0.01	51.45–55.53	0.22–0.24	0.03	0.03	0.000	0.000
	m	31	56.76	0.22	1.71	0.01	53.04–60.04	0.20–0.23	0.03	0.03		
Breadth of orbit	f	5	45.94	0.20	0.83	0.01	44.82–46.85	0.19–0.21	0.02	0.04	0.000	0.004
	m	30	49.72	0.19	1.96	0.01	46.03–53.49	0.17–0.20	0.04	0.04		
Mandible and teeth												
Length of mandible	f	3	156.03	0.67	4.39	0.01	152.37–160.89	0.66–0.67	0.03	0.01	0.000	0.000
	m	11	182.88	0.69	6.56	0.01	173.68–191.54	0.67–0.71	0.04	0.02		
Length of mandibular tooth row	f	3	65.70	0.28	1.65	0.01	64.33–67.53	0.28–0.29	0.03	0.02	0.000	0.069
	m	11	77.19	0.29	3.87	0.01	70.28–83.20	0.27–0.30	0.05	0.04		
Mesiodistal diameter of lower canines	f	3	7.95	0.03	0.22	0.01	7.70–8.08	0.03–0.04	0.03	0.17	0.000	0.000
	m	11	16.93	0.07	1.68	0.01	13.35–18.73	0.05–0.07	0.10	0.11		
Distance becaudal border of upper canines	f	5	59.36	0.26	4.42	0.02	51.56–62.36	0.23–0.27	0.07	0.06	0.000	0.000
	m	31	64.05	0.24	4.87	0.02	56.27–72.06	0.21–0.27	0.08	0.08		
Height of upper canines above alveolus	f	4	17.64	0.08	1.16	0.01	16.40–19.19	0.07–0.08	0.07	0.08	0.000	0.000
	m	24	24.05	0.09	1.43	0.01	21.33–27.09	0.08–0.11	0.06	0.08		
Mesiodistal diameter of postcanines	f	4	7.97	–	0.61	–	7.30–8.69	–	0.08	–	0.000	–
	m	18	8.75	–	0.70	–	6.78–9.91	–	0.08	–		
Length of lower postcanine row	f	3	48.52	0.21	0.61	0.01	47.83–48.96	0.20–0.22	0.01	0.06	0.000	0.000
	m	11	53.42	0.20	2.01	0.00	49.59–56.01	0.19–0.21	0.04	0.02		
Height of mandible at meatus	f	3	41.17	0.17	1.84	0.01	39.61–43.20	0.17–0.18	0.05	0.03	0.000	0.000
	m	11	58.63	0.22	4.00	0.01	53.32–66.41	0.20–0.25	0.07	0.06		
Angularis – coronoideus	f	3	46.81	0.20	1.30	0.01	45.48–48.08	0.20–0.21	0.03	0.03	0.000	0.000
	m	11	61.00	0.23	4.59	0.01	54.68–66.77	0.21–0.25	0.08	0.06		
Length of masseteric fossa	f	3	45.74	0.20	7.42	0.03	37.48–51.86	0.17–0.22	0.16	0.13	0.000	0.000
	m	11	59.72	0.23	4.95	0.02	50.46–67.38	0.19–0.25	0.08	0.07		
Breadth of masseteric fossa	f	3	30.91	0.13	2.81	0.01	27.69–32.86	0.12–0.14	0.09	0.09	0.000	0.000
	m	11	39.22	0.15	4.53	0.02	32.06–46.50	0.12–0.17	0.12	0.11		

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 6 Summary statistics for skull measurements – adult male and female *Zalophus californianus wollebaeki*.

Table 7 *Z. c. japonicus*

Variable	Sex	n	Mean		SD		Range		CV		***P***	
			Actual (mm)	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual**	**Relative to CBL**	**Actual**	**Relative to CBL**
Length of skull												
Condylobasal length (CBL)	f	1	242.00	1.00	–	–	–	–	–	–	–	–
	m	12	312.02	1.00	8.17	–	299.51–323.44	–	0.03	–		
Gnathion – mid-occipital crest	f	1	213.38	0.88	–	–	–	–	–	–	–	–
	m	12	288.00	0.92	10.30	0.03	265.87– 307.20	0.88–0.98	0.04	0.04		
Gnathion – posterior end of nasals	f	1	82.28	0.34	–		–		–		–	–
	m	11	116.89	0.37	3.69	0.01	112.07–125.07	0.35–0.40	0.03	0.04		
Length of nasals	f	1	44.36	0.18	–		–		–		–	–
	m	11	59.96	0.19	1.69	0.01	57.73–63.34	0.18–0.20	0.03	0.04		
Palatal notch – incisors	f	1	99.48	0.41	–		–		–		–	–
	m	12	138.68	0.45	6.53	0.01	129.55–148.58	0.42–0.46	0.05	0.03		
Gnathion – posterior of maxilla (palatal)	f	1	113.03	0.47	–		–		–		–	–
	m	12	148.42	0.48	7.27	0.01	137.13–160.84	0.46–0.50	0.05	0.03		
Basion – zygomatic root	f	1	160.19	0.66	–		–		–		–	–
	m	13	208.70	0.67	8.47	0.02	192.87–220.77	0.64–0.69	0.04	0.03		
Basion – bend of pterygoid	f	1	78.79	0.33	–		–		–		–	–
	m	19	91.10	0.30	5.89	0.02	84.76–108.49	0.26–0.34	0.07	0.07		
Gnathion – caudal border postglenoid process	f	1	182.36	0.75	–		–		–		–	–
	m	12	239.57	0.77	8.94	0.01	222.37–249.85	0.74–0.78	0.04	0.02		
Gnathion – foramen infraorbitale	f	1	79.92	0.33	–		–		–		–	–
	m	14	106.08	0.34	4.88	0.01	93.55–113.26	0.31–0.35	0.05	0.04		
Gnathion – caudal border of preorbital process	f	1	81.28	0.34	–		–		–		–	–
	m	14	111.39	0.35	5.61	0.02	97.10–116.81	0.32–0.37	0.05	0.05		
Breadth of skull												
Breadth of nares	f	1	27.00	0.11	–	–	–	–	–	–	–	–
	m	15	36.10	0.12	2.75	0.01	28.77–41.01	0.11–0.13	0.08	0.06		
Breadth at preorbital processes	f	1	66.49	0.27	–	–	–	–	–	–	–	–
	m	11	95.94	0.31	4.97	0.02	85.06–102.88	0.28–0.34	0.05	0.05		
Interorbital constriction	f	1	39.38	0.16	–	–	–	–	–	–	–	–
	m	19	54.87	0.17	3.86	0.01	46.96–60.83	0.16–0.19	0.07	0.06		
Breadth at supraorbital processes	f	1	59.56	0.25	–	–	–	–	–	–	–	–
	m	17	80.54	0.26	5.02	0.02	70.22–86.93	0.23–0.29	0.06	0.07		
Breadth of braincase	f	1	82.15	0.34	–	–	–	–	–	–	–	–
	m	18	89.57	0.29	3.19	0.01	84.05–94.58	0.26–0.30	0.04	0.04		
Occipital crest – mastoid	f	1	100.44	0.42	–	–	–	–	–	–	–	–
	m	19	143.48	0.46	8.31	0.03	126.44–158.93	0.43–0.53	0.06	0.06		
Rostral width	f	1	42.08	0.17	–	–	–	–	–	–	–	–
	m	12	70.72	0.23	5.38	0.02	59.86–77.73	0.20–0.25	0.08	0.07		
Breadth of zygomatic root of maxilla	f	1	14.79	0.06	–	–	–	–	–	–	–	–
	m	17	20.45	0.07	2.11	0.01	15.61–23.48	0.05–0.07	0.10	0.11		
Zygomatic breadth	f	1	133.83	0.55	–	–	–	–	–	–	–	–
	m	13	183.19	0.58	8.34	0.03	162.03–193.90	0.54–0.64	0.05	0.05		

Auditory breadth	f	1	102.80	0.42	–	–	–	–	–	–	–	–
	m	19	147.97	0.47	8.29	0.03	132.92–162.61	0.44–0.52	0.06	0.06		
Mastoid breadth	f	1	114.24	0.47	–	–	–	–	–	–	–	–
	m	17	170.80	0.55	8.52	0.03	154.27–186.38	0.51–0.61	0.05	0.05		
Height of skull at supraorbital processes	f	1	67.07	0.28	–	–	–	–	–	–	–	–
	m	13	93.72	0.30	5.47	0.02	83.02–100.67	0.28–0.33	0.06	0.06		
Height of skull at ventral margin of mastoid	f	1	85.89	0.35	–	–	–	–	–	–	–	–
	m	19	118.39	0.38	6.77	0.03	108.51–134.32	0.35–0.45	0.06	0.07		
Height of sagittal crest	f	1	3.69	0.02	–	–	–	–	–	–	–	–
	m	17	38.70	0.13	8.48	0.03	20.11–48.67	0.07–0.16	0.22	0.24		
Breadth of palate at postcanines 3-4	f	1	31.97	0.13	–	–	–	–	–	–	–	–
	m	16	45.33	0.15	3.18	0.01	38.34–49.44	0.13–0.16	0.07	0.06		
Breadth of palate at postcanines 4-5	f	1	37.12	0.15	–	–	–	–	–	–	–	–
	m	16	49.00	0.16	2.88	0.01	41.15–53.15	0.15–0.17	0.06	0.05		
Breadth of palate at postcanine 5	f	1	35.43	0.15	–	–	–	–	–	–	–	–
	m	16	47.04	0.15	3.21	0.01	38.96–53.12	0.13–0.17	0.07	0.08		
Length of orbit	f	1	56.80	0.23	–	–	–	–	–	–	–	–
	m	9	60.97	0.19	2.71	0.01	57.24–65.89	0.18–0.21	0.04	0.05		
Breadth of orbit	f	1	50.67	0.21	–	–	–	–	–	–	–	–
	m	11	59.19	0.19	2.50	0.01	52.98–62.44	0.18–0.20	0.04	0.04		
Mandible and teeth												
Length of mandible	f	1	164.99	0.68	–	–	–	–	–	–	–	–
	m	2	218.14	0.73	21.84	–	202.69–233.58	0.73–0.73	0.10	1.00		
Length of mandibular tooth row	f	1	70.78	0.29	–	–	–	–	–	–	–	–
	m	2	94.80	0.32	12.53	–	85.94–103.66	0.32–0.32	0.13	1.00		
Mesiodistal diameter of lower canines	f	1	9.47	0.04	–	–	–	–	–	–	–	–
	m	2	21.73	0.08	3.96	–	18.93–24.53	0.08–0.08	0.18	1.00		
Distance becaudal border of upper canines	f	1	66.92	0.28	–	–	–	–	–	–	–	–
	m	15	76.09	0.25	7.72	0.02	59.52–89.17	0.22–0.28	0.10	0.08		
Height of upper canines above alveolus	f	1	21.07	0.09	–	–	–	–	–	–	–	–
	m	4	31.00	0.10	4.51	0.02	27.97–37.58	0.09–0.12	0.15	0.15		
Mesiodistal diameter of postcanines	f	1	9.50	–	–	–	–	–	–	–	–	–
	m	4	10.74	–	1.38	–	9.23–12.52	–	0.13	–		
Length of lower postcanine row	f	1	52.17	0.22	–	–	–	–	–	–	–	–
	m	2	63.03	0.21	7.45	–	57.76–68.30	0.21–0.21	0.12	1.00		
Height of mandible at meatus	f	1	51.17	0.21	–	–	–	–	–	–	–	–
	m	2	78.88	0.28	13.17	–	69.57–88.19	0.28–0.28	0.17	1.00		
Angularis – coronoideus	f	1	52.86	0.22	–	–	–	–	–	–	–	–
	m	2	80.02	0.27	9.66	–	73.19–86.85	0.27–0.27	0.12	1.00		
Length of masseteric fossa	f	1	50.09	0.21	–	–	–	–	–	–	–	–
	m	2	66.67	0.22	5.94	–	62.47–70.87	0.22–0.22	0.09	1.00		
Breadth of masseteric fossa	f	1	37.07	0.15	–	–	–	–	–	–	–	–
	m	2	48.35	0.17	6.39	–	43.83–52.86	0.17–0.17	0.13	1.00		

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 7 Summary statistics for skull measurements – adult male and female *Zalophus californianus Japonicus*.

Table 8 *Callorhinus ursinus*

			Mean		SD		Range		CV		*P*	
Variable	**Sex**	**n**	**Actual (mm)**	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual**	**Relative to CBL**	**Actual**	**Relative to CBL**
Length of skull												
Condylobasal length (CBL)	f	131	185.99	1.00	4.92	–	175.20–198.83	–	0.03	–	0.000	0.000
	m	50	240.53	1.00	9.09	–	220.73–262.65	–	0.04	–		
Gnathion – mid-occipital crest	f	131	158.52	0.85	5.22	0.02	146.70–177.74	0.81–0.90	0.03	0.02	0.000	0.000
	m	50	216.25	0.90	9.59	0.02	199.17–240.32	0.86–0.94	0.04	0.02		
Gnathion – posterior end of nasals	f	131	55.00	0.30	2.86	0.01	49.10–63.03	0.27–0.33	0.05	0.04	0.000	0.000
	m	50	80.47	0.33	4.94	0.02	71.95–94.12	0.30–0.37	0.06	0.05		
Length of nasals	f	120	28.88	0.15	2.71	0.01	21.82–25.80	0.12–0.19	0.09	0.09	0.000	0.000
	m	48	40.61	0.17	3.54	0.01	34.32–51.49	0.14–0.20	0.09	0.08		
Palatal notch – incisors	f	131	70.02	0.38	3.71	0.02	61.64–80.56	0.33–0.41	0.05	0.05	0.000	0.169
	m	50	91.75	0.38	5.51	0.02	79.43–103.99	0.34–0.42	0.06	0.05		
Gnathion – posterior of maxilla (palatal)	f	131	79.58	0.43	2.91	0.01	71.58–86.32	0.40–0.46	0.04	0.03	0.000	0.016
	m	50	103.96	0.43	3.74	0.01	92.06–114.02	0.40–0.47	0.04	0.03		
Basion – zygomatic root	f	131	132.21	0.71	3.99	0.01	122.18–143.93	0.68–0.74	0.03	0.01	0.000	0.329
	m	50	171.29	0.71	7.15	0.01	159.14–188.99	0.69–0.74	0.04	0.02		
Basion – bend of pterygoid	f	131	61.54	0.33	2.57	0.01	55.65–70.67	0.30–0.37	0.04	0.04	0.000	0.000
	m	50	72.70	0.30	4.45	0.02	63.34–85.43	0.28–0.35	0.06	0.06		
Gnathion – caudal border postglenoid process	f	131	134.52	0.72	3.87	0.01	124.32–143.83	0.70–0.74	0.03	0.01	0.000	0.000
	m	50	179.45	0.75	6.56	0.01	164.80–194.50	0.73–0.77	0.04	0.01		
Gnathion – foramen infraorbitale	f	126	51.74	0.28	3.44	0.02	42.14–60.27	0.23–0.32	0.07	0.06	0.000	0.160
	m	45	68.59	0.29	8.13	0.03	36.76–81.09	0.15–0.32	0.12	0.11		
Gnathion – caudal border of preorbital process	f	131	52.38	0.28	2.20	0.01	47.39–59.71	0.26–0.31	0.04	0.03	0.000	0.000
	m	50	75.89	0.32	4.10	0.01	65.94–86.43	0.29–0.34	0.05	0.04		
Breadth of skull												
Breadth of nares	f	129	24.08	0.13	1.51	0.01	19.73–28.13	0.11–0.15	0.06	0.06	0.000	0.000
	m	50	33.16	0.14	2.43	0.01	27.50–37.76	0.12–0.16	0.07	0.07		
Breadth at preorbital processes	f	128	46.28	0.25	2.35	0.01	39.68–53.18	0.22–0.27	0.05	0.05	0.000	0.000
	m	49	68.14	0.28	4.95	0.02	56.93–79.91	0.25–0.32	0.07	0.06		
Interorbital constriction	f	131	24.02	0.13	1.96	0.01	20.42–29.51	0.11–0.16	0.08	0.08	0.000	0.000
	m	50	40.42	0.17	4.20	0.01	32.51–49.95	0.14–0.20	0.10	0.09		
Breadth at supraorbital processes	f	129	39.33	0.21	3.42	0.02	30.79–47.53	0.17–0.26	0.09	0.08	0.000	0.000
	m	49	59.53	0.25	5.51	0.02	49.16–75.76	0.21–0.29	0.09	0.08		
Breadth of braincase	f	127	74.92	0.40	2.33	0.02	69.00–80.42	0.36–0.44	0.03	0.04	0.000	0.000
	m	49	77.08	0.32	2.95	0.01	70.72–84.72	0.29–0.35	0.04	0.04		
Occipital crest – mastoid	f	131	81.76	0.44	2.32	0.01	76.05–87.56	0.41–0.48	0.03	0.03	0.000	0.000
	m	50	115.41	0.48	5.40	0.02	104.12–125.25	0.44–0.51	0.05	0.04		
Rostral width	f	130	33.69	0.18	1.92	0.01	28.84–41.27	0.15–0.21	0.06	0.06	0.000	0.000
	m	50	52.78	0.22	3.13	0.01	45.93–60.57	0.19–0.24	0.06	0.05		
Breadth of zygomatic root of maxilla	f	131	10.97	0.06	1.11	0.01	8.41–14.41	0.05–0.08	0.10	0.12	0.000	0.000
	m	50	16.72	0.07	1.71	0.01	12.28–21.96	0.05–0.09	0.10	0.11		
Zygomatic breadth	f	128	108.34	0.58	3.56	0.02	99.41–119.64	0.54–0.62	0.03	0.03	0.000	0.000
	m	49	146.12	0.61	5.93	0.02	133.77–160.02	0.56–0.65	0.04	0.03		

Auditory breadth	f	130	84.31	0.45	2.29	0.01	79.38–89.34	0.42–0.49	0.03	0.03	0.000	0.000
	m	50	111.95	0.47	5.01	0.01	102.98–122.22	0.44–0.50	0.05	0.03		
Mastoid breadth	f	130	90.26	0.49	3.15	0.02	82.58–98.96	0.45–0.53	0.04	0.04	0.000	0.000
	m	50	126.88	0.53	7.23	0.02	112.97–141.54	0.48–0.58	0.06	0.04		
Height of skull at supraorbital processes	f	131	56.78	0.31	2.25	0.01	52.37–63.49	0.28–0.33	0.04	0.04	0.000	0.000
	m	50	78.96	0.33	5.55	0.02	70.06–94.21	0.29–0.37	0.07	0.05		
Height of skull at ventral margin of mastoid	f	131	71.93	0.39	2.19	0.01	66.87–79.89	0.36–0.43	0.03	0.04	0.000	0.000
	m	50	105.32	0.44	6.73	0.02	88.47–116.81	0.39–0.47	0.06	0.05		
Height of sagittal crest	f	131	0.00	0.00	0.00	0.00	0.00–0.00	0.00–0.00	–	–	0.000	–
	m	50	6.10	0.03	2.33	0.01	1.99–14.04	0.01–0.06	0.38	0.39		
Breadth of palate at postcanines 3–4	f	131	21.97	0.12	1.57	0.01	18.20–25.49	0.10–0.14	0.07	0.08	0.000	0.000
	m	50	32.14	0.13	2.00	0.01	27.31–37.19	0.11–0.15	0.06	0.07		
Breadth of palate at postcanines 4–5	f	131	23.53	0.13	1.74	0.01	20.19–27.41	0.10–0.15	0.07	0.07	0.000	0.000
	m	50	33.66	0.14	2.08	0.01	28.86–37.68	0.12–0.16	0.06	0.06		
Breadth of palate at postcanine 5	f	131	23.82	0.13	1.72	0.01	20.67–29.06	0.11–0.15	0.07	0.07	0.000	0.000
	m	50	33.86	0.14	2.20	0.01	28.63–37.89	0.12–0.16	0.07	0.07		
Length of orbit	f	126	50.91	0.27	1.38	0.01	47.21–54.14	0.25–0.29	0.03	0.03	0.000	0.000
	m	50	55.28	0.23	1.88	0.01	51.89–60.06	0.21–0.26	0.03	0.04		
Breadth of orbit	f	131	47.90	0.26	1.29	0.01	44.62–51.39	0.23–0.28	0.03	0.03	0.000	0.000
	m	50	55.22	0.23	2.08	0.01	50.77–60.88	0.21–0.25	0.04	0.04		
Mandible and teeth												
Length of mandible	f	129	122.49	0.66	3.94	0.01	111.54–134.04	0.61–0.69	0.03	0.02	0.000	0.000
	m	48	164.73	0.68	6.45	0.01	149.77–179.65	0.65–0.72	0.04	0.02		
Length of mandibular tooth row	f	129	47.87	0.26	1.82	0.01	42.74–53.23	0.22–0.28	0.04	0.03	0.000	0.000
	m	48	63.68	0.27	3.09	0.01	58.07–72.50	0.24–0.29	0.05	0.04		
Mesiodistal diameter of lower canines	f	103	6.68	0.04	0.48	0.01	5.59–8.63	0.03–0.04	0.07	0.13	0.000	0.000
	m	43	15.44	0.06	1.60	0.01	12.52–22.30	0.05–0.09	0.10	0.11		
Distance becaudal border of upper canines	f	131	44.43	0.24	2.16	0.01	36.05–49.52	0.20–0.26	0.05	0.05	0.000	0.000
	m	50	53.98	0.23	2.79	0.01	44.42–59.02	0.19–0.25	0.05	0.05		
Height of upper canines above alveolus	f	95	17.07	0.09	1.56	0.01	12.20–22.11	0.07–0.11	0.09	0.09	0.000	0.000
	m	44	25.65	0.11	3.33	0.01	16.95–33.25	0.07–0.14	0.13	0.12		
Mesiodistal diameter of postcanines	f	87	5.62	0.03	0.23	0.00	5.05–6.26	0.03–0.03	0.04	0.00	0.002	–
	m	18	5.95	0.02	0.39	0.01	5.19–6.63	0.02–0.03	0.07	0.21		
Length of lower postcanine row	f	129	35.32	0.19	2.31	0.01	31.29–51.02	0.17–0.27	0.07	0.06	0.000	0.000
	m	48	42.49	0.18	2.53	0.01	34.53–47.87	0.15–0.20	0.06	0.05		
Height of mandible at meatus	f	129	34.03	0.18	2.02	0.01	29.13–39.13	0.16–0.21	0.06	0.06	0.000	0.000
	m	48	58.93	0.25	3.92	0.01	50.40–72.28	0.22–0.28	0.07	0.06		
Angularis – coronoideus	f	129	37.95	0.20	2.23	0.01	32.76–43.88	0.18–0.23	0.06	0.05	0.000	0.000
	m	48	61.06	0.25	3.67	0.01	52.94–72.72	0.23–0.29	0.06	0.05		
Length of masseteric fossa	f	129	35.90	0.19	3.02	0.02	27.78–43.24	0.15–0.23	0.08	0.08	0.000	0.000
	m	48	56.93	0.24	4.76	0.02	46.38–66.26	0.20–0.28	0.08	0.08		
Breadth of masseteric fossa	f	129	20.73	0.11	2.16	0.01	15.88–26.80	0.09–0.14	0.10	0.10	0.000	0.000
	m	48	32.69	0.14	3.20	0.01	24.83–39.24	0.11–0.17	0.10	0.09		

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 8 Summary statistics for skull measurements – adult male and female *Callorhinus ursinus*.

Table 9 *Arctocephalus gazella*

Variable	Sex	n	Mean		SD		Range		CV		*P*	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	33	189.99	1.00	5.71	–	179.65–203.45	–	0.03	–		
	m	53	240.68	1.00	6.92	–	226.71–261.83	–	0.03	–	0.000	–
Gnathion – mid-occipital crest	f	33	163.49	0.86	5.74	0.02	151.47–172.38	0.83–0.89	0.04	0.02		
	m	53	220.42	0.92	7.40	0.02	205.49–246.69	0.87–0.97	0.03	0.02	0.000	0.000
Gnathion – posterior end of nasals	f	33	61.32	0.32	3.14	0.01	56.26–69.66	0.30–0.34	0.05	0.04		
	m	53	83.31	0.35	3.86	0.01	76.30–94.93	0.32–0.37	0.05	0.03	0.000	0.000
Length of nasals	f	31	29.47	0.16	2.11	0.01	26.03–34.15	0.14–0.18	0.07	0.06		
	m	47	39.68	0.16	2.84	0.01	34.95–45.47	0.14–0.19	0.07	0.07	0.000	0.000
Palatal notch – incisors	f	33	82.23	0.43	4.33	0.02	74.65–91.24	0.41–0.46	0.05	0.04		
	m	53	111.03	0.46	4.49	0.01	100.74–120.54	0.42–0.48	0.04	0.03	0.000	0.000
Gnathion – posterior of maxilla (palatal)	f	33	89.93	0.47	4.28	0.01	82.26–101.51	0.45–0.50	0.05	0.03		
	m	53	118.40	0.49	4.77	0.01	108.71–133.71	0.46–0.51	0.04	0.02	0.000	0.000
Basion – zygomatic root	f	33	128.70	0.68	4.34	0.01	122.29–139.20	0.66–0.70	0.03	0.02		
	m	53	163.89	0.68	5.31	0.01	151.27–176.69	0.66–0.70	0.03	0.02	0.000	0.084
Basion – bend of pterygoid	f	33	67.08	0.35	2.84	0.01	58.67–73.14	0.31–0.38	0.04	0.04		
	m	53	81.19	0.34	3.74	0.01	73.58–89.87	0.32–0.36	0.05	0.03	0.000	0.000
Gnathion – caudal border postglenoid process	f	33	136.12	0.72	4.46	0.01	127.01–147.52	0.70–0.73	0.03	0.01		
	m	53	178.80	0.74	5.38	0.01	169.18–194.13	0.72–0.76	0.03	0.01	0.000	0.000
Gnathion – foramen infraorbitale	f	33	55.66	0.29	4.05	0.02	49.68–65.14	0.27–0.34	0.07	0.06		
	m	53	77.32	0.32	4.63	0.02	68.79–87.82	0.29–0.36	0.06	0.05	0.000	0.000
Gnathion – caudal border of preorbital process	f	33	54.89	0.29	2.17	0.01	50.75–59.68	0.28–0.30	0.04	0.03		
	m	53	75.40	0.31	3.19	0.01	68.55–88.05	0.30–0.34	0.04	0.03	0.000	0.000
Breadth of skull												
Breadth of nares	f	33	25.53	0.14	1.47	0.01	22.06–29.74	0.12–0.15	0.06	0.05		
	m	53	34.11	0.14	1.95	0.01	30.28–39.01	0.13–0.16	0.06	0.06	0.000	0.000
Breadth at preorbital processes	f	33	48.24	0.25	2.98	0.02	42.71–55.45	0.23–0.29	0.06	0.07		
	m	53	66.47	0.28	4.07	0.02	59.41–73.91	0.25–0.31	0.06	0.06	0.000	0.000
Interorbital constriction	f	33	24.66	0.13	1.87	0.01	21.77–28.97	0.12–0.15	0.08	0.08		
	m	53	38.38	0.16	3.47	0.01	30.53–45.68	0.13–0.19	0.09	0.09	0.000	0.000
Breadth at supraorbital processes	f	30	43.27	0.23	4.10	0.02	34.23–53.37	0.18–0.27	0.10	0.09		
	m	52	63.57	0.26	6.38	0.03	50.75–76.44	0.22–0.33	0.10	0.10	0.000	0.000
Breadth of braincase	f	33	77.56	0.41	2.97	0.02	72.25–85.60	0.37–0.44	0.04	0.04		
	m	52	80.12	0.33	2.85	0.02	74.03–87.26	0.30–0.37	0.04	0.05	0.000	0.000
Occipital crest – mastoid	f	33	83.88	0.44	2.48	0.01	78.29–89.93	0.42–0.47	0.03	0.03		
	m	53	119.51	0.50	5.69	0.02	103.95–129.99	0.45–0.53	0.05	0.04	0.000	0.000
Rostral width	f	33	33.27	0.18	2.07	0.01	28.91–37.29	0.16–0.19	0.06	0.05		
	m	53	56.82	0.24	3.12	0.01	51.18–64.32	0.22–0.28	0.06	0.06	0.000	0.000
Breadth of zygomatic root of maxilla	f	33	14.22	0.08	1.40	0.01	11.28–18.44	0.06–0.10	0.10	0.11		
	m	53	20.95	0.09	1.69	0.01	16.68–24.79	0.07–0.11	0.08	0.09	0.000	0.000
Zygomatic breadth	f	33	110.75	0.58	3.87	0.02	103.83–118.87	0.55–0.62	0.04	0.03		
	m	53	148.40	0.62	5.36	0.02	136.86–160.15	0.56–0.66	0.04	0.03	0.000	0.000

Auditory breadth	f	33	87.91	0.46	2.54	0.02	83.07–91.89	0.44–0.49	0.03	0.04		
	m	52	119.46	0.50	4.86	0.02	108.77–129.24	0.44–0.54	0.04	0.04	0.000	0.000
Mastoid breadth	f	32	95.23	0.50	3.06	0.02	90.04–101.63	0.47–0.54	0.03	0.03		
	m	53	139.38	0.58	7.22	0.03	123.45–154.37	0.51–0.63	0.05	0.04	0.000	0.000
Height of skull at supraorbital processes	f	33	57.59	0.30	2.52	0.01	52.97–63.00	0.28–0.33	0.04	0.04		
	m	53	74.23	0.31	3.99	0.01	66.52–84.45	0.28–0.34	0.05	0.05	0.000	0.061
Height of skull at ventral margin of mastoid	f	33	73.13	0.39	3.49	0.02	63.84–82.71	0.35–0.43	0.05	0.05		
	m	53	100.19	0.42	6.92	0.02	80.96–115.56	0.35–0.46	0.07	0.05	0.000	0.000
Height of sagittal crest	f	33	0.00	0.00	0.00	0.00	0.00–0.00	0.00–0.00	0.00	0.00		
	m	52	8.69	0.04	3.06	0.01	3.19–16.68	0.01–0.07	0.35	0.35	0.000	0.000
Breadth of palate at postcanines 3–4	f	33	24.91	0.13	1.90	0.01	21.61–30.24	0.11–0.16	0.08	0.08		
	m	53	33.53	0.14	2.55	0.01	26.30–37.70	0.11–0.16	0.08	0.08	0.000	0.001
Breadth of palate at postcanines 4–5	f	33	28.52	0.15	1.69	0.01	25.47–34.02	0.13–0.18	0.06	0.06		
	m	53	38.06	0.16	2.68	0.01	27.83–42.97	0.12–0.18	0.07	0.07	0.000	0.000
Breadth of palate at postcanine 5	f	33	29.94	0.16	1.75	0.01	26.86–34.86	0.14–0.18	0.06	0.06		
	m	53	40.72	0.17	2.89	0.01	31.33–46.04	0.14–0.19	0.07	0.07	0.000	0.000
Length of orbit	f	33	53.80		1.60		50.26–56.70		0.03			
	m	53	58.56	–	1.63	–	54.14–63.22	–	0.03	–	0.000	0.000
Breadth of orbit	f	33	50.57		1.63		47.20–54.07	–	0.03			
	m	53	55.51	–	1.53	–	53.45–60.38	–	0.03	–	0.000	0.000
Mandible and teeth												
Length of mandible	f	33	121.42	0.64	4.72	0.01	112.47–130.03	0.61–0.66	0.04	0.02		
	m	40	163.23	0.68	4.47	0.01	149.77–176.83	0.65–0.71	0.03	0.02	0.000	0.000
Length of mandibular tooth row	f	33	54.39	0.29	2.46	0.01	48.94–59.17	0.27–0.31	0.05	0.03		
	m	40	72.00	0.30	2.58	0.01	64.38–77.87	0.26–0.32	0.04	0.04	0.000	0.000
Mesiodistal diameter of lower canines	f	33	6.81	0.04	0.39	0.01	5.98–7.37	0.03–0.04	0.06	0.13		
	m	36	15.87	0.07	1.50	0.01	13.59–19.43	0.06–0.08	0.09	0.09	0.000	0.000
Distance becaudal border of upper canines	f	33	52.41	0.28	3.71	0.02	42.74–57.91	0.23–0.30	0.07	0.06		
	m	53	64.35	0.27	3.85	0.02	55.02–72.01	0.23–0.30	0.06	0.06	0.000	0.024
Height of upper canines above alveolus	f	33	16.77	0.09	1.47	0.01	13.91–20.13	0.07–0.11	0.09	0.09		
	m	37	25.41	0.11	3.05	0.01	17.22–33.35	0.07–0.13	0.12	0.11	0.000	0.000
Mesiodistal diameter of postcanines	f	33	4.95		0.31		4.37–5.60		0.06			
	m	30	5.60	–	0.46	–	4.45–6.52	–	0.08	–	0.000	0.000
Length of lower postcanine row	f	33	39.59	0.21	3.18	0.02	31.61–52.68	0.17–0.28	0.08	0.08		
	m	40	45.97	0.19	2.43	0.01	37.24–49.09	0.15–0.20	0.05	0.06	0.000	0.000
Height of mandible at meatus	f	33	34.18	0.18	2.34	0.01	29.35–39.84	0.16–0.20	0.07	0.06		
	m	40	56.96	0.24	4.18	0.02	49.36–68.38	0.20–0.29	0.07	0.07	0.000	0.000
Angularis – coronoideus	f	33	37.64	0.20	2.23	0.01	32.93–43.81	0.18–0.22	0.06	0.05		
	m	40	59.62	0.25	4.56	0.02	52.71–69.52	0.22–0.29	0.08	0.07	0.000	0.000
Length of masseteric fossa	f	33	30.06	0.16	3.85	0.02	22.64–37.02	0.12–0.19	0.13	0.11		
	m	40	46.67	0.19	3.65	0.02	37.78–54.64	0.16–0.22	0.08	0.08	0.000	0.000
Breadth of masseteric fossa	f	33	20.78	0.11	1.90	0.01	15.24–23.62	0.08–0.13	0.09	0.09		
	m	40	32.40	0.13	2.70	0.01	26.39–39.20	0.11–0.16	0.08	0.08	0.000	0.000

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 9 Summary statistics for skull measurements – adult male and female *Arctocephalus gazella*.

Table 10 *A. tropicalis*

Variable	Sex	n	Mean		SD		Range		CV		*P*	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	13	186.24	1.00	7.23	–	175.78–197.36	–	0.04	–	0.000	0.000
	m	36	221.84	1.00	7.33	–	203.87–234.76	–	0.03	–		
Gnathion – mid-occipital crest	f	13	161.19	0.87	7.31	0.02	149.73–173.69	0.83–0.91	0.05	0.03	0.000	0.774
	m	36	192.53	0.87	7.05	0.02	173.50–203.74	0.82–0.91	0.04	0.02		
Gnathion – posterior end of nasals	f	13	58.70	0.32	3.93	0.02	51.10–65.43	0.29–0.34	0.07	0.05	0.000	0.007
	m	36	73.05	0.33	3.73	0.01	63.73–80.32	0.29–0.36	0.05	0.04		
Length of nasals	f	12	30.85	0.17	2.62	0.01	25.56–35.08	0.14–0.18	0.09	0.07	0.000	0.562
	m	27	37.62	0.17	3.31	0.01	30.47–43.02	0.14–0.19	0.09	0.08		
Palatal notch – incisors	f	13	79.98	0.43	4.06	0.01	73.95–87.41	0.42–0.44	0.05	0.02	0.000	0.000
	m	36	99.74	0.45	5.58	0.02	87.38–108.97	0.42–0.48	0.06	0.04		
Gnathion – posterior of maxilla (palatal)	f	13	87.12	0.47	4.41	0.01	78.48–93.16	0.45–0.49	0.05	0.02	0.000	0.000
	m	36	108.28	0.49	4.45	0.01	96.66–115.92	0.47–0.51	0.04	0.02		
Basion – zygomatic root	f	13	130.39	0.70	6.15	0.01	122.47–140.95	0.69–0.71	0.05	0.01	0.000	0.005
	m	36	154.00	0.69	5.58	0.01	138.07–162.35	0.68–0.72	0.04	0.01		
Basion – bend of pterygoid	f	13	65.39	0.35	2.07	0.01	61.91–68.91	0.33–0.37	0.03	0.04	0.000	0.000
	m	36	74.08	0.33	2.45	0.01	67.68–79.19	0.32–0.35	0.03	0.03		
Gnathion – caudal border postglenoid process	f	13	134.41	0.72	6.42	0.01	125.28–145.28	0.70–0.74	0.05	0.02	0.000	0.000
	m	36	164.13	0.74	5.83	0.01	149.01–171.60	0.72–0.76	0.04	0.01		
Gnathion – foramen infraorbitale	f	13	59.16	0.32	4.76	0.02	52.97–68.03	0.29–0.36	0.08	0.06	0.000	0.133
	m	36	72.93	0.33	6.79	0.03	56.83–86.95	0.28–0.38	0.09	0.08		
Gnathion – caudal border of preorbital process	f	13	51.73	0.28	2.82	0.01	47.90–57.57	0.26–0.30	0.05	0.03	0.000	0.000
	m	36	66.03	0.30	3.30	0.01	57.56–72.00	0.28–0.32	0.05	0.04		
Breadth of skull												
Breadth of nares	f	13	21.22	0.12	1.14	0.01	19.06–23.68	0.11–0.12	0.05	0.05	0.000	0.000
	m	36	27.54	0.12	1.67	0.01	23.36–30.86	0.11–0.14	0.06	0.07		
Breadth at preorbital processes	f	13	39.59	0.21	2.05	0.01	35.57–42.43	0.20–0.23	0.05	0.04	0.000	0.000
	m	36	51.67	0.23	3.23	0.01	45.29–58.38	0.20–0.26	0.06	0.05		
Interorbital constriction	f	13	15.89	0.09	2.16	0.01	11.27–20.00	0.06–0.10	0.14	0.13	0.000	0.000
	m	36	22.65	0.10	2.50	0.01	17.84–28.15	0.08–0.13	0.11	0.11		
Breadth at supraorbital processes	f	12	37.30	0.20	3.41	0.02	32.38–44.51	0.17–0.23	0.09	0.08	0.000	0.004
	m	34	48.35	0.22	4.25	0.02	39.71–58.16	0.19–0.26	0.09	0.08		
Breadth of braincase	f	13	75.47	0.41	3.00	0.02	68.36–80.14	0.37–0.44	0.04	0.05	0.135	0.000
	m	36	76.94	0.35	2.66	0.02	73.53–82.52	0.32–0.40	0.04	0.05		
Occipital crest – mastoid	f	13	84.93	0.46	3.54	0.01	80.16–90.59	0.44–0.48	0.04	0.03	0.000	0.000
	m	36	105.86	0.48	4.90	0.02	94.98–114.85	0.45–0.51	0.05	0.04		
Rostral width	f	13	30.70	0.17	2.33	0.01	26.86–33.80	0.15–0.18	0.08	0.06	0.000	0.000
	m	36	44.80	0.20	2.73	0.01	37.76–51.33	0.18–0.23	0.06	0.05		
Breadth of zygomatic root of maxilla	f	13	9.59	0.05	1.18	0.01	7.66–11.32	0.04–0.06	0.12	0.12	0.000	0.000
	m	36	14.48	0.07	1.76	0.01	9.41–17.45	0.05–0.08	0.12	0.11		
Zygomatic breadth	f	13	113.28	0.61	4.92	0.02	105.10–120.63	0.58–0.64	0.04	0.02	0.000	0.531
	m	36	135.57	0.61	4.98	0.02	124.70–146.54	0.57–0.65	0.04	0.03		

Auditory breadth	f	13	88.01	0.47	3.72	0.02	79.33–92.30	0.44–0.51	0.04	0.04	0.000	0.000
	m	36	109.88	0.50	5.14	0.02	97.61–118.25	0.47–0.53	0.05	0.04		
Mastoid breadth	f	13	95.50	0.51	6.37	0.02	86.88–104.21	0.48–0.55	0.07	0.04	0.000	0.000
	m	36	125.39	0.57	6.81	0.03	115.07–137.19	0.52–0.62	0.05	0.04		
Height of skull at supraorbital processes	f	13	54.63	0.29	2.52	0.01	49.35–57.84	0.27–0.31	0.05	0.04	0.000	0.692
	m	36	65.30	0.29	3.22	0.01	57.83–71.77	0.27–0.32	0.05	0.04		
Height of skull at ventral margin of mastoid	f	13	74.77	0.40	2.92	0.01	70.13–79.02	0.39–0.43	0.04	0.03	0.000	0.712
	m	36	88.83	0.40	5.90	0.02	76.86–108.88	0.35–0.47	0.07	0.06		
Height of sagittal crest	f	13	0.11	0.00	0.41	0.00	0.00–1.48	0.00–0.01	3.61	3.61	0.000	0.000
	m	36	4.32	0.02	2.23	0.01	0.00–8.31	0.00–0.04	0.52	0.52		
Breadth of palate at postcanines 3–4	f	13	20.20	0.11	0.27	0.01	17.69–22.37	0.10–0.12	0.06	0.06	0.000	0.050
	m	36	25.71	0.12	2.22	0.01	22.21–31.43	0.10–0.14	0.09	0.09		
Breadth of palate at postcanines 4–5	f	13	22.03	0.12	1.16	0.01	19.69–23.77	0.11–0.13	0.05	0.07	0.000	0.002
	m	36	28.30	0.13	2.61	0.01	24.00–33.81	0.11–0.15	0.09	0.09		
Breadth of palate at postcanine 5	f	13	22.51	0.12	1.30	0.01	20.50–25.75	0.11–0.14	0.06	0.08	0.000	0.002
	m	36	29.33	0.13	2.71	0.01	23.69–34.80	0.11–0.15	0.09	0.09		
Length of orbit	f	13	52.00	0.28	2.50	0.01	47.00–56.10	0.26–0.30	0.05	0.05	0.000	0.000
	m	35	57.09	0.26	1.64	0.01	52.86–59.81	0.24–0.27	0.03	0.04		
Breadth of orbit	f	13	48.79	0.26	2.02	0.01	44.62–52.34	0.25–0.27	0.04	0.03	0.000	0.000
	m	35	52.37	0.24	1.74	0.01	49.19–56.47	0.22–0.25	0.03	0.03		
Mandible and teeth												
Length of mandible	f	10	118.98	0.64	6.42	0.01	110.42–130.01	0.63–0.66	0.05	0.02	0.000	0.000
	m	26	147.45	0.66	6.77	0.02	130.41–156.37	0.63–0.69	0.05	0.02		
Length of mandibular tooth row	f	10	52.30	0.28	2.97	0.01	48.44–56.16	0.27–0.29	0.06	0.03	0.000	0.012
	m	26	64.41	0.29	3.12	0.01	57.50–68.51	0.27–0.31	0.05	0.04		
Mesiodistal diameter of lower canines	f	8	6.84	0.04	0.74	0.01	5.82–7.76	0.03–0.04	0.11	0.14	0.000	0.000
	m	22	12.91	0.06	1.20	0.01	10.59–15.84	0.05–0.07	0.09	0.11		
Distance becaudal border of upper canines	f	13	52.41	0.28	2.73	0.01	47.66–55.96	0.27–0.29	0.05	0.03	0.000	0.002
	m	36	59.98	0.27	4.17	0.02	42.73–67.46	0.21–0.30	0.07	0.06		
Height of upper canines above alveolus	f	7	17.62	0.10	1.27	0.01	16.21–20.06	0.09–0.10	0.07	0.05	0.000	0.815
	m	26	21.42	0.10	2.40	0.01	15.94–25.88	0.08–0.11	0.11	0.09		
Mesiodistal diameter of postcanines	f	9	5.79	0.03	0.41	0.00	5.26–6.63	0.03–0.03	0.07	0.00	0.111	–
	m	26	6.08	0.03	0.53	0.00	5.23–7.33	0.02–0.03	0.09	0.08		
Length of lower postcanine row	f	10	38.14	0.20	2.80	0.01	33.31–42.65	0.18–0.22	0.07	0.05	0.000	0.047
	m	26	43.63	0.20	2.38	0.01	36.71–46.80	0.18–0.21	0.06	0.04		
Height of mandible at meatus	f	10	37.65	0.20	2.34	0.01	34.49–43.39	0.19–0.22	0.06	0.05	0.000	0.000
	m	26	52.49	0.24	3.08	0.01	47.61–62.64	0.22–0.28	0.06	0.06		
Angularis – coronoideus	f	10	41.17	0.22	2.92	0.01	37.32–48.04	0.21–0.24	0.07	0.05	0.000	0.000
	m	26	53.46	0.24	3.54	0.01	47.59–63.32	0.22–0.28	0.07	0.06		
Length of masseteric fossa	f	10	38.64	0.21	3.61	0.01	33.75–46.27	0.19–0.24	0.09	0.06	0.000	0.001
	m	26	51.40	0.23	3.96	0.02	42.25–57.96	0.20–0.25	0.08	0.07		
Breadth of masseteric fossa	f	10	24.20	0.13	1.22	0.01	22.87–26.30	0.12–0.14	0.05	0.06	0.000	0.000
	m	26	33.77	0.15	2.75	0.01	29.21–38.90	0.13–0.17	0.08	0.07		

SD = standard deviation, CV = coefficient of variation, P = probability values derived from students t-test.

Table 10 Summary statistics for skull measurements – adult male and female *Arctocephalus tropicalis*.

Table 11 *A. forsteri*

Variable	Sex	n	Mean Actual (mm)	Mean Relative to CBL	SD Actual (mm)	SD Relative to CBL	Range Actual (mm)	Range Relative to CBL	CV Actual	CV Relative to CBL	*P* Actual	*P* Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	16	204.11	1.00	8.60	–	190.79–224.50	–	0.04	–	0.000	0.000
	m	60	237.71	1.00	7.28	–	220.44–251.00	–	0.03	–		
Gnathion – mid-occipital crest	f	16	169.63	0.83	6.75	0.01	161.27–187.92	0.81–0.86	0.04	0.02	0.000	0.000
	m	60	206.86	0.87	8.92	0.02	183.24–239.95	0.82–0.96	0.04	0.03		
Gnathion – posterior end of nasals	f	15	68.63	0.34	4.65	0.02	62.41–77.03	0.32–0.37	0.07	0.05	0.000	0.000
	m	60	84.42	0.36	4.08	0.01	75.03–93.64	0.32–0.38	0.05	0.04		
Length of nasals	f	13	36.56	0.18	3.04	0.02	30.80–41.80	0.16–0.20	0.08	0.08	0.000	0.603
	m	53	41.69	0.18	3.70	0.01	31.80–49.60	0.14–0.20	0.09	0.08		
Palatal notch – incisors	f	16	89.56	0.44	5.14	0.01	79.88–101.74	0.42–0.46	0.06	0.03	0.000	0.011
	m	60	106.23	0.45	4.79	0.02	95.57–188.48	0.41–0.48	0.05	0.03		
Gnathion – posterior of maxilla (palatal)	f	16	98.44	0.48	4.77	0.01	90.47–109.92	0.46–0.50	0.05	0.03	0.000	0.019
	m	60	116.87	0.49	5.85	0.02	103.92–142.54	0.45–0.57	0.05	0.04		
Basion – zygomatic root	f	16	138.01	0.68	6.20	0.01	129.06–152.43	0.65–0.69	0.05	0.02	0.000	0.025
	m	60	162.73	0.69	5.32	0.01	145.35–174.79	0.66–0.72	0.03	0.02		
Basion – bend of pterygoid	f	16	69.66	0.34	3.10	0.01	63.38–74.28	0.33–0.35	0.05	0.03	0.000	0.000
	m	60	78.62	0.33	3.07	0.01	70.01–86.02	0.30–0.36	0.04	0.03		
Gnathion – caudal border postglenoid process	f	16	149.64	0.73	6.73	0.01	139.52–166.99	0.71–0.75	0.05	0.01	0.000	0.000
	m	60	178.89	0.75	6.53	0.02	157.65–192.99	0.67–0.78	0.04	0.02		
Gnathion – foramen infraorbitale	f	16	61.13	0.30	4.18	0.02	52.17–71.36	0.26–0.32	0.07	0.05	0.000	0.000
	m	60	76.58	0.32	4.24	0.02	65.70–85.26	0.29–0.35	0.06	0.05		
Gnathion – caudal border of preorbital process	f	15	63.41	0.31	3.53	0.01	57.08–71.19	0.29–0.33	0.06	0.03	0.000	0.000
	m	60	79.45	0.33	6.56	0.02	69.89–122.05	0.30–0.50	0.08	0.07		
Breadth of skull												
Breadth of nares	f	16	25.07	0.12	1.71	0.01	21.64–27.48	0.10–0.13	0.07	0.07	0.000	0.000
	m	60	32.94	0.14	2.51	0.01	24.72–39.06	0.11–0.16	0.08	0.08		
Breadth at preorbital processes	f	15	45.86	0.22	3.65	0.01	37.53–50.73	0.20–0.24	0.08	0.06	0.000	0.000
	m	59	57.99	0.24	3.19	0.01	52.65–67.85	0.22–0.28	0.06	0.06		
Interorbital constriction	f	16	20.16	0.10	1.72	0.01	16.93–22.63	0.09–0.11	0.09	0.08	0.000	0.000
	m	60	28.69	0.12	2.61	0.01	23.71–36.03	0.10–0.15	0.09	0.09		
Breadth at supraorbital processes	f	16	36.72	0.18	3.51	0.02	31.06–43.01	0.15–0.21	0.10	0.10	0.000	0.000
	m	60	51.07	0.21	5.50	0.02	36.46–60.57	0.16–0.26	0.11	0.10		
Breadth of braincase	f	15	74.86	0.37	2.93	0.02	70.66–79.58	0.34–0.40	0.04	0.06	0.055	0.000
	m	60	76.56	0.32	2.74	0.02	69.32–82.94	0.28–0.35	0.04	0.05		
Occipital crest – mastoid	f	16	88.85	0.44	3.52	0.01	83.34–94.75	0.42–0.45	0.04	0.02	0.000	0.000
	m	60	113.00	0.48	5.48	0.02	92.78–123.02	0.43–0.52	0.05	0.04		
Rostral width	f	16	35.51	0.17	2.36	0.01	31.63–39.80	0.16–0.19	0.07	0.07	0.000	0.000
	m	60	53.72	0.23	3.19	0.01	44.36–60.22	0.19–0.25	0.06	0.05		
Breadth of zygomatic root of maxilla	f	16	12.63	0.06	0.10	0.01	10.53–14.37	0.05–0.07	0.08	0.09	0.000	0.000
	m	60	16.95	0.07	1.53	0.01	13.31–20.28	0.06–0.08	0.09	0.10		
Zygomatic breadth	f	16	116.60	0.57	5.12	0.02	106.97–126.72	0.54–0.60	0.04	0.03	0.000	0.000
	m	60	146.86	0.62	5.77	0.02	125.64–159.17	0.57–0.67	0.04	0.03		

Auditory breadth	f	16	91.21	0.45	2.76	0.02	84.96–94.48	0.42–0.47	0.03	0.03	0.000	0.000
	m	60	114.89	0.48	4.77	0.02	98.03–122.16	0.45–0.53	0.04	0.04		
Mastoid breadth	f	16	101.68	0.50	5.00	0.02	92.52–107.92	0.47–0.53	0.05	0.04	0.000	0.000
	m	60	135.22	0.57	6.81	0.02	115.44–147.09	0.50–0.63	0.05	0.04		
Height of skull at supraorbital processes	f	16	59.35	0.29	1.28	0.01	56.75–61.15	0.27–0.32	0.02	0.04	0.000	0.021
	m	60	71.17	0.30	3.50	0.01	62.43–78.96	0.28–0.33	0.05	0.04		
Height of skull at ventral margin of mastoid	f	16	80.57	0.40	6.94	0.02	70.81–89.97	0.36–0.43	0.09	0.06	0.000	0.077
	m	60	96.81	0.41	5.88	0.02	79.59–109.50	0.37–0.46	0.06	0.05		
Height of sagittal crest	f	15	1.14	0.01	0.32	0.01	0.00–4.08	0.00–0.02	1.16	1.09	0.000	0.000
	m	60	9.27	0.04	3.38	0.01	4.20–18.45	0.02–0.08	0.36	0.36		
Breadth of palate at postcanines 3–4	f	16	25.47	0.13	1.62	0.01	21.88–27.82	0.11–0.14	0.06	0.07	0.000	0.003
	m	60	31.66	0.13	2.56	0.01	24.05–37.63	0.10–0.15	0.08	0.07		
Breadth of palate at postcanines 4–5	f	16	29.48	0.14	1.92	0.01	26.67–32.58	0.13–0.16	0.07	0.07	0.000	0.026
	m	60	35.71	0.15	2.84	0.01	28.46–41.69	0.11–0.17	0.08	0.08		
Breadth of palate at postcanine 5	f	16	29.62	0.15	3.21	0.02	24.97–38.02	0.12–0.19	0.11	0.11	0.000	0.622
	m	60	35.31	0.15	3.05	0.01	28.83–44.13	0.12–0.18	0.09	0.09		
Length of orbit	f	0	–	–	–	–	–	–	–	–	0.000	0.000
	m	2	56.35	–	0.20	–	56.21–56.49	–	0.00	–		
Breadth of orbit	f	0	–	–	–	–	–	–	–	–	0.000	0.000
	m	2	54.67	–	0.70	–	54.16–55.15	–	0.01	–		
Mandible and teeth												
Length of mandible	f	10	133.42	0.66	5.85	0.01	123.90–142.67	0.63–0.67	0.04	0.02	0.000	0.000
	m	53	163.47	0.69	6.03	0.02	146.05–179.68	0.66–0.72	0.04	0.02		
Length of mandibular tooth row	f	10	54.38	0.27	3.15	0.01	48.49–58.32	0.25–0.28	0.06	0.04	0.000	0.018
	m	53	65.54	0.28	2.66	0.01	59.68–70.72	0.25–0.30	0.04	0.04		
Mesiodistal diameter of lower canines	f	9	8.78	0.04	1.26	0.01	6.88–10.74	0.04–0.06	0.14	0.16	0.000	0.000
	m	48	15.06	0.06	1.66	0.01	9.66–18.38	0.04–0.08	0.11	0.11		
Distance becaudal border of upper canines	f	16	54.41	0.27	3.18	0.01	47.29–59.66	0.25–0.29	0.06	0.04	0.000	0.000
	m	60	59.56	0.25	2.71	0.01	52.51–65.08	0.22–0.28	0.05	0.05		
Height of upper canines above alveolus	f	11	19.11	0.09	1.53	0.01	16.15–21.46	0.08–0.11	0.08	0.10	0.000	0.001
	m	45	25.73	0.12	3.23	0.01	16.38–31.60	0.07–0.13	0.13	0.13		
Mesiodistal diameter of postcanines	f	16	6.43	–	0.59	–	4.68–8.08	–	0.15	–	0.000	0.000
	m	60	6.90	–	0.64	–	5.66–9.38	–	0.16	–		
Length of lower postcanine row	f	10	42.49	0.21	3.19	0.01	37.08–47.06	0.19–0.22	0.08	0.05	0.012	0.001
	m	53	45.69	0.19	2.16	0.01	40.05–49.64	0.16–0.21	0.05	0.05		
Height of mandible at meatus	f	10	42.27	0.21	2.29	0.01	38.74–47.25	0.20–0.22	0.05	0.03	0.000	0.000
	m	53	60.54	0.26	4.03	0.02	47.31–68.13	0.22–0.28	0.07	0.06		
Angularis – coronoideus	f	10	42.17	0.21	2.93	0.01	36.57–47.08	0.19–0.21	0.07	0.03	0.000	0.000
	m	53	59.86	0.25	4.19	0.02	46.74–66.73	0.22–0.28	0.07	0.06		
Length of masseteric fossa	f	10	41.54	0.20	3.29	0.01	37.01–46.93	0.18–0.22	0.08	0.06	0.000	0.000
	m	53	55.87	0.24	4.01	0.02	46.07–65.23	0.20–0.27	0.07	0.07		
Breadth of masseteric fossa	f	10	27.66	0.14	2.07	0.01	25.39–32.22	0.13–0.14	0.08	0.04	0.000	0.000
	m	53	38.72	0.16	3.24	0.01	30.46–46.60	0.13–0.19	0.08	0.08		

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 11 Summary statistics for skull measurements – adult male and female *Arctocephalus forsteri*.

Table 12 *A. pusillus pusillus*

Variable	Sex	n	Mean		SD		Range		CV		*P*	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	43	217.01	1.00	8.89	–	196.54–235.19	–	0.04	–	0.000	0.000
	m	37	270.17	1.00	7.45	–	249.46–288.08	–	0.03	–		
Gnathion – mid-occipital crest	f	43	185.62	0.86	8.73	0.02	163.31–201.82	0.82–0.88	0.05	0.02	0.000	0.000
	m	38	242.45	0.90	8.41	0.02	227.45–264.04	0.86–0.93	0.04	0.02		
Gnathion – posterior end of nasals	f	43	72.39	0.33	6.13	0.02	44.06–80.85	0.20–0.35	0.09	0.07	0.000	0.000
	m	38	97.64	0.36	4.99	0.01	85.32–108.08	0.32–0.39	0.05	0.04		
Length of nasals	f	39	38.28	0.18	3.60	0.01	30.46–45.71	0.14–0.20	0.09	0.08	0.000	0.030
	m	34	49.57	0.18	4.41	0.02	39.01–58.98	0.14–0.21	0.09	0.08		
Palatal notch – incisors	f	43	92.34	0.43	5.45	0.02	78.99–104.86	0.38–0.45	0.06	0.04	0.000	0.003
	m	38	117.54	0.44	6.25	0.01	104.01–128.57	0.40–0.46	0.05	0.03		
Gnathion – posterior of maxilla (palatal)	f	43	101.85	0.47	5.47	0.01	86.35–112.52	0.44–0.49	0.05	0.02	0.000	0.104
	m	38	127.78	0.47	4.74	0.01	118.14–137.27	0.45–0.50	0.04	0.03		
Basion – zygomatic root	f	43	147.21	0.68	6.65	0.01	127.20–160.81	0.65–0.70	0.05	0.02	0.000	0.453
	m	37	184.53	0.68	11.67	0.04	124.22–200.73	0.48–0.71	0.06	0.05		
Basion – bend of pterygoid	f	42	68.37	0.32	3.07	0.01	61.42–73.39	0.29–0.34	0.05	0.04	0.000	0.001
	m	37	82.43	0.31	2.64	0.01	76.01–88.18	0.28–0.33	0.03	0.04		
Gnathion – caudal border postglenoid process	f	43	162.55	0.75	8.48	0.01	137.60–178.07	0.70–0.78	0.05	0.02	0.000	0.000
	m	38	208.16	0.77	6.84	0.01	188.42–220.36	0.75–0.80	0.03	0.01		
Gnathion – foramen infraorbitale	f	43	67.89	0.31	4.31	0.01	58.43–78.91	0.29–0.35	0.06	0.05	0.000	0.000
	m	38	90.47	0.34	6.29	0.02	77.52–108.83	0.30–0.39	0.07	0.06		
Gnathion – caudal border of preorbital process	f	43	67.71	0.31	4.04	0.01	58.45–75.61	0.29–0.34	0.06	0.04	0.000	0.000
	m	38	91.85	0.34	3.50	0.01	83.83–99.02	0.33–0.35	0.04	0.02		
Breadth of skull												
Breadth of nares	f	43	26.29	0.12	2.09	0.01	21.54–31.19	0.10–0.14	0.08	0.07	0.000	0.046
	m	38	34.17	0.13	3.56	0.01	25.21–41.16	0.09–0.15	0.10	0.11		
Breadth at preorbital processes	f	43	55.63	0.26	3.40	0.01	48.44–67.76	0.23–0.29	0.06	0.05	0.000	0.000
	m	37	77.60	0.29	4.59	0.02	67.50–86.06	0.25–0.32	0.06	0.53		
Interorbital constriction	f	43	29.27	0.14	2.38	0.01	23.63–34.66	0.11–0.16	0.08	0.08	0.000	0.000
	m	37	42.85	0.16	3.33	0.01	36.95–50.06	0.14–0.19	0.08	0.08		
Breadth at supraorbital processes	f	40	45.50	0.21	4.14	0.02	34.15–55.51	0.16–0.26	0.09	0.10	0.000	0.000
	m	36	64.71	0.24	5.82	0.02	53.72–75.74	0.19–0.28	0.09	0.09		
Breadth of braincase	f	42	75.44	0.35	2.26	0.02	70.42–80.78	0.31–0.39	0.03	0.04	0.000	0.000
	m	38	77.40	0.29	2.02	0.01	73.20–81.07	0.26–0.31	0.03	0.04		
Occipital crest – mastoid	f	43	95.56	0.44	4.99	0.02	85.82–109.02	0.41–0.48	0.05	0.04	0.000	0.000
	m	38	127.86	0.47	5.23	0.02	120.74–141.53	0.45–0.51	0.04	0.04		
Rostral width	f	43	38.41	0.18	2.65	0.01	31.36–43.32	0.16–0.20	0.07	0.05	0.000	0.000
	m	37	60.57	0.22	3.44	0.01	52.73–68.13	0.20–0.25	0.06	0.05		
Breadth of zygomatic root of maxilla	f	43	12.94	0.06	1.12	0.01	10.17–15.54	0.05–0.07	0.09	0.09	0.000	0.000
	m	38	19.32	0.07	1.85	0.01	15.93–23.57	0.06–0.08	0.10	0.09		
Zygomatic breadth	f	43	123.88	0.57	7.56	0.02	108.59–137.53	0.53–0.62	0.06	0.04	0.000	0.000
	m	38	162.03	0.60	6.86	0.02	146.42–179.01	0.56–0.64	0.04	0.04		

Auditory breadth	f	43	97.99	0.45	4.48	0.02	88.26–109.25	0.42–0.48	0.05	0.03	0.000	0.000
	m	38	131.31	0.49	6.18	0.02	118.75–145.67	0.44–0.53	0.05	0.05		
Mastoid breadth	f	42	111.66	0.51	8.39	0.03	82.62–127.77	0.40–0.56	0.08	0.06	0.000	0.000
	m	38	154.80	0.57	7.09	0.03	144.18–176.40	0.53–0.63	0.05	0.04		
Height of skull at supraorbital processes	f	43	64.17	0.30	3.54	0.01	56.89–71.89	0.27–0.32	0.06	0.04	0.000	0.001
	m	38	82.73	0.31	3.99	0.02	76.52–93.62	0.28–0.34	0.05	0.05		
Height of skull at ventral margin of mastoid	f	42	83.20	0.38	3.75	0.02	75.74–94.52	0.34–0.43	0.05	0.05	0.000	0.000
	m	38	108.46	0.40	5.61	0.02	99.10–119.74	0.36–0.44	0.05	0.05		
Height of sagittal crest	f	40	1.99	0.01	1.53	0.01	0.00–5.70	0.00–0.02	0.77	0.75	0.000	0.000
	m	37	12.25	0.05	3.86	0.01	6.82–23.12	0.03–0.08	0.32	0.31		
Breadth of palate at postcanines 3–4	f	42	24.59	0.11	2.34	0.01	17.79–29.42	0.08–0.14	0.10	0.10	0.000	0.000
	m	38	34.59	0.13	2.99	0.01	30.32–41.86	0.11–0.15	0.09	0.09		
Breadth of palate at postcanines 4–5	f	42	27.44	0.13	2.48	0.01	20.58–32.95	0.09–0.16	0.09	0.10	0.000	0.001
	m	38	37.28	0.14	3.77	0.01	25.73–45.16	0.09–0.16	0.10	0.10		
Breadth of palate at postcanine 5	f	42	27.83	0.13	2.39	0.01	21.59–32.54	0.10–0.15	0.09	0.09	0.000	0.000
	m	38	37.51	0.14	2.99	0.01	32.09–45.38	0.12–0.16	0.08	0.08		
Length of orbit	f	39	51.98	0.24	1.77	0.01	47.54–55.42	0.22–0.26	0.03	0.03	0.000	0.000
	m	36	57.57	0.21	1.91	0.01	53.02–61.30	0.19–0.23	0.03	0.04		
Breadth of orbit	f	39	48.03	0.22	1.79	0.01	44.75–51.39	0.20–0.24	0.04	0.04	0.000	0.000
	m	36	54.76	0.20	2.03	0.01	51.07–58.99	0.18–0.22	0.04	0.05		
Mandible and teeth												
Length of mandible	f	42	148.25	0.68	7.98	0.02	125.39–163.02	0.64–0.71	0.05	0.02	0.000	0.000
	m	31	190.52	0.71	8.10	0.02	168.41–206.24	0.68–0.74	0.04	0.02		
Length of mandibular tooth row	f	42	59.70	0.28	3.32	0.01	51.85–66.16	0.25–0.29	0.06	0.04	0.000	0.000
	m	31	76.74	0.29	3.31	0.01	69.74–84.43	0.26–0.31	0.04	0.04		
Mesiodistal diameter of lower canines	f	39	8.76	0.04	1.00	0.00	7.09–11.33	0.03–0.05	0.11	0.10	0.000	0.000
	m	29	17.75	0.07	1.84	0.01	14.29–22.24	0.05–0.08	0.10	0.11		
Distance becaudal border of upper canines	f	43	55.85	0.26	3.35	0.01	47.98–64.45	0.24–0.28	0.06	0.05	0.000	0.000
	m	38	64.41	0.24	3.73	0.01	54.43–72.12	0.22–0.27	0.06	0.05		
Height of upper canines above alveolus	f	30	20.81	0.10	2.88	0.01	13.67–25.51	0.07–0.12	0.14	0.12	0.000	0.841
	m	23	25.92	0.10	4.25	0.02	12.55–32.62	0.05–0.12	0.16	0.15		
Mesiodistal diameter of postcanines	f	30	7.60	0.04	0.47	0.00	6.64–8.75	0.03–0.04	0.06	0.12	0.000	0.000
	m	31	8.20	–	0.65	–	6.80–9.27	–	0.08	–		
Length of lower postcanine row	f	42	43.46	0.20	3.32	0.01	38.75–59.69	0.19–0.28	0.08	0.07	0.000	0.000
	m	31	50.53	0.19	2.12	0.01	46.49–55.24	0.17–0.20	0.04	0.04		
Height of mandible at meatus	f	41	45.45	0.21	3.78	0.01	37.01–52.62	0.19–0.23	0.08	0.06	0.000	0.000
	m	31	69.28	0.26	4.46	0.01	62.83–82.00	0.24–0.29	0.06	0.05		
Angularis – coronoideus	f	42	48.80	0.23	3.57	0.01	38.84–54.85	0.20–0.24	0.07	0.05	0.000	0.000
	m	31	70.38	0.26	4.47	0.01	64.28–80.43	0.24–0.29	0.06	0.05		
Length of masseteric fossa	f	42	52.53	0.24	5.53	0.02	39.74–62.57	0.20–0.27	0.11	0.08	0.000	0.000
	m	31	76.09	0.28	5.00	0.02	64.91–83.31	0.25–0.31	0.07	0.06		
Breadth of masseteric fossa	f	42	31.20	0.14	2.76	0.01	23.89–36.20	0.12–0.17	0.09	0.07	0.000	0.000
	m	31	44.79	0.17	4.33	0.02	30.11–52.93	0.11–0.19	0.10	0.09		

SD = standard deviation, CV = coefficient of variation, P = probability values derived from students t-test.

Table 12 Summary statistics for skull measurements – adult male and female *Arctocephalus pusillus pusillus*.

Table 13 *A. p. doriferus*

Variable	Sex	n	Mean Actual (mm)	Mean Relative to CBL	SD Actual (mm)	SD Relative to CBL	Range Actual (mm)	Range Relative to CBL	CV Actual	CV Relative to CBL	*P* Actual	*P* Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	42	226.46	1.00	6.98	–	207.52–238.41	–	0.03	–	0.000	0.000
	m	45	281.69	1.00	7.99	–	265.77–302.15	–	0.03	–		
Gnathion – mid-occipital crest	f	42	191.45	0.85	7.41	0.02	176.38–205.97	0.81–0.89	0.04	0.02	0.000	0.000
	m	45	248.56	0.88	8.98	0.02	227.50–270.45	0.84–0.92	0.04	0.02		
Gnathion – posterior end of nasals	f	42	76.37	0.34	3.68	0.01	67.09–84.09	0.30–0.36	0.05	0.04	0.000	0.000
	m	45	98.66	0.35	5.06	0.01	86.83–107.96	0.32–0.38	0.05	0.04		
Length of nasals	f	41	40.92	0.18	2.90	0.01	34.50–47.20	0.16–0.20	0.07	0.06	0.000	0.414
	m	39	50.07	0.18	4.56	0.01	38.40–58.30	0.14–0.21	0.09	0.08		
Palatal notch – incisors	f	42	96.41	0.43	5.00	0.02	82.62–105.91	0.38–0.45	0.05	0.04	0.000	0.328
	m	45	121.33	0.43	11.14	0.04	85.51–140.31	0.32–0.47	0.09	0.08		
Gnathion – posterior of maxilla (palatal)	f	42	107.76	0.48	4.39	0.01	96.04–117.04	0.45–0.50	0.04	0.02	0.000	0.044
	m	45	135.21	0.48	5.03	0.01	125.80–149.99	0.46–0.51	0.04	0.02		
Basion – zygomatic root	f	42	152.93	0.68	5.09	0.01	140.35–163.35	0.66–0.69	0.03	0.01	0.000	0.037
	m	45	191.45	0.68	6.76	0.01	180.40–207.63	0.66–0.70	0.04	0.02		
Basion – bend of pterygoid	f	42	70.39	0.31	2.62	0.01	63.70–77.61	0.28–0.33	0.04	0.04	0.000	0.102
	m	45	86.41	0.31	3.72	0.01	79.65–97.05	0.29–0.33	0.04	0.03		
Gnathion – caudal border postglenoid process	f	42	170.60	0.75	6.19	0.01	153.34–181.23	0.73–0.77	0.04	0.01	0.000	0.000
	m	45	217.35	0.77	7.16	0.01	199.09–235.40	0.75–0.80	0.03	0.01		
Gnathion – foramen infraorbitale	f	42	69.70	0.31	2.96	0.01	63.41–77.02	0.29–0.32	0.04	0.03	0.000	0.000
	m	45	91.66	0.33	4.77	0.01	78.56–100.05	0.29–0.34	0.05	0.04		
Gnathion – caudal border of preorbital process	f	42	72.03	0.32	3.33	0.01	65.10–78.30	0.30–0.34	0.05	0.03	0.000	0.000
	m	45	94.87	0.34	3.87	0.01	84.33–104.07	0.31–0.35	0.04	0.03		
Breadth of skull												
Breadth of nares	f	42	26.61	0.12	1.85	0.01	22.91–30.71	0.10–0.13	0.07	0.06	0.000	0.000
	m	45	37.24	0.13	2.13	0.01	32.75–43.60	0.12–0.15	0.06	0.06		
Breadth at preorbital processes	f	42	56.50	0.25	2.99	0.01	49.57–63.50	0.24–0.28	0.05	0.05	0.000	0.000
	m	45	79.29	0.28	4.19	0.01	69.44–87.71	0.25–0.31	0.05	0.05		
Interorbital constriction	f	42	29.16	0.13	1.36	0.01	26.28–32.44	0.12–0.14	0.05	0.05	0.000	0.000
	m	45	42.71	0.15	3.04	0.01	35.59–47.80	0.13–0.17	0.07	0.07		
Breadth at supraorbital processes	f	41	45.89	0.20	4.46	0.02	26.43–55.28	0.11–0.23	0.10	0.09	0.000	0.000
	m	45	66.17	0.24	5.50	0.02	55.66–76.07	0.20–0.27	0.08	0.08		
Breadth of braincase	f	42	75.27	0.33	2.09	0.02	70.02–79.24	0.30–0.37	0.03	0.05	0.000	0.000
	m	45	78.17	0.28	2.25	0.01	72.60–83.87	0.25–0.30	0.03	0.05		
Occipital crest – mastoid	f	42	96.52	0.43	4.81	0.02	81.84–104.69	0.36–0.46	0.05	0.04	0.000	0.000
	m	45	130.89	0.46	5.39	0.02	116.97–140.12	0.42–0.50	0.04	0.04		
Rostral width	f	42	39.19	0.17	2.13	0.01	35.18–44.25	0.16–0.19	0.05	0.04	0.000	0.000
	m	45	62.18	0.22	3.60	0.01	52.37–69.76	0.19–0.24	0.06	0.05		
Breadth of zygomatic root of maxilla	f	42	13.61	0.06	1.31	0.01	11.09–16.54	0.05–0.07	0.10	0.09	0.000	0.000
	m	45	19.01	0.07	1.84	0.01	13.56–22.46	0.05–0.08	0.10	0.11		
Zygomatic breadth	f	42	124.45	0.55	4.95	0.02	110.53–133.96	0.52–0.60	0.04	0.03	0.000	0.000
	m	45	164.72	0.59	5.99	0.02	153.68–178.95	0.54–0.63	0.04	0.03		

Auditory breadth	f	42	98.97	0.44	3.74	0.01	89.13–106.79	0.41–0.46	0.04	0.03	0.000	0.000
	m	45	135.02	0.48	8.53	0.02	120.16–179.00	0.44–0.59	0.06	0.05		
Mastoid breadth	f	42	113.03	0.50	6.39	0.02	95.45–128.73	0.46–0.54	0.06	0.04	0.000	0.000
	m	45	158.04	0.56	5.72	0.02	147.71–170.40	0.52–0.60	0.04	0.03		
Height of skull at supraorbital processes	f	42	65.00	0.29	3.13	0.01	59.87–72.11	0.27–0.31	0.05	0.04	0.000	0.001
	m	45	83.36	0.30	4.12	0.01	68.99–90.48	0.26–0.32	0.05	0.05		
Height of skull at ventral margin of mastoid	f	42	85.79	0.38	4.16	0.02	76.85–97.47	0.35–0.41	0.05	0.04	0.000	0.000
	m	45	114.75	0.41	5.50	0.02	100.98–128.12	0.37–0.46	0.05	0.05		
Height of sagittal crest	f	42	2.58	0.01	1.51	0.01	0.00–4.99	0.00–0.02	0.59	0.60	0.000	0.000
	m	45	10.71	0.04	2.41	0.01	6.88–16.48	0.02–0.06	0.23	0.23		
Breadth of palate at postcanines 3–4	f	42	26.80	0.12	2.34	0.01	22.35–32.01	0.10–0.14	0.09	0.10	0.000	0.000
	m	44	38.53	0.14	3.26	0.01	28.90–44.49	0.11–0.16	0.09	0.09		
Breadth of palate at postcanines 4–5	f	42	29.66	0.13	2.80	0.01	24.45–35.09	0.10–0.15	0.09	0.10	0.000	0.000
	m	45	42.64	0.15	3.18	0.01	36.07–48.54	0.13–0.18	0.08	0.08		
Breadth of palate at postcanine 5	f	42	27.89	0.12	2.53	0.01	22.59–33.88	0.10–0.15	0.09	0.10	0.000	0.000
	m	45	39.77	0.14	2.78	0.01	33.51–45.10	0.12–0.16	0.07	0.08		
Length of orbit	f	2	53.53	0.23	0.47	0.00	53.19–53.86	0.23–0.23	0.01	0.00	–	–
	m	1	56.52	–	–	–	–	–	–	–	–	–
Breadth of orbit	f	2	47.76	0.21	0.77	0.01	47.21–48.30	0.20–0.21	0.02	0.03	–	–
	m	1	54.19	–	–	–	–	–	–	–		
Mandible and teeth												
Length of mandible	f	42	153.98	0.68	6.11	0.01	134.96–167.07	0.65–0.71	0.04	0.02	0.000	0.000
	m	41	198.10	0.70	7.22	0.01	181.70–214.60	0.67–0.73	0.04	0.02		
Length of mandibular tooth row	f	42	57.85	0.25	3.16	0.01	50.32–66.91	0.22–0.28	0.06	0.05	0.000	0.000
	m	41	75.15	0.27	3.20	0.01	69.23–84.17	0.24–0.29	0.04	0.04		
Mesiodistal diameter of lower canines	f	42	10.20	0.05	0.99	0.01	8.13–12.43	0.04–0.05	0.10	0.11	0.000	0.000
	m	41	18.35	0.07	1.66	0.01	14.25–21.54	0.05–0.08	0.09	0.11		
Distance becaudal border of upper canines	f	42	57.72	0.26	3.80	0.02	45.29–66.77	0.21–0.28	0.07	0.06	0.000	0.000
	m	45	66.61	0.24	2.85	0.01	61.70–73.24	0.22–0.26	0.04	0.04		
Height of upper canines above alveolus	f	40	20.07	0.09	3.16	0.01	12.90–27.47	0.06–0.12	0.16	0.16	0.000	0.186
	m	36	26.03	0.09	4.81	0.02	12.18–32.28	0.04–0.11	0.19	0.18		
Mesiodistal diameter of postcanines	f	2	8.42	0.04	0.28	0.01	8.22–8.61	0.03–0.04	0.03	0.20	0.000	0.000
	m	1	8.76	–	–	–	–	–	–	–		
Length of lower postcanine row	f	42	44.75	0.20	2.50	0.01	38.12–49.62	0.17–0.21	0.06	0.05	0.000	0.000
	m	41	51.61	0.18	2.56	0.01	43.86–57.53	0.16–0.20	0.05	0.05		
Height of mandible at meatus	f	42	45.35	0.20	3.95	0.01	32.74–52.09	0.16–0.22	0.09	0.07	0.000	0.000
	m	41	69.03	0.25	5.30	0.02	47.66–78.04	0.17–0.28	0.08	0.07		
Angularis – coronoideus	f	42	48.20	0.21	4.24	0.02	38.80–55.60	0.19–0.24	0.09	0.07	0.000	0.000
	m	41	68.77	0.25	4.35	0.02	56.33–76.81	0.21–0.28	0.06	0.06		
Length of masseteric fossa	f	42	52.44	0.23	3.98	0.02	39.54–61.42	0.19–0.26	0.08	0.06	0.000	0.000
	m	41	75.00	0.27	4.63	0.02	62.58–83.13	0.23–0.30	0.06	0.06		
Breadth of masseteric fossa	f	42	31.09	0.14	2.60	0.01	24.36–35.99	0.11–0.15	0.08	0.07	0.000	0.000
	m	41	45.70	0.16	3.23	0.01	36.85–51.53	0.14–0.18	0.07	0.07		

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 13 Summary statistics for skull measurements – adult male and female *Arctocephalus pusillus doriferus*.

Table 14 *A. townsendi*

Variable	Sex	n	Mean		SD		Range		CV		*P*	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	1	221.00	1.00	–	–	–	–	–	–	–	–
	m	2	250.41	1.00	5.33	–	246.64–254.17	–	0.02	–		
Gnathion – mid-occipital crest	f	1	189.00	0.86	–	–	–	–	–	–	–	–
	m	2	213.73	0.86	5.90	0.00	209.56–217.90	0.85–0.86	0.03	0.01		
Gnathion – posterior end of nasals	f	1	70.40	0.32	–	–	–	–	–	–	–	–
	m	2	82.08	0.33	1.44	0.00	81.06–83.10	0.33–0.33	0.02	0.00		
Length of nasals	f	1	37.00	0.17	–	–	–	–	–	–	–	–
	m	2	37.92	0.15	0.74	0.00	37.40–38.44	0.15–0.15	0.02	0.00		
Palatal notch – incisors	f	1	90.40	0.41	–	–	–	–	–	–	–	–
	m	2	113.28	0.45	6.54	0.01	108.65–117.90	0.44–0.46	0.06	0.03		
Gnathion – posterior of maxilla (palatal)	f	1	107.30	0.49	–	–	–	–	–	–	–	–
	m	2	126.31	0.51	4.72	0.01	122.97–129.64	0.50–0.51	0.04	0.01		
Basion – zygomatic root	f	1	151.10	0.68	–	–	–	–	–	–	–	–
	m	2	166.84	0.67	1.98	0.01	165.44–168.24	0.66–0.67	0.01	0.01		
Basion – bend of pterygoid	f	1	65.30	0.30	–	–	–	–	–	–	–	–
	m	2	73.21	0.29	1.60	0.01	72.08–74.34	0.28–0.30	0.02	0.05		
Gnathion – caudal border postglenoid process	f	1	164.70	0.75	–	–	–	–	–	–	–	–
	m	2	187.74	0.75	3.92	0.00	184.96–190.51	0.75–0.75	0.02	0.00		
Gnathion – foramen infraorbitale	f	1	64.80	0.29	–	–	–	–	–	–	–	–
	m	2	90.19	0.36	4.77	0.01	86.82–93.56	0.35–0.37	0.05	0.04		
Gnathion – caudal border of preorbital process	f	1	68.70	0.31	–	–	–	–	–	–	–	–
	m	2	78.67	0.32	4.43	0.01	75.54–81.80	0.31–0.32	0.06	0.02		
Breadth of skull												
Breadth of nares	f	1	20.37	0.09	–	–	–	–	–	–	–	–
	m	2	27.35	0.11	0.57	0.00	26.95–27.75	0.11–0.11	0.02	0.00		
Breadth at preorbital processes	f	1	42.40	0.19	–	–	–	–	–	–	–	–
	m	2	54.31	0.22	2.60	0.01	52.47–56.15	0.21–0.23	0.05	0.06		
Interorbital constriction	f	1	19.20	0.09	–	–	–	–	–	–	–	–
	m	2	25.32	0.10	1.78	0.00	24.06–26.58	0.10–0.10	0.07	0.00		
Breadth at supraorbital processes	f	1	39.15	0.18	–	–	–	–	–	–	–	–
	m	2	50.62	0.21	6.54	0.02	45.99–55.24	0.19–0.22	0.13	0.10		
Breadth of braincase	f	1	82.20	0.37	–	–	–	–	–	–	–	–
	m	2	81.09	0.32	2.03	0.00	79.65–82.52	0.32–0.32	0.03	0.00		
Occipital crest – mastoid	f	1	86.20	0.39	–	–	–	–	–	–	–	–
	m	2	101.54	0.41	5.49	0.01	97.66–105.42	0.40–0.41	0.05	0.02		
Rostral width	f	1	33.45	0.15	–	–	–	–	–	–	–	–
	m	2	48.08	0.19	1.24	0.00	47.20–48.95	0.19–0.19	0.03	0.00		
Breadth of zygomatic root of maxilla	f	1	15.70	0.07	–	–	–	–	–	–	–	–
	m	2	19.89	0.08	3.37	0.01	17.50–22.27	0.07–0.09	0.17	0.18		
Zygomatic breadth	f	1	122.95	0.56	–	–	–	–	–	–	–	–
	m	2	137.68	0.55	5.30	0.01	133.93–141.42	0.54–0.56	0.04	0.03		

Auditory breadth	f	1	93.70	0.42	–	–	–	–	–	–	–	–
	m	2	107.06	0.43	4.99	0.01	103.53–110.59	0.42–0.44	0.05	0.03		
Mastoid breadth	f	1	104.60	0.47	–	–	–	–	–	–	–	–
	m	2	120.50	0.49	4.32	0.01	117.44–123.55	0.48–0.49	0.04	0.02		
Height of skull at supraorbital processes	f	1	57.30	0.26	–	–	–	–	–	–	–	–
	m	2	67.19	0.27	0.56	0.01	66.79–67.58	0.26–0.27	0.01	0.03		
Height of skull at ventral margin of mastoid	f	1	76.55	0.35	–	–	–	–	–	–	–	–
	m	2	88.07	0.36	3.72	0.01	85.44–90.70	0.35–0.36	0.04	0.02		
Height of sagittal crest	f	1	0.00	–	–	–	–	–	–	–	–	–
	m	2	4.94	0.02	1.77	0.01	3.69–6.19	0.01–0.02	0.36	0.47		
Breadth of palate at postcanines 3-4	f	1	25.50	0.12	–	–	–	–	–	–	–	–
	m	2	27.95	0.12	0.96	0.01	27.27–28.62	0.11–0.12	0.03	0.06		
Breadth of palate at postcanines 4-5	f	1	28.15	0.13	–	–	–	–	–	–	–	–
	m	2	29.78	0.12	1.32	0.01	28.84–30.71	0.11–0.12	0.04	0.06		
Breadth of palate at postcanine 5	f	1	28.10	0.13	–	–	–	–	–	–	–	–
	m	2	32.81	0.13	1.53	0.01	31.72–33.89	0.12–0.14	0.05	0.11		
Length of orbit	f	1	53.75	0.24	–	–	–	–	–	–	–	–
	m	2	56.59	0.23	2.54	0.01	54.79–58.38	0.22–0.24	0.05	0.06		
Breadth of orbit	f	1	46.85	0.21	–	–	–	–	–	–	–	–
	m	2	52.81	0.21	1.07	0.01	52.05–53.56	0.20–0.22	0.02	0.07		
Mandible and teeth												
Length of mandible	f	1	147.90	0.67	–	–	–	–	–	–	–	–
	m	2	171.80	0.69	5.85	0.01	167.66–175.93	0.68–0.69	0.03	0.01		
Length of mandibular tooth row	f	0	–	–	–	–	–	–	–	–	–	–
	m	2	81.39	0.33	1.41	0.01	80.39–82.38	0.32–0.33	0.02	0.02		
Mesiodistal diameter of lower canines	f	0	–	–	–	–	–	–	–	–	–	–
	m	2	7.32	0.03	10.35	0.04	0.00–14.64	0.00–0.06	1.41	1.41		
Distance becaudal border of upper canines	f	1	70.20	0.32	–	–	–	–	–	–	–	–
	m	2	74.38	0.30	3.78	0.01	71.70–77.05	0.29–0.30	0.05	0.02		
Height of upper canines above alveolus	f	1	20.15	0.09	–	–	–	–	–	–	–	–
	m	2	23.69	0.10	1.67	0.01	22.51–24.87	0.09–0.10	0.07	0.07		
Mesiodistal diameter of postcanines	f	0	–	–	–	–	–	–	–	–	–	–
	m	1	7.55	0.03	–	0.01	–	0.03–0.03	–	1.00		
Length of lower postcanine row	f	0	–	–	–	–	–	–	–	–	–	–
	m	2	57.56	0.23	0.47	0.00	57.23–57.89	0.23–0.23	0.01	0.00		
Height of mandible at meatus	f	1	36.70	0.17	–	–	–	–		–	–	–
	m	2	52.70	0.21	0.42	0.00	52.40–53.00	0.21–0.21	0.01	0.00		
Angularis – coronoideus	f	1	42.65	0.19	–	–	–	–	–	–	–	–
	m	2	55.25	0.22	2.70	0.00	53.34–57.16	0.22–0.22	0.05	0.00		
Length of masseteric fossa	f	1	38.95	0.18	–	–	–	–	–	–	–	–
	m	2	49.52	0.20	3.25	0.01	47.22–51.81	0.19–0.21	0.07	0.07		
Breadth of masseteric fossa	f	1	27.45	0.12	–	–	–	–	–	–	–	–
	m	2	28.91	0.12	1.08	0.01	28.14–29.67	0.11–0.12	0.04	0.06		

SD = standard deviation, CV = coefficient of variation, P = probability values derived from students t-test.

Table 14 Summary statistics for skull measurements – adult male and female *Arctocephalus townsendi*.

Table 15 *A. galapagoensis*

Variable	Sex	n	Mean		SD		Range		CV		*P*	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	5	176.85	1.00	2.78	–	174.81–180.32	–	0.02	–	–	–
	m	6	204.43	1.00	6.85	–	195.25–212.29	–	0.03	–		
Gnathion – mid-occipital crest	f	5	156.13	0.88	3.72	0.01	153.24–162.18	0.88–0.90	0.02	0.01	–	–
	m	6	175.37	0.86	8.94	0.02	164.33–189.93	0.84–0.89	0.05	0.02		
Gnathion – posterior end of nasals	f	5	56.42	0.32	2.68	0.01	53.40–58.83	0.31–0.33	0.05	0.03	–	–
	m	6	67.11	0.33	3.82	0.01	61.69–71.72	0.31–0.34	0.06	0.04	–	–
Length of nasals	f	5	26.94	0.15	2.17	0.01	24.14–29.99	0.14–0.17	0.08	0.07	–	–
	m	4	29.43	0.15	1.21	0.01	27.84–30.77	0.14–0.15	0.04	0.04		
Palatal notch – incisors	f	5	72.69	0.41	3.27	0.02	68.62–77.21	0.39–0.43	0.05	0.04	–	–
	m	6	85.96	0.42	3.59	0.01	81.11–90.49	0.40–0.44	0.04	0.03		
Gnathion – posterior of maxilla (palatal)	f	5	82.86	0.47	2.35	0.01	79.32–85.11	0.45–0.48	0.03	0.02	–	–
	m	6	93.61	0.46	4.96	0.02	89.24–100.30	0.42–0.47	0.05	0.04		
Basion – zygomatic root	f	5	122.50	0.69	2.74	0.01	118.99–125.79	0.68–0.70	0.02	0.01	–	–
	m	6	143.66	0.70	5.81	0.02	137.41–153.55	0.69–0.73	0.04	0.02		
Basion – bend of pterygoid	f	5	61.44	0.35	1.10	0.01	59.77–62.66	0.34–0.36	0.02	0.03	–	–
	m	6	69.49	0.34	3.50	0.02	64.33–75.21	0.32–0.36	0.05	0.05		
Gnathion – caudal border postglenoid process	f	5	129.08	0.73	3.67	0.01	125.16–133.17	0.72–0.74	0.03	0.01	–	–
	m	6	151.15	0.74	5.54	0.01	145.34–158.35	0.73–0.75	0.04	0.01		
Gnathion – foramen infraorbitale	f	5	58.64	0.33	3.60	0.02	53.70–62.69	0.31–0.35	0.06	0.05	–	–
	m	6	67.36	0.33	5.27	0.03	61.51–75.63	0.29–0.36	0.08	0.08		
Gnathion – caudal border of preorbital process	f	5	52.36	0.30	1.93	0.01	49.77–54.40	0.28–0.30	0.04	0.03	–	–
	m	6	63.54	0.31	3.02	0.01	59.18–66.92	0.29–0.32	0.05	0.04		
Breadth of skull												
Breadth of nares	f	5	22.08	0.12	1.03	0.01	20.95–23.05	0.12–0.13	0.05	0.04	–	–
	m	6	27.69	0.14	2.56	0.01	24.98–31.96	0.12–0.15	0.09	0.08		
Breadth at preorbital processes	f	5	41.19	0.23	2.25	0.01	38.66–43.99	0.22–0.25	0.06	0.06	–	–
	m	5	50.71	0.24	4.22	0.02	44.44–54.81	0.22–0.26	0.08	0.06		
Interorbital constriction	f	5	19.12	0.11	1.38	0.01	17.26–20.60	0.10–0.12	0.07	0.08	–	–
	m	5	25.02	0.12	2.48	0.01	21.34–27.00	0.11–0.13	0.10	0.07		
Breadth at supraorbital processes	f	5	38.08	0.22	1.63	0.01	35.92–40.14	0.21–0.23	0.04	0.04	–	–
	m	5	43.53	0.21	3.79	0.02	38.95–48.17	0.19–0.23	0.09	0.07		
Breadth of braincase	f	5	74.41	0.42	1.04	0.01	73.18–75.70	0.41–0.43	0.01	0.02	–	–
	m	6	74.37	0.37	1.71	0.02	72.17–75.67	0.34–0.39	0.02	0.05		
Occipital crest – mastoid	f	5	79.98	0.45	2.29	0.01	77.17–81.99	0.44–0.47	0.03	0.03	–	–
	m	6	95.07	0.47	5.36	0.02	87.34–101.33	0.44–0.49	0.06	0.04		
Rostral width	f	5	33.17	0.19	2.18	0.01	30.31–35.73	0.17–0.20	0.07	0.06	–	–
	m	6	46.46	0.23	4.48	0.02	41.50–53.25	0.21–0.25	0.10	0.08		
Breadth of zygomatic root of maxilla	f	5	12.57	0.07	1.32	0.00	11.39–14.57	0.07–0.08	0.11	0.06	–	–
	m	6	15.80	0.08	0.99	0.00	14.64–17.46	0.07–0.08	0.06	0.05		
Zygomatic breadth	f	5	109.33	0.62	3.54	0.01	104.24–113.30	0.60–0.63	0.03	0.02	–	–
	m	6	127.82	0.63	7.32	0.03	117.54–136.88	0.59–0.68	0.06	0.05		

Auditory breadth	f	5	85.11	0.48	2.91	0.01	82.04–88.77	0.47–0.49	0.03	0.02	–	–
	m	6	98.86	0.49	6.54	0.03	91.51–109.08	0.46–0.52	0.07	0.05		
Mastoid breadth	f	5	91.86	0.52	4.68	0.02	87.59–97.62	0.50–0.54	0.05	0.03	–	–
	m	6	114.02	0.56	7.69	0.03	105.04–125.21	0.52–0.59	0.07	0.05		
Height of skull at supraorbital processes	f	5	51.80	0.29	0.54	0.01	51.11–52.46	0.29–0.30	0.01	0.02	–	–
	m	6	61.61	0.30	3.16	0.01	57.57–66.30	0.29–0.32	0.05	0.04		
Height of skull at ventral margin of mastoid	f	5	70.36	0.40	2.35	0.02	68.66–74.44	0.38–0.43	0.03	0.05	–	–
	m	6	79.72	0.39	3.91	0.02	73.34–83.31	0.36–0.42	0.05	0.05		
Height of sagittal crest	f	5	0.00	0.00	0.00	0.00	0.00–0.00	0.00–0.00	–	–	–	–
	m	6	4.05	0.02	2.32	0.01	0.00–6.92	0.00–0.03	0.57	0.54		
Breadth of palate at postcanines 3–4	f	5	23.28	0.13	1.36	0.01	22.12–25.35	0.12–0.14	0.06	0.06	–	–
	m	6	29.71	0.15	2.11	0.01	26.72–33.22	0.13–0.17	0.07	0.10		
Breadth of palate at postcanines 4–5	f	5	26.85	0.15	1.54	0.01	25.09–28.99	0.14–0.16	0.06	0.07	–	–
	m	6	34.65	0.17	2.33	0.01	31.54–37.33	0.16–0.19	0.07	0.07		
Breadth of palate at postcanine 5	f	5	27.96	0.16	1.70	0.01	26.05–30.55	0.14–0.17	0.06	0.07	–	–
	m	6	36.04	0.18	2.38	0.02	32.68–38.63	0.16–0.20	0.07	0.09		
Length of orbit	f	5	48.89	0.28	0.89	0.00	47.89–49.90	0.27–0.28	0.02	0.02	–	–
	m	6	52.44	0.26	1.93	0.01	50.10–55.01	0.25–0.27	0.04	0.03		
Breadth of orbit	f	5	45.34	0.26	0.84	0.01	44.40–46.25	0.25–0.26	0.02	0.02	–	–
	m	6	49.00	0.24	2.52	0.01	45.56–51.60	0.23–0.26	0.05	0.05		
Mandible and teeth												
Length of mandible	f	5	115.73	0.65	4.43	0.02	110.85–121.74	0.63–0.68	0.04	0.03	–	–
	m	4	138.14	0.68	6.03	0.02	130.98–145.73	0.66–0.69	0.04	0.02		
Length of mandibular tooth row	f	5	52.78	0.30	4.38	0.02	48.19–59.93	0.28–0.33	0.08	0.06	–	–
	m	4	60.04	0.30	1.40	0.01	58.07–61.06	0.29–0.30	0.02	0.02		
Mesiodistal diameter of lower canines	f	3	6.96	0.04	0.14	0.00	6.82–7.09	0.04–0.04	0.02	0.00	–	–
	m	3	12.51	0.06	0.47	0.00	12.15–13.04	0.06–0.06	0.04	0.00		
Distance becaudal border of upper canines	f	5	48.01	0.27	1.19	0.00	46.73–49.30	0.27–0.28	0.03	0.02	–	–
	m	6	50.07	0.24	5.15	0.02	39.80–53.46	0.20–0.26	0.10	0.09		
Height of upper canines above alveolus	f	4	17.87	0.10	2.16	0.01	15.35–20.03	0.09–0.11	0.12	0.09	–	–
	m	2	23.94	0.12	1.35	0.01	22.98–24.89	0.11–0.12	0.06	0.06		
Mesiodistal diameter of postcanines	f	5	6.15	0.04	0.41	0.01	5.53–6.57	0.03–0.04	0.07	0.15	–	–
	m	3	6.73	0.03	0.71	0.00	5.94–7.31	0.03–0.03	0.11	0.00		
Length of lower postcanine row	f	5	37.36	0.21	2.73	0.01	35.12–41.77	0.20–0.23	0.07	0.06	–	–
	m	4	39.30	0.19	1.19	0.01	38.01–40.48	0.18–0.20	0.03	0.04		
Height of mandible at meatus	f	5	35.42	0.20	1.98	0.01	32.35–37.71	0.19–0.21	0.06	0.05	–	–
	m	4	46.72	0.23	1.91	0.01	44.20–48.62	0.22–0.25	0.04	0.06		
Angularis – coronoideus	f	5	37.93	0.22	2.09	0.01	34.68–39.83	0.20–0.23	0.06	0.05	–	–
	m	4	47.23	0.23	1.10	0.01	46.09–48.41	0.22–0.25	0.02	0.05		
Length of masseteric fossa	f	5	35.61	0.20	1.62	0.01	33.87–37.38	0.19–0.21	0.05	0.04	–	–
	m	4	46.25	0.23	1.15	0.01	45.22–47.52	0.22–0.23	0.03	0.02		
Breadth of masseteric fossa	f	5	22.44	0.13	1.69	0.01	20.75–25.06	0.12–0.14	0.08	0.07	–	–
	m	4	28.94	0.13	2.73	0.01	25.85–32.13	0.12–0.14	0.09	0.07		

SD = standard deviation, CV = coefficient of variation, P = probability values derived from students t-test.

Table 15 Summary statistics for skull measurements – adult male and female *Arctocephalus galapagoensis*.

Table 16 *A. australis*

Variable	Sex	n	Mean		SD		Range		CV		*P*	
			Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual (mm)	Relative to CBL	Actual	Relative to CBL	Actual	Relative to CBL
Length of skull												
Condylobasal length (CBL)	f	26	179.58	1.00	8.05	–	179.58–223.16	–	0.04	–		
	m	37	241.67	1.00	6.28	–	228.16–251.43	–	0.03	–	<0.001	<0.001
Gnathion – mid-occipital crest	f	26	171.24	0.84	7.75	0.03	153.73–191.68	0.77–0.88	0.05	0.03		
	m	37	208.29	0.86	6.20	0.02	193.82–223.24	0.80–0.90	0.03	0.03	<0.001	<0.001
Gnathion – posterior end of nasals	f	26	63.25	0.31	3.74	0.01	55.69–74.88	0.29–0.34	0.06	0.04		
	m	37	80.11	0.33	3.55	0.01	72.03–85.89	0.31–0.36	0.04	0.04	<0.001	<0.001
Length of nasals	f	20	30.93	0.15	5.14	0.02	22.93–46.54	0.12–0.22	0.17	0.15		
	m	28	36.68	0.15	3.05	0.01	29.80–41.28	0.13–0.17	0.08	0.08	0.005	0.948
Palatal notch – incisors	f	26	85.42	0.42	4.42	0.02	76.64–95.18	0.37–0.44	0.05	0.04		
	m	37	102.05	0.42	6.53	0.02	91.13–114.92	0.38–0.46	0.06	0.05	<0.001	0.282
Gnathion – posterior of maxilla (palatal)	f	26	96.38	0.47	4.73	0.01	85.16–104.51	0.45–0.49	0.05	0.02		
	m	37	113.81	0.47	4.99	0.01	103.74–123.44	0.45–0.50	0.04	0.03	<0.001	0.943
Basion – zygomatic root	f	26	139.97	0.68	6.24	0.01	119.25–149.65	0.66–0.71	0.04	0.02		
	m	37	166.52	0.69	5.95	0.01	153.77–176.09	0.67–0.73	0.04	0.02	<0.001	0.134
Basion – bend of pterygoid	f	26	66.60	0.33	3.13	0.02	58.24–70.58	0.27–0.35	0.05	0.05		
	m	37	77.04	0.32	3.03	0.01	68.46–82.56	0.29–0.34	0.04	0.04	<0.001	0.058
Gnathion – caudal border postglenoid process	f	26	152.14	0.74	7.42	0.01	130.45–168.62	0.72–0.76	0.05	0.02		
	m	37	182.78	0.76	6.09	0.01	171.68–193.26	0.74–0.78	0.03	0.01	<0.001	<0.001
Gnathion – foramen infraorbitale	f	26	65.41	0.32	4.02	0.02	60.34–76.02	0.28–0.37	0.06	0.07		
	m	37	81.36	0.34	7.36	0.03	52.21–95.38	0.21–0.39	0.09	0.08	<0.001	0.012
Gnathion – caudal border of preorbital process	f	26	62.42	0.30	3.67	0.01	54.83–74.35	0.28–0.33	0.06	0.03		
	m	37	77.57	0.32	2.59	0.01	69.31–82.10	0.30–0.34	0.03	0.03	<0.001	<0.001
Breadth of skull												
Breadth of nares	f	26	24.82	0.12	1.63	0.01	20.42–27.41	0.11–0.13	0.07	0.05		
	m	37	31.74	0.13	1.96	0.01	26.74–35.53	0.11–0.14	0.06	0.06	<0.001	<0.001
Breadth at preorbital processes	f	24	48.58	0.24	3.51	0.01	40.34–57.43	0.22–0.26	0.07	0.06		
	m	35	63.30	0.26	3.96	0.02	55.04–70.59	0.23–0.29	0.06	0.06	<0.001	<0.001
Interorbital constriction	f	26	24.97	0.12	2.30	0.01	21.28–30.14	0.10–0.14	0.09	0.09		
	m	36	35.12	0.15	3.21	0.01	29.76–41.67	0.12–0.17	0.09	0.09	<0.001	<0.001
Breadth at supraorbital processes	f	24	39.83	0.19	3.88	0.02	34.72–50.43	0.17–0.23	0.10	0.09		
	m	35	52.59	0.22	5.61	0.02	40.29–63.48	0.17–0.27	0.11	0.11	<0.001	<0.001
Breadth of braincase	f	26	73.10	0.36	1.84	0.02	68.91–77.52	0.33–0.40	0.03	0.05		
	m	36	75.50	0.31	2.50	0.01	70.35–81.84	0.28–0.33	0.03	0.04	0.002	<0.001
Occipital crest – mastoid	f	26	88.99	0.43	4.71	0.02	80.10–97.88	0.41–0.47	0.05	0.04		
	m	37	111.56	0.46	6.35	0.02	99.90–124.59	0.42–0.51	0.06	0.05	<0.001	<0.001
Rostral width	f	26	37.15	0.18	3.13	0.01	30.26–41.59	0.16–0.20	0.08	0.07		
	m	37	54.52	0.23	3.45	0.01	48.26–60.98	0.20–0.25	0.06	0.05	<0.001	<0.001
Breadth of zygomatic root of maxilla	f	26	13.77	0.07	1.50	0.01	11.29–16.93	0.06–0.08	0.11	0.11		
	m	37	17.42	0.07	1.26	0.01	14.41–20.27	0.06–0.08	0.07	0.08	<0.001	0.063
Zygomatic breadth	f	25	117.11	0.57	6.58	0.02	98.27–127.80	0.54–0.62	0.06	0.04		
	m	36	143.57	0.59	7.15	0.03	125.53–161.26	0.53–0.65	0.05	0.04	<0.001	0.001

Auditory breadth	f	26	91.93	0.45	4.14	0.01	82.61–98.56	0.43–0.47	0.05	0.03		
	m	37	112.83	0.47	5.64	0.02	102.37–127.62	0.43–0.53	0.05	0.05	<0.001	0.001
Mastoid breadth	f	26	102.35	0.50	7.15	0.03	87.46–114.90	0.45–0.55	0.07	0.05		
	m	37	132.62	0.55	7.15	0.03	115.27–149.97	0.49–0.61	0.05	0.05	<0.001	<0.001
Height of skull at supraorbital processes	f	26	59.12	0.29	3.08	0.01	50.09–67.73	0.27–0.31	0.05	0.04		
	m	37	71.21	0.29	3.14	0.01	63.88–77.09	0.26–0.32	0.04	0.05	<0.001	0.102
Height of skull at ventral margin of mastoid	f	26	75.14	0.37	3.92	0.02	69.16–84.13	0.34–0.41	0.05	0.05		
	m	37	91.93	0.38	7.20	0.03	74.89–105.50	0.32–0.44	0.08	0.07	<0.001	0.015
Height of sagittal crest	f	26	1.45	0.01	1.84	0.01	0.00–6.61	0.00–0.03	1.27	1.28		
	m	37	9.03	0.04	3.46	0.01	2.27–16.81	0.01–0.07	0.38	0.37	<0.001	<0.001
Breadth of palate at postcanines 3-4	f	26	25.09	0.12	2.97	0.01	20.09–29.54	0.09–0.14	0.12	0.11		
	m	37	32.56	0.14	3.06	0.01	24.71–40.11	0.11–0.17	0.09	0.09	<0.001	0.001
Breadth of palate at postcanines 4-5	f	26	28.03	0.14	3.16	0.01	21.26–33.27	0.10–0.16	0.11	0.11		
	m	37	36.23	0.15	3.48	0.01	29.71–44.62	0.13–0.19	0.10	0.09	<0.001	0.001
Breadth of palate at postcanine 5	f	26	28.76	0.14	3.02	0.01	23.39–33.77	0.10–0.16	0.11	0.11		
	m	37	36.92	0.15	3.45	0.01	31.13–45.43	0.13–0.19	0.09	0.09	<0.001	0.003
Length of orbit	f	26	50.20	0.24	2.04	0.01	45.23–53.74	0.23–0.26	0.04	0.04		
	m	37	54.02	0.22	2.03	0.01	50.02–57.464	0.21–0.25	0.04	0.04	<0.001	<0.001
Breadth of orbit	f	26	46.55	0.23	1.99	0.01	40.68–50.33	0.21–0.25	0.04	0.03		
	m	37	50.56	0.21	1.81	0.01	46.69–54.43	0.19–0.23	0.04	0.04	<0.001	<0.001
Mandible and teeth												
Length of mandible	f	17	136.89	0.67	8.68	0.02	115.15–153.60	0.64–0.71	0.06	0.03		
	m	10	169.33	0.71	8.96	0.03	156.26–181.10	0.67–0.78	0.05	0.05	<0.001	0.008
Length of mandibular tooth row	f	17	59.67	0.29	2.98	0.01	51.90–63.96	0.28–0.32	0.05	0.03		
	m	10	72.52	0.30	3.05	0.01	68.67–78.22	0.28–0.32	0.04	0.03	<0.001	0.026
Mesiodistal diameter of lower canines	f	14	8.13	0.04	0.96	0.00	6.78–10.07	0.03–0.05	0.12	0.12		
	m	8	14.59	0.06	1.00	0.00	13.41–16.45	0.06–0.07	0.07	0.06	<0.001	<0.001
Distance becaudal border of upper canines	f	26	53.33	0.26	3.05	0.01	45.27–58.79	0.22–0.28	0.06	0.05		
	m	37	59.25	0.25	3.62	0.02	49.83–66.07	0.20–0.27	0.06	0.06	<0.001	<0.001
Height of upper canines above alveolus	f	14	21.50	0.11	2.32	0.01	17.64–25.41	0.09–0.12	0.11	0.08		
	m	18	24.19	0.10	2.91	0.01	17.75–28.31	0.08–0.12	0.12	0.12	0.276	0.211
Mesiodistal diameter of postcanines	f	19	7.12	0.03	0.39	0.01	6.59–8.07	0.03–0.04	0.05	0.15		
	m	23	7.53	0.03	0.43	0.00	6.67–8.28	0.03–0.03	0.06	0.00	0.112	–
Length of lower postcanine row	f	17	43.61	0.21	5.49	0.02	36.38–62.69	0.19–0.30	0.13	0.11		
	m	10	47.07	0.20	1.94	0.01	43.66–50.42	0.19–0.21	0.04	0.04	0.691	0.022
Height of mandible at meatus	f	17	42.76	0.21	4.21	0.02	34.66–53.93	0.19–0.26	0.10	0.08		
	m	10	61.75	0.26	3.67	0.02	56.51–66.92	0.23–0.28	0.06	0.07	<0.001	<0.001
Angularis – coronoideus	f	17	43.84	0.22	4.39	0.02	33.79–54.36	0.19–0.26	0.10	0.07		
	m	10	60.03	0.25	4.66	0.02	55.36–67.28	0.22–0.29	0.08	0.08	<0.001	<0.001
Length of masseteric fossa	f	17	43.52	0.21	4.90	0.02	33.90–51.45	0.19–0.24	0.11	0.09		
	m	10	58.38	0.24	4.98	0.02	51.06–65.51	0.21–0.28	0.09	0.10	<0.001	0.003
Breadth of masseteric fossa	f	17	28.58	0.14	2.55	0.01	23.01–32.44	0.12–0.165	0.09	0.07		
	m	10	37.71	0.16	3.80	0.01	32.98–43.29	0.14–0.18	0.10	0.10	<0.001	0.010

SD = standard deviation, CV = coefficient of variation, *P* = probability values derived from students *t*-test.

Table 16 Summary statistics for cranial measurements – adult male and female *Arctocephalus australis*.

Table 17 *A. philippii*

			Mean		SD		Range		CV		***P***	
Variable	**Sex**	**n**	**Actual (mm)**	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual (mm)**	**Relative to CBL**	**Actual**	**Relative to CBL**	**Actual**	**Relative to CBL**
Length of skull												
Condylobasal length (CBL)	f	1	221.34	1.00	–	–	–	–	–	–	–	–
	m	1	267.72	1.00	–	–	–	–	–	–		
Gnathion – mid-occipital crest	f	1	188.92	0.85	–	–	–	–	–	–	–	–
	m	1	236.40	0.88	–	–	–	–	–	–		
Gnathion – posterior end of nasals	f	1	71.63	0.32	–	–	–	–	–	–	–	–
	m	1	102.83	0.38	–	–	–	–	–	–		
Length of nasals	f	1	35.83	0.16	–	–	–	–	–	–	–	–
	m	1	53.12	0.20	–	–	–	–	–	–		
Palatal notch – incisors	f	1	100.47	0.45	–	–	–	–	–	–	–	–
	m	1	119.95	0.45	–	–	–	–	–	–		
Gnathion – posterior of maxilla (palatal)	f	1	111.31	0.50	–	–	–	–	–	–	–	–
	m	1	137.53	0.51	–	–	–	–	–	–		
Basion – zygomatic root	f	1	147.66	0.67	–	–	–	–	–	–	–	–
	m	1	178.06	0.67	–	–	–	–	–	–		
Basion – bend of pterygoid	f	1	69.03	0.31	–	–	–	–	–	–	–	–
	m	1	71.80	0.27	–	–	–	–	–	–		
Gnathion – caudal border postglenoid process	f	1	165.31	0.75	–	–	–	–	–	–	–	–
	m	1	205.07	0.77	–	–	–	–	–	–		
Gnathion – foramen infraorbitale	f	1	73.48	0.33	–	–	–	–	–	–	–	–
	m	1	95.15	0.36	–	–	–	–	–	–		
Gnathion – caudal border of preorbital process	f	1	68.92	0.31	–	–	–	–	–	–	–	–
	m	1	92.24	0.34	–	–	–	–	–	–		
Breadth of skull												
Breadth of nares	f	1	24.46	0.11	–	–	–	–	–	–	–	–
	m	1	30.96	0.12	–	–	–	–	–	–		
Breadth at preorbital processes	f	1	51.90	0.23	–	–	–	–	–	–	–	–
	m	1	63.63	0.24	–	–	–	–	–	–		
Interorbital constriction	f	1	23.19	0.10	–	–	–	–	–	–	–	–
	m	1	34.87	0.13	–	–	–	–	–	–		
Breadth at supraorbital processes	f	1	41.26	0.19	–	–	–	–	–	–	–	–
	m	1	59.57	0.22	–	–	–	–	–	–		
Breadth of braincase	f	1	78.93	0.36	–	–	–	–	–	–	–	–
	m	1	83.25	0.31	–	–	–	–	–	–		
Occipital crest – mastoid	f	1	91.88	0.42	–	–	–	–	–	–	–	–
	m	1	116.43	0.43	–	–	–	–	–	–		
Rostral width	f	1	33.54	0.15	–	–	–	–	–	–	–	–
	m	1	58.98	0.22	–	–	–	–	–	–		
Breadth of zygomatic root of maxilla	f	1	15.97	0.07	–	–	–	–	–	–	–	–
	m	1	24.15	0.09	–	–	–	–	–	–		
Zygomatic breadth	f	1	122.91	0.56	–	–	–	–	–	–		
	m	1	153.73	0.57	–	–	–	–	–	–	–	–

Auditory breadth	f	1	96.19	0.43	–	–	–	–	–	–		
	m	1	122.78	0.46	–	–	–	–	–	–	–	–
Mastoid breadth	f	1	104.55	0.47	–	–	–	–	–	–		
	m	1	141.08	0.53	–	–	–	–	–	–	–	–
Height of skull at supraorbital processes	f	1	63.53	0.29	–	–	–	–	–	–		
	m	1	82.26	0.31	–	–	–	–	–	–	–	–
Height of skull at ventral margin of mastoid	f	1	80.68	0.36	–	–	–	–	–	–		
	m	1	97.80	0.37	–	–	–	–	–	–	–	–
Height of sagittal crest	f	1	1.78	0.01	–	–	–	–	–	–		
	m	1	10.45	0.04	–	–	–	–	–	–	–	–
Breadth of palate at postcanines 3-4	f	1	21.01	0.09	–	–	–	–	–	–		
	m	1	24.17	0.09	–	–	–	–	–	–	–	–
Breadth of palate at postcanines 4-5	f	1	23.04	0.10	–	–	–	–	–	–	–	–
	m	1	31.11	0.12	–	–	–	–	–	–	–	–
Breadth of palate at postcanine 5	f	1	27.06	0.12	–	–	–	–	–	–		
	m	1	34.33	0.13	–	–	–	–	–	–	–	–
Length of orbit	f	1	53.18	0.24	–	–	–	–	–	–		
	m	1	57.05	0.21	–	–	–	–	–	–	–	–
Breadth of orbit	f	1	49.95	0.23	–	–	–	–	–	–		
	m	1	53.69	0.20	–	–	–	–	–	–	–	–
Mandible and teeth												
Length of mandible	f		151.33	0.68	–	–	–	–	–	–	–	–
	m		184.51	0.69	–	–	–	–	–	–		
Length of mandibular tooth row	f		69.31	0.31	–	–	–	–	–	–	–	–
	m		81.23	0.30	–	–	–	–	–	–		
Mesiodistal diameter of lower canines	f		8.57	0.04	–	–	–	–	–	–	–	–
	m		8.87	0.03	–	–	–	–	–	–		
Distance becaudal border of upper canines	f		69.75	0.32	–	–	–	–	–	–	–	–
	m		77.65	0.29	–	–	–	–	–	–		
Height of upper canines above alveolus	f		20.86	0.09	–	–	–	–	–	–	–	–
	m		26.94	0.10	–	–	–	–	–	–		
Mesiodistal diameter of postcanines	f		6.93	0.03	–	–	–	–	–	–	–	–
	m		8.15	0.03	–	–	–	–	–	–		
Length of lower postcanine row	f		50.64	0.23	–	–	–	–	–	–	–	–
	m		57.01	0.21	–	–	–	–	–	–		
Height of mandible at meatus	f		41.93	0.19	–	–	–	–	–	–	–	–
	m		63.12	0.24	–	–	–	–	–	–		
Angularis – coronoideus	f		47.29	0.21	–	–	–	–	–	–	–	–
	m		62.86	0.23	–	–	–	–	–	–		
Length of masseteric fossa	f		39.04	0.18	–	–	–	–	–	–	–	–
	m		58.99	0.22	–	–	–	–	–	–		
Breadth of masseteric fossa	f		26.61	0.12	–	–	–	–	–	–	–	–
	m		42.70	0.16	–	–	–	–	–	–		

SD = standard deviation, CV = coefficient of variation, P = probability values derived from students t-test.

Table 17 Summary statistics for skull measurements – adult male and female *Arctocephalus philippii*.